99-372M

JANUARY 2001

NORTHVIEW DRAINAGE STUDY

PRESENTED TO:

CITY OF MANHATTAN
KANSAS

PRESENTED BY:

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AUTHORIZATION AND SCOPE

The City of Manhattan, KS adopted the Stormwater Management Master Plan (SWMMP) in May of 1995. This Plan identified, studied, and made improvement recommendations for the City's major drainage system. The major drainage system was defined as 36" diameter pipes and larger. Since that study, it has come to the attention of the City that the Northview area required a more detailed study. Residents of Northview were not satisfied with the scope of the 95' Master Plan for their area. A majority of the area is very flat with an approximate slope of 0.5%. There is generally a lot of standing water and backwater problems after normal rainstorms. In November of 1999, the City of Manhattan authorized BG Consultants, Inc., of Manhattan to perform the Northview Drainage Study. Services of this study are:

- Field investigation of the Northview drainage system.
- Preparation of watershed maps for the study area.
- Analyze the existing stormwater system (15" diameter pipes and larger).
- Recommend improvement projects with cost estimates and priorities.

The area included in the Northview Drainage Study is from US24 (west border), Tuttle Creek Blvd., to the Big Blue River (east border) and from Casement Rd. (south border) to Marlatt Ave. (north border). Later, in May 2000, the City authorized Phase 2 of the Northview Study. Phase 2 added the area north of Marlatt Ave. to Barnes Rd. to the study for a total of approximately 1,900 acres (3.00 mi^2).

METHOD OF ANALYSIS

There were 272 inlets and approximately 366 reaches identified and classified by field investigation and review of existing maps and other records. (The actual amount of reaches is somewhat lower than the 366 because some reaches were split into sections for the computer model analysis that will be discussed later). Then, maps were developed to show these existing elements and their respective watersheds (drainage areas). Each Major Watershed generally consists of many Minor Watersheds whose flows culminate at a common outlet. The number of Minor Watersheds is greater than the number of inlets due to the addition of Minor Watersheds that flow directly into open channels. There are 7 Major Watersheds for a total of approximately 4,630 acres (7.23 mi^2) of contributing stormwater runoff in the Northview Area. The drainage area is more than double that of the study area. Much of the additional drainage area comes from the west side of US24 and its stormwater runoff flows into the Northview area through RCB's under US24. The 7 Major Watersheds, listed from south to north, are shown in the table below with their respective drainage area and common outlet description.

Major Watershed	Drainage Area (Ac.)	Common Outlet
1. Casement	1.5	15" RCP into Levy Stream
2. Dix	17	24" RCP into cultivated field
3. Northview	397	8'x5' RCB into Levy Stream
4. Spain	32	36" RCP into ditch to Big Blue River
5. Blue Hills	608	Butterfield Channel to Big BlueRiver
6. Marlatt	3150	Marlatt Channel to Big Blue River
7. Barnes	420	Barnes Channel to Big Blue River

Once the inlets, pipes, open channels, and drainage areas were identified, hydrologic models of each Major Watershed were developed using HEC-1 computer software. HEC stands for Hydrologic Engineering Center and is an office of the US Army Corps of Engineers. The HEC-1 computer model is designed to simulate the runoff (unit hydrograph) from each Minor Watershed going to each inlet, pipe, or open channel and calculate the peak flows (joining unit hydrographs) through the interconnected system of pipes and open channels. The peak flows were calculated for 2, 5, 10, 25, 50, and 100 year design storms using precipitation data for the City of Manhattan. HEC-1 uses the SCS method to calculate watershed runoff and the Muskingum-Cunge method for channel and pipe routing. Typical input data includes drainage area, SCS curve number, and SCS lag time for watershed runoff; diameter or width, slope, Manning's "n" value, and length for pipes and box culverts; and a typical cross section, length, slope, and Manning's "n" value for open channels. The overall method of analysis for HEC-1 modeling is best demonstrated by the flow chart on the next page.

Once the flows for each design storm through each element were calculated with the HEC-1 program, the next step was to determine the Maximum Capacity of each Element. For inlets, Maximum Capacity was calculated using the various inlet capacity nomographs in the SWMMP. The input factors for inlet analysis were the type of inlet (curb, area, or otherwise) and whether it was in a sump or on grade. Maximum Capacity for each Reach was slightly more complicated. Each reach was analyzed when it is "full". For pipes and boxes, "full" simply means the pipe/box is completely full of stormwater. The slope, size, type, condition (silted, corroded, or deteriorating for example), and amount of maximum headwater of the pipe/box determined the estimated, maximum amount of flow each pipe/box can convey. Inlet and Friction control nomographs in the SWMMP for pipes/boxes were the tools used for analysis. For channels, "full" normally is calculated at the elevation of overflow such as when stormwater overtops the bank of a stream. In some instances, Maximum Capacity of channels is based on property damage to surrounding buildings. The elevations of low residential dwellings determined the estimated, maximum amount of flow that the channel could convey. The typical cross-sectional area of the channel, it's roughness, slope, and maximum depth to overflow (or the depth when property damage occurs) were the criteria used in Manning's steady flow, open-channel equation to calculate the Maximum Capacity of each channel.

Further analysis of some open channels in the Northview area was done using HEC-RAS computer software. The RAS stands for River Analysis System. HEC-RAS generates water surface profiles to determine flood elevations and evaluate open channels, bridges, and culverts. The procedure used for computations in the program is generally known as the standard step method and is based on solution of the one-dimensional energy equation with energy loss due to friction determined by Manning's equation. HEC-RAS was utilized at various stages of the HEC-1 analysis process. In this study, HEC-RAS was very useful in the

analysis of channels that discharge directly into the Blue River. It adds another dimension of accuracy to the standard analysis of a channel as it takes into consideration the elevation of the Blue River and the constantly changing shape for the length of the channel (many cross-sections along the length of the channel are part of the input data).

The Level of Service of each element was determined by comparing the Maximum Capacity of the element to the design storm flows that were calculated for that element. For instance, if the Maximum Capacity flow is greater than the flow of a 25-yr. design storm but less than the flow from a 50-yr. design storm through that element, then the element's Level of Service is said to be >25-yr. The Level of Service is important for measuring each element's effectiveness. The City of Manhattan presently requires that all new stormwater systems be designed to meet the 10-yr. design storm peak flow. (Section 1.5 of Stormwater Management Criteria) The 10-yr. peak flow is the basic rule by which each element's adequacy is measured. In the case of analyzing existing structures, as this study does, the 2-yr. design storm peak flow is also very important for a couple of reasons. Number one, it is the lowest flow calculated. If an element is at or below a 2-yr. Level of Service, it is functioning poorly at the lowest Level of Service. A 2-yr. design storm means that the peak flows generated from it have a 50% chance of occurring in any given year. Secondly, a 5-yr. design storm was the requirement for new construction in the city's "Design Criteria and Procedures for Storm Drainage" from the 1970's. Most design prior to the 1990's used the rational method for calculating stormwater runoff, rather than the SCS method. Hand computations for the SCS method were very tedious and computers were not readily utilized. The SCS method is generally considered more accurate, especially for large drainage areas, and it produces slightly higher flows than the Rational Method. The old 5-yr. design standard using the Rational Method may very well be a 2-yr. design storm using the SCS method. As a reminder, in the 1995 SWMMP, the Rational Method is allowed when the "total upstream area tributary to the point of consideration is less than 300 acres" (Section 2.2A of Stormwater Management Criteria). In the Northview study, 4 of the 7 major watersheds had to be analyzed by the SCS method as they were greater than 300 acres. Minor watersheds, such as to each inlet, could have been analyzed using the Rational Method. For this study, the SCS method was chosen exclusively to make analysis consistent and tie the study together as a whole.

For distinguishing Capital Improvement Project Recommendations, the Level of Service is the most important factor. When an element has a low Level of Service rating, a flag for investigating the stormwater system or element more in-depth goes up. Other important factors are historical performance and visual assessment of the system for erosion, siltation, and deterioration. Many of these factors go into the quantitative value of the element's Maximum Capacity. There are instances where historical performance may contradict the computed Level of Service. In that scenario, more field study is done to calibrate the Maximum Capacity of the element or the HEC-1 computer model to match the known conditions. All of these factors together make for a well-rounded complete analysis of all storm drainage systems within the scope of this study.

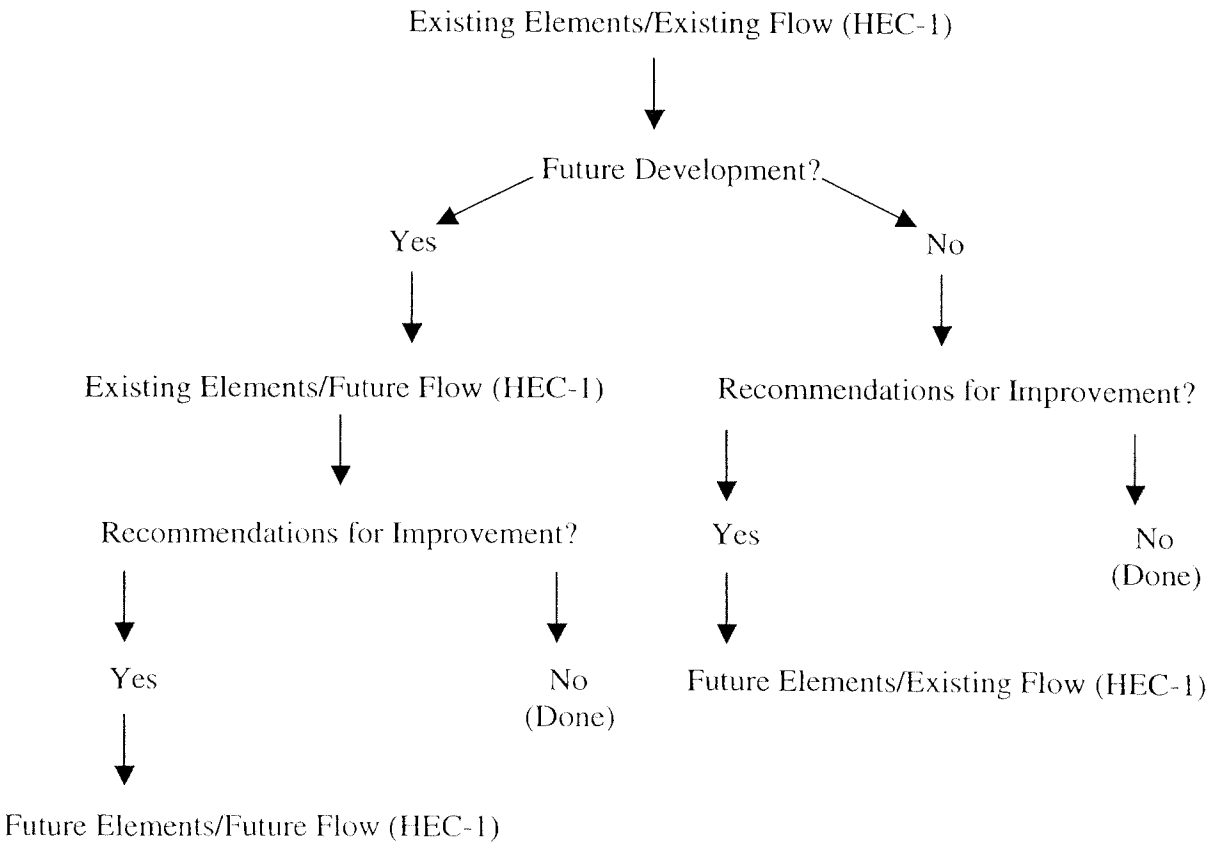
Costs for the Capital Improvement Project Recommendations have been broken down into four categories:

Const. - The direct Construction cost (includes utility adjustments).
Esmt. - The cost of purchased Easements.
E & I - Fees and contingencies as an allowance to include Engineering and Inspection.
Total - The sum of Const., Esmt., and E & I categories.

Detention, as a consideration for any Capital Improvement Project Recommendation in the Northview Drainage Study Area, has been considered and declined for many reasons. First, and most importantly, detention is most effective in the upstream portion of a watershed where the downstream facilities are inadequate to accommodate higher flows due to development. The entire Northview Study Area is located close to the Big Blue River and is most definitely at the downstream end of the various watersheds in the area. The most effective solution to the drainage problems in the Northview Study Area is not slowing down the discharge of stormwater into the river, but rather to speed up the discharge of stormwater into the river. The River can handle the flow. Another reason is that (also because the area is at the downstream end of the watershed) the detention facilities would have to be quite large to accommodate the large flows that have accumulated by this point. Excavation would be costly because of the large volume of soil that would be moved and also because the water table is quite high (approximately 3' below the surface), causing construction difficulties. Lastly, the flat grades in the area create an environment suitable for siltation, standing water in streets, and marshy, wet areas (with mosquito problems) in backyards and earth channels. These conditions are disagreeable to residents in the area. With the flat grades of the area, any detention facility would have a bottom also very flat that probably wouldn't drain well. It would likely create many of the same problems that local residents want solved. Again, the main idea is that stormwater is almost to the river; the goal is to assist the stormwater to flow through the Northview Area more quickly.

The Northview Study Results, Section III of this report, discuss each Major Watershed in three sections: Discussion, Capital Improvement Project Recommendations, and Tables. Some Major Watersheds have been separated into smaller sections, not necessarily Minor Watersheds, and follow the same format. Each Capital Improvement Recommendation includes a cost estimate and is prioritized. A Prioritization Summary is discussed in Section IV of this report. Section V contains the Watershed Maps and Section VI is the HEC-1 Index.

Method of Analysis Flowchart



DEFINITION OF TERMS

CMP – Corrugated Metal Pipe

CMMAC – Corrugated Metal – Metal Arched Culvert

Detention Facility – Any structure, device or combination thereof that functions to accept inflow from surface runoff and discharge it at a controlled rate less than the peak inflow rate.

Development – Any activity that alters the surface of the land to create addition impervious surfaces, including, but not limited to, pavement, buildings, and structures.

Easement – Authorization by a property owner for the use by another for a specified purpose, of any designated part of the property.

Elements – Refers to ALL reaches and inlets in a particular drainage system.

Enclosed Drainage System – A drainage system consisting of essentially continuous pipes and/or culverts below the ground surface.

Freeboard – The vertical difference in elevation between the hydraulic gradient and a referenced point. Examples are the difference between the maximum water surface level behind a dam and the top of a dam, or the difference in elevation between the water surface at a culvert beneath the roadway and the surface of the roadway.

HEC-1 – computer modeling software that simulates the runoff (hydrograph) from each Minor Watershed going to each inlet, pipe, or open channel and calculates the peak flows (joining hydrographs) through the interconnected system of pipes and open channels.

HEC-RAS – computer modeling software that generates water surface profiles to determine flood elevations and evaluate open channels, bridges, and culverts.

Inlets – A drainage structure that allows stormwater to enter into an enclosed system. (i.e. curb inlet or area inlet)

Level of Service – The return period for which a drainage system, or an individual element of that system has adequate hydraulic capacity.

