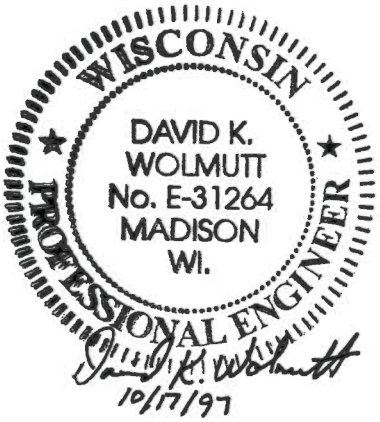
51100

Report on
Shorewood Hills

Stormwater Management Study
University Avenue / Midvale Boulevard Area



Prepared by:

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October 1997

STRAND
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ENGINEERS

Shorewood Hills

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EXECUTIVE SUMMARY

ES.01 PURPOSE AND SCOPE OF STUDY

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over fifty years. Public records indicate severe flooding has occurred on numerous occasions, with damages impacting single family homes and commercial lots. In addition, recurrent flooding has resulted in closure of both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street.

The intent of this report is to analyze drainage conditions within the area tributary to the existing culvert system which serves the University Avenue/Midvale Boulevard intersection to assess the adequacy of existing stormwater facilities and evaluate future needs. This assessment includes:

1. Identification of physical characteristics of the tributary area which impact stormwater runoff amounts and depths to the University/Midvale intersection.

2. Evaluation of the adequacy of the existing box culvert system serving the University/Midvale intersection to convey stormwater discharges,

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative for alleviating existing flooding problems in the study area.

The results of this study will serve as a guideline for Village of Shorewood Hills and City of Madison officials to evaluate how best to alleviate flooding conditions within the study area.

ES.02 CONTRIBUTING WATERSHED AND EXISTING DRAINAGE SYSTEM

The University Avenue/Midvale Boulevard intersection is served by a mainline box culvert system draining northerly along Midvale Boulevard and Rose Place, passing under the Kohl's grocery store to Locust Avenue, then turning easterly along the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way. The culvert follows University Avenue from Grand Avenue to just east of Walnut Street. At this point, the culvert turns northerly, eventually crossing Campus Drive, and discharging into Willow Creek. The culvert varies in size from 12-feet (wide) by 4.5-feet (high) near the outlet to 15-feet (wide) by 6-feet (high) from Shorewood Boulevard to University Bay Drive.

The contributing watershed area to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Approximately 84 percent of the total

1952 acres within the watershed lies within the City of Madison, with the remaining portion in the Village of Shorewood Hills.

ES.03 METHOD AND RESULTS OF ANALYSIS

The computer program HEC-1, developed by the U.S. Army Corps of Engineers, was used to generate stormwater runoff hydrographs for existing conditions from the tributary area. To determine the capacity of the existing mainline culvert and analyze the performance of proposed alternatives, the Extended Transport (EXTRAN) module of the Stormwater Management Model (SWMM) computer program, developed by the United States Environmental Protection Agency, was used. EXTRAN is a dynamic flow routing model that routes inflow hydrographs through an open channel and/or closed conduit system, computing the time history of flows and hydraulic heads throughout the system.

Computer modeling results indicate that the existing culvert has a hydraulic capacity of only approximately thirty percent of the anticipated inflow to the culvert for a one hundred-year storm and a hydraulic capacity of less than the anticipated peak discharge for a ten-year year storm. Stormwater flows in excess of the existing culvert capacity overflow to the surface through manholes and inlets, inundating the Garden Homes subdivision, Kohl's parking lot area, and the University/Midvale intersection. In the event of a 100-year storm, computer models indicate that as much as 3,000,000 cubic feet of stormwater volume may overflow the drainage system. During the June 17, 1996 storm event, an estimated 800,000-1,000,000 cubic feet of stormwater overflowed the drainage system.

ES.04 ALTERNATIVES ANALYSIS

To identify the most cost-effective solution to alleviate flooding problems near the University/Midvale intersection, several individual plan components were evaluated. These plan components included the following:

1. Provision of Stormwater Detention at Rennebohm Park.

2. Provision of Stormwater Detention at Lucia Crest Park.

3. Provision of a Stormwater Detention Chamber underneath the Kohl's Parking Lot.

4. Construction of a relief sewer to the existing outlet at Willow Creek.

5. Construction of a new relief tunnel under Blackhawk Country Club discharging to Lake Mendota.

6. Floodproofing the existing Garden Homes Subdivision.

To determine the most cost-effective stormwater management plan, 14 alternatives consisting of various combinations of these individual stormwater management components were developed. The lowest cost alternative evaluated was $1,890,000 for floodproofing individual homes in the Garden Homes Subdivision. However, this alternative would provide the least overall benefit since it would continue to allow flooding of the Kohl's Shopping Center site, the University/Midvale intersection, and other points eastward. The lowest cost alternative which would provide a 100-year level of protection is construction of a 108-inch diameter relief tunnel underneath Blackhawk Country Club to Lake Mendota.

The most expensive alternatives analyzed were those including construction of an underground storage chamber in the Kohl's Parking Lot. This is because the structure would have to be extremely large and as deep as 50 feet to have sufficient capacity to significantly reduce peak discharge rates. Also, construction of a relief culvert eastward to Willow Creek along the existing culvert route was determined to be prohibitively expensive due to the size and length of the culvert required and the potential conflicts encountered.

ES.05 RECOMMENDED ALTERNATIVE

Construction of a 108-inch diameter relief tunnel under Blackhawk Country Club, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with project design criteria.

2. Most of the work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands should not be necessary. Easements for work within the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way would be required.

3. Due to the depth of the tunnel, there should be a relatively minimal number of utility conflicts, and minimal disruption to traffic.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

Construction of the Blackhawk Relief Tunnel would include the following:

1. Construction of a diversion structure at the Midvale/University intersection to direct culvert flow in excess of the existing culvert capacity (approximately 350 cfs) to the new tunnel.

2. Construction of an 11-foot (wide) by 6-foot (high) box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a 108-inch diameter tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina.

3. Construction of an outlet structure at the marina to dissipate energy prior to discharge into Lake Mendota. Restoration of the marina and shoreline would be completed.

4. Construction of special inlet structures at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-year storm flow is collected and transported from the surface to the underground drainage system.

5. Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

Completion of this work would upgrade the level of protection of the Kohl's site, Garden Homes subdivision, and adjacent areas from less than a 10-year storm frequency (10 percent annual recurrence probability) to a 100-year storm frequency (1 percent recurrence probability).

ES.06 OPINION OF PROBABLE PROJECT COST

The probable cost of the recommended alternative is $6,739,000, including engineering and contingencies. A cost-sharing agreement for this work should be negotiated between the City of Madison and the Village of Shorewood Hills to fund the project.

SECTION 1
INTRODUCTION

1.01 INTRODUCTION

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over fifty years. Public records indicate severe flooding has occurred on numerous occasions, with damages impacting single family homes and commercial lots. In addition, recurrent flooding has resulted in closure of both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street.

To address this issue, several studies have been undertaken in the past by the City of Madison and the Village of Shorewood Hills. Records indicate that various studies were completed in 1945, 1954, 1964, and 1966. Flood relief alternatives evaluated include stormwater detention, improvement of the culvert capacity easterly along University Avenue, and construction of a relief tunnel underneath Blackhawk Golf Course to Lake Mendota. Recommendations included construction of a 78-inch relief tunnel. This work, however, was never performed.

Recent residential flooding and consideration of redeveloping commercial properties in the area has spurred renewed interest in resolving the recurrent flooding problem in the area. Strand Associates, Inc. was hired in July 1997, to update the previous studies and recommend a new strategy for alleviating existing flooding problems. Results of this investigation are summarized in this report.

1.02 PURPOSE AND SCOPE OF STUDY

The intent of this report is to analyze drainage conditions within the area tributary to the existing culvert system which serves the University Avenue/Midvale Boulevard intersection to assess the adequacy of existing stormwater facilities and evaluate future needs. This assessment includes:

1. Identification of physical characteristics of the tributary area which impact stormwater runoff amounts and depths to the University/Midvale intersection.

2. Evaluation of the adequacy of the existing box culvert system serving the University/Midvale intersection to convey stormwater discharges,

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative for alleviating existing flooding problems in the study area.

The results of this study will serve as a guideline for Village of Shorewood Hills and City of Madison officials to evaluate how best to alleviate flooding conditions within the study area. The study area is found in Figure 1.02-1.

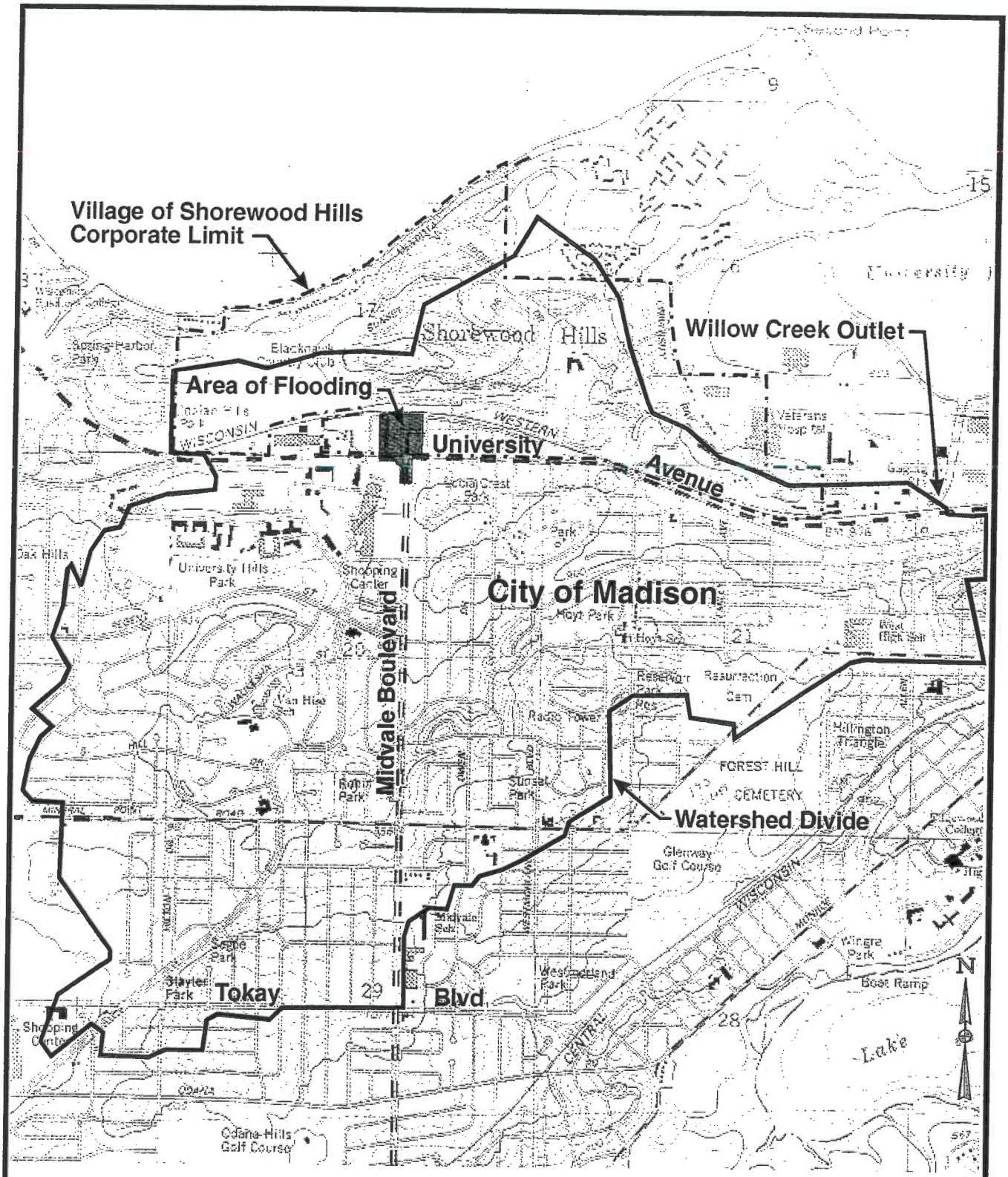
1.03 DESIGN CRITERIA

Traditionally, design of stormwater management facilities is on a "design storm" basis. A design storm is a theoretical storm event recurring at a statistically determined interval. Stormwater discharge from a storm up to and including the severity of the designated design storm will be managed by the proposed drainage facility. Storm events exceeding the design storm may exceed the capacity of the facility and must be managed through other means, such as overland flow.

The statistical basis for the analysis of storm events is the recurrence interval. The recurrence interval is defined as the average interval between the occurrence of a storm of a specified magnitude and an equal or larger storm. If a storm event has a recurrence interval of x years, then the probability of it being equaled or exceeded in any given year is 1/x. Therefore, a "one-hundred year storm" has a one in one-hundred, or one percent, chance of occurring in a given x year. The determination of the recurrence interval is based upon long-term precipitation data for the region. Therefore, on average, a one-hundred year storm will occur once in one hundred years. However, this does not imply that a one-hundred year storm cannot occur more than one time in a one-hundred year period, nor does it imply that a one-hundred year storm will definitely occur in a one-hundred year period.

Typically, municipal drainage networks consist of minor and major drainage systems. The minor system, consisting of facilities such as storm sewers, ditches, and roadway inlets is designed to carry nuisance flooding for convenience, health, and safety. A typical minor system would be for a design storm of a five- to ten-year return frequency. The major system, consisting of major drainageways, detention ponds, and overland flow routes, is typically designed to prevent structural damages and endangerment of human life. A typical major system design storm event is the one-hundred year recurrence interval.

The University/Midvale intersection is served by a series of culverts. Since the intersection is located in a large depression, there is no overland flow route available. Therefore, the drainage system must serve as both the major and minor flow route. For this reason, and because occurrence of a one-hundred year storm event under present conditions could cause significant flood damages, it is recommended that all drainage improvements be designed for a one-hundred year recurrence frequency.



Source: USGS Madison West, WI Topographic Quadrangle
(7.5 Minute Series)
Scale: 1" = 2000'

Figure No. 1.02-1	Village of Shorewood Hills University Avenue / Midvale Boulevard Stormwater Management Study General Location Map	STRAND ASSOCIATES, INC.

SECTION 2
CONTRIBUTING WATERSHED CHARACTERISTICS AND EXISTING DRAINAGE SYSTEM

2.01 OVERVIEW OF TRIBUTARY AREA

This study includes an investigation of the existing trunk line culvert system serving the University Avenue/Midvale Boulevard intersection. The limits of detailed hydraulic analysis of this system are approximately the Vernon Boulevard/Midvale Boulevard intersection to the culvert outlet at Willow Creek, which is east of Walnut Street and north of Campus Drive.

Municipality	Contributing Watershed Area (Ac)	Percentage of Total Watershed Area
Village of Shorewood Hills	321	16.4%
City of Madison	1631	83.6%
TOTAL	1952	100%

Table 2.01-1 Relative Contribution of Watershed Areas

The contributing watershed to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Table 2.01-1 includes a breakdown of the relative portions of the watershed located in the Village of Shorewood Hills and the City of Madison.

2.02 WATERSHED SUBBASINS

For purposes of this study, the contributing watershed has been divided into several smaller subbasins. Basin divisions were selected with consideration of topography, homogeneity of land usage, and locations of major drainage systems. Descriptions of subbasin areas are included in this section.

A. Segoe Road Catchment

This 505 acre catchment includes tributary areas to the Segoe Road drainage system, and includes Subbasins 500-535, as identified in Figure 2.01-1. Included in this catchment are areas generally along Segoe Road, extending southerly to Tokay Boulevard, and northerly to approximately Regent Street. The area is primarily medium density residential, with moderately sloping terrain. The main drainage system serving this area consists of a box culvert in the median of Segoe Road ranging in size from seven-feet (wide) by 2.5-feet (high), to seven feet (wide) by four feet (high). This culvert discharges to the box culvert at Vernon Boulevard.

B. Midvale South Catchment

This 349 acre catchment includes tributary areas to the Midvale Road drainage system, and includes Subbasins 400-435, as identified in Figure 2.01-1. Included are areas generally along, and mostly east of, Midvale Boulevard extending southerly to Tokay Boulevard, and northerly to approximately Regent Street. The area is primarily medium density residential, with moderately to steeply sloping terrain. Several drainage systems serve this area, including seven-foot (wide) by 2.5 foot (high) open concrete flumes draining northerly in the mid-block areas between Midvale Boulevard and Hillcrest Drive, and between Midvale Boulevard and Merlham Drive; an open ditch serving the Sunset Village subdivision east of Midvale Boulevard and south of Hillcrest Drive; and a 30-inch storm sewer serving the Midvale Terrace Subdivision east of Midvale Boulevard and north of Regent Street. These systems join at Midvale Boulevard and are carried to a junction with systems serving the Segoe Road and University Hills/Regent Street catchments at Vernon Boulevard.

C. University Hills/Regent St. Catchment

This 164 acre catchment includes Subbasins 300-310, as identified in Figure 2.01-1. Included are areas generally along Regent Street, west of Segoe Road. The catchment includes commercial office development and multi-family housing, as well as low to medium density residential development. Rennebohm Park occupies approximately a twenty acre portion of the catchment. The main drainage system consists of a 30- to 36-inch storm sewer crossing Rennebohm Park. This storm sewer discharges to an open channel with a concrete invert, draining easterly to a detention basin near Segoe Road. The detention basin discharges via a control structure to a seven-foot (wide) by three-foot (high) box culvert at Segoe Road. The control structure consists of a three foot high weir with three twelve inch rectangular orifices.

D. University/Midvale Catchment

This 231 acre catchment includes areas draining directly to University Avenue west of Shorewood Boulevard and directly to Midvale Boulevard north of Regent Street, including Subbasins 205-215 and 225-255, as identified in Figure 2.01-1. A large amount of highly intensive land usage, including the Hilldale Shopping Center, Kohl's Shopping Center, and other commercial and office developments are present in this catchment. Ground slopes are generally flat, with standing water common after large rain events. The main drainage system consists of a twelve-foot (wide) by five foot (high) box culvert running in a northerly direction along Midvale Boulevard to Locust Avenue. At Locust Avenue, the culvert turns easterly and runs parallel to the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way to Shorewood Boulevard.

E. Shorewood Hills Catchment

This 296 acre catchment includes areas draining from the Village of Shorewood Hills, north of the Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way, including Subbasins 111, 135, 200, and 220, as shown in Figure 2.01-1. The area is primarily medium density residential, with steeply sloping terrain. The catchment drains southerly to an existing open ditch located north of the Chicago, Milwaukee, St. Paul, and Pacific Railroad tracks. The open ditch carries stormwater discharge easterly to Shorewood Boulevard, where it discharges to the main box culvert system, via an 18-inch restricted opening with a check valve. Additional flow is carried into the main system from a 48-inch storm sewer along Shorewood Boulevard.

F. University East Catchment

This 407 acre catchment includes areas east of Shorewood Boulevard directly tributary to the main culvert system, including Subbasins 100, 110, and 130, as shown in Figure 2.01-1. Stormwater runoff from this area does not directly impact the University/Midvale Intersection. However, it is included in the analysis because it impacts the downstream capacity of the culvert system serving the intersection. The area includes a large amount of commercial and high density residential development, and has moderate to flat ground slopes.

2.03. LAND USE

As indicated in Table 2.03-1 and Figure 2.03-1, overall land use in the watershed is predominately low to high density residential (65%), with a substantial portion of commercial development also present (23%). The watershed is almost fully developed, with open space areas occupying only approximately twelve percent of the total area. Most of this open space is either park lands or school grounds.

Since the area is nearly fully developed, it is not anticipated that future conditions stormwater discharges will substantially increase in comparison with existing conditions discharges.

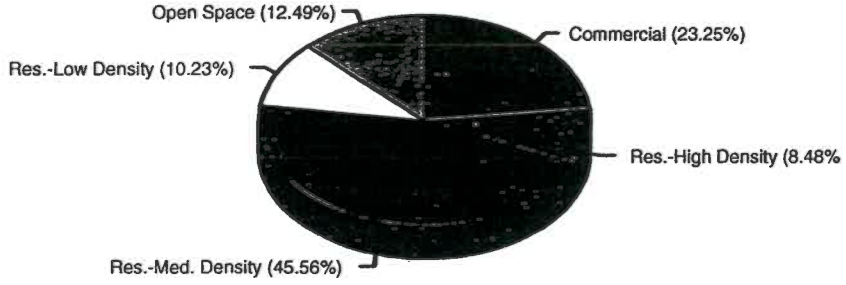


Figure 2.03-1 Watershed Land Use Breakdown

The limits of the watershed are identified in Figure 2.03-1.

Subbasin Designation	Land Use (Ac) Commercial	High Density Residential	Medium Density Residential	Low Density Residential	Open Space	Total Area (Ac)
University - East						
100	79.5	84.2	63.1		41.2	268.0
110	11.2	25.3	27.8	3.3	7.3	74.9
130	23.0	28.4	7.6	—	5.4	64.4
Subtotal	113.7	137.9	98.5	3.3	53.9	407.3
University/Midvale						
205	29.2	10.0	15.1		14.6	68.9
210	5.4		4.4			9.8
215			9.5			9.5
225	14.9	6.3			6.6	27.8
230	23.3					23.3
235	16.8					16.8
240	16.0					16.0
245	16.6					16.6
250	14.8		4.2			19.0
255	12.8	2.2	7.6	—	0.7	23.3
Subtotal	149.8	18.5	40.8	0.0	21.9	231.0
University Hills/Regent						
300	43.3				18.9	62.2
305	21.1		28.0	44.8	2.4	96.3
310	—	—	—	5.3	—	5.3
Subtotal	64.4	0.0	28.0	50.1	21.3	163.8
Shorewood Hills						
111	22.0	0.0	5.0	0.0	0.0	27.0
135	10.0	0.0	5.0	0.0	15.0	30.0
200	23.2	0.0	25.4	47.7	15.0	111.3
220	3.5	0.0	43.3	12.7	67.8	127.3
Subtotal	58.7	0.0	78.7	60.4	97.8	295.6
Midvale South						
400	7.1		36.0	7.3	13.9	64.3
405			48.1	0.9	6.9	55.9
410	5.4	9.1	82.3			96.8
415	3.4		6.2			9.6
420	2.4		17.3			19.7
425			14.0			14.0
430	2.0		17.6			19.6
435	3.7	—	61.7	—	3.7	69.1
Subtotal	24.0	9.1	283.2	8.2	24.5	349.0
Segoe Road						
500	5.1		7.3	41.6		54.0
505	5.8		18.0		15.7	39.5
510	1.0		99.9	11.9		112.8
515	2.5		12.4			14.9
520	11.2		52.0	4.7	3.1	71.0
525			17.3		2.0	19.3
530			49.4			49.4
535	17.5		103.7	19.5	3.5	144.2
Subtotal	43.1	0.0	360.0	77.7	24.3	505.1

Table 2.03-1 Land Use Summary

2.04 SOILS

The amount of stormwater runoff produced by a storm event is greatly impacted by the types of soil underlying the watershed. Soils consisting of a high percentage of sand and gravel will tend to absorb a higher percentage of stormwater than will soils having a high clay content. Therefore, relatively less stormwater runoff will occur in sandy areas.