Open System – A drainage system consisting of open channels with only comparatively short lengths enclosed by pipes or culverts.

RCB – Reinforced Concrete Box

RCP – Reinforced Concrete Pipe

RCPHE – Reinforced Concrete Pipe Horizontal Elliptical

Reaches – Pipes, Open Channels, or RCBs (Reinforced Concrete Boxes)

Return Period – A statistical term for the average frequency that a given event may be expected to occur although it does not imply that the event will occur regularly at even intervals. It can also be defined as the reciprocal of the probability of an event. For example, a storm having a 10-year return period statistically can be expected to occur in a period of 10 years, an annual probability of occurrence of 0.10, or 10%. However, the event may happen at any time and two such events may actually occur on successive days.

Storm Drainage System – All of the natural and constructed facilities and appurtenances, such as ditches, natural channels, pipes, culverts, bridges, improved channels, street gutters, inlets, and detention facilities, that serve to collect and convey surface drainage within the City.

Watershed – All land that drains surface water runoff to a common point (or outlet). Also referred to as drainage area, drainage basin, tributary area, and catchment area.

NORTHVIEW DRAINAGE STUDY RESULTS

CASEMENT WATERSHED

CASEMENT WATERSHED
(MAP NO. 1)

LOCATION

The Casement 1 watershed covers approximately 1.5 acres (.00239 mi^2) and consists mainly of Casement Road pavement from Tuttle Creek Blvd. to the 2 inlets located just west of the intersection with Hayes Dr. The common outlet drains west of Hayes Dr. into the Levy Stream. The watershed slopes to the east at an average slope of 5%.

LAND USE

The land in this watershed is mostly pavement. It is highly impervious and has high runoff values.

EXISTING DRAINAGE SYSTEM

The drainage system is a very small, enclosed system with only 2 inlets and 2 reaches. Flow at the outlet joins in with the Levy Stream just west of Hayes Dr.

SYSTEM PERFORMANCE

REACHES & INLETS

The reaches, R019 and R020, and inlets, 18 and 19, have an existing Level of Service less than a 2-year storm. However, no improvements are recommended. Flow in the south gutter of Casement road that doesn't enter inlet 19 will turn and flow southerly onto Hayes Drive. When the curb and gutter ends on Hayes, the stormwater flow enters the Levy Stream. Flow in the north gutter of Casement road that doesn't enter inlet 18 will travel down to inlet 1 and, in larger rainstorms, down to sump inlet 20 where it is adequately captured.

CASEMENT WATERSHED – CMTEX (MAP NO. 1)

Table 1: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
R019*	15" RCP: inlet 18 - 19	6.5	11	15	18	22	25	29	<<2
R020*	15" RCP: inlet 19 - Levy Stream	13	23	32	38	46	52	59	<<2

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
18*	A-5 4% grade	3.1	11	15	18	22	25	29	<<2
19*	A-5 4% grade	3.1	13	17	20	24	27	30	<<2

DIX

WATERSHED

DIX WATERSHED
(MAP NO. 2)

LOCATION (MAP NO. 2)

The Dix 2 watershed is basically the east half of the Dix area and occupies approximately 17 acres (.027 mi^2). The west boundary is along Dogwood Dr. and Poppy Ct. while the north boundary follows the City Limits. The east boundary is to the west of Morning Glory Dr. and the south boundary is at the bottom of Tulip Terr. and Columbine Ct. The common outlet drains south of Columbine Ct. onto farmland and eventually into the Levy Stream. The watershed slopes down to the southeast corner at an average slope of approximately 0.4%.

LAND USE

The entire Dix Watershed is single-family residential.

EXISTING DRAINAGE SYSTEM

The drainage system is a rather small, enclosed system with 4 inlets and 4 reaches. Flow at the outlet drains onto farmland and eventually into the Levy Stream. The flow across the farmland is not a distinct channel and appears to spread out into shallow channels and sheet flow until it reaches the Levy Stream.

This area was evacuated for a time during the 1993 flood. Backwater from the Big Blue River flooded many basements as well as first floors of homes. This analysis does not examine system drainage when the Big Blue and/or Kansas River elevations are high and create backwater situations. It assumes low river elevations for normal flow conditions.

SYSTEM PERFORMANCE

REACHES

All of the reaches in this drainage system have a Level of Service above a 2-year storm capacity. Reach D003 across Harvey Dr. is above a 10-year storm capacity. However, the Northeast Park proposal, discussed as part of the Northview Watershed system, may provide an opportunity to improve the storm capacity of all existing reaches and inlets in the Dix Watershed. The Northeast Park proposal consists of placing an open channel from Knox Lane south to the Levy stream, running just east of the Dix Addition. The Dix Watershed proposals will intercept stormwater flowing to the existing system and direct it to the Northeast Park proposed system.

INLETS

Inlet number 26 has the lowest Level of Service in this area with a storm capacity < 5-yr. All other inlets perform very well and no recommendation for improvement is needed.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Dix Drive

PROJECT IDENTIFICATION NUMBER: 1

PERTINENT DATA SUMMARY
Watershed: Dix
Priority No.: Discretionary
Design Capacity: 19 cfs
Model Reach Designation(s): D013 - D018 (new)
Model Inlet Designations(s): NEW1-NEW6
Map Reference Number: 2 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$80,000
E & I	$20,000
Total	$100,000

RECOMMENDED IMPROVEMENTS

This project is contingent upon completion of the Northeast Park Channel, Project No. 7. It consists of an enclosed system of 6 Type-A curb inlets and approximately 1020 L.F. of piping along Dix Dr. between the intersection of Lilac Lane and the open field to the east where Dix Dr. dead ends. The intersection of Lilac Lane and Dix Dr. is an ideal location to place a set of 4 inlets (on each corner) that will intercept a large portion of stormwater that would otherwise be going to inlets 26 and 27. The proposed piping would continue East along the south side of Dix Dr. to another set of inlets located about halfway between the intersection and Dix Drive's dead end. The piping continues on the south side of Dix Dr. and discharges into the proposed Northeast Park channel at the east end of Dix Dr. Improved flows and Levels of Service of affected elements in the existing Dix system are shown in Table 3.

PROJECT NAME: Morning Glory Drive Alternate 1: Closed Conduit

PROJECT IDENTIFICATION NUMBER: 2

PERTINENT DATA SUMMARY
Watershed: Proposed NE Park
Priority No.: Discretionary
Design Capacity: 13 cfs
Model Reach Designation(s): D019-D022 (new)
Model Inlet Designations(s): NEW7-NEW10
Map Reference Number: 2 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$45,500
E & I	$11,375
Total	$56,875

RECOMMENDED IMPROVEMENTS

Due to it's geographical location, recommended improvements for the residential area between the Dix Watershed and the proposed Northeast Park will be discussed here. This area consists mainly of Morning Glory Drive and the southeast portion of Lilac Ln. This area is currently not a part of any existing watershed. It is included in the watershed that contributes to the proposed Northeast Park channel system. Stormwater flow from this area empties into the farmland from Lilac Lane's dead end at the southeast corner of the Dix Watershed. There aren't any visible channels. The water seems to spread out and eventually find it's way to the Levy stream. There are 2 alternates for improvement of this area that are contingent on the completion of the proposed Northeast Park Channel.

Alternate 1: Enclosed system of 4 Type-A inlets and approximately 550 L.F. of piping along Morning Glory Drive and the Southeast end of Lilac Lane. The piping would begin along Morning Glory Dr. with a set of inlets and travel south where another set of inlets are placed at the intersection of Morning Glory Dr. and Lilac Ln. The piping then travels southeast to the end of Lilac Lane where the stormwater flow will outlet into the proposed Northeast Park Channel.

PROJECT NAME: Morning Glory Drive Alternate 2: Concrete Flumes

PROJECT IDENTIFICATION NUMBER: 3

PERTINENT DATA SUMMARY

Watershed: Proposed NE Park
Priority No.: Discretionary
Design Capacity: 45 cfs
Map Reference Number: 2 and INDEX MAP C
Return Period: >100-yr.

Cost Estimate:	
Const.	$3,500
E & I	$875
Total	$4,375

RECOMMENDED IMPROVEMENTS

Alternate 2: Construct concrete ditch lining from gutters of Lilac Ln. to the proposed Northeast Park Open Channel.

DIX WATERSHED – DIXEX (MAP NO. 2)

Table 2: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
D001	15" RCP from inlet 27 to 26	6.2	6	10	13	18	21	25	>2
D002	24" RCP from inlet 26 to 29	12.8	11	18	23	31	37	43	>2
D003	15" RCP from inlet 28 to 29	4.2	2	3	4	5	6	7	>10
D004	24" RCP from inlet 29 to field outlet	22	18	29	38	50	60	70	>2

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
26	A-5 sump	12	5	8	10	13	16	19	>10
27	A-5 sump	12	6	10	13	18	21	25	>5
28	A-5 sump	12	2	3	4	5	6	7	>100
29	A-5 sump	12	5	9	11	15	18	21	>10

DIX WATERSHED – DIXFUT and NEPARKPRO (INDEX MAP C)

Table 3: *Future* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
D001	15" RCP: inlet 27 - 26	6.2	4	6	7	10	12	14	>5
D002	24" RCP: inlet 26 - 29	12.8	5	7	9	12	15	17	>25
D003	15" RCP: inlet 28 - 29	4.2	2	3	4	5	6	7	>10
D004	24" RCP: inlet 29 - field outlet	22	12	19	24	32	38	45	>5
D013$^{\Phi}$	18" RCP: inlet new1 – new2	6.5	3	4	5	7	8	10	>10
D014$^{\Phi}$	24" RCP: inlet new2 – new4	11	4	7	9	12	14	16	>10
D015$^{\Phi}$	18" RCP: inlet new3 – new4	6.5	1	2	2	3	3	4	>100
D016$^{\Phi}$	24" RCP: inlet new4 – new6	12	6	9	12	16	20	23	10
D017$^{\Phi}$	18" RCP: inlet new5 – new6	6.5	1	2	3	4	4	5	>100
D018$^{\Phi}$	30" RCP: inlet new6-NE park chan	19	8	13	17	22	27	32	>10
D019$^{\Phi}$	18" RCP: inlet new7 – new8	6.5	1	1	1	2	2	3	>100
D020$^{\Phi}$	18" RCP: inlet new8 – new10	6.5	2	3	3	4	5	6	100
D021$^{\Phi}$	18" RCP: inlet new9 – new10	6.5	2	3	4	5	6	7	50
D022$^{\Phi}$	24" RCP: inlet new10 – NE park channel	13	6	9	12	15	19	22	>10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
26	A-5 sump	12	1	2	2	3	3	4	>100
27	A-5 sump	12	4	6	7	10	12	14	50
NEW1$^{\Phi}$	A-7.5 0.5% grade	6	3	4	5	7	8	10	>10
NEW2$^{\Phi}$	A-5 0.5% grade	3.9	2	3	4	5	6	7	10
NEW3$^{\Phi}$	A-5 0.5% grade	3.9	1	2	2	3	3	4	100
NEW4$^{\Phi}$	A-5 0.5% grade	3.9	1	1	2	2	3	3	>100
NEW5$^{\Phi}$	A-5 0.5% grade	3.9	1	2	3	4	4	5	50
NEW6$^{\Phi}$	A-5 0.5% grade	3.9	1	2	2	3	3	4	100
NEW7$^{\Phi}$	A-5 0.5% grade	3.9	1	1	1	2	2	3	>100
NEW8$^{\Phi}$	A-5 0.5% grade	3.9	1	1	2	2	3	3	>100
NEW9$^{\Phi}$	A-5 0.5% grade	3.9	2	3	4	5	6	7	10
NEW10$^{\Phi}$	A-5 0.5% grade	6	2	4	5	6	7	9	25

$^{\Phi}$ New Proposed Elements

NORTHVIEW WATERSHED

NORTHVIEW WATERSHED

The Northview Watershed is a large, complicated watershed covering approximately 397 acres (.62 mi^2). Most of this watershed is located east of Tuttle Creek Blvd. Approximately 38 acres (.06 mi^2) lay west of Tuttle Creek Blvd. It is roughly bounded on the south by Casement Rd. and on the north by Tuttle St. The East boundary runs diagonally from Harvey Dr. northeast to a point east of the Spain Addition. The major outlet is an 8'x5' RCB that runs along Casement Rd. from Allen Rd. south to the bend in Casement Rd. The flow from this RCB empties into a small tributary to the Levy Stream. The main portion east of Tuttle Creek Blvd., the area of concern, has average watershed slopes of 0.5% or less.

Most of the Northview Watershed is single-family residential (approx. 67%). There is also a substantial amount of mobile home parks (approx. 15%) and open, undeveloped space (approx. 18%).

Since this watershed is so massive, with over 200 reaches and 250 inlets, it's discussion has been divided into the Minor Watersheds that contribute to it. The Minor Watersheds are listed below. The Location, Land Use, Existing Drainage System, System Performance, and Capital Improvement Project Recommendations will be covered in detail for each minor watershed.

Minor Watersheds	MAP
1.) Gross Street Area	1
2.) Dix & Knox Area	2 & 5
3.) Allen Road Area	4
4.) Griffith Dr. Area	3,4, 6, & 7
5.) Main Branch Area	1,2,4, & 5

NORTHVIEW WATERSHED

GROSS STREET AREA (MAP NO. 1)

LOCATION

The Gross St. Area is bounded on the south and east by Casement Rd, on the north by Gross St., and on the west by Tuttle Creek Blvd. In the 1995 study, this area was thought to drain south to the Levy Stream through the 15" RCP (R020) located just west of the intersection of Hayes Dr. and Casement Rd. During this study, it was determined that this area drains east into the 8'x5' RCB along Casement Rd. Subsequently, it was removed from the Downtown East Watershed and added into the Northview Watershed. It is approximately 38 acres (.06 mi^2.) and slopes generally to the southeast corner. Slopes average 0.5% or less.

LAND USE

Aside from a used car lot located at the northwest corner, this entire watershed is single-family residential.

EXISTING DRAINAGE SYSTEM

The Gross St. Area Drainage system consists of 22 reaches and 21 inlets. Stormwater flow from this area drains into the 8'x5' RCB along Casement Rd.

Historically, this area has not been a chronic problem. There were no substantial problems reported during the 1993 flood. During this study, reports of stormwater reaching about halfway between the curb and homes were reported to occur maybe once or twice a year from the east side of Strong Ave. The water reportedly went down quickly.

SYSTEM PERFORMANCE

REACHES

Reaches R018 and R012 have a Level of Service less than a 2-year storm. R018 is a 12" RCP and the first reach at the top of the system. This reach is taking additional stormwater from inlets 47 and 48 on Lincoln Dr. which daylight onto Gross St. and flow onto Strong to inlet 16. Flow through this reach is probably twice of what it was designed for. The Allen Rd. system discussion includes a Capital Improvement Project that will divert flow from inlets 47 and 48 to the north as part of the new Lincoln Dr. system. Without the flow from inlets 47 and 48, both R018 and R012 would meet a 2-yr. storm capacity. 11 of the 20 reaches left in the Gross Area Minor Watershed rate at or just above a 2-yr. storm capacity. The overall effectiveness of this system is not great, but with it's current rating and performance history, it is adequate. There are no improvement recommendations at this time.