According to the Dane County, Wisconsin Soils Survey, published by the U.S. Department of Agriculture in cooperation with the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin, local soils are primarily silt loams. These soils are classified by the Soil Conservation Service in Hydrologic Soil Group B, meaning they are moderately well to well-drained soils with moderately fine to moderately coarse textures. Stormwater will typically infiltrate into these soils at a rate of 0.15 to 0.30 inches per hour.

2.05 PRECIPITATION DEPTHS

Potential sources of stormwater runoff include rainfall, snow melt, groundwater, or a combination of these. A review of precipitation records for the project area indicates that the highest potential for flooding results from intense rainstorm events. Therefore, for this study, stormwater runoff modeling was based strictly upon rainfall events.

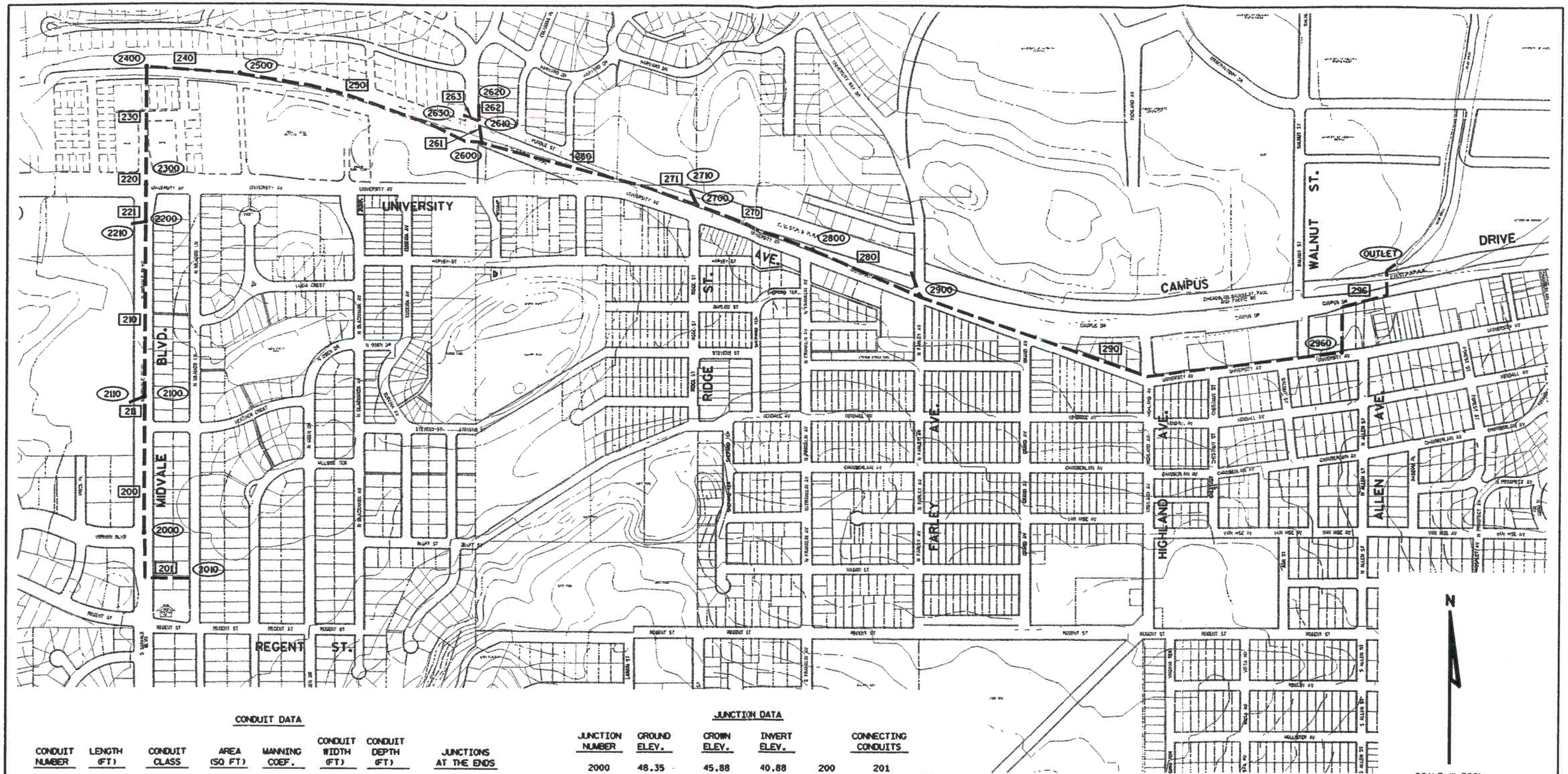
Rainfall depths for the City of Madison were obtained from the publication *Rainfall Frequency of the Midwest* (Bulletin 71), by the Midwestern Climate Center. This document is an atlas of rainfall depths for various storm durations based upon several decades of data from a network of rainfall gauges. Rainfall depths for storm events of various durations and return frequencies are summarized in Table 2.05-1.

	Precipitation Depth (in)				
Frequency	30-min	1-Hour	3-Hour	6-Hour	24-hr
2-Year	1.03	1.31	1.78	2.09	2.78
5-Year	1.31	1.66	2.26	2.65	3.53
10-Year	1.55	1.97	2.69	3.15	4.20
50-Year	2.24	2.85	3.88	4.55	6.06
100-Year	2.61	3.32	4.52	5.30	7.06

Reference: Huff, Floyd A., and Angel, James R., Rainfall Frequency Atlas of the Midwest, Midwestern Climate Center, Bulletin 71, Table 9, 1992.

Table 2.05-1 Precipitation Data

Precipitation depths were distributed over various storm durations modeled using the First Quartile Huff Rainfall Distribution.



N

SCALE: 1"=300'

CONDUIT DATA

CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	CONDUIT WIDTH (FT)	CONDUIT DEPTH (FT)	JUNCTIONS AT THE ENDS	
200	680	R.C. BOX	60	0.016	12	5	2000	2100
210	1190	R.C. BOX	60	0.016	12	5	2100	2200
220	240	R.C. BOX	60	0.016	12	5	2200	2300
230	640	R.C. BOX	60	0.016	12	5	2300	2400
240	630	R.C. BOX	60	0.016	12	5	2400	2500
250	1440	R.C. BOX	60	0.016	12	5	2500	2600
260	1420	R.C. BOX	75	0.016	15	5	2600	2700
270	770	R.C. BOX	90	0.016	15	6	2700	2800
280	700	R.C. BOX	90	0.016	15	6	2800	2900
290	2530	R.C. BOX	72	0.016	12	6	2900	2960
296	750	R.C. BOX	54	0.016	12	4.5	2960	OUTLET
221	100	R.C. PIPE	4.91	0.016	2.5	2.5	2210	2200
211	100	R.C. PIPE	4.91	0.016	2.5	2.5	2110	2100
201	330	R.C. PIPE	4.91	0.016	2.5	2.5	2010	2000
261	80	R.C. BOX	25	0.016	5	5	2610	2600
262	100	R.C. PIPE	9.62	0.016	3.5	3.5	2620	2610
263	100	R.C. PIPE	9.62	0.016	3.5	3.5	2630	2610
271	100	R.C. PIPE	9.62	0.016	3.5	3.5	2710	2700
291	150	R.C. PIPE	0.79	0.016	1	1	2910	2900

JUNCTION DATA

JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.		CONNECTING CONDUITS		
2000	48.35	45.88	40.88	200	201		
2100	45.51	43.2	38.2	200	210	211	
2200	40.25	38.13	33.13	210	220	221	
2300	39.66	36.63	31.63	220	230		
2400	38.67	32.74	27.74	230	240		
2500	42.45	32.73	27.73	240	250		
2600	36.68	30.55	25.55	250	260	261	
2700	34.49	29.83	23.83	260	270	271	
2800	30.85	28.6	22.6	270	280		
2900	31.03	27.73	21.73	280	290	291	
2960	27.18	19.05	13.05	290	296		
OUTLET	12.28	5.7	1.2	296			
2210	45	37.5	35	221			
2110	48.5	41.5	39	211			
2010	50	44.78	42.28	201			
2610	36	35	30	261	262	263	
2620	35	34.5	31	262			
2630	36	34.5	31	263			
2710	33.5	32	28.5	271			
2910	31.5	29	28	291			

LEGEND

EXISTING BOX CULVERT

SWMM CONDUIT NUMBER [201]

SWMM JUNCTION NUMBER (2000)

VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
2.06-1

EXISTING DRAINAGE SYSTEM

2.06 EXISTING DRAINAGE SYSTEM

The University Avenue/Midvale Boulevard intersection is served by a mainline box culvert system draining northerly along Midvale Boulevard and Rose Place, passing under the Kohl's grocery store to Locust Avenue, then turning easterly along the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way. The culvert follows University Avenue from Grand Avenue to just east of Walnut Street. At this point, the culvert turns northerly, eventually crossing Campus Drive, and discharging into Willow Creek. The culvert varies in size from twelve feet (wide) by 4.5 feet (high) near the outlet to 15 feet (wide) by 6 feet (high) from Shorewood Boulevard to University Bay Drive. The layout of the culvert, along with relevant physical data is included in Figure 2.06-1.

A visual inspection of the culvert was performed by City of Madison engineers in September, 1997. City staff reports that, in general, the culvert is in fairly good structural condition.

SECTION 3
STUDY METHODOLOGY AND RESULTS

3.01 STUDY METHODOLGY

A. Method of Estimating Storm Flows

The volume of stormwater produced by a rainfall event is dependent, primarily, upon the following factors:

1. The depth, duration, and spatial and temporal distribution of precipitation.
2. The size of the drainage area upstream from the point of concern.
3. The land cover (e.g., grass, pavement, etc.) of the tributary drainage area.
4. The travel time from the most remote portions of the watershed to the point of concern.
5. The type and degree of saturation of the underlying soils.
6. The presence and extent of stormwater storage areas in the floodplain and watershed.
7. The presence of manmade structures within the watershed which accelerate or restrict flows to downstream areas.

To model runoff characteristics of a watershed, hydrologists typically produce and analyze graphs of flow versus time, known as hydrographs, at the point of interest in the watershed. Hydrographs can be mathematically manipulated to determine the effects of adding or removing storage volume, accelerating or slowing travel times, or adding or reducing the amount of imperviousness. Analysis of hydrographs in this manner enables evaluation of existing and future conditions and impacts of proposed alternatives on stormwater flows.

For this project, the computer program HEC-1, produced by the U.S. Army Corps of Engineers, was used to generate hydrographs for existing conditions. Input to HEC-1 included mathematical parameters representing precipitation depth and distribution, drainage areas, land usage, and flow times for each of the 36 subbasins identified in Figure 2.01-1. The result is a rainfall-runoff model for the storm frequency of interest in the watershed. For this study, hydrographs of the 10-year, 50-year and 100-year storm events were produced. A range of storm durations were modeled to determine the storm duration producing the highest peak discharge for each storm frequency.

A summary of HEC-1 input parameters is included in Table 3.01-1.

Subbasin Designation	Subbasin Area (acres)	Subbasin Area (sq. mi.)	Runoff Curve Number	Time of Concentration (hr)	Lag Time (hr)
Shorewood Hills					
111	27.0	0.042	92	0.33	0.20
135	30.0	0.0469	77	0.62	0.37
200	161.2	0.2517	75	0.8	0.48
220	89.3	0.1395	69	1.12	0.67
University - East					
100	268.0	0.4327	78	0.62	0.37
110	73.9	0.1254	85	0.48	0.29
130	65.4	0.1302	86	0.41	0.25
University/Midvale					
205	68.8	0.1075	86	0.4	0.24
210	9.8	0.0153	86	0.36	0.22
215	9.5	0.0148	77	0.30	0.18
225	27.8	0.0435	83	0.26	0.16
230	23.3	0.0364	92	0.13	0.08
235	16.8	0.0263	92	0.17	0.10
240	16.0	0.0250	92	0.09	0.05
245	16.6	0.0259	94	0.08	0.05
250	19.0	0.0296	89	0.12	0.07
255	23.3	0.0363	87	0.70	0.42
University Hills/Regent					
300	62.2	0.0971	83	0.95	0.57
305	96.2	0.1503	77	0.51	0.31
310	5.3	0.0083	71	0.51	0.31
Midvale South					
400	64.3	0.1005	79	0.6	0.36
405	55.9	0.0874	76	0.44	0.26
410	96.7	0.1510	77	0.72	0.43
415	9.5	0.0149	81	0.13	0.08
420	19.7	0.0307	77	0.63	0.38
425	14.0	0.0218	75	0.48	0.29
430	19.5	0.0305	77	0.43	0.26
435	69.1	0.1080	76	0.72	0.43
Segoe					
500	53.9	0.0842	74	0.71	0.43
505	39.5	0.0617	72	0.82	0.49
510	112.4	0.1755	75	0.54	0.32
515	14.9	0.0232	78	0.32	0.19
520	70.9	0.1108	77	0.44	0.26
525	19.2	0.0300	74	0.41	0.25
530	49.0	0.0772	75	0.79	0.47
535	144.2	0.2252	77	1.25	0.75

Table 3.01-1 Summary of Hydrologic Parameters

B. Method of Determining Culvert Capacity

To determine the capacity of the existing mainline culvert and analyze the performance of proposed alternatives, the Extended Transport (EXTRAN) module of the Stormwater Management Model (SWMM) computer program, developed by the United States Environmental Protection Agency was used. EXTRAN is a dynamic flow routing model that routes inflow hydrographs through an open channel and/or closed conduit system, computing the time history of flows and heads throughout the system. Input to EXTRAN includes the following:

1. The physical geometry of the culvert system. This includes culvert sizes and shapes, ground and invert elevations, and culvert connectivity information. For this project, physical information regarding the culvert system was obtained from the City of Madison storm sewer atlas along with actual field survey information.

2. Data regarding special hydraulic structures in the system such as weirs, check valves, and storage junctions.

3. Roughness coefficients for existing and proposed conduits.

4. Inflow hydrographs at critical nodes in the system. For this project, hydrographs were computed using the HEC-1 computer program, as described in Section 3.01A and read into the EXTRAN model.

5. Boundary conditions defining starting water surface elevations and other inlet and outlet conditions. For this project, the approximate ten-year lake level, obtained from FEMA mapping was used as the downstream starting water surface elevation.

Output information from the EXTRAN model includes the following:

1. Time histories of flows and depths through individual culvert reaches for various storm events.

2. Estimates of cumulative stormwater volumes overflowing the system at various locations for extreme storm events.

3.02 RESULTS OF HYDROLOGIC AND HYDRAULIC MODELING

A. Evaluation June 16-17, 1996 Storm Event

Major flooding of the study area last occurred on June 16 and 17, 1996. This consisted of two individual storm events. The first occurred between the hours of approximately 11 P.M. and 6 A.M. on June 16, during which time approximately 3.6 inches of precipitation fell. The second event occurred between the hours of approximately 6 P.M. and 8 P.M. on June 17, during which time approximately 2.9 inches of precipitation fell. Although the June 17 event was less severe than the morning event, a greater amount of flooding apparently occurred. This is likely due to the fact that the ground was saturated in the evening because of the morning event. Therefore, a greater portion of the evening rainfall became surface runoff, rather than infiltration, compared to the morning event. The rainfall pattern of the June 16-17 storm is shown in Figure 3.02-1.

Reports from Village of Shorewood staff and residents indicate that the University Avenue/Midvale Boulevard intersection was flooded with depths of up to three feet. The Kohl's parking lot experienced flooding depths in some locations of as much as four feet. Widespread basement and surface flooding occurred in the Garden Homes subdivision, just northwest of the intersection.

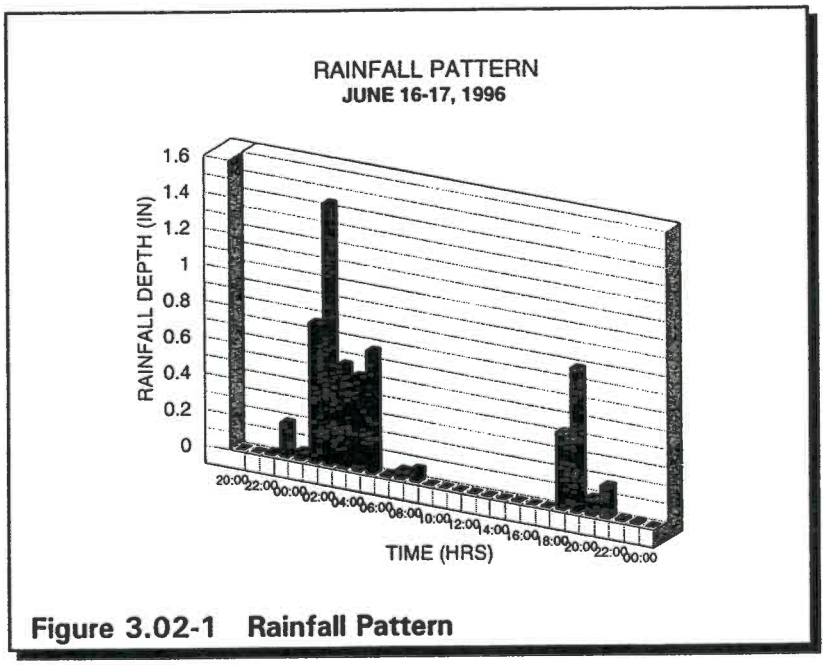


Figure 3.02-1 Rainfall Pattern

To determine the effectiveness of the hydrologic and hydraulic models for predicting peak discharges and volumes, the rain event of June 17, 1996, was modeled. Precipitation measured by recording rainfall gages at the Madison Airport and various sites at the University of Wisconsin was obtained and input to the HEC-1 model to generate inflow hydrographs. HEC-1 hydrographs were input to the EXTRAN model to simulate the performance of the existing culvert system. According to the EXTRAN model, approximately 17 acre-feet of stormwater discharged from the drainage system onto the surface between Junctions 2000 and 2400, which would cause inundation of the University/Midvale intersection, Kohl's parking lot, and Garden Homes subdivision. An approximation of the volume of stormwater actually stored in the study area based on observations of nearby residents indicates that approximately 20 acre-feet was stored.

The runoff hydrograph at the University/Midvale intersection estimated by the HEC-1 model is shown in Figure 3.02-2.

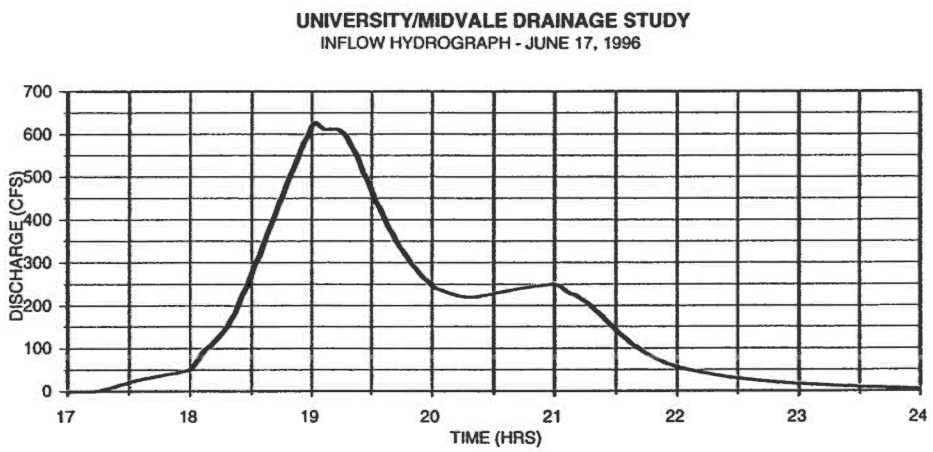


Figure 3.02-2 Inflow Hydrograph - June 17, 1996

Based upon these results, it appears that the model adequately simulates stormwater runoff from the watershed under average antecedent moisture conditions.

B. Stormwater Peak Discharges

Stormwater peak discharges to individual junctions in the existing culvert system were calculated using the HEC-1 computer program. A sensitivity analysis was performed in which 30-minute, 1-, 3-, 6-, 12-, and 24-hour storm durations were run to determine which storm duration produced the highest peak discharge at the University/Midvale intersection. Results of this analysis concluded that the 1-hour storm duration produces the highest peak discharges.

Location	Contributing Subbasins	Drainage Area (Ac)	Peak Q (CFS) 10-Year	50-Year	100-Year
Segoe Road Catchment	500-535	505	163	369	502
University Hills / Regent Catchment	300-310	164	45	158	221
Midvale South Catchment	400-485	346	163	368	498
University / Midvale Intersection	215, 230, 235, 240, 245, 250, 255, 300-500	1180	418	934	1,333

Table 3.02-1 Calculated Peak Discharges

A one-hour storm duration was modeled for return frequencies of 10-, 50-, and 100-years (i.e., the 10%, 2%, and 1% probability storms). Resulting peak discharges at various watershed locations are summarized in Table 3.02-1. Inflow hydrographs to the University/Midvale intersection for the 10-, 50-, and 100-year storm events are shown in Figure 3.02-3.

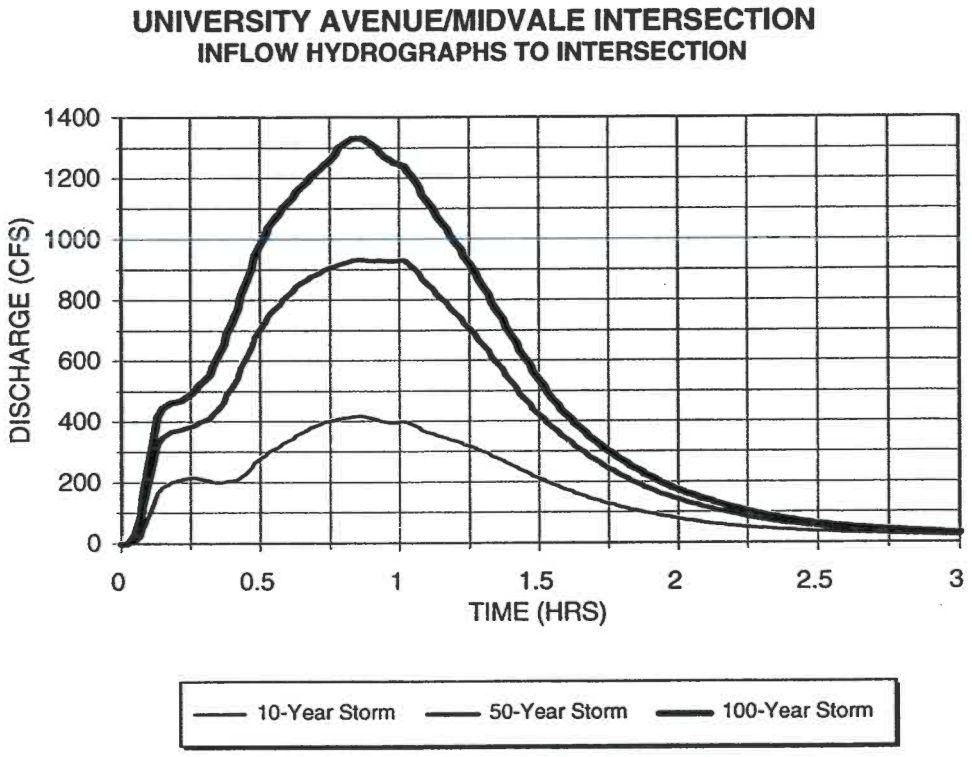


Figure 3.02-3 Inflow Hydrographs to Intersection

C. Existing Culvert Capacity

The EXTRAN model was used to evaluate culvert performance for existing conditions for the 10-year (10%), 50-year (2%), and 100-year (1%) storm events. Computer modeling results indicate that the existing culvert conduits downstream from the University/Midvale intersection have a hydraulic capacity of approximately 400 cfs, in comparison with a 100-year stormwater inflow peak of 1300 cfs. This indicates that the existing culvert capacity is only approximately thirty percent of the anticipated inflow to the culvert for a one hundred-year storm and less than the anticipated peak discharge for a ten-year year storm. Stormwater flows in excess of the existing culvert capacity overflow to the surface through manholes and inlets, inundating the Garden Homes subdivision, Kohl's parking lot area, and the University/Midvale intersection. In the event of a 100-year storm, computer models indicate that as much as 72

acre-feet of stormwater volume may overflow the drainage system. During the June 17, 1996 storm event, an estimated 20 acre-feet of stormwater overflowed the drainage system.