INLETS

All but one of the inlets in the Gross St. Area have a Level of Service above a 100-yr storm. Inlet 1 can only accommodate a 2-yr storm event. Inlet 1 is a standard A-7.5 on an approximate 2% grade and is located at the east corner of Beck St. and Casement Rd. Improving the performance of this inlet is unnecessary. Overflow will travel down Casement Rd. to inlet 20. Inlet 20 is an A-12.5 sump and has a Level of Service >100-yr storm. When overflow from inlet 1 is considered, inlet 20 will still rate very well at just <50-yr. storm.

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

GROSS STREET AREA (MAP NO. 1)

Table 4: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
R001	30" RCP: 8'x5' RCB - inlet 1	48	25	44	60	83	103	123	>5
R002	30" RCP: inlet 1 - MH	30	22	39	53	73	90	107	>2
R003	30" RCP: MH - inlet 2	30	22	39	53	73	90	107	>2
R004	12" RCP: inlet 2 - 3	2	1	2	2	3	4	5	10
R005	15" RCP: inlet 2 - 4	6.5	2	3	4	6	7	8	>25
R006	12" RCP: inlet 4 - 5	2	1	1	2	2	3	4	25
R007E	30" RCP: inlet 32 - 2	21	18	32	43	59	73	87	>2
R007W	27" RCP: inlet 7 - 32	18	17	29	40	55	68	81	>2
R008	15" RCP: inlet 9 - 7	6.5	4	7	9	12	15	18	<5
R009	12" RCP: inlet 8 - 9	2	1	1	1	2	2	3	50
R010	12" RCP: inlet 11 - 9	3.2	2	4	5	8	9	11	<5
R011	12" RCP: inlet 10 - 11	2	2	3	4	6	7	9	2
R012*	24" RCP: inlet 6 - 7	9.5	12	21	28	39	48	58	<2
R013E	24" RCP: inlet 31 - 6	12.3	10	18	25	34	42	51	>2
R013W	24" RCP: inlet 13 - 31	13	9	16	22	31	38	45	>2
R014	12" RCP: inlet 12 - 13	2	2	3	5	6	8	9	2
R015	18" RCP: inlet 15 - 13	7.8	7	12	16	23	28	33	>2
R016	12" RCP: inlet 14 - 15	2	2	3	4	6	7	8	2
R017	15" RCP: inlet 17 - 15	5	5	8	11	15	19	22	2
R018*	12" RCP: inlet 16 – 17	2	4	7	10	14	17	20	<2
R021	15" RCP: inlet 47 – 48	4	1	2	3	4	5	6	25
R022	15" RCP: inlet 48 - Gross St.	12	2	4	5	7	9	10	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
1	A-7.5 2% grade	4.9	5	8	11	15	18	21	2
2	A-5 sump	12	2	3	4	6	7	8	>100
3	A-5 sump	12	1	2	2	3	4	5	>100
4	A-5 sump	12	1	2	2	3	4	5	>100
5	A-5 sump	12	1	1	2	2	3	4	>100
6	A-5 sump	12	2	3	4	5	6	7	>100
7	A-5 sump	12	1	2	3	4	5	5	>100
8	A-5 sump	12	1	1	1	2	2	3	>100
9	A-5 sump	12	1	2	3	4	4	5	>100
10	A-5 sump	12	2	3	4	6	7	9	>100
11	A-5 sump	12	1	1	1	2	2	3	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

GROSS STREET AREA (MAP NO. 1) CONTINUED

Table 4: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
12	A-5 1% grade	3.7	2	3	5	6	8	9	>5
13	A-5 1% grade	3.7	1	1	2	3	3	4	100
14	A-5 sump	12	2	3	4	6	7	8	>100
15	A-5 sump	12	1	2	2	3	4	4	>100
16	A-5 sump	12	2	4	5	7	9	11	>100
17	A-5 sump	12	1	1	1	2	2	3	>100
47	5'x8" sump	11.5	1	2	3	4	5	6	>100
48	5'x8" sump	11.5	1	2	2	3	4	5	>100
266	Special Yard – 5'x9" opening each side	24	4	6	8	10	12	14	>100
267	Special Yard – 5'x9" opening each side	24	2	3	3	5	6	6	>100

NORTHVIEW WATERSHED

DIX AND KNOX AREA (MAP NO. 2&5)

LOCATION

The Dix and Knox Area is bounded on the west by Casement Rd. and the south boundary is just south of Violet Cir., Gardenia Terr., Daisy Ct. The north boundary follows along Knox Lane from it's intersection at Casement Rd. and travels in a northeasterly direction to a point located east of the Spain Addition. The east boundary goes north along Dogwood Dr. and Poppy Ct. Then it travels east and northeast to the point east of the Spain Addition. It is approximately 109 acres (.17 mi^2) and drains to the southwest corner of the watershed at an average 0.5% slope.

LAND USE

This watershed is largely made up of open space, approximately 45%. Mobile home parks account for 40% and Single-family residential dwellings are 15% of the acreage.

EXISTING DRAINAGE SYSTEM

The drainage area for the Dix and Knox watershed is quite large, however, the enclosed drainage system is rather small. There are 13 enclosed reaches, 2 open channel reaches, and 11 inlets. The dominating entity of this system is the Powerline channel that distinctly stretches from Knox Lane southwesterly under Powerline Pl. and down to the intersection of Dix Dr. and Casement Rd. There are two small systems of pipes and inlets. One such system contributes stormwater at the top of the Powerline channel and is located at the intersection of Spain Dr. and Knox Ln. The other system is located at the bottom of the Powerline channel and is located in the Dix Addition. All flow in the Powerline channel enters the enclosed system in Dix and empties into the 8'x5' RCB along Casement.

SYSTEM PERFORMANCE

REACHES

Most of the reaches in the Dix and Knox area have levels of service above a 2-yr. storm. However, there have been many complaints in this area and this study gives credence to those complaints.

The entire area north of Knox Lane contributes to the Powerline channel (K008), yet, has no drainage structures beyond a few crossroad pipes under driveways and one 18" steel pipe (K009) under Knox Lane. The area north of Knox is approximately 43 acres. Roughly half is open space and half is mobile home park. Stormwater flow from this area alone is 42 cfs in a 2-yr. storm up to 137 cfs in a 100-yr. storm. Part of this water is flowing on a path through the mobile home's backyards between Patricia Pl and Spruce Pl. Most of this water is congregating at the low point on the north side of Knox Lane between Patricia Pl. and Spruce Pl. to exit through an 18" steel pipe under Knox .The roadside ditch on the north side of Knox seems to provide some detention for this area as the crossroad pipes are inadequate within the mobile home park as is the 18" steel pipe under Knox. The slopes within the park

are approximately 0.4%. With the flat slopes, poor condition of the streets, and poor outlet structures, there is a lot of standing water in most any storm event. In larger storms, water is flowing over Knox Lane to join the top end of the Powerline Channel. At the bottom end of the Powerline channel, there were reports of water in basements along Gladiola Ct. Residents report that the channel fills up regularly to a high level. At the flowline of the channel there is a 48" RCP, D007, and another 48" overflow RCP, D005, located 4-5' above the flowline of the channel. Even with these two pipes, this channel acts just as much as a detention basin as a channel. With the 24" CMP under Powerline Pl. and 24" CMP under Waterway Pl., it is actually like a series of detention basins.

There are complaints of standing water in intersection of Knox Lane and Spain Dr. on a regular basis. In 1993, water is reported to have gotten very close to the house on the east side of the T-intersection. Reaches K002 and K006 have Levels of Service <2-yr. storm. Also, upon inspection, the 18" RCP of K005 and 24" RCP of K006 are substantially silted in. Reach K006 is approximately 50% silted. The roadside ditch, K007, on the south side of Knox in which K006 empties into, is also substantially silted in. It has 5-yr. Level of Service. The silted conditions are greatly impeding flow in this area.

All of the reaches in the Dix area have levels of service >2-yr. storm. Most of them rate just >2-yr.storm, namely the main 48" RCP of this system, which includes reaches D007, D008, D009, D011, and D012. These reaches are already basically at maximum capacity with flow from the Powerline channel before stormwater from the immediate Dix area even enters the system.

INLETS

There are a few inlets that have levels of service <2-yr. storm. The first is inlet 169 on Knox Ln. Overflow from 169 goes down to inlet 174. Inlet 174 has a very small drainage area. With the overflow inlet 174 is rated >2-yr storm and improvements may be necessary. Inlets 22 and 25 in the Dix area also rate <2-yr. storm. No improvements are necessary here for a couple of reasons. First of all, flow to these inlets will likely cross the crown of the road and be shared by the inlet on the other side of the street. Inlet 22 will share with 23 and inlet 25 will share with 24. Secondly, these inlets can easily overflow onto Casement road where their flow will be picked up by the sump inlets 20 and 21.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: **Knox Lane Crossroad Pipe Replacement**

PROJECT IDENTIFICATION NUMBER: **4**

PERTINENT DATA SUMMARY
Watershed: Northview
Priority No.: **6**
Design Capacity: 80 cfs
Model Reach Designation(s): K009
Map Reference Number: 5 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:	
Const.	$20,000
Esmt.	$2,000
E & I	$5,000
Total	$27,000

RECOMMENDED IMPROVEMENTS

The 18" steel crossroad pipe, K009, is located underneath Knox Lane immediately west of the intersection with Spruce Place. It currently has a Level of Service <<2-yr. storm. This pipe should be replaced with 2-42"x 27" RCPHE's to increase this reach to a 10-yr. Level of Service. Channel clearing and regrading will be necessary on both the inlet and outlet sides of the new crossroad pipe, particularly with respect to reaches K007 (roadside ditch) and K008 (Powerline Channel) on the outlet side. . Easement acquisition cost may be lowered based on the probability of the construction of the proposed Northeast Park south of Knox Lane.

PROJECT NAME: Knox Lane Alternate 1: Roadside Ditch

PROJECT IDENTIFICATION NUMBER: 5

PERTINENT DATA SUMMARY
Watershed: Northview
Priority No.: Discretionary
Design Capacity: 83 cfs
Model Reach Designation(s): K005, K006, K007
Map Reference Number: 5 and INDEX MAP C
Return Period: >25-yr. (K007)

Cost Estimate:	
Const.	$63,000
Esmt.	$24,000
E & I	$15,750
Total	$102,750

RECOMMENDED IMPROVEMENTS

Reaches K005 and K006 along with inlets 173 and 174 need cleaned out. A 4' bottom concrete ditch liner with 3:1 sides, providing a min. 1.5' depth, is recommended for reach K007, the roadside ditch on the south side of Knox. This 1200' long ditch will begin at the outlet of K006 and end near K009, the crossroad pipe under Knox, and the top of the Powerline Channel. It is estimated to be at a 0.4% grade. This ditch liner will reduce siltation and improve flow given its lower Manning's coefficient. Easement acquisition cost may be lowered based on the probability of the construction of the proposed Northeast Park south of Knox Lane.

PROJECT NAME: Knox Lane Alternate 2: Closed Conduit

PROJECT IDENTIFICATION NUMBER: 6

PERTINENT DATA SUMMARY
Watershed: Northview
Priority No.: Discretionary
Design Capacity: 9 cfs (174), 21 cfs (K006)
Model Reach Designation(s): K006
Model Inlet Designation(s): 174
Map Reference Number: 5 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:	
Const.	$24,240
Esmt.	$16,960
E & I	$6,060
Total	$47,260

RECOMMENDED IMPROVEMENTS

Another solution is to establish a 16' drainage easement on the east side of the storage units located south of Knox and east of the mobile home park. The easement will stretch southerly from Knox Lane to the Powerline Channel approximately 530'. Reach K006, a 24" RCP, will be replaced with a 30" RCP and extended south through the new easement and discharge into the Powerline Channel. The slope of the new piping will be approximately 1%. Also, inlet 174 (A-5), will be replaced as an A-10. Reach K002 shows an existing Level of Service of <2-yr. storm. The stormwater not entering inlet169 and not traveling through K002 is going on to inlet 174. Since reach K007, the open channel (roadside ditch), is being abandoned, it is important to capture as much flow as possible. This can be done by replacing inlet 174. The roadside ditch can still operate as an overflow route in rainstorms exceeding a 10-yr. return period.

PROJECT NAME: Northeast Park Channel

PROJECT IDENTIFICATION NUMBER: 7

PERTINENT DATA SUMMARY
Watershed: Northview
Priority No.: Discretionary
Design Capacity: 360 cfs
Model Reach Designation(s): K010
Map Reference Number: 2&5 and INDEX MAP C
Return Period: 100-yr.

Cost Estimate:

Const.	$300,000
E & I	$75,000
Total	$375,000

RECOMMENDED IMPROVEMENTS

From the new crossroad pipe under Knox, a new 4' bottom earth channel with 4:1 sides is recommended to run from Knox Lane south through the proposed Northeast Park located east of the Dix Addition and down to the Levy Stream. The Levy Stream is approximately 300' from the centerline of the Levy, so this proposal will require a permit from the Army Corps. Of Engineers. This channel, the Northeast Park channel, will head off drainage from the Knox area, the east part of the Dix Addition, and a portion of the proposed Northeast Park. If overflow is to occur, it would happen at the top end of the channel close to Knox where the depth is approximately 3'. As the channel continues south, it will increase in depth through the proposed Northeast Park. At approximately 0.4% slope, the channel is estimated to be about 14' deep at the greatest point of cut located just east of the dead end of Dix Dr. Because of the large amount of excavation, cost for this proposal with incidentals (foot bridges, concrete lining from gutters on Dix Dr. and Lilac Lane, etc.) is on the order of $300,00.00. The Northeast Park channel will greatly improve the performance of the 48" RCP and Powerline channel reaches in the Dix area.

The property directly east of the storage facility and south of Knox Lane has no drainage easement for approximately 1000' of the Powerline Channel, reach K008, and has not been maintainable. At one time the channel was filled in on this property and backed up stormwater flow into the mobile home park north of Knox Lane. The Northeast Park Channel will effectively redirect stormwater from traveling through this property and end the maintenance problems.

The Northeast Park channel can be made possible if the City of Manhattan will establish a 120' drainage easement on the west side of the proposed Northeast Park. Before, during, and even after construction of the park, soil from this area can be offered to local contractors as contractor-furnished borrow. In this scenario, cost of the Northeast Park Channel will justify the benefit. The improved flows and Levels of Service for affected reaches are provided in Table 6.