Capacities of individual culvert reaches, overflow volumes, and other relevant hydraulic data for the 10-, 50-, and 100-year storm event are summarized in Table 3.02-2.

			Conduit Discharge (cfs)				Surcharge at Upstream Junction (Acre-Feet)			
EXTRAN Conduit Number	Conduit Size/Type (RC Box)	Conduit Capacity (cfs)	10-Year	50-Year	100-Year	June, 1997	10-Year	50-Year	100-Year	June, 1996
200	12'x5'	511	347	535	535	530	0	12.7	32.6	0.1
210	12'x5'	531	372	541	541	541	0	1.4	2.5	0.0
220	12'x5'	643	382	403	403	403	0	12.2	14.9	7.0
230	12'x5'	634	350	384	433	358	2.6	12.0	15.0	8.2
240	12'x5'	32.4	361	498	576	395	0	3.9	6.7	1.4
250	12'x5'	317	364	486	553	376	0	0	0	0
260	15'x5'	369	466	606	636	472	0	0	0	0
270	15'x6'	555	536	637	719	565	0	0	0	0
280	15'x6'	490	501	637	719	441	10.6	35.8	49.2	20.7
290	12'x6'	622	501	510	513	506	0	0.2	0.1	.01
296	12'x4.5'	875	501	510	513	0	0	0	0	0

Table 3.02-2 Existing Culvert Performance

D. Analysis of Alternatives

To determine the effectiveness of various alternatives for relieving flooding in the study area, the existing conditions EXTRAN model was modified, as required. Modifications included addition of relief culverts of various sizes, installation of control structures, and modifications to inflow hydrographs for upstream stormwater detention alternatives. Results of these analyses form the basis for the discussion in Section 4.

SECTION 4
RECOMMENDED STORMWATER PLAN

4.01 GENERAL

Previous sections of this report have discussed the project background and purpose, existing drainage systems and patterns in the project area, design criteria and goals, and study methodology and results. In this section, a plan for achieving design criteria discussed in Section 1 is presented. Stormwater management facilities have been sized and analyzed in accordance with methodologies presented in Section 3.

4.02 APPROACHES TO STORMWATER MANAGEMENT

Four different approaches are typically considered in identifying solutions to stormwater management issues. *Conveyance* involves constructing relief conduits or channels to increase the drainage system capacity so that in flowing stormwater can be safely conveyed from the site of interest. *Storage* involves constructing impoundments such as detention ponds or underground storage chambers to hold excess stormwater runoff volumes until existing downstream drainage systems can safely drain the impoundment. *Diversion* involves relieving an existing drainage system by redirecting a portion of the contributing flow to another stormwater outlet. *Floodproofing* involves allowing occasional flooding, however, protecting existing structures from damage by elevating, berming, diking, or other measures.

The selection of the most desirable approach is contingent upon a number of project-specific criteria. In developing areas, storage is typically the most desirable solution because availability of open space may not be an issue. Provision of sufficient storage can prevent stormwater peak discharges from increasing downstream in excess of existing drainage system capacities, thus eliminating the need to reconstruct long reaches of existing underground structures. Storage can also be beneficial in providing sedimentation areas for removing stormwater pollutants prior to discharging to lakes or streams.

Where storage is not possible, conveyance solutions may be appropriate. Though commonly more expensive, conveyance facilities tend to be less maintenance-intensive than storage facilities and may reduce the presence of standing water for long periods of time. A major disadvantage is that conveyance solutions can solve flooding issues in one area only to inadvertently create new problems at the next downstream "bottleneck."

Diversion of stormwater is a less common approach. This is because it is often expensive and technically difficult to remove stormwater from its "natural" outlet. Also, as with conveyance alternatives, diversion of stormwater may solve a flooding problem in one area only to create a new problem at some point downstream. However, it may be a viable solution where there is a nearby drainage outlet with excess capacity.

Floodproofing may be a cost-effective solution in cases where conveyance, storage, and diversion solutions are not feasible. The goal of floodproofing is to eliminate structural

damages and significant financial impacts. Floodproofing will not eliminate occasional periods of standing water.

4.03 POTENTIAL COMPONENTS OF STORMWATER MANAGEMENT PLAN

A. General

To identify the most cost effective solution to flooding problems near the University/Midvale intersection, several individual plan components were evaluated. Individual plan components may not singularly alleviate flooding problems. However, a combination of these individual components may prove more cost effective than a single large scale public works project. For this analysis, individual plan components were analyzed separately. Then, 14 stormwater management alternatives were developed based upon various combinations of individual plan components.

Individual plan components included various storage, conveyance, diversion, and floodproofing elements. Each of the individual components analyzed are described in this section and shown graphically in Figure 4.03-1. Stormwater management alternatives based upon various combinations of these components are described in Section 4.04.

B. Stormwater Detention/Retention Components

Storage alternatives consider the feasibility of providing sufficient stormwater detention to reduce the peak stormwater discharge to a level that can be accommodated by the existing drainage system. Field inspection and review of existing aerial photography indicate that there are three locations in the watershed where the presence of open space may enable construction of stormwater management facilities.

1. Rennebohm Park Detention/Retention Basin

The first location is in Rennebohm Park, west of Segoe Road and south of Regent Street. The western portion of the park is developed, with a pavilion and recreational facilities. A dry detention basin is present at the eastern edge of the park, near Segoe Road. Discharge from the basin is restricted by a three foot high by seven foot long weir, including three one-foot by one foot low flow orifices. Overflow from the structure discharges to a seven foot wide by three foot high box culvert. A tributary area of approximately 164 acres drains to this structure, which comprises approximately 14 percent of the total area to the Midvale/University Avenue intersection.

There is a large amount of open space between the existing detention pond and the developed portion of the park. A detention or wet retention basin providing 15 to 20 acre-feet of storage could be constructed in this area. Hydrologic modeling indicates this could reduce the peak stormwater discharge from the contributing area by as much

ENERGY DISSIPATION STRUCTURE

BLACKHAWK RELIEF TUNNEL

BLACKHAWK COUNTRY CLUB

REINFORCED CONCRETE BOX (OPEN CUT)

JUNCTION CHAMBER

POSSIBLE UNDERGROUND DETENTION CHAMBER AT KOHL'S PARKING LOT

NOTE: INLETS AT UNIVERSITY/MIDVALE INTERSECTION SPACED TO COLLECT 100-YR. STORM

JUNCTION CHAMBER

POSSIBLE LUCIA CREST PARK DETENTION (20 AC-FT±)

POSSIBLE RENNEBOHM PARK RETENTION POND (18 AC-FT)

N

SCALE: 1"=300'

VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
4.03-1

POTENTIAL COMPONENTS OF FLOOD RELIEF PLAN

as 65 percent, and the overall peak discharge to the Midvale/University Avenue intersection by as much as 15 percent. Increasing the size of the proposed basin beyond 15 to 20 acre feet would probably have little additional benefit at the Midvale/University intersection since the controlled portion of the watershed would be only approximately 14 percent of the overall contributing area.

Results of this analysis indicate that it is not possible to resolve flooding problems at the Midvale/University intersection strictly by the provision of stormwater detention at Rennebohm Park. However, construction of a basin at this location may provide local benefits (such as control of pollutant discharges from the contributing area) and may be beneficial if incorporated into an overall basin-wide plan for reducing stormwater discharges.

2. Lucia Crest Park Detention Basin

The second location where it may be feasible to provide stormwater detention is in Lucia Crest Park, approximately one block east of Midvale Boulevard and one block south of University Avenue. Presently, Lucia Crest Park is located in a natural depression, encompassing an area of approximately five acres. The ground elevation of the park is generally lower than the invert elevation of the existing storm sewer in Midvale Boulevard. Therefore, it would be possible to develop the park site as an off-line, dry detention pond having a storage capacity of approximately twenty acre-feet. This would require providing a control structure and sufficient inlet capacity at Midvale Boulevard to intercept stormwater flow exceeding the capacity of the existing Midvale Boulevard drainage system. Excess stormwater flow would be conveyed by gravity to the park by means of an eleven foot by six foot box culvert. Excess flow would be detained in the basin until after the hydraulic gradient in the Midvale Boulevard system drops below the water surface elevation in the basin. The basin would then drain into the Midvale Boulevard system, possibly with the assistance of pumps.

Hydraulic analysis of this alternative indicates that, like the Rennebohm Park basin option, it is not possible to resolve flooding problems at the Midvale/University intersection strictly by the provision of stormwater detention at Lucia Crest Park. However, construction of a basin at this location may be beneficial if incorporated into an overall basin-wide plan for reducing stormwater discharges. If this plan is incorporated, it would be critical to incorporate dry weather improvements to the park to make the plan more acceptable to affected residents. In addition, safety provisions, such as gradual slopes and a rapid dewatering time must be incorporated.

3. Stormwater Detention Chamber at Kohl's Parking Lot

The Midvale Boulevard/University Avenue intersection and the Kohl's parking lot are located in a low-lying area. This area is densely developed at present, and the value of

this land is very high. Therefore, provision of surface stormwater detention is not a feasible alternative. Instead, to provide a substantial amount of detention, it would be necessary to construct an underground storage chamber. The most practical location for this chamber would be under the Kohl's parking lot, having "footprint" dimensions of approximately 200 feet by 300 feet (1.4 acres). Provision of an adequate storage volume would require excavation to significant depths. A pumping station would be necessary to drain the chamber and keep it dry between storm events.

Hydraulic analysis indicates that under existing conditions, approximately 72 acre-feet of stormwater would discharge from the system for a 100-year storm frequency. Therefore, a storage chamber having a capacity of 72 acre-feet would be necessary to reduce the stormwater discharge to the capacity of the downstream system. With a 1.4 acre footprint, this would require a chamber having a depth of approximately 51 feet. Preliminary calculations indicate that such a structure would cost in excess of $16,000,000.

Based upon this analysis, it is evident that provision of a stormwater detention chamber would not be a cost effective method of alleviating existing flooding. Provision of a smaller chamber in combination with additional detention in the watershed and/or in combination with construction of a relief sewer may be feasible.

B. Stormwater Conveyance Components

1. Relief Sewer to Willow Creek Outlet

Conveyance components evaluated involve increasing the conveyance capability of the existing box culvert from the Midvale/University intersection easterly to the existing outlet at Willow Creek. This would be accomplished by constructing a new box culvert parallel to the existing box culvert to increase the conveyance capacity to a level which would alleviate upstream flooding. Hydraulic calculations indicate that to accomplish this, a twelve foot wide by six foot high box culvert would be required. The most feasible location of this culvert would be along the existing culvert alignment from the Midvale/University intersection, easterly to approximately Farley Avenue. East of Farley Avenue, the culvert would be located along Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way, north of Campus Drive. As discussed in previous studies by the City of Madison, numerous conflicts are likely along this route, including existing utilities, disruption to traffic, and construction under existing pavement. In addition, if the route along the railroad tracks were selected, coordination with the railroad and construction directly adjacent to the railroad tracks would be necessary. To protect the railroad tracks and sewer trench adequately, sheet pile may be required, adding to the construction cost. The proposed culvert would have to cross Walnut Drive, which may be difficult, given the low available clearance.

Other relief sewer routes considered are described below:

a. Consideration was given to intercepting excess stormwater discharge on Midvale Boulevard at Heather Crest Drive, one block north of Regent Street. A new relief sewer would be constructed easterly along Heather Crest Drive, northerly along Owen and Blackhawk, and easterly along Harvey Street to Ridge Street. The relief sewer would connect to the existing culvert at Ridge Street and University Avenue.

It was concluded that this alternative is not desirable because, while it would alleviate flooding at the University/Midvale intersection, it may significantly increase flooding potential along low lying points north of University Avenue east of Ridge Street. This is because flooding at University/Midvale presently acts as stormwater detention, reducing peak discharges through the culvert east of the flooded area. Since the existing culvert east of the Midvale/University intersection does not have sufficient capacity to carry a 100-year storm peak discharge, connecting a relief sewer to the existing culvert would force additional discharge through a culvert flowing at capacity, thus causing the culvert to surcharge onto adjacent lands.

b. Consideration was also given to constructing a relief sewer along the existing culvert route, as described in Section B, above. However, instead of routing the culvert easterly along the Chicago, Milwaukee, St. Paul and Pacific Railroad tracks east of Farley Avenue, the culvert would be routed easterly along University Avenue, parallel to the existing culvert. This route is not recommended because there would be a greater number of utility conflicts and easements would probably be necessary since University Avenue is relatively narrow. Also, this route would cause a significant disruption to traffic along University Avenue.

C. Diversion Components

1. Blackhawk Relief Tunnel

A report titled "University Avenue-West End Relief Storm Sewer, Report No. 2" prepared by the Engineering Division of the City of Madison in 1965 investigated construction of the "Blackhawk Relief Tunnel" from the University/Midvale intersection to a new outlet at Lake Mendota, via a new tunnel across Blackhawk Country Club. Proposed work included the following:

a. Construction of 2,300 feet of 78-inch storm sewer by tunneling.

b. Construction of 800 feet of 78-inch storm sewer by open trench methods.

c. Construction of 850 feet of 48-inch storm sewer to serve the Hill Farms/Hilldale Shopping Center area.

The proposed storm sewer would be designed to provide a ten year level of protection to the area.

Findings of the report were as follows:

a. Results of a geological investigation underneath Blackhawk Country Club indicated that the tunnel would be in Franconia Sandstone, making conditions favorable for tunneling.

b. The route lies entirely within the Village of Shorewood Hills.

c. Due to the depth of the tunnel, relocation and reconnection of existing utilities should be minimal.

d. This alternative should not cause disruption of traffic or utility service.

For the 1997 study, the Blackhawk Relief Tunnel alternative has been reconsidered in light of its favorable consideration in the 1965 report. Findings of this investigation are summarized below:

a. The proposed work required would include the following:

1) Construction of a junction chamber at the Midvale/University intersection to divert culvert flow in excess of the existing culvert capacity (approximately 350 cfs).

2) Construction of a box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina. Construction of tunneling shafts allows tunneling equipment to be lowered to the level of construction. These shafts would become permanent junction chambers once tunneling operations are complete.

3) An outlet structure would be constructed at the marina to dissipate energy. Restoration of the marina and shoreline would be completed.

4) Special inlet structures would be constructed at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-year storm flow is collected.

5) Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

b. The 1965 report considered construction of a 78-inch tunnel. This design would provide a ten-year level of protection. As previously discussed, because homes, businesses, and two major arterial roadways are threatened with recurrent flooding, the design criteria for this study is the 100-year storm. To provide a 100-year level of protection to the adjacent area, a 108-inch diameter tunnel would be necessary. This tunnel diameter could be reduced by providing stormwater detention either in the watershed or in an underground chamber in the Kohl's parking lot. The cost difference for tunneling varying pipe sizes is not significant. A cost analysis of various combinations of alternative components is discussed in Section 4.04.

D. Floodproofing

A potentially lower cost alternative to construction of flood relief or storage structures may be floodproofing the Garden Homes Subdivision. Floodproofing would provide a 100-year level of structural protection to properties in the Garden Homes Subdivision. However, standing water may still be present immediately following heavy rains. Also, floodproofing would not alleviate existing flooding at the Kohl's development, the University/Midvale intersection, or other locations to the east.

Two approaches to floodproofing were considered for this project. One approach is to construct a combination levee/storage/pumping system to isolate the entire Garden Homes Subdivision from the trunk drainage system. A second approach is to make structural improvements to individual homes to prevent entry of stormwater during flood events. These approaches are discussed in greater detail in Sections 4.04 B.13 and 4.04 B.14.

4.04 STORMWATER MANAGEMENT ALTERNATIVES

A. General

To determine the most cost-effective stormwater management plan, 14 alternatives consisting of various combinations of individual stormwater management components discussed in Section 4.03 were developed.

Approximate opinions of probable costs for each of the alternative components were developed. The overall alternative cost was determined by the sum of the approximate costs of individual alternative components, plus an adjustment factor for engineering and contingencies. Descriptions of various alternatives analyzed are provided below. Each alternative should provide a 100-year level of protection, except where indicated.

Table 4.04 summarizes alternatives analyzed, and includes opinions of probable cost for each alternative.

Alternative	Blackhawk Relief Tunnel Diameter	Stormwater Detention Volume (Ac-ft) Kohl's	Rennebohm Park	Lucia Crest Park	Willow Creek Relief Sewer	Flood Proofing	Alternative Cost
A-1	108"	0	Existing	0	N/A	N/A	$6,739,000
A-2	96"	14.2	Existing	0	N/A	N/A	$13,472,000
A-3	96"	7.0	18	0	N/A	N/A	$10,630,000
A-4	72"	40.8	Existing	0	N/A	N/A	$23,027,000
A-5	0	71.5	Existing	0	N/A	N/A	$21,630,000
A-6	0	62.5	18	0	N/A	N/A	$21,751,000
A-7	0	26.3	18	20	N/A	N/A	$14,195,000
A-8	96"	0	Existing	20	N/A	N/A	$7,742,000
A-9	72"	3.8	Existing	20	N/A	N/A	$9,163,000
A-10	96"	0	18	20	N/A	N/A	$8,155,000
A-11	72"	2.2	18	20	N/A	N/A	$8,653,000
A-12	0	0	Existing	0	12' x 6'	N/A	$19,342,000
A-13 *	0	0	Existing	0	N/A	YES	$2,099,000
A-14 *	0	0	Existing	0	N/A	YES	$1,890,000

*Note: Alternatives A-13 and A-14 do not provide a 100-year level of protection to areas outside the Garden Homes neighborhood.

Table 4.04 Description of Alternatives

B. Stormwater Management Alternatives

1. Alternative A-1 - Blackhawk Relief Tunnel, 108-inch Diameter

Alternative A-1 includes construction of the Blackhawk Relief Tunnel sized to convey the entire excess peak discharge for a 100-year storm event. Hydraulic modeling results indicate that this would require a 108-inch diameter tunnel under the country club, and an eleven foot wide by six foot high box culvert in open cut areas. Construction would include junction chambers, an energy dissipator, special inlets, tunneling shafts, and surface restoration, as described in Section 4.03 and depicted in Figure 4.04-1.

The probable cost of Alternative A-1 is $6,739,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-1.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 11' x 6'	LF	1,300	$700	$910,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 108"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Subtotal				$4,992,000
Engineering/Contingencies (35%)				$1,747,200
Grand Total				$6,739,200

Table 4.04-1 Alternative A-1 Blackhawk Relief Sewer, 108 Inch Opinion of Probable Cost

2. Alternative A-2 - Blackhawk Relief Tunnel, 96-inch Diameter/Kohl's Detention Storage

Alternative A-2 includes construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event, with the remainder being stored in a detention chamber in the Kohl's parking lot. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel, an excess stormwater volume of 14.2 acre-feet would continue to overflow the

drainage system. To store this excess volume, a 200 foot by 300 foot underground detention chamber, approximately 10 feet in depth would be constructed under the Kohl's parking lot. A pumping station would be required to dewater the detention chamber after and between storm events.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Subtotal				$9,979,000
Engineering/Contingencies (35%)				$3,492,650
Grand Total				$13,471,650

Table 4.04-2 Alternative A-2 - Blackhawk Relief Sewer, 96-inch Kohl's Detention, Opinion of Probable Cost

The probable cost of Alternative A-2 is $13,472,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-2.

3. Alternative A-3 - Blackhawk Relief Tunnel, 96-inch Diameter/Stormwater Detention at Rennebohm Park and Kohl's Parking Lot

Alternative A-3 includes the following:

a. Construction of a retention basin at Rennebohm Park to reduce the peak discharge to the Midvale/University intersection. This basin would have a total storage capacity of approximately 18 acre-feet.

b. Construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03.

drainage system. To store this excess volume, a 200 foot by 300 foot underground detention chamber, approximately 10 feet in depth would be constructed under the Kohl's parking lot. A pumping station would be required to dewater the detention chamber after and between storm events.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Subtotal				$9,979,000
Engineering/Contingencies (35%)				$3,492,650
Grand Total				$13,471,650

Table 4.04-2 Alternative A-2 - Blackhawk Relief Sewer, 96-inch Kohl's Detention, Opinion of Probable Cost

The probable cost of Alternative A-2 is $13,472,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-2.

3. Alternative A-3 - Blackhawk Relief Tunnel, 96-inch Diameter/Stormwater Detention at Rennebohm Park and Kohl's Parking Lot

Alternative A-3 includes the following:

a. Construction of a retention basin at Rennebohm Park to reduce the peak discharge to the Midvale/University intersection. This basin would have a total storage capacity of approximately 18 acre-feet.

b. Construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03.

c. Hydraulic modeling indicates that with a 96-inch tunnel and 18 acre-feet of detention storage at Rennebohm Park, an excess stormwater volume of 7.0 acre-feet would continue to overflow the drainage system. To store this excess volume, a 200 foot by 150 foot underground detention chamber, approximately 10 feet in depth would be constructed under the Kohl's parking lot. A pumping station would be required to dewater the detention chamber after and between storm events.

The probable cost of Alternative A-3 is $10,630,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-3.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Subtotal				$7,874,200
Engineering/Contingencies (35%)				$2,755,970
Grand Total				$10,630,170

Table 4.04-3 Alternative A-3 - Blackhawk Relief Sewer, 96-inch Kohl's Detention, Opinion of Probable Cost

4. Alternative A-4 - Blackhawk Relief Tunnel, 72-inch/Kohl's Detention Storage

Alternative A-4 includes construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event, with the remainder being stored in a detention chamber in the Kohl's parking lot. For this alternative, a 72-inch tunnel would be constructed under the country club, with the open trench portions being a 72-inch reinforced concrete pipe. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 72-inch tunnel, an excess stormwater volume of 40.8 acre-feet would continue to overflow the drainage system. To store this excess volume, a 200 foot by 300 foot underground detention chamber, approximately 30 feet in depth would be constructed under the Kohl's parking

lot. A pumping station would be required to dewater the detention chamber after and between storm events.