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

DIX AND KNOX AREA (MAP NO. 2&5)

Table 5: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
K001	15" RCP: inlet 170 - 169	6	3	4	5	6	7	8	25
K002*	18" RCP: inlet 169 - 174	6.5	9	14	17	22	25	29	<2
K003	15" RCP: inlet 171 - 172	6	1	2	2	3	3	4	>100
K004	18" RCP: inlet 172 - 173	6.5	2	3	4	6	7	8	25
K005	18" RCP: inlet 173 - 174	6.5	2	3	4	6	7	8	25
K006*	24" RCP: inlet 174 - Powerline Channel	9	11	16	21	26	31	36	<2
K007	Roadside Ditch to Powerline Channel	16	11	16	20	26	31	36	5
K008	Powerline Channel to inlet 25	2370	77	118	149	194	231	267	>100
K009	18" steel pipe under Knox Lane	6.5	42	63	78	101	119	137	<<2
D005	48" RCP Overflow Pipe	145	77	118	149	194	231	267	<10
D007	48" RCP: Powerline Ditch - inlet 25	85	77	118	149	194	231	267	>2
D008	48" RCP: inlet 25 - 24	85	79	120	152	198	235	273	>2
D009	48" RCP: inlet 24 - 23	85	80	122	154	201	238	276	>2
D010	18" RCP: inlet 30 - 23	12.5	0	0	1	1	1	1	>100
D011	48" RCP: inlet 23 - 22	85	81	124	157	204	242	281	>2
D012	48" RCP: inlet 22 - 8x5 RCB	85	84	128	162	212	252	292	>2

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
169*	A-5 0.5% grade	3.9	7	10	13	16	19	21	<2
170	A-5 0.5% grade	3.9	3	4	5	6	7	8	5
171	A-5 0.5% grade	3.9	1	2	2	3	3	4	100
172	A-5 0.5% grade	3.9	1	2	2	3	4	5	50
173	A-5 0.5% grade (overflow from 170-172)	3.9	0	0	1	2	3	5	>50
174	A-5 0.5% grade (overflow from 169)	3.9	3	6	9	12	15	17	>2
22*	A-10 1% grade	3.7	6	10	13	17	21	24	<2
23	A-10 1% grade	3.7	3	4	5	7	8	10	>2
24	A-10 0.5% grade	3.9	2	4	5	6	7	9	5
25*	A-10 0.5% grade	3.9	4	7	9	11	14	16	2
30	Area Inlet 2'-2"x2'-7"	7.7	0	0	1	1	1	1	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVPRO & NEPARKPRO

DIX AND KNOX AREA (INDEX MAP C)

WITH NORTHEAST PARK CHANNEL PROPOSAL

Table 6: *Future* Flow/*Future* Elements

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						PROPOSED LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
K006	30" RCP: inlet 174 - Powerline Channel	21	11	16	21	26	31	36	10
K007	Roadside Ditch to Powerline Channel	83	11	16	20	26	31	36	>100
K008	Powerline Channel to inlet 25	2370	27	44	56	75	90	106	>100
K009	2-42"x27" RCPHE Knox Lane	80	42	63	78	101	119	137	10
K010[Φ]	NE Park Channel : 4', 4:1	360	76	119	152	201	240	281	>100
D005	48" RCP Overflow Pipe	145	27	44	56	75	90	106	>100
D007	48" RCP: Powerline Ditch - inlet 25	83	27	44	56	75	90	106	>25
D008	48" RCP: inlet 25 - 24	85	29	46	59	79	94	111	>25
D009	48" RCP: inlet 24 - 23	85	30	47	61	81	97	114	>25
D011	48" RCP: inlet 23 - 22	85	31	49	63	84	101	119	25
D012	48" RCP: inlet 22 - 8x5 RCB	85	34	54	70	92	111	130	<25
C001	8'x5' RCB: Levy Stream – Gross	569	268	438	573	774	937	1105	10
C002	8'x5' RCB: Gross flow to inlet 21	569	245	398	520	700	847	997	>10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
174	A-5 0.5% grade (overflow from 169)	8	3	6	9	12	15	17	10

[Φ] New Proposed Elements

NORTHVIEW WATERSHED

ALLEN ROAD AREA (MAP NO. 4)

LOCATION

The Allen Road Area of the Northview Watershed encompasses approximately 147 acres (.23 mi^2). About 9.7 acres (.0151 mi^2) of area west of Tuttle Creek Blvd. make up the west boundary. The north boundary follows along Griffith Dr. and Griffith Ter. The east boundary is Casement Rd. and the south boundary travels from the south entrance of Lincoln Dr. east along Gross St. The common outlet is a 6'x4' RCB that drains into the 8'x5' RCB at the intersection of Allen Rd. and Casement Rd. The area west of Tuttle Creek Blvd is mostly the rock ledge from the Manhattan Country Club golf course down to Tuttle Creek Blvd. It is approximately at a 2:1 slope. East of Tuttle, the ground slopes down to the west at 6-7% for approximately 200'. From there, the ground is very flat. Streets are built in a slight up and down pattern to direct stormwater to the many sump inlets. Slopes range from 0.2% to 0.5%.

LAND USE

The 147 acres of the Allen Road Area are divided as such: 71% Single Family Residential, 13% mobile home park, 9% Medium-High Density Residential, and 7% open space (with 35% impermeable for Tuttle Creek Blvd.).

EXISTING DRAINAGE SYSTEM

The Allen Road Area has a complex enclosed drainage system that consists of 112 reaches and 120 inlets. The major component of this system is the RCB system that runs down the north side of Allen Rd. Fourteen substantial drainage systems branch off of this main line. The 8'x3' RCB from the mobile home park to Green Ave. and the 6'x4'RCB from Green Ave. to Hayes Dr. were constructed in 1995 in response to the Stormwater Management Master Plan of 1995. The old system of RCP and CMMAC had Levels of Service <2-yr. storm. This has been improved to levels of service ranging from >100 yr. storm at the top of the new RCB system to >5-yr. storm at the bottom of the new RCB system. Residents on Allen Rd. reported that they were pleased with the improvement. There are 2 RCB's that carry stormwater under Tuttle Creek Blvd. At the intersection of Allen Rd. and Tuttle Creek Blvd. is a 3'x2' RCB that creates the very top of the main line for the Allen Rd. Area drainage system. There is also a 4'x4' RCB located halfway between the two entrances of Lincoln Dr. The Lincoln Dr. drainage system is a major subsystem, contributing approximately 27% of the total stormwater flow of the Allen Rd. Area system.

SYSTEM PERFORMANCE

REACHES

The mobile home park on the north side of Allen Rd. has many reaches, A086, A087, A089, A091, and A092, with Levels of Service close to a 2-yr storm. Many of these inlets and reaches are partially silted in and blocked with debris. There is likely a lot of standing

water in the park during an intense rainstorm. Since the storm drainage is privately owned and not the responsibility of the City of Manhattan, there are no recommendations for improvement in this report.

The Lincoln Drive system, reaches A107, A108, A109E, A109N, and A110, have levels of service <<2-yr. storm. This system is grossly undersized. Stormwater traveling under Tuttle Creek Blvd. through the 4'x4' RCB is expected to enter A110, a 15" RCP. Without an analysis, it is easy to see the discrepancy in geometry. In a general sense, stormwater from the RCB that doesn't enter the Lincoln Dr. system is overflowing east onto Green Ave. and Strong Ave. south of Allen Rd.

Stormwater that doesn't enter A110 travels west between lots 9 and 10 (Roehl Addition) on the west side of Lincoln Dr. to the street. From here, stormwater that doesn't enter the system does one of two things.

1.) The stormwater continues east to Green Ave. by going over the curb at inlet 50 and traveling between lots 22 and 23 (Roehl Addition) on the east side of Lincoln Dr. and then down between lots 15A and 16 (Glendale Addition) on the east side Green Ave. It is then believed that much of this water travels south to Gross St. and then flows east onto Strong Ave. Interestingly, there is a drainage easement established between lots 22 and 23, suggesting that stormwater was expected to travel this way at some point. There isn't one between lots 15A and 16, however. Residents in this area report a lot of water traveling the route described. One resident has placed a 12" HDPE section of pipe at the common property corner of the above-mentioned lots.

2.) The stormwater travels north toward inlets 51 and 52. Following the path of the existing, enclosed system, excessive stormwater will then go over the curb at inlet 52 and travel east between lots 17 and 18 (Roehl Addition) on the east side of Lincoln Dr. and down to the special yard inlet number 265. For most rains, water is probably contained in the area surrounding inlet 265. In larger rains it is believed that stormwater finds its way through backyards and exits onto Green Ave. on the north side of the house on the corner of Green Ave. and Allen Rd, lot 19 of the Glendale Addition. There are sandbags on the north side of this home. Many of the sandbags have broken open and the sand has washed down towards the street suggesting the path of the water.

Historically, there have been complaints in the Green and Strong area between Gross St. and Allen Rd. These complaints consist mostly of very high water in the street. At times it is high enough to flood the floors of parked cars. On their own merit, the stormwater systems on Green Ave and Strong Ave. have adequate Levels of Service. Refer to reaches A070 and A071 (Green Ave.) and A047, A048, A049, and A050 (Strong Ave.). Correction of the Lincoln Dr. system will alleviate the problems on Green and Strong between Allen Rd. and Gross St.

INLETS

Inlet 54 has a Level of Service <<2-yr. storm. It is an A-5 standard curb inlet located on the west end of Allen Rd. on a 6.7% grade. Overflow travels down to inlet 56, which is rated as 2-yr. storm capacity. If 56 cannot handle the additional flow, it will continue down to inlet 58, which has a >100-yr. storm capacity. Recommendations for improvement are not necessary.

Inlet 280 also has a Level of Service <2-yr. storm. It is an area inlet located in the driveway of the USD 383 Maintenance Shop at the corner of Allen Rd. and Casement Rd. Overflow will travel down to inlet 72 on Allen. Inlet 72 rates >100-yr. and can easily handle the additional stormwater flow. Again, recommendations for improvement are not necessary.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION (S)

PROJECT NAME: **Lincoln Drive**

PROJECT IDENTIFICATION NUMBER: **8**

PERTINENT DATA SUMMARY

Watershed: Northview
Priority No.: **2**
Design Capacity: 100 cfs
Model Reach Designation(s): R021, R022, A110, A106, A107, A108, A109E, A109N
Model Inlet Designation(s): 47, 48, 49, 50, 51, 52, 265
Map Reference Number: 1&4
Return Period: 10-yr.

Cost Estimate:

Const.	$289,150
Esmt.	$7,040
E & I	$72,278
Total	$368,468

RECOMMENDED IMPROVEMENTS

Replace reaches A110, A107, A108, A109E, and A109N, with a 4.5'x3' RCB. Replacement of reach A106 with an 18" RCP. Add inlets 47 and 48 from the Gross Area to the Lincoln Dr. system. Reach R021 is replaced with an 18" RCP and place a new 18" RCP from inlet 47 to 49, designated as R022NEW. A new drop box, approximately 6'x6', will be constructed where the 4'x4' RCB (reach 3060) under Tuttle Creek Blvd. discharges to create the top of this new system. All inlets shall be replaced or reconstructed. Inlets 47, 48, 50, 51, and 52 are to be standard A-5 curb inlets. Inlet 49 is to be a standard A-10 curb inlet, while inlet 265 is to be a standard 3'x3' grated area inlet. 10' easements are present along reach A110 and A109E. Reach A109N has a variable easement from 11' to 20'. According to the Stormwater Master Plan easements for this project need to be the outside the width of the box plus 6' on each side for a total of approximately 18'. Additional easement purchases are needed if they can be attained. There may be a problem with space constraints, particularly along reach A109E. The Lincoln Dr. Improvement will have a great impact on the Lincoln Dr. Area as well as the Green St. and Strong Ave. area. The current overflows of stormwater will be contained. A table illustrating the improved Levels of Service of the proposed elements of the Lincoln Dr. system is on page N-24.

Note: The Levels of Service for the RCB's along Allen Rd (discussed earlier, >100 at the top to >5 at the bottom of the system) were figured with the assumption that *all* of the stormwater flow from the Lincoln Dr. system is emptying into the 8'x3' RCB under Allen Rd. In current conditions, the RCB's along Allen Rd. have greater Levels of Service. The Levels of Service shown will be accurate upon completion of the Lincoln Dr. project.

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4)