The probable cost of Alternative A-4 is $23,027,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-4.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Cut	LF	1,300	$150	$195,000
Restoration	LS		$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 72"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Subtotal				$9,979,000
Engineering/Contingencies (35%)				$3,492,650
Grand Total				$13,471,650

Table 4.04-4 Alternative A-4- Blackhawk Relief Sewer, 72-inch Kohl's Detention, Opinion of Probable Cost

5. Alternative A-5 - Provide Detention Storage at Kohl's Parking Lot Only

Alternative A-5 includes construction of an underground detention chamber to store the

Item	Unit	Quantity	Unit Cost	Cost
Roof Slab	SF	60,000	$25	$1,500,000
Base Slab	CY	6,666	$260	$1,733,160
Walls	CY	5,778	$575	$3,322,350
Columns	LS	1	$2,000,000	$2,000,000
Excavation	CY	163,100	$25	$4,077,500
Dewater	LS	1	$1,500,000	$1,500,000
Rock Anchors	LS	1	$1,800,000	$1,800,000
Backfill	CY	9,030	$20	$89,000
Subtotal				$16,022,010
Engineering/Contingencies (35%)				$5,607,704
Grand Total				$21,629,714

Table 4.04-5 Alternative 5 - Stormwater Detention Chamber at Kohl's Only - Opinion of Probable Cost

entire stormwater volume in excess of the capacity of the existing culvert. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 71.5 acre-feet of storage volume would be required. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 50 feet.

The probable cost of Alternative A-5 is $21,630,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-5.

6. Alternative A-6 - Provide Detention Storage at Kohl's Parking Lot and Rennebohm Park

Alternative A-6 includes construction of a retention basin at Rennebohm Park to reduce the peak discharge rate to the Midvale/University intersection, and construction of an underground detention facility at the Kohl's Parking Lot to store the remaining excess stormwater volume. The Rennebohm Park detention pond would have a total storage capacity of approximately 18 acre-feet. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 62.5 acre-feet of storage volume would be required at the Kohl's Parking Lot, in this case. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 45 feet.

The probable cost of Alternative A-6 is $21,751,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-6.

Item	Unit	Quantity	Unit Cost	Cost
Underground Detention Chamber	LS	1	$15,806,000	$15,806,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Subtotal				$16,112,200
Engineering/Contingencies (35%)				$5,639,270
Grand Total				$21,751,470

Table 4.04-6 **Alternative A-6 - Stormwater Detention at Kohl's Parking Lot / Rennebohm Park - Opinion of Probable Cost**

7. Alternative A-7 - Provide Detention Storage at Kohl's Parking Lot, Rennebohm Park, and Lucia Crest Park

Alternative A-7 includes construction of detention/retention basins at Rennebohm Park and Lucia Crest Park to reduce the peak discharge rate to the Midvale/University intersection, and construction of an underground detention facility at the Kohl's Parking Lot to store the remaining excess stormwater volume. The Rennebohm Park detention pond would have a total storage capacity of approximately 18 acre-feet. The Lucia Crest

Park detention pond would have a capacity of approximately 20 acre-feet. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 26.3 acre-feet of storage volume would be required at the Kohl's Parking Lot, in this case. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 19 feet.

The probable cost of Alternative A-7 is $14,195,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-7.

Item	Unit	Quantity	Unit Cost	Cost
Underground Detention Chamber	LS	1	$9,336,000	$9,336,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$10,514,700
Engineering/Contingencies (35%)				$3,680,145
Grand Total				$14,194,845

Table 4.04-7 **Alternative A-7 - Stormwater Detention at Kohl's, Rennebohm Park, and Lucia Crest Park - Opinion of Probable Cost**

8. Alternative A-8 - Blackhawk Relief Sewer, 96-Inch/Lucia Crest Park Detention

Alternative A-8 includes construction of a detention basin in Lucia Crest Park to reduce the peak discharge to the Midvale/University intersection, along with construction of the

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$5,734,500
Engineering/Contingencies (35%)				$2,007,075
Grand Total				$7,741,575

Table 4.04-8 **Alternative A-8 - Blackhawk Relief Sewer, 96-inch Lucia Crest Detention - Opinion of Probable Cost**

Blackhawk Relief Tunnel. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel and detention at Lucia Crest Park, the 100-year design criteria would be achieved without provision of additional storage in the Kohl's Parking Lot.

The probable cost of Alternative A-8 is $7,742,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-8.

9. Alternative A-9 - Blackhawk Relief Sewer, 72-inch/Detention at Lucia Crest Park and Kohl's Parking Lot

Alternative A-9 is identical to Alternative A-8, except the proposed Blackhawk Relief Tunnel diameter would be 72 inches rather than 96 inches in diameter. This would cause an excess stormwater volume of 3.8 acre-feet from the system. To accommodate this excess volume, a detention chamber would be constructed in the Kohl's parking lot. This chamber would have dimensions of approximately 130 feet by 130 feet by 10 feet deep.

The probable cost of Alternative A-9 is $9,163,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-9.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Trench	LF	1300	$150	$195,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 72"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/Pumping Station	LS	1	$1,638,000	$1,638,000
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,787,500
Engineering/Contingencies (35%)				$2,375,625
Grand Total				$9,163,125

Table 4.04-9 **Alternative A-9 - Blackhawk Relief Sewer, 72-inch Kohl's Detention / Lucia Crest Park Detention - Opinion of Probable Cost**

10. Alternative A-10 - Blackhawk Relief Sewer, 96-inch/Detention at Lucia Crest Park and Rennebohm Park

Alternative A-10 includes construction of retention/detention basins in Lucia Crest Park and Rennebohm Park to reduce the peak discharge to the Midvale/University intersection, along with construction of the Blackhawk Relief Tunnel. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel and detention at Lucia Crest Park and Rennebohm Park, the 100-year design criteria would be achieved without provision of additional storage in the Kohl's Parking Lot.

The probable cost of Alternative A-10 is $8,155,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-10.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,040,700
Engineering/Contingencies (35%)				$2,114,245
Grand Total				$8,154,945

Table 4.04-10 Alternative A-10 - Blackhawk Relief Sewer, 96-inch Rennebohm Park Detention / Lucia Crest Detention - Opinion of Probable Cost

11. Alternative A-11 - Blackhawk Relief Sewer, 108-inch/Detention at Lucia Crest Park, Rennebohm Park, and Kohl's Parking Lot

Alternative A-11 is identical to Alternative A-10, except the proposed Blackhawk Relief Tunnel diameter would be 72 inches rather than 96 inches in diameter. This would

cause an excess stormwater volume of 2.2 acre-feet from the system. To accommodate this excess volume, a detention chamber would be constructed in the Kohl's parking lot. This chamber would have dimensions of approximately 90 feet by 90 feet by 12 feet deep.

The probable cost of Alternative A-11 is $8,653,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-11.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Cut	LF	1300	$150	$195,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/Pumping Station	LS	1	$954,000	$954,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,409,700
Engineering/Contingencies (35%)				$2,243,395
Grand Total				$8,653,095

Table 4.04-11 Alternative A-11 - Blackhawk Relief Sewer, 72-inch Kohl's Detention / Rennebohm Park Detention / Lucia Crest Park Detention - Opinion of Probable Cost

12. Alternative A-12 - Relief Storm Sewer to East

Alternative A-12 includes construction of a new relief conduit easterly to the existing outlet at Willow Creek. The new conduit would consist of a twelve foot wide by six foot high box culvert. The culvert would be constructed generally parallel with the existing culvert easterly to Farley Avenue. East of Farley Avenue, the culvert would generally follow the Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way to the existing outlet at Willow Creek. Necessary work would include construction of approximately 8,500 feet of box culvert, utility relocation, construction of a junction chamber at the University/Midvale intersection, restoration of streets, and reconstruction of the outlet at Willow Creek.

The probable cost of Alternative A-12 is $19,342,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-12.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 12' x 6'	LF	8,475	$800	$6,780,000
Restoration	LF	8,475	$100	$847,500
Jctn Chambers/Connections	EA	10	$50,000	$500,000
Outlet Structure/Shore Rest.	LS	1	$100,000	$100,000
Utility Relocation	LS	1	$800,000	$800,000
Sheet Pile	LS	1	$200,000	$200,000
Special Inlet Construction	LS	1	$100,000	$100,000
Underground Storage Chamber	LS	1	$5,000,000	$5,000,000
Subtotal				$14,327,500
Engineering/Contingencies (35%)				$5,014,625
Grand Total				$19,342,125

Table 4.04-12 Alternative A-12 - Relief Sewer to Willow Creek Outlet - Opinion of Probable Cost

13. Alternative A-13 - Floodproof Garden Homes Subdivision

Alternative A-13 includes construction of a combination levee/berm/pumping system to isolate the Garden Homes Subdivision from the existing drainage system. This construction would create an "island" of dry land from the west line of the Kohl's development to Maple Terrace from east to west, and from University Avenue to Locust Drive, from south to north.

To accomplish this, the following work would be necessary:

a. A berm or wall would be constructed adjacent to the Kohl's development and along University Avenue to Burbank Place to prevent stormwater in the Kohl's parking lot and University/Midvale intersection from overflowing into the subdivision. This berm or wall would have a maximum height of three to five feet.

b. An underground storage reservoir and pumping station would be constructed underneath Burbank Place to hold drainage from inside the bermed area. The storage reservoir would be sized to hold the entire stormwater runoff volume within the Garden Homes subdivision for the 100-year storm event. A submersible pumping station would be constructed to dewater the reservoir after the mainline culvert has drained.

c. An additional levee and stormwater pumping station would likely be necessary to intercept stormwater from the office complex immediately west of the subdivision. This pumping station would force stormwater flow into the mainline culvert downstream from the subdivision.

d. Water, sanitary sewers, and other utilities would be relocated under Burbank Place to accommodate the storage reservoir.

e. Burbank Place would be reconstructed after installation of the underground reservoir.

Potential problems with this alternative, include:

a. This alternative would not improve the flooding situation downstream. In fact, it may aggravate flooding due to the loss of stormwater storage volume in the Garden Homes area.

b. Flooding problems due to seepage, particularly for properties adjacent to the Kohl's development may continue.

c. The underground storage chambers and pumping stations would have relatively high annual maintenance costs.

The probable cost of Alternative A-13 is $2,099,000, including engineering and contingencies. A breakdown of this cost is included in Table 4.04-13.

Item	Unit	Quantity	Unit Cost	Cost
Berm/Wall at Kohl's	LS	1	$80,000	$80,000
10' x 5' Box Culvt Sections for Underground Storage	LF	1,000	$600	$600,000
Utility Relocation	LS	1	$50,000	$50,000
Street Restoration	LF	600	$125	$75,000
Junctions/Connections	LS	1	$50,000	$50,000
Pumping Station for Garden Homes	LS	1	$200,000	$200,000
Pumping/Storage/Levee For Office Bldgs. To West	LS	1	$500,000	$500,000
Subtotal				$1,555,000
Engineering/Contingencies (35%)				$544,250
Grand Total				$2,099,250

Table 4.04-13 Alternative A-13 - Floodproof Existing Garden Homes - Opinion of Probable Cost

14. Alternative A-14 - Floodproof Individual Homes

Alternative 14 includes floodproofing individual homes in the Garden Homes Subdivision, rather than isolating the entire subdivision. This work would involve raising the homes and reconstructing foundations. Furnaces, water heaters, electrical services, and other utilities would be relocated from basements, where necessary, and relocated above ground. To do this, ground floor additions onto existing homes would be constructed. This work has been performed and funded by the Federal Emergency Management Agency in a number of other floodplain areas throughout the country.

Potential problems with this alternative, include:

a. This alternative would alleviate the likelihood of structural and property damages to homes in the Garden Homes Subdivision in the event of a 100-year storm. However, the Kohl's development, the University/Midvale intersection, and other locations to the east would see no benefit from this work.

b. This alternative would not prevent the occurrence of standing water and associated health and safety hazards following heavy rainfall events in the Garden Homes subdivision and adjacent areas.

The probable cost of Alternative A-14 is $1,890,000, including engineering and contingencies. A breakdown of this cost is included in Table 4.04-14.

Item	Unit	Quantity	Unit Cost	Cost
COST PER HOME	LS	35	$40,000	$1,400,000
Subtotal				$1,400,000
Engineering/Contingencies (35%)				$490,000
Grand Total				$1,890,000

Table 4.04-14 Alternative A-14 - Floodproof Individual Homes

4.05 DISCUSSION OF ALTERNATIVES

A. Comparison of Alternative Costs

Table 4.03-1 indicates a wide range in probable costs for Alternatives A-1 through A-14. The lowest cost alternative evaluated was $1,890,000 for floodproofing individual homes. However, this alternative would also provide the least overall benefit since it would continue to allow flooding of the Kohl's Shopping Center site and other points eastward. The lowest

cost alternative which will provide a 100-year level of protection is Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel.

Overall, the most expensive alternatives are those including construction of an underground storage chamber in the Kohl's Parking Lot. This is because the structure would have to be extremely large and as deep as 50 feet to have sufficient capacity to significantly reduce peak discharge rates. Also, Alternative A-12, construction of a relief culvert eastward to Willow Creek is prohibitively expensive due to the size and length of the culvert required and the potential conflicts encountered.

Based on this discussion, only the following alternatives appear to be viable from a cost-effectiveness standpoint:

	Relief Tunnel Diameter	Kohl's Detention	Rennebohm Park Detention	Lucia Crest Park Detention	Alternative Cost
A-1	108"	0	Existing	0	$6,739,000
A-8	96"	0	Existing	20	$7,742,000
A-9	72"	3.8	Existing	20	$9,163,000
A-10	96"	0	18	20	$8,155,000
A-11	72"	2.2	18	20	$8,653,000
A-13	0	0	Existing	0	$2,099,000
A-14	0	0	Existing	0	$1,890,000

Except for Alternatives A-1, A-13, and A-14, each of these alternatives would involve a potential loss of park lands at either Rennebohm Park and/or Lucia Crest park. Procurement of these lands for stormwater detention could be difficult and unpopular. Alternatives A-13 and A-14, as discussed, would not provide a 100-year level of protection for areas outside the Garden Homes subdivision.

B. Recommended Alternative

Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with design criteria.

cost alternative which will provide a 100-year level of protection is Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel.

Overall, the most expensive alternatives are those including construction of an underground storage chamber in the Kohl's Parking Lot. This is because the structure would have to be extremely large and as deep as 50 feet to have sufficient capacity to significantly reduce peak discharge rates. Also, Alternative A-12, construction of a relief culvert eastward to Willow Creek is prohibitively expensive due to the size and length of the culvert required and the potential conflicts encountered.

Based on this discussion, only the following alternatives appear to be viable from a cost-effectiveness standpoint:

	Relief Tunnel Diameter	Kohl's Detention	Rennebohm Park Detention	Lucia Crest Park Detention	Alternative Cost
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A-11	72"	2.2	18	20	$8,653,000
A-13	0	0	Existing	0	$2,099,000
A-14	0	0	Existing	0	$1,890,000

Except for Alternatives A-1, A-13, and A-14, each of these alternatives would involve a potential loss of park lands at either Rennebohm Park and/or Lucia Crest park. Procurement of these lands for stormwater detention could be difficult and unpopular. Alternatives A-13 and A-14, as discussed, would not provide a 100-year level of protection for areas outside the Garden Homes subdivision.

B. Recommended Alternative

Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with design criteria.

2. It appears that all work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands would not be necessary.

3. There should be a relatively minimal number of utility conflicts.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

A conceptual drawing of the recommended alternative is included in Figure 4.05-1.

ENERGY DISSIPATION STRUCTURE

SHORELINE RESTORATION

108" RELIEF TUNNEL

BLACKHAWK COUNRTY CLUB

11'(W)X6'(H) REINFORCED CONCRETE BOX CULVERT (OPEN CUT)

JUNCTION CHAMBER

NOTE: INLETS AT UNIVERSITY/MIDVALE INTERSECTION SPACED TO COLLECT 100-YR. STORM.

N

SCALE: 1"=300'

VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
4.05-1

RECOMMENDED ALTERNATIVE

ENERGY DISSIPATION STRUCTURE

SHORELINE RESTORATION

108" RELIEF TUNNEL

BLACKHAWK COUNTRY CLUB

11'(W)X6'(H) REINFORCED CONCRETE BOX CULVERT (OPEN CUT)

JUNCTION CHAMBER

NOTE: INLETS AT UNIVERSITY/MIDVALE INTERSECTION SPACED TO COLLECT 100-YR. STORM

JUNCTION CHAMBER

N

SCALE: 1"=300'

VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
4.05-1

RECOMMENDED ALTERNATIVE

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

5.01 CONCLUSIONS

A. The contributing watershed area to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Approximately 84 percent of the total 1,952 acres lies within the City of Madison, with the remaining portion in the Village of Shorewood Hills.

B. The existing culvert at the intersection has sufficient capacity for approximately 400 cfs. This is less than the cumulative inflow for a 10-year storm event. Fifty-year and 100-year storm events significantly exceed the capacity of the existing culvert, resulting in overflow onto adjacent streets and parking areas.

C. Because the study area is located in a depression, there is no opportunity for overland flow if the capacity of the drainage system is exceeded. Therefore, the culverts serving the area must serve as both the minor and major drainage system. For this reason, stormwater management improvements should provide a 100-year level of protection to the adjacent area.

D. To divert a sufficient amount of stormwater from the project area via a relief tunnel to Lake Mendota, a 108-inch conduit diameter would be necessary. The most likely route would be across Blackhawk Country Club, to the marina.

E. Provision of stormwater detention in the watershed alone cannot sufficiently reduce peak discharges below the capacity of the existing storm sewer system. Provision of stormwater detention at Rennebohm Park and Lucia Crest Park in combination with construction of an underground storage chamber at the Kohl's parking lot could reduce stormwater discharges below the capacity of the existing system. This, however, is not the most cost effective alternative.

F. Construction of a new relief culvert to the existing outlet at Willow Creek is probably not a practical alternative due to the size and length of conduit required, potential utility conflicts, disruption to University Avenue traffic, and other factors.

G. The least expensive alternative evaluated is floodproofing individual homes in the Garden Homes subdivision, at a probable cost of $1,890,000. This alternative would not provide a 100-year level of protection to the Kohl's development, University/Midvale intersection, or points to the east.

H. The most cost-effective alternative which provides a 100-year level of protection to the Garden Homes subdivision, Kohl's Development, and University/Midvale intersection is construction of a 108-inch diameter relief tunnel under Blackhawk Country Club to

Lake Mendota. The probable cost of this alternative is $6,739,000, including engineering and contingencies.

5.02 RECOMMENDATIONS

A. Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with design criteria.

2. It appears that all work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands would not be necessary. Easements for work within the Chicago, Milwaukee, St. Paul, & Pacific railroad right-of-way would be required.

3. There should be a relatively minimal number of utility conflicts.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

Construction of the Blackhawk Relief Tunnel would include the following:

1. Construction of a diversion structure at the Midvale/University intersection which would direct culvert flow in excess of the existing culvert capacity (approximately 400 cfs) to the new tunnel.

2. Construction of an 11-foot (wide) by 6-foot (high) box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a 108-inch tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina.

3. Construction of an outlet structure at the marina to dissipate energy prior to discharge into Lake Mendota. Restoration of the marina and shoreline would be completed.

4. Special inlet structures would be constructed at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-

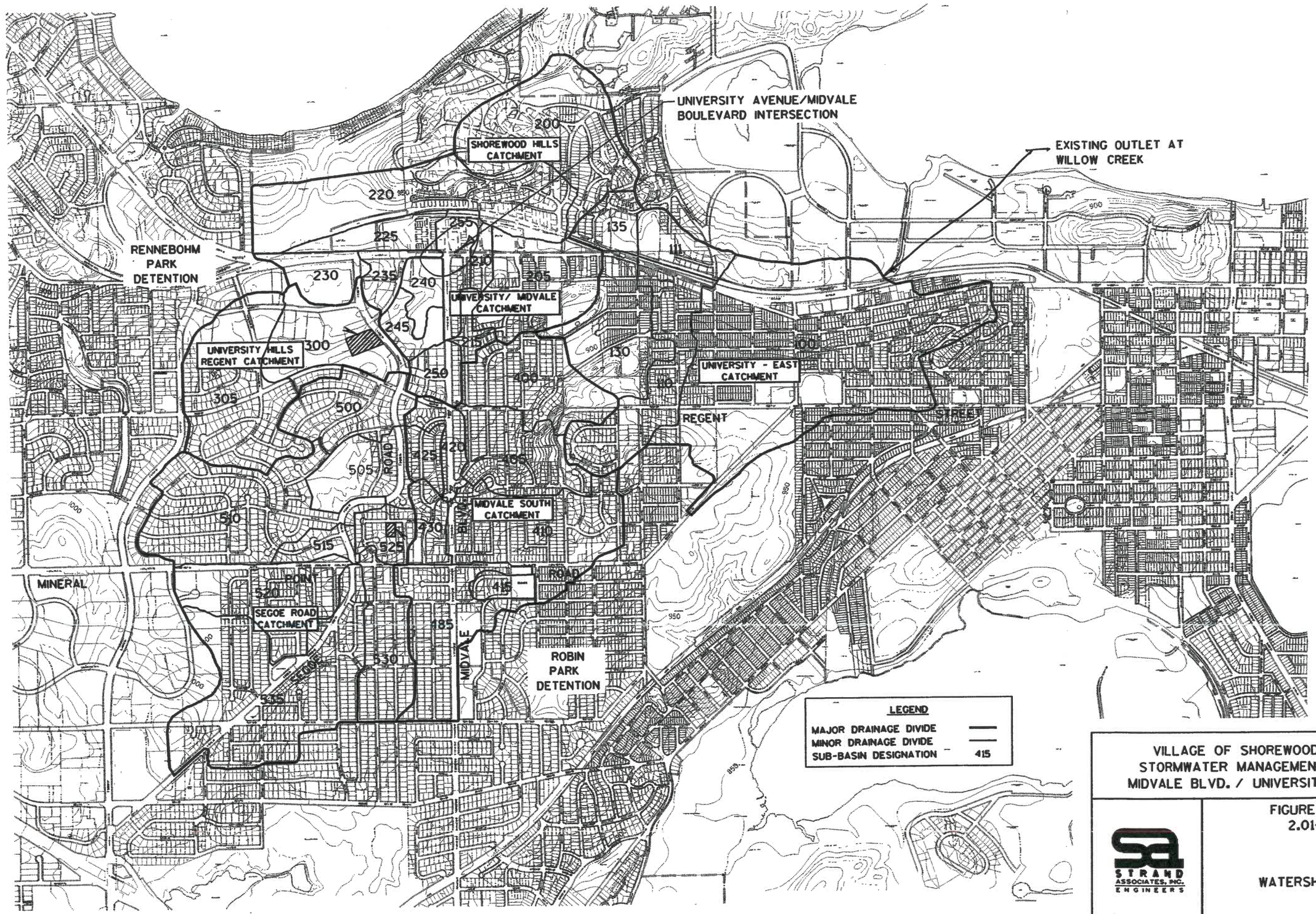
year storm flow is collected and transported from the surface to the underground drainage system.

5. Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

Completion of this work would upgrade the level of protection of the Kohl's site, Garden Homes subdivision, and adjacent areas from less than a 10-year storm frequency (10 percent annual recurrence probability) to a 100-year storm frequency (1 percent recurrence probability).

B. A cost sharing agreement should be negotiated between the City of Madison and Village of Shorewood Hills to fund project construction. This agreement should be reached within the earliest possible time frame.

C. Coordination with the Wisconsin Department of Natural Resources should be initiated as soon as possible to determine any special requirements for constructing a new outlet to Lake Mendota.



VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
2.01-1

WATERSHED MAP