Table 7: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
A001	6'x4' RCB: inlet 73 - 8'x5' RCB	209	116	193	256	351	428	508	>5
A002	15" RCP from inlet 72 to 73	3	0	1	1	1	1	2	>100
A003	6'x4' RCB: Prairie Field - inlet 73	209	115	192	255	349	426	507	>5
A004	18"x11" CMP: inlet 71 - 6x4 RCB	4	1	3	4	5	7	8	10
A005	18" CMP: inlet 117 - 6'x4' RCB	5.8	3	5	6	8	10	12	10
A006	18"x11" CMMAC: inlet 119 - 117	4	2	3	3	4	5	6	25
A007	25"x16" CMMAC: inlet 120 - 117	4.8	1	1	2	2	3	4	>100
A008	18"x11" CMMAC: inlet 121 - 120	4	0	0	1	1	1	1	>100
A009E	6'x4' RCB: Beck St. - Prairie Field	209	111	186	246	336	411	488	>5
A009W	6'x4' RCB: Prairie Lea - Beck St.	209	109	182	240	328	400	474	>5
A010	25"x16" CMMAC: inlet 14-6x4 RCB	5	1	3	4	6	7	9	>10
A011	25"x16" CMMAC: inlet 115 - 114	5	1	2	3	4	5	7	50
A012	18"x11" CMMAC: inlet 116 - 115	4	0	1	1	1	2	2	>100
A013	22"x13" CMMAC: inlet 117 - 115	4.4	0	1	1	1	2	2	>100
A014	6'x4' RCB: inlet 70 - Prairie Lea	209	108	179	237	323	393	467	<10
A015	30"x19" RCPHE: inlet 69 - 70	12	1	2	2	3	4	4	>100
A016E	6'x4' RCB: Hays Dr. - inlet 70	209	107	177	234	319	389	462	<10
A016W	6'x4' RCB: Prairie Glen -Hays Dr.	209	105	173	229	311	379	450	<10
A017	15" RCP: inlet 67 - 68	4	1	1	2	2	3	3	>100
A018	24" CMP: inlet 108 - 106	10	3	5	7	10	13	16	25
A019	25"x16" CMMAC: inlet 110 - 108	6.7	2	3	5	7	9	11	25
A021	25"x16" CMMAC: inlet 111 - 110	6.3	1	2	3	4	6	7	50
A022	18"x11" CMMAC: inlet 113 - 111	3.5	1	2	2	4	4	5	<25
A023	15" RCP: inlet 46 – 45	4	1	2	3	5	6	8	>10
A024	24" RCP: inlet 45 - 6'x4' RCB	15	3	5	7	10	13	16	<100
A025	21" RCP: 6'x4' RCB - inlet 43	9.5	2	4	6	9	12	14	>25
A026	15" RCP: inlet 44 – 43	4	1	1	2	2	3	3	>100
A027	18" RCP: inlet 43 – 35	7	1	2	3	4	6	7	25
A028	15" RCP: inlet 36 – 35	4	1	1	1	2	3	3	>100
A029E	6'x4' RCB: Judson St. - inlet 68	209	100	165	217	295	360	426	<10
A029W	6'x4' RCB: inlet 66 - Judson St.	209	98	161	212	288	350	414	<10
A030	21" RCP: 6'x4' RCB - inlet 41	9.5	2	4	6	9	11	14	25
A031	15" RCP: inlet 42 – 41	4	1	1	1	2	3	3	>100
A032	18" RCP: inlet 41 – 33	7	1	2	3	5	6	7	100
A033	15" RCP: inlet 33 – 34	4	1	1	2	2	3	3	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
A034	15" RCP: inlet 65 – 66	4	0	0	0	1	1	1	>100
A035	24" RCP: inlet 99 - 6'x4' RCB	12.5	4	8	11	17	21	26	10
A036	15" RCP: inlet 98 – 99	4	0	1	1	2	2	3	>100
A037	21" RCP: inlet 101 – 99	10	3	6	9	13	16	20	>10
A038	15" RCP: inlet 100 – 101	4	0	1	1	2	3	3	>100
A039	18" RCP: inlet 103 – 101	6.5	2	4	5	7	9	12	25
A040	15" RCP: inlet 102 – 103	4	0	1	1	2	3	3	>100
A041	15" RCP: inlet 105 – 103	4.5	1	2	2	4	5	6	50
A042	15" RCP: inlet 104 – 105	4	0	1	1	2	2	3	>100
A043	6'x4' RCB: Northview - inlet 66	209	98	161	212	287	349	413	<10
A044	6'x4' RCB: inlet 64 - Northview	209	95	154	201	271	329	388	>10
A045	18" RCP: inlet 63 - 64	6	1	1	1	2	2	2	>100
A046	6'x4' RCB: Strong - 64	209	94	153	200	269	327	386	>10
A047	21" RCP: inlet 39 - 6'x4' RCB	9.5	4	7	10	14	18	22	10
A048	15" RCP: inlet 40 - 39	4	1	1	2	3	3	4	100
A049	18" RCP: inlet 31 - 39	7	2	4	6	9	11	14	>10
A050	15" RCP: inlet 32 - 31	4	1	1	2	3	4	4	100
A051	6'x4' RCB from Blaker to Strong	209	91	147	191	257	310	366	>10
A052	24" RCP: inlet 91 - 6'x4' RCB	12.5	3	6	9	13	16	20	25
A053	15" RCP: inlet 90 - 91	4	0	1	1	2	2	2	>100
A054	21" RCP: inlet 96 - 97	10	2	5	7	10	13	15	25
A055	15" RCP: inlet 92 - 93	4	0	1	1	2	2	3	>100
A056	18" RCP: inlet 95 - 93	6.5	2	3	5	7	8	10	25
A057	15" RCP: inlet 94 - 95	4	0	1	1	2	2	3	>100
A058	15" RCP: inlet 97 - 95	4.5	1	2	2	3	4	5	>50
A059	15" RCP: inlet 96 - 97	4	0	1	1	2	2	3	>100
A060E	6'x4' RCB: inlet 62 - Blaker	209	89	141	183	244	294	346	>10
A060W	6'x4' RCB: Green - inlet 62	209	88	140	181	242	291	344	>10
A061	38"x24" RCPHE: inlet 61 - 62	19	1	1	1	1	2	2	>100
A062	24" RCP: inlet 83 - 6'x4' RCB	12.5	3	6	9	13	16	20	25
A063	15" RCP: inlet 82 - 83	4	0	1	1	1	2	2	>100
A064	21" RCP: inlet 85 - 83	10	3	5	7	10	13	16	25
A065	15" RCP: inlet 84 - 85	4	0	1	1	2	2	2	>100
A066	18" RCP: inlet 87 - 85	6.5	2	3	5	7	9	11	25
A067	15" RCP: inlet 86 - 87	4	0	1	1	1	2	2	>100
A068	15" RCP: inlet 89 - 87	4.5	1	2	3	4	5	6	>25

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
A069	15" RCP: inlet 88 - 89	4	0	1	1	2	3	3	>100
A070	18" RCP: inlet 38 - 6'x4' RCB	9.5	2	4	6	8	10	13	50
A071	15" RCP: inlet 37 - 38	4	1	2	3	5	6	7	>10
A072	8'x3' RCB: inlet 60 - Green	209	84	131	168	223	268	314	>10
A073	30"x18" RCPHE: inlet 59 - 60	11.5	3	4	5	7	8	10	>100
A074	8'x3' RCB: inlet 58 - Sloan St.	209	82	127	164	217	260	305	<25
A075	24" RCP: inlet 75 - 8'x3' RCB	12.5	6	11	16	22	27	33	>5
A076	15" RCP: inlet 74 - 75	4	1	1	2	2	3	3	>100
A077	21" RCP: inlet 77 - 75	10	6	10	13	19	23	28	5
A078	15" RCP: inlet 76 - 77	4	1	1	2	3	4	4	100
A079	18" RCP: inlet 79 - 77	6.5	5	8	11	15	18	22	>2
A080	15" RCP: inlet 78 - 79	4	1	2	3	5	6	7	>10
A081	15" RCP: inlet 81 - 79	4.5	3	5	7	9	11	13	5
A082	15" RCP: inlet 80 - 81	4	3	4	6	7	9	10	5
A083	8'x3' RCB: inlet 58 - Sloan	209	78	120	152	200	239	278	>25
A084	2.5'x1.5' RCPHE: inlet 57 - 58	11.5	1	2	3	4	6	7	>100
A085E	8'x3' RCB: mobile home park inlet 58	209	77	117	149	195	232	269	>25
A085W	8'x3' RCB: inlet 58 - mobile home park	209	27	42	55	75	91	107	>100
A086	18" RCP: inlet 136 - 8'x3' RCB	7	6	13	18	26	33	40	>2
A087	18" RCP: inlet 135 - 136	7	6	12	18	26	33	40	>2
A088	18" RCP: inlet 134 - 135	5.5	0	0	1	1	1	2	>100
A089	18" RCP: inlet 132 - 135	7	5	11	15	22	28	34	>2
A090	12" RCP: inlet 131 - 132	2	0	1	1	2	2	3	50
A091*	12" RCP: inlet 129 - 132	3	4	8	12	17	22	27	<2
A092*	12" RCP: inlet 127 - 129	3	4	7	10	14	18	22	<2
A093	12" RCP: inlet 261 - 127	2	0	1	1	2	2	3	50
A094	12" RCP: inlet 126 - 127	3	2	4	6	8	10	12	>2
A095	12' RCP: inlet 123 - 125	2	0	1	1	2	2	3	50
A096	12" RCP: inlet 122 - 125	3	1	2	2	3	4	5	25
A097	2'x1' RCPHE: inlet 55 - 56	6	1	2	3	4	5	6	100
A098	5'x3' RCPHE: inlet 54 - 56	47	23	32	39	50	58	67	<25
A099	5'x3' RCPHE: inlet 53 - 54	47	19	27	33	43	50	57	<50
A100	5'x3' RCPHE: 3'x2' RCB -inlet 53	47	18	26	32	41	48	55	50
A106	15" RCP: inlet 50 - 49	4	1	1	2	2	2	3	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
A107*	15" RCP: inlet 49 - 51	6	49	73	90	115	135	155	<<2
A108*	15" RCP: inlet 51 - 52	4	50	74	92	118	138	158	<<2
A109E*	15" RCP: inlet 52 - 265	6	51	75	93	120	141	162	<<2
A109N*	24" RCP: 265 – 8x3 RCB	10	51	76	94	121	142	164	<<2
A110*	15" RCP: 3060 - inlet 49	4	48	70	87	110	129	147	<<2
A111	18"x24" RCPHE from 8'x3' RCB to Junction Box	9	4	6	7	8	9	10	50
A112	15" RCP: Junction Box - inlet 280	5.4	4	6	7	8	9	10	>2
3060	4'x4' RCB under Tuttle Crk. Blvd.	240	48	71	87	111	129	148	>100
3030	3'x2' RCB under Tuttle Crk. Blvd.	60	18	26	32	41	48	55	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
31	5'x9" sump	12	2	3	4	6	8	10	>100
32	5'x7.5" sump	11	1	1	2	3	4	4	>100
33	3'x7" sump	6.3	1	1	2	2	3	4	>100
34	3'x7" sump	6.3	1	1	2	2	3	3	>100
35	3'x7" sump	6.3	1	1	2	2	3	4	>100
36	3'x7" sump	6.3	1	1	1	2	3	3	>100
37	A-5 sump	12	1	2	3	5	6	7	>100
38	A-5 sump	12	1	2	2	4	5	6	>100
39	5'x8" sump	11.5	1	1	2	3	3	4	>100
40	5'x8" sump	11.5	1	1	2	3	3	4	>100
41	3'x7" sump	6.3	1	1	1	2	3	3	>100
42	3'x7" sump	6.3	1	1	1	2	3	3	>100
43	3'x7" sump	6.3	1	1	1	2	3	3	>100
44	3'x7" sump	6.3	1	1	2	3	3	4	>100
45	A-5 0.5% grade	3.9	1	3	4	6	7	9	10
46	A-5 0.5% grade	3.9	1	2	3	5	6	8	>10
49	A-5 0.5% grade	3.9	1	2	3	5	6	8	>10
50	A-5 0.5% grade	3.9	1	1	2	2	2	3	>100
51	4'-8"x7" sump	9.8	1	1	2	2	3	4	>100
52	5'x8" sump	11.5	1	2	2	3	4	5	>100
53	A-5 6.7% grade	2.4	1	2	2	2	3	3	>25
54*	A-5 6.7% grade	2.4	5	6	7	8	9	11	<<2
55	A-5 0.5% grade	3.9	1	2	3	4	5	6	25

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
56	A-5 0.5% grade	3.9	1	1	2	3	4	5	50
57	Area Inlet 3'-10"x1'-6" sump	7.8	1	2	3	4	6	7	>100
58	A-5 sump	12	1	1	2	2	3	3	>100
59	A-5 sump	12	3	4	5	7	8	10	>100
60	A-5 sump	12	1	1	1	2	2	2	>100
61	A-5 sump	12	1	1	1	1	2	2	>100
62	A-5 sump	12	1	1	1	2	2	2	>100
63	A-5 sump	12	1	1	1	2	2	2	>100
64	A-5 sump	12	1	1	1	2	2	2	>100
65	A-5 sump	12	0	0	0	1	1	1	>100
66	A-5 sump	12	0	0	0	1	1	1	>100
67	4'-10"x7" sump, 3" depression	7.7	1	1	2	2	3	3	>100
68	A-5 sump	12	1	1	1	1	2	2	>100
69	A-10 sump	24	1	2	2	3	4	4	>100
70	A-10 sump	24	1	2	2	3	3	3	>100
71	1.5' high x 2' wide opening in back of box	19	1	3	4	5	7	8	>100
72	A-5 sump	12	0	1	1	1	1	2	>100
73	A-5 sump	12	1	1	2	2	2	3	>100
74	3'x8" sump	6.9	1	1	2	2	3	3	>100
75	3'x8" sump	6.9	0	1	1	2	2	2	>100
76	3.5'x8" sump	8	1	1	2	3	4	4	>100
77	3.5'x8" sump	8	0	1	1	2	3	3	>100
78	3.5'x8" sump	8	1	2	3	5	6	7	>100
79	3.5'x8" sump	8	0	1	1	2	2	3	>100
80	3.5'x8" sump	8	3	4	6	7	9	10	>25
81	3.5'x8" sump	8	1	1	1	2	3	3	>100
82	3'x8" sump	6.9	0	1	1	1	2	2	>100
83	3'x8" sump	6.9	0	1	1	1	2	2	>100
84	3.5'x8" sump	8	0	1	1	2	2	2	>100
85	3.5'x8" sump	8	0	1	1	2	2	3	>100
86	3.5'x8" sump	8	0	1	1	1	2	2	>100
87	3.5'x8" sump	8	0	1	1	1	2	2	>100
88	3.5'x8" sump	8	0	1	1	2	3	3	>100
89	3.5'x8" sump	8	0	1	1	2	2	3	>100
90	3.5'x8" sump	8	0	1	1	2	2	2	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
91	3.5'x8" sump	8	0	1	1	1	2	2	>100
92	3.5'x8" sump	8	0	1	1	2	2	3	>100
93	3.5'x8" sump	8	0	1	1	2	2	3	>100
94	3.5'x8" sump	8	0	1	1	2	2	3	>100
95	3.5'x8" sump	8	0	1	1	2	2	3	>100
96	3.5'x8" sump	8	0	1	1	2	2	3	>100
97	3.5'x8" sump	8	0	1	1	2	2	3	>100
98	5'x9" sump	12	0	1	1	2	2	3	>100
99	5'x9" sump	12	0	1	1	2	3	3	>100
100	5'x9" sump	12	0	1	1	2	3	3	>100
101	5'x9" sump	12	1	2	2	4	5	6	>100
102	3'x9" sump	7.2	0	1	1	2	3	3	>100
103	5'x9" sump	12	0	1	1	2	2	3	>100
104	5'x8" sump	11.5	0	1	1	2	2	3	>100
105	5'x8" sump	11.5	0	1	1	2	2	3	>100
106	Area Inlet 2.5'x2.5'	8.5	1	2	2	3	3	3	>100
107	Area Inlet 2.5'x2.5'	8.5	1	2	2	3	3	3	>100
108	Area Inlet 2.5'x2.5'	8.5	1	1	1	2	2	3	>100
109	Area Inlet 2.5'x2.5'	8.5	1	1	1	2	2	3	>100
110	Area Inlet 2.5'x2.5'	8.5	1	1	2	3	3	4	>100
111	Area Inlet 2.5'x2.5'	8.5	0	0	1	1	1	2	>100
112	Area Inlet 2.5'x2.5'	8.5	1	1	1	2	2	3	>100
113	Area Inlet 2.5'x2.5'	8.5	1	1	1	2	2	3	>100
114	Area Inlet 3'x3'	12.2	0	1	1	2	2	3	>100
115	Area Inlet 3'x3'	12.2	0	1	1	2	2	2	>100
116	Area Inlet 3'x3'	12.2	0	1	1	1	2	2	>100
117	Area Inlet 3'x3'	12.2	0	1	1	1	2	2	>100
118	Area Inlet 3'x3'	12.2	1	1	1	2	2	3	>100
119	Area Inlet 3'x3'	12.2	2	3	3	4	5	6	>100
120	Area Inlet 3'x3'	12.2	0	1	1	2	2	3	>100
121	Area Inlet 3'x3'	12.2	0	0	1	1	1	1	>100
122	A-2.5 sump	6	1	2	2	3	4	5	>100
123	2'-3"x5" sump	3	0	1	1	1	1	2	>100
124	A-2.5 sump	6	0	1	1	1	1	2	>100
125	2'-4"x6" sump	4	0	1	2	3	3	4	100
126	A-2.5 sump	6	0	1	2	3	3	4	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

ALLEN ROAD AREA (MAP NO. 4) CONTINUED

Table 7: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
127	2'x3" sump	1.8	0	1	1	2	2	2	100
128	3'x4" sump	3.6	0	1	1	2	2	2	>100
129	A-2.5 sump	6	0	1	1	2	2	3	>100
130	1'-8"x9" sump	4	0	1	1	2	2	3	>100
131	Area Inlet 27" diam.	5.4	0	1	1	2	2	3	>100
132	A-2.5 sump	6	1	1	2	3	4	5	>100
133	2'-4"x5.5" sump	4	0	0	1	1	1	1	>100
134	3'x4" sump	3.6	0	0	1	1	1	1	>100
135	2'-3"x6" sump	4.4	1	2	2	3	4	5	>50
136	2'-6" 0.5% grade	2	0	0	0	0	1	1	>100
137	Unknown – silted in	NA	NA	NA	NA	NA	NA	NA	NA
138	Area Inlet 1'-6"x1'-10" – silted in	NA	NA	NA	NA	NA	NA	NA	NA
139	Area Inlet 1'-6"x1'-10" – silted in	NA	NA	NA	NA	NA	NA	NA	NA
140	Area Inlet 1'-6"x1'-10" – silted in	NA	NA	NA	NA	NA	NA	NA	NA
141	Area Inlet 27" diam. – silted in	NA	NA	NA	NA	NA	NA	NA	NA
142	5'x6.5" – silted in	NA	NA	NA	NA	NA	NA	NA	NA
144	A-5 sump	12	4	6	8	11	13	15	>25
145	A-5 0.5% grade	3.9	3	5	6	8	10	12	>2
146	A-5 0.5% grade	3.9	2	3	4	5	6	7	10
147	A-5 0.5% grade	3.9	2	3	3	5	5	6	>10
148	A-5 0.5% grade	3.9	1	2	3	4	5	6	25
261	A-2.5 sump	6	0	1	1	1	1	2	>100
262	2'-7"x5" sump	3.9	0	1	1	1	1	2	>100
263	Area Inlet 27" diam.	5.4	0	1	1	2	2	2	>100
264	Area Inlet 27" diam.	5.4	0	1	1	2	2	2	>100
265	Special Yard Inlet 3'-2" x 11"	10	1	1	2	2	3	4	>100
270	Area Inlet 2'-8"x4'-2"	15.2	1	2	3	4	4	5	>100
280*	Area Inlet 1'-2"x2'-3"	3.4	4	6	7	8	9	10	<2
290	Area Inlet 2'-8"x4'-2"	15.2	1	2	3	4	5	6	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVPRO

IMPROVED ALLEN ROAD AREA (INDEX MAP C)

Table 8: *Future* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						PROPOSED LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
A106	18" RCP from inlet 50 to 49	6	1	1	2	2	2	3	>100
A107	4.5'x3' RCB from inlet 49 to 51	110	51	76	95	122	143	165	>10
A108	4.5'x3' RCB from inlet 51 to 52	110	52	77	96	124	146	168	>10
A109E	4.5'x3' RCB from inlet 52 to 265	110	53	79	98	126	149	172	>10
A109N	4.5'x3' RCB from 265 to	110	53	79	99	128	150	173	>10
A110	4.5'x3' RCB from 3060 to inlet 49	271	48	70	87	110	129	147	>100
R021	18" RCP from inlet 47 to 48	8	1	2	3	4	5	6	>100
R022 NEW	18" RCP from inlet 47 to 49	7.5	2	4	5	7	9	10	>25

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						PROPOSED LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
47	A-5 sump	12	1	2	3	4	5	6	>100
48	A-5 sump	12	1	2	3	4	5	6	>100
49	A-10 0.5% grade	6.3	3	4	6	8	9	11	>10
50	A-5 0.5% grade	3.9	1	1	2	2	2	3	>100
51	A-5 sump	12	1	2	3	4	4	5	>100
52	A-5 sump	12	1	2	3	3	4	5	>100
265	Area Inlet 3'x3'	12.2	1	2	2	3	4	5	>100

NORTHVIEW WATERSHED

GRIFFITH DRIVE AREA (MAP NO. 3, 4, 6, & 7)

LOCATION

The Griffith Area is bounded on the south along Griffith Dr. and Griffith Ter. The west boundary is Tuttle Creek Blvd. while the east boundary is Casement Rd. The north boundary follows along Smith St. and south of Butterfield Rd. The common outlet is a 54" RCP at the corner of Allen Rd. and Casement Rd that discharges into the 8'x5' RCB along Casement. The Griffith Area is about 90 acres (.14 mi^2). From Tuttle Creek Blvd west to Brockman is an average slope of 3.33%. From Brockman to the corner of Allen and Casement, the slope is much more flat, approximately 0.4%.

LAND USE

Most of the Griffith Area is single-family residential, about 93%. The other 7% is school grounds.

EXISTING DRAINAGE SYSTEM

The Griffith Area drainage system is an enclosed system of 55 reaches and 37 inlets. The major components of this system are a 4'x3' RCB that begins at the east (dead) end of Frey Dr. and runs along the north side of Griffith Dr. to Casement Rd. On the west side of Casement Rd. from Griffith Dr. to the cul-de-sac at the end of Griffith Ter. is a 72"x44" CMMAC, and from Griffith Ter. to the outlet at Allen Rd. is a 54" RCP. There are two notable subsystems that contribute to this main branch. One is located in the Brockman St. and Manfax Ave. area while the other is concentrated along Sloan St.

SYSTEM PERFORMANCE

REACHES

Historically, the Griffith Dr. area has a lot of standing water in the streets during most storm events. There are 26 reaches that have levels of service <2-yr. storm and 12 reaches that have Levels of Service matching a 2 or >2-yr. storm. Essentially, the entire Griffith Dr. area drainage system is undersized and needs replaced. Only 13 of the 55 total reaches do not need replaced.

INLETS

There are basically two sets of inlets that need replaced. The first set is along Brockman and includes inlets 164 and 167 (see Map 4). Inlets 164 and 167 have levels of service <2-yr. The second set of inlets, 217, 218, and 219 (see Map 7) creates the top of the Sloan St. subsystem and are part of a private system built by local residents. These inlets do need replaced and have been included in the Griffith Proposal. Funding options for the improvements of the private system at the top of Sloan St. must be determined between the City of Manhattan and the homeowners association in that area.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION (S)

PROJECT NAME: Griffith Drive

PROJECT IDENTIFICATION NUMBER: 9

PERTINENT DATA SUMMARY

Watershed: Northview
Priority No.: Discretionary
Design Capacity: 185 cfs
Model Reach Designation(s): G001-G009, G011, G012, G014-G016, G018-G019, G021-G024E, G026, G028, G030, G032, G033, G035-G043, G046N-G047, G049, G050, & G052
Model Inlet Designation(s): 164, 165, 166, 167, & 168 : 217, 218, & 219
Map Reference Number: 3, 4, 6, & 7
Return Period: 10-yr.

Cost Estimate:

Const.	$2,136,250
E & I	$534,063
Total	$2,670,313

RECOMMENDED IMPROVEMENTS

The Griffith Drive proposal is primarily an extensive replacement of reaches. The main branch of the Griffith Drive area is vastly undersized as are the two subsystems located at Brockman St. and Sloan St. For replacement of the main branch, a 7'x 3.5' RCB is proposed to run from the intersection of Sloan St. and Frey Dr. and follow the path of the existing main branch south and east down to the intersection of Allen Rd and Casement Rd. Also, a 5'x 3' RCB is proposed to run from the intersection of Sloan St. and Frey Dr. west to inlet 168 on Brockman St. An easement purchase will be necessary to widen the existing 10' easement between lots 4 and 5 of the Northview Acres Addition. There are many other subsystem reaches requiring replacement. This project can easily be broken up into phases as necessary. The following table on pages N-29 and N-30 shows the reaches and inlets being replaced and provides an easier way to view the scope of the project. Also see Capital Improvement Project Map C. Proposed size and increased Level of Service for each element are listed accordingly.

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

GRIFFITH DRIVE AREA (MAP NO. 3, 4, 6, & 7)

Table 9: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
G001*	12" CMP: inlet 217 – 218	1.5	3	5	7	9	11	12	<2
G002*	15" CMP: inlet 218 – 219	2.4	5	9	11	15	18	21	<2
G003*	15" CMP: inlet 219 – 212	2.5	13	22	29	39	48	56	<<2
G004*	15" RCP: inlet 212 – 211	3	14	23	30	40	48	57	<<2
G005*	15" RCP: inlet 211 – MH	4	14	23	30	41	49	58	<<2
G006	15" RCP: inlet 210 – 209	3.5	2	4	5	7	8	9	<5
G007	18" RCP: inlet 209 – MH	5.8	5	8	10	14	17	20	>2
G008	15" RCP: inlet 216 – 215	1.5	1	1	2	2	3	3	>5
G009	15" RCP: inlet 215 – 213	3.8	2	4	5	6	8	9	5
G010	15" RCP: inlet 214 – 213	2.5	1	1	1	2	2	3	>50
G011	18" RCP: inlet 213 – MH	4.7	4	6	8	10	12	14	>2
G012*	18" RCP: MH – inlet 208	4.5	22	37	48	64	77	91	<<2
G013	15" RCP: inlet 207 – 208	3.5	1	1	1	2	2	2	>100
G014*	18" RCP: inlet 208 – MH	7.2	24	38	50	67	81	95	<<2
G015	15" RCP: inlet 204 – 203	3.5	3	5	6	8	10	12	>2
G016*	36" RCP: inlet 203 – MH	23	41	63	79	103	122	141	<<2
G017	15" RCP: inlet 206 – 205	3.5	1	2	2	3	4	4	>25
G018*	54"x36" CMP: MH – inlet 205	37	71	111	142	188	224	261	<<2
G019*	18" RCP: inlet 160 – MH	6	7	11	15	19	23	27	<2
G020	15" RCP: inlet 161 – 160	3.5	2	2	3	4	5	6	>10
G021	15" RCP: inlet 160 – MH	5	5	8	11	14	17	20	2
G022*	15" RCP: inlet 159 – MH	4.5	5	8	11	14	17	20	<2
G023*	12" RCP: inlet 158 – 159	2.4	3	4	5	7	9	10	<2
G024W*	54"x36" CMP: inlet 205 – MH	26	73	115	147	193	231	269	<<2
G024E	4'x3' RCB: MH – MH	73.6	73	114	146	193	230	268	>2
G025	18" RCP: inlet 157 – MH	10	2	3	3	4	5	6	>100
G026*	4'x3' RCB: MH – 156	73.6	75	117	149	197	235	273	<2
G027	18" RCP: inlet 155 – 156	10	1	2	3	4	4	5	>100
G028*	4'x3' RCB: inlet 156 – 154	73.6	77	121	155	204	244	285	<2
G029	18" RCP: inlet 153 – 154	10	1	2	2	3	4	4	>100
G030*	4'x3' RCB: inlet 154 – 152	73.6	79	123	158	208	248	289	<2
G031	18" RCP: inlet 151 – 152	10	1	2	2	3	3	4	>100
G032*	4'x3' RCB: inlet 152 – 150	73.6	81	126	161	212	254	296	<2
G033*	4'x3' RCB: inlet 150 – Csmt Rd	73.6	81	127	162	214	255	298	<2
G034	18" CMP: inlet 149 – MH	10	1	1	1	1	2	2	>100
G035	36" RCP: MH – inlet 203	45	36	54	69	89	105	121	>2

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

GRIFFITH DRIVE AREA (MAP NO. 3, 4, 6, & 7) CONTINUED

Table 9: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
G036*	33" RCP: inlet 168 - MH	22	33	50	62	81	95	110	<2
G037	15" RCP: inlet 162 - MH	3.8	3	5	6	8	10	11	>2
G038	15" RCP: inlet 163 - 162	3.8	2	4	5	6	7	9	>2
G039*	34"x22" RCPE: inlet 167 - 168	10	15	24	31	41	50	58	<2
G040	15" RCP: inlet 166 - 167	3.5	3	5	7	9	11	13	>2
G041*	18" RCP: inlet 165 - 168	6.5	17	23	28	34	39	45	<<2
G042*	15" RCP: inlet 164 - 165	3.5	14	19	22	26	30	33	<<2
G043N*	72"x44" CMMAC: MH - MH	68	81	126	161	212	253	295	<2
G043S*	72"x44" CMMAC: MH - inlet 290	68	81	126	161	212	252	294	<2
G044	15" RCP: inlet 147 - 148	3.8	2	3	3	5	5	6	>10
G045	18" RCP: inlet 148 – 72"x44" CMMAC	9	3	5	6	8	10	12	>25
G046N*	72"x44" CMMAC: inlet 290 - MH	68	82	128	163	215	256	298	<2
G046S*	72"X44" CMMAC: MH - MH	68	83	130	166	218	260	303	<2
G047	15" RCP: inlet 145 - 146	3.8	3	5	6	8	10	12	>2
G048	18" RCP: inlet 146 - 144	10.2	5	8	10	14	16	19	>10
G049	18" RCP: inlet 144 - 72"x44" CMMAC	13	9	14	18	24	29	34	<5
G050	54" RCP: G051 - G049	117	92	143	183	241	287	335	>2
G051	24" RCP: end section - inlet 270	20	1	2	3	4	5	5	>100
G052	54" RCP: G051 - A001	117	93	146	187	246	294	342	>2

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
149	A-5 sump	12	1	1	1	1	2	2	>100
150	A-5 sump	12	1	1	2	2	3	3	>100
151	A-5 sump	12	1	2	2	3	3	4	>100
152	A-5 sump	12	1	2	3	4	5	5	>100
153	A-5 sump	12	1	2	2	3	4	4	>100
154	4'x9" sump	9.6	1	2	2	3	4	4	>100
155	A-5 sump	12	1	2	3	4	4	5	>100
156	A-5 sump	12	2	3	4	5	6	7	>100
157	A-10 sump	24	2	3	3	5	5	6	>100
158	5'x7" sump	10.5	3	4	5	7	9	10	>100
159	Area Inlet 3'x1.5'	6.1	3	4	6	7	9	10	10
160	A-7.5 sump	18	0	1	1	1	1	2	>100
161	A-5 sump	12	2	2	3	4	5	6	>100

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

GRIFFITH DRIVE AREA (MAP NO. 3, 4, 6, & 7) CONTINUED

Table 9: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
162	5'x9" sump	12	1	1	1	2	2	3	>100
163	A-2.5	6	2	4	5	6	7	9	25
164*	5'x7" sump	10.5	14	19	22	26	30	33	<2
165	6'x6" sump	12	3	5	7	9	10	12	100
166	5'x7" sump	10.5	3	5	7	9	11	13	>25
167*	5'x5.5" sump	8.5	12	19	24	32	39	45	<2
168	5'-3"x7" sump	11	2	4	5	6	8	9	>100
203	A-7.5 sump	18	2	4	5	6	8	9	>100
204	A-7.5 sump	18	3	5	6	8	10	12	>100
205	A-7.5 sump	18	1	2	2	3	3	4	>100
206	A-5 sump	12	1	2	2	3	4	4	>100
207	A-5 sump	12	1	1	1	2	2	2	>100
208	A-5 sump	12	1	1	1	2	2	2	>100
209	A-5 sump	12	3	4	6	7	9	10	>100
210	A-5 sump	12	2	4	5	7	8	9	>100
211	5'x9" sump – erosion at entrance	12	0	1	1	1	1	2	>100
212	4'-8"x8" sump	10.7	0	1	1	1	1	1	>100
213	4'x6" sump	8	1	1	2	2	3	3	>100
214	5'x8" sump	11.5	1	1	1	2	2	3	>100
215	5'x7" sump	10.5	1	2	3	4	5	5	>100
216	5'x7" sump	10.5	1	1	2	2	3	3	>100
217*	2-5" diameter holes sump	1	3	5	7	9	11	12	<2
218*	2-6" square cut-outs sump	2	3	5	6	8	9	11	<2
219	Special Yard – 1'-9"x1' West 1'-11"x8" East	14	8	14	19	26	31	37	5

NORTHVIEW WATERSHED REACH ANALYSIS - 2NOVPRO

GRIFFITH DRIVE AREA (INDEX MAP C)

Table 10: *Future* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
G001	24" RCP: inlet 217 - 218	11	3	5	7	9	11	12	50
G002	24" RCP: inlet 218 - 219	15	5	9	11	15	18	21	25
G003	36" RCP: inlet 219 - 212	30	13	22	29	39	48	56	10
G004	36" RCP: inlet 212 - 211	30	14	23	30	40	48	57	10
G005	36" RCP: inlet 211 - MH	38	14	23	30	41	49	58	>10
G006	18" RCP: inlet 210 - 209	7.5	2	4	5	7	8	9	25
G007	24" RCP: inlet 209 - MH	12	5	8	10	14	17	20	>10
G008	18" RCP: inlet 216 - 215	6	1	1	2	2	3	3	>100
G009	18" RCP: inlet 215 - 213	6.5	2	4	5	6	8	9	25
G011	24" RCP: inlet 213 - MH	12	4	6	8	10	12	14	50
G012	49"x32" RCPHE: MH - inlet 208	49	22	37	48	64	77	91	10
G014	49"x32" RCP: inlet 208 - MH	55	24	38	50	67	81	95	>10
G015	18" RCP: inlet 204 - 203	6	3	5	6	8	10	12	10
G016	5'x3' RCB: inlet 203 - MH	80	42	63	80	103	122	142	10
G018	7'x3.5' RCB: MH - inlet 205	185	72	112	143	189	225	263	<25
G019	30" RCP: inlet 160 - MH	19	7	11	15	19	23	27	25
G021	24" RCP: MH - inlet 160	14	5	8	11	14	17	20	25
G022	24" RCP: inlet 159 - MH	14	5	8	11	14	17	20	25
G023	18" RCP: inlet 158 - 159	6	3	4	5	7	9	10	>10
G024W	7'x3.5' RCB: inlet 205 - MH	185	74	115	148	195	233	271	>10
G024E	7'x3.5' RCB: MH - MH	185	74	115	148	194	232	271	>10
G026	7'x3.5' RCB: MH - 156	185	75	117	150	198	237	276	>10
G028	7'x3.5' RCB: inlet 156 - 154	185	78	122	156	206	246	287	>10
G030	7'x3.5' RCB: inlet 154 - 152	185	79	125	159	210	251	293	>10
G032	7'x3.5' RCB: inlet 152 - 150	185	81	128	164	216	258	300	>10
G033	7'x3.5' RCB: inlet 150 - Csmt Rd	185	82	128	164	216	258	301	>10
G035	5'x3' RCB: MH - inlet 203	80	36	55	69	89	105	122	>10
G036	5'x3' RCB: inlet 168 - MH	80	33	50	63	81	96	111	<25
G037	18" RCP: inlet 162 - MH	8	3	5	6	8	10	11	25
G038	18" RCP: inlet 163 - 162	6	2	4	5	6	7	9	25
G039	49"x32" RCPE: inlet 167 - 168	35	15	24	31	41	50	58	>10
G040	24" RCP: inlet 166 - 167	11	3	5	7	9	11	13	50
G041	45"x29" RCPHE: inlet 165 - 168	36	17	23	28	34	39	45	>25
G042	45"x29" RCPHE: inlet 164 - 165	24	14	19	22	26	30	33	>10
G043N	7'x3.5' RCB: MH - MH	185	82	128	164	216	258	301	>10
G043S	7'x3.5' RCB: MH - Inlet 290	185	82	128	164	216	258	300	>10

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVPRO

GRIFFITH DRIVE AREA (INDEX MAP C) CONTINUED

Table 10: *Future* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
G046N	7'x3.5' RCB: Inlet 290 - MH	185	82	128	163	215	256	298	>10
G046S	7'x3.5' RCB: MH - MH	185	83	130	166	218	260	303	>10
G047	18" RCP: inlet 145 - 146	6	3	5	6	8	10	12	10
G049	30" RCP: inlet 144 - 72"x44" CMMAC	24	9	14	18	24	29	34	25
G050	7'x3.5' RCB: G051 - G049	185	92	143	183	241	287	335	>10
G052	7'x3.5' RCB: G051 - A001	185	93	146	187	246	294	342	10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
164	A-10 sump	24	14	19	22	26	30	33	>10
165	A-5 sump	12	3	5	7	9	10	12	100
166	A-5 sump	12	3	5	7	9	11	13	>50
167	A-10 sump	24	12	19	24	32	39	45	10
168	A-5 sump	12	2	4	5	6	8	9	>100
217	A-5 sump	12	3	5	7	9	11	12	100
218	A-5 sump	12	3	5	6	8	9	11	>100
219	Area Inlet 4'-6"x4'-6"	20.5	8	14	19	26	31	37	>10

NORTHVIEW EXISTING WATERSHED

MAIN BRANCH AREA (MAP 1, 2, 4, & 5)

LOCATION

The main branch of the Northview Watershed is the 8'x5' RCB that runs under Casement Rd. The drainage area associated with this main branch is Casement Rd. itself (from Allen Rd. south to where Casement bends) and strips of ground on either side. The inlets included here drain directly into this main branch and are not part of any subsystem previously discussed. The 8'x5' RCB is the common outlet near the bend in Casement Rd. Stormwater drains south to the Levy Stream. Much of Casement Rd. slopes at approximately 0.30% but is closer to 4% when approaching the sump inlets by Harvey Dr. The 8'x5' RCB carries stormwater from approximately 397 acres (.62 mi^2). The inlets that discharge directly into this RCB account for about 12 acres (.02 mi^2) of the total drainage area.

LAND USE

93% of the drainage area is single family residential and 7% is mobile home park.

EXISTING DRAINAGE SYSTEM

This drainage system includes the main 8'x5' RCB, 3 other enclosed reaches, and 5 inlets. 2 of those inlets are directly above the RCB and have no reach associated with them. There aren't many components to this system but it is very important. The 8'x5' RCB is the very fabric that holds the entire Northview Watershed (397 acres) together.

SYSTEM PERFORMANCE

REACHES & INLETS

The 5 inlets and 3 reaches perform quite well and generally have high Levels of Service. The 8'x5' RCB rates <25-yr. storm north Harvey Drive and just >10-yr. storm below Harvey Dr. There are no recommendations for improvement at this time.

NORTHVIEW WATERSHED REACH ANALYSIS – 2NOVEX

MAIN BRANCH (MAP NO. 1, 2, & 5)

Table 11: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
C001	8'x5' RCB: inlet 21 - Levy Stream	569	291	471	616	830	1004	1183	<10
C002	8'x5' RCB: Gross flow - inlet 21	569	267	430	560	752	908	1069	>10
C003	8'x5' RCB: inlet 21 - 143	569	207	336	439	590	713	839	<25
C004	8'x5' RCB: inlet 143 - Allen Rd.	569	207	336	439	592	715	843	<25
C005	24" RCP: inlet 143 - 8'x5' RCB	12	1	1	2	2	3	3	>100
C006	18" RCP: inlet 256 - 8'x5' RCB	11	1	1	2	2	2	3	>100
C007	24" RCP: inlet 20 - 21	22	5	8	11	16	19	23	<100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
20	A-12.5 sump	30	7	11	15	20	24	28	>100
21	A-5 sump	12	3	5	7	9	11	13	>50
143	Area Inlet 3'-8"x3'-8"	17.3	1	1	2	2	3	3	>100
256	Area Inlet 3'-8"x3'-8"	17.3	1	1	2	2	2	3	>100
257	Area Inlet 3'-8"x3'-8"	17.3	1	1	1	2	2	2	>100

SPAIN

WATERSHED

SPAIN EXISTING WATERSHED
(MAP NO. 5)

LOCATION

The Spain watershed is approximately 32 acres (.05 mi^2). It includes the Halls Landing area, most of Spain Dr., all of Blueberry Dr., and the southern portion of Knoxberry Dr. The common outlet is located at the dead end of Blueberry Dr. and drains northeasterly through a defined earth channel to the Big Blue River. Most of the watershed generally slopes to the northeast at an average 0.2%, while the northern portion has slopes in the range of 0.5% to 0.9%.

LAND USE

Approximately 37% of the watershed is undeveloped, uncultivated field, while the remaining 63% is single-family residential.

EXISTING DRAINAGE SYSTEM

The drainage system is an enclosed system composed of a network of 20 inlets and 23 reaches. Flow at the outlet drains into a well-defined earth ditch (approximate dimensions: 5' bottom, 3:1 side slopes, 4' depth, 0.7% slope) and travels northeast to the Big Blue River.

This area generated complaints from adjoining homeowners on the east side of Halls Landing and the west side of Spain Dr. reporting that their backyards were not draining in the summer of 1993. An area inlet, number 200, is located at the north end of these properties. The grassy area to the north of Halls Landing is extremely flat and shows no distinct drainage pattern when examining a topography map of the area. Upon further field investigation, an overflow route was identified that takes excess water from this area (inlets 175,176, and 200) to the north where it flows over the curb on Spain Dr. and into the inlets located at the Spain Dr. and Knoxberry Dr. intersection.

SYSTEM PERFORMANCE

REACHES

Six of the reaches, S001, S002, S003, S005, S006, and S007, in the Spain Watershed are at or below a 2-year storm capacity. The drainage area contributing stormwater runoff into inlet 175 is approximately 7.4 acres and creates substantial amounts of flow. The top of the system is grossly undersized. Due to the small 15" RCP's at the top of the system, much of the stormwater cannot enter the system and is entering the overflow route shown on Map 5.

There is also an earth ditch on the north side of the last property on the northwest end of Halls Landing that collects flow in large part from the surrounding field and empties into a knock-out on the back, or west, side of inlet 175. This ditch is small and full of debris. The knock-out in the back of inlet 175 is not big enough. It appears that much of the stormwater flow is circumventing inlet 175 and following the overflow route as shown on the plans.

INLETS

All of the inlets have a Level of Service above a 10-year storm capacity. However, as mentioned above, the knock-out in the back of inlet 175 is not big enough.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Halls Landing

PROJECT IDENTIFICATION NUMBER: 10

PERTINENT DATA SUMMARY
Watershed: Spain
Priority No.: Discretionary
Design Capacity: 13 cfs
Model Reach Designation(s): S001, S002, S003, S005, S006, S007
Map Reference Number: 5
Return Period: 5-yr

Cost Estimate:

Const.	$50,166
E & I	$12,542
Total	$62,708

RECOMMENDED IMPROVEMENTS

Replacement of the 15" RCP in reaches S001, S002, and S003, and the 18" RCP in reaches S005, S006, and S007, with approximately 780 L.F of 24" RCP or equivalent RCPHE. The 24" RCP will increase the Level of Service to a 5-year storm in reaches S005-S007, not quite meeting the city's 10-year storm design standard. The 24" RCP was chosen as the most economical choice. A larger pipe size would require replacement of reaches S008 and S011, approximately 900 additional feet.

Corresponding inlets to these reaches may need reconstructed for adjustment of flowlines and will be determined by a hard design in the future. Also, construct a 4' bottom concrete ditch liner, 3:1 side slopes with 1' of depth, on the north side of the last property on the northwest end of Halls Landing. This ditch liner will begin at the back of inlet 175 and extend the full distance of the north border of said property, approximately 140 L.F. The knock-out in the back of inlet 175 needs to be reconstructed on it's own merits if the entire inlet isn't replaced. If the entire inlet is replaced, the knock-out will become part of the inlet design.

SPAIN WATERSHED – SPAINEX (MAP NO. 5)

Table 12: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
S001*	15" RCP: inlet 175 - 176	3.5	4	6	8	12	14	17	<2
S002	15" RCP: inlet 176 - 232	4	4	7	9	13	16	19	2
S003*	15" RCP: inlet 232 - 178	4.2	5	8	11	15	19	22	<2
S004	15" RCP: inlet 177 - 178	4.1	1	2	3	4	5	6	>25
S005*	18" RCP: inlet 178 - 179	5.5	6	11	14	19	23	28	<2
S006*	18" RCP: inlet 179 - 180	6.1	7	11	15	20	24	28	<2
S007	18" RCP: inlet 180 - 181	7.5	7	11	15	21	25	30	>2
S008	24" RCP: inlet 181 - 184	10.2	7	12	16	21	26	30	>2
S009	24" RCP: inlet 183 - 184	10.6	1	1	1	2	2	3	>100
S010	15" RCP: inlet 182 - 183	4.1	0	1	1	1	1	2	>100
S011	24" RCP: inlet 184 - 191	16	8	13	17	23	27	33	<10
S012	15" RCP: inlet 185 - 186	4.1	3	4	5	7	8	10	>5
S013	21" RCP: inlet 186 - 188	12	5	7	10	13	16	18	>10
S014	15" RCP: inlet 187 - 188	4.1	1	2	3	4	4	5	>50
S015	24" RCP: inlet 188 - 189	12	6	10	13	18	21	25	<10
S016	15" RCP: inlet 190 - 189	4.1	0	1	1	1	1	1	>100
S017	24" RCP: inlet 189 - 191	23	7	11	14	18	22	26	>50
S018	30" RCP: inlet 191 - 192	20	16	26	34	46	56	66	>2
S019	36" RCP: inlet 192 - 193	30	21	33	43	57	69	81	<5
S020	36" RCP: inlet 193 – Earth Ditch	38	21	34	44	59	71	84	>5
S021	5' Earth Ditch to Big Blue River	415	24	39	51	69	83	98	>100
S022	44"x29" RCPHE Crossroad Pipe	60	24	39	51	69	83	98	>10
S023	44"x29" RCPHE Crossroad Pipe	60	24	39	51	69	83	98	>10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
175	A-5 sump w/9" overflow above curb	20	4	6	8	12	14	17	>100
176	A-5 sump w/9" overflow above curb	20	1	2	3	4	5	6	>100
177	A-5 sump	12	1	2	3	4	5	6	>100
178	A-5 sump	12	1	2	3	4	5	5	>100
179	A-5 .3% grade	4.2	0	1	1	1	2	2	>100
180	A-5 .3% grade	4.2	1	1	1	2	2	3	>100
181	A-5 sump	12	0	1	1	1	1	2	>100
182	A-5 .3% grade	4.2	0	1	1	1	1	2	>100
183	A-5 .3% grade	4.2	0	0	0	1	1	1	>100
184	A-2.5 .4% grade	4.2	0	0	1	1	1	1	>100
185	A-5 .3% grade	4.2	3	4	5	7	8	10	>5

SPAIN WATERSHED – SPAINEX (MAP NO. 5)

CONTINUED

Table 12: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
186	A-5 .3% grade	4.2	2	4	5	6	7	9	>5
187	A-5 .3% grade	4.2	1	2	3	4	4	5	>50
188	A-5 .3% grade	4.2	1	1	1	2	2	2	>100
189	A-5 .9% grade (DA n/a – overflow only)	3.7	0	0	0	0	0	0	>100
190	A-5 .9% grade	3.7	0	1	1	1	1	1	>100
191	A-5 sump	12	2	4	5	6	8	9	>100
192	A-5 sump	12	5	7	9	12	14	16	>10
193	A-5 sump	12	1	1	2	2	2	3	>100
200	Area Inlet 3'-5"x3'-5"	16	1	2	2	3	3	4	>100

SPAIN WATERSHED – SPAINPRO (INDEX MAP C)

Table 13: *Future* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
S001	24" RCP: inlet 175 - 176	13	3	6	8	11	13	16	50
S002	24" RCP: inlet 176 - 232	13	4	7	10	13	16	19	25
S003	24" RCP: inlet 232 - 178	13	5	9	12	16	20	23	>10
S005	24" RCP: inlet 178 - 179	13	7	12	16	22	27	32	>5
S006	24" RCP: inlet 179 - 180	13	8	13	17	23	28	33	5
S007	24" RCP: inlet 180 - 181	13	8	14	18	24	30	35	5
S024$^{\Phi}$	4' bottom concrete ditch liner	41	2	4	6	8	10	12	>100

$^{\Phi}$ New Proposed Elements

BLUE HILLS WATERSHED

BLUE HILLS EXISTING WATERSHED

The Blue Hills Watershed is a large watershed covering approximately 608 acres (.95 mi^2). 250 of those acres are located west of Tuttle Creek Blvd. The south border of the remaining acreage runs just south of Butterfield Rd. and Parker Dr. The east border is the Big Blue River and the north border runs along Goodrich Dr. and between the Marlatt and Butterfield channels. The common outlet is the natural earth channel (Butterfield Channel) east of Casement Rd. that discharges directly into the Big Blue River. The average slope is approximately 3% from Tuttle Creek Blvd. to Butterfield Rd. and 0.20% - 0.50% from Butterfield Rd. to the river.

West of Tuttle Creek Blvd., the primary land use is single-family residential and golf course. There is also some commercial development, the Blue Hills shopping center, and some residential high density, the Meadowlark Hills complex. The land east of Tuttle Creek Blvd., and the area of concern of this study, is 84% agricultural and 16% single-family residential. A substantial portion of the agricultural land will be developed. This study takes that development and it's impact on increasing stormwater flows into consideration.

The existing drainage system is basically a large open channel main branch with three distinct areas of contributing subsystems; the Northfield Rd. Area, the Butterfield Rd. Area, and the Parker Dr. Area. Location, Land Use, Existing Drainage System, System Performance, and Capital Improvement Project Recommendations will be covered in detail for each minor watershed.

BLUE HILLS WATERSHED

NORTHFIELD ROAD AREA (MAP NO. 6)

LOCATION

The Northfield Rd. Area is the land between Tuttle Creek Blvd. and Butterfield Rd, about 50 acres (.08 mi^2). Most drainage from this area discharges through the 3-10'x3' RCB under Butterfield Rd. The land slopes to the east at approximately 3.0%.

LAND USE

This area is entirely single-family residential.

EXISTING DRAINAGE SYSTEM

This drainage system is mostly a network of open channels that discharge into a very flat, swampy, and silty area just east of the Northfield Rd. and Butterfield Rd. intersection. This flat area has historically been recognized as a problem. When stormwater hits this flat area, it deposits its silt load. Maintenance is needed periodically to remove the silt. The standing water in this area creates a serious mosquito problem. Also, the water can get quite high in this area during most any rainstorm. There are only 2 curb inlets, on Mission Ave. just east of Brockman St., and their corresponding pipes. Runoff from this area concentrates on Butterfield Rd. (just north of Northfield Rd.) and flows off by way of valley gutters and concrete ditch lining (N005 and N006). There is a main open channel (N001A-N001C) that starts from the 8'x6' RCB under Tuttle Creek Blvd. and extends down to the 3-10'x3' RCB under Butterfield Rd. Flow in the main channel is quite high because there are 250 acres of drainage area on the west side of Tuttle Creek Blvd. that contribute. The bottom part of the main open channel, from Brockman to Butterfield (N001C), was concrete ditch lined after being recommended for improvement in the 1995 SWAMP report.

SYSTEM PERFORMANCE

REACHES

The top part of the main open channel from Tuttle Creek Blvd. to Brockman St. (N001A) was recommended for improvement as part of the 1995 study. This study echoes that finding. Right now, the channel is quite rough with brush and trees growing on the sides about 1' up from the flowline. The bottom of the channel itself is quite rough. Residents have reported high water in their yards. With a maximum capacity estimated to be approximately 200 cfs, its Level of Service is <2-yr storm.

Reaches N002 and N003 at the intersection of Brockman St. and Mission Ave, and N004, crossroad pipes under Butterfield Rd., all have levels of service <2-yr storm. These conduits are grossly undersized.

Reaches N005 and N006, the shallow concrete ditch lining that runs behind the houses on the east side of Butterfield Rd, have adequate levels of service. However, these channels discharge directly into the flat, silty area. Often, stormwater backs up into the channels and after a storm event there is still standing water in the channels at the low end where they should discharge. The lining itself, also at the point of discharge, is broken and has settled. Correction downstream of the "flat" area and the Butterfield ditch (discussed later) will provide an opportunity for improvement of these reaches.

INLETS

Inlet 232 has a Level of Service <<2-yr. storm while inlet 233 is above a 10-yr.storm. Inlet 232 will not be replaced due to its Level of Service. Once new drainage areas are established for the Northview Rd. project, the flow to inlet 232 decreases substantially and it's Level of Service will become >100-yr. storm. However, both inlets need reconstructed and may need to be replaced to accommodate the new pipe sizes proposed.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Smith St.

PROJECT IDENTIFICATION NUMBER: 11

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: Discretionary
Design Capacity: 612 cfs
Model Reach Designation(s): N001A
Map Reference Number: 6 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$80,000
E & I	$20,000
Total	$100,000

RECOMMENDED IMPROVEMENTS

This open channel is inadequate for the flow it receives. The existing Level of Service is <2-yr storm. Concrete ditch lining is recommended to improve this channel to handle a 10-yr storm capacity. A 6' flat bottom liner with 3:1 sides and a minimum of 3' in height is recommended.

PROJECT NAME: Northfield Rd.

PROJECT IDENTIFICATION NUMBER: 12

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: Discretionary
Design Capacity: 114 cfs
Cost Estimates: $220,000.00
Model Reach Designation(s): N002-N006
Model Inlet Designations(s): 232 & 233
Map Reference Number: 6 & 9 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:	
Const.	$214,786
E & I	$53,697
Total	$268,483

RECOMMENDED IMPROVEMENTS

This project is a total rehabilitation of the Northfield Rd. Area. It will provide a system of enclosed Type-A curb inlets and underground conduits to bring the Level of Service up to a 10-yr storm capacity. It is contingent upon the Butterfield Channel Improvement that is fully discussed in the next section, the Butterfield Rd. Area. The Butterfield Channel Improvement entails constructing a more defined channel from the 3-10'x3' RCB under Butterfield Rd. to the 2-8'x8' RCB under Casement Rd. by deepening, widening, and improving the existing channel. Without the Butterfield Channel Improvement, the conduits of the Northfield Rd. Improvement won't have anywhere to discharge. The deepening of the Butterfield Channel is key to the improvement of the Northfield Rd. Area. Giving the Northfield Rd. Area an enclosed system of stormwater drainage will greatly enhance the quality of living there, especially in the downstream area around the 3-10'x3' RCB under Butterfield Rd. The underground system will eliminate the swampy, silty conditions of this area. With the improvements to the Butterfield Channel, much of the low, flat area can be filled in.

The Northfield Rd. Improvement involves the placement of 12 Type-A curb inlets and approximately 2,400 L.F. of Reinforced Concrete Pipe. A description of this system is as follows: 3 A-5 inlets constructed at the Kirkwood Dr./Butterfield Rd. intersection. A 30" RCP from these inlets will replace reach N005. 2 A-5 inlets will be placed in the sump on Butterfield just north of the intersection of Northfield Rd and Butterfield Rd. An 18" RCP from these inlets will replace reach N006. A manhole will be placed where these two reaches join together and a 36" RCP will continue to the south. An A-10 inlet on the north and an A-5 inlet on the south will be placed at the intersection of Northfield Rd. and Butterfield Rd. A 49"x32" RCPHE from here will join with the 36" RCP at a junction box where 2-42"x27" RCPHE's will continue carrying flow south towards the Butterfield Channel. To the south, 2 inlets will be placed at the intersection of Church Ave. and Brockman St. The inlet on the south will be an A-10 while the inlet on the north will be an A-5. From here, a 45"x29" RCPHE will carry flow north to a new A-5 inlet at the SW corner of the intersection of Brockman St. and Mission Ave. Flow will continue through inlet 232 and 233 (reconstructed). 2-45"x29" RCPHE's will carry stormwater from inlet 233 east to a junction box to join with the 2-42"x27" RCPHE's. Finally, 3-49"x32" RCPHE's will carry the stormwater south to the Butterfield Channel. Please refer to the Capital Improvement Index Map C for visualization.

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHEX

NORTHFIELD ROAD AREA (MAP NO. 6)

Table 14: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
4020	8'x6' RCB under Tuttle Crk. Blvd.	1000	281	445	573	760	910	1064	>50
N001A*	4' bot. earth ditch - Brockman St.	200	283	447	576	763	913	1068	<2
N001B	3-6'x4' RCB under Brockman St.	650	283	447	576	763	913	1068	>10
N001C*	9' bot. Conc. Ditch-Butterfield Rd.	722~	285	450	579	768	918	1074	<25
N001D	3-10'x3' RCB under Butterfield	780	285	450	579	768	918	1074	>25
N002*	15" RCP: inlet 232 - 233	3.5	21	34	44	59	71	83	<<2
N003*	25"x16" RCP: inlet 233 – outlet	11	25	39	51	68	82	96	<<2
N004*	2-25"x16" RCP: under Butterfield	25	29	46	59	79	95	111	<2
N005	9' bottom concrete ditch	22	7	12	15	20	25	29	>25
N006	9' bottom concrete ditch	22	12	19	25	33	39	46	>5

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
232	5'-2"x5.5" sump	8.5	21	34	44	59	71	83	<<2
233	5'x5" sump	7.5	4	6	8	11	13	15	10

~ Maximum Capacity of reach N001C was calculated with a 1" clearance to the bottom of the siding on the duplex located at the southwest corner of the intersection of Butterfield Rd. and Northfield Rd.

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHPRO

NORTHFIELD ROAD AREA (INDEX MAP C)

Table 15: *Future* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
N001A	6' concrete ditch liner	904	283	447	576	763	913	1068	<50
NEW8$^{\Phi}$	24" RCP : inlet 8-9	10	4	7	9	11	14	16	>10
NEW9$^{\Phi}$	30" RCP : inlet 9-10	19	7	11	14	19	23	27	25
N005	30" RCP : inlet 10 to MH	26	8	13	17	22	27	32	50
NEW6$^{\Phi}$	18" RCP : inlet 6-7	6.5	1	2	2	3	4	5	>100
N006	18" RCP : inlet 7-MH	6.5	2	3	4	5	7	8	>25
N007	36" RCP : MH-MH	28	10	16	21	28	34	39	25
NEW5$^{\Phi}$	36" RCP : inlet 5-4	28	12	19	25	33	40	47	>10
N008	49"x32" RCPHE : inlet 4 - MH	38	16	26	34	46	55	64	>10
N009N	2-42"x27" RCPHE : MH-MH	56	26	42	55	73	88	103	10
NEW1$^{\Phi}$	45"x29" RCPHE : inlet 1-2	30	14	22	29	38	46	54	10
NEW2$^{\Phi}$	45"x29" RCPHE : inlet 2-3	37	18	28	37	49	59	69	10
NEW3$^{\Phi}$	2-45"x29" RCPHE : inlet 3-232	58	21	34	45	59	71	84	25
N002	2-45"x29" RCPHE : 232-233	58	24	38	50	66	80	93	>10
N003	2-45"x29" RCPHE : 233-MH	70	28	45	58	77	92	108	>10
N009S	3-49"x32" RCPHE : MH-N012	114	54	87	112	150	180	211	10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
232	5'-2"x5.5" sump	8.5	3	4	5	7	9	10	>25
1$^{\Phi}$	A-10 sump : Church Ave. S.	24	14	22	29	38	46	54	>5
2$^{\Phi}$	A-5 sump : Church Ave. N.	12	4	7	9	11	14	16	>25
3$^{\Phi}$	A-5 sump : Mission Ave.	12	4	6	8	11	13	15	>25
4$^{\Phi}$	A-5 sump : Northfield Rd. S.	12	5	8	10	13	16	18	>10
5$^{\Phi}$	A-10 sump : Northfield Rd. N.	24	12	19	25	33	40	47	10
6$^{\Phi}$	A-5 sump : Butterfield Rd.	12	1	2	2	3	4	5	>100
7$^{\Phi}$	A-5 sump : Butterfield Rd.	12	1	1	2	2	3	3	>100
8$^{\Phi}$	A-5 sump : Kirkwood Dr.	12	4	7	9	11	14	16	25
9$^{\Phi}$	A-5 sump : Kirkwood Dr.	12	4	6	7	10	12	14	50
10$^{\Phi}$	A-5 sump : Kirkwood Dr.	12	1	2	3	4	4	5	>100

$^{\Phi}$ New Proposed Elements

BLUE HILLS WATERSHED

BUTTERFIELD ROAD AREA (MAP NO. 6 & 7)

LOCATION

The Butterfield Rd Area is approximately 193 acres (.30 mi^2). It is bounded on the West by Butterfield Rd and on the east by Casement Rd. The north boundary is between the Marlatt and Butterfield Channel. The south boundary runs south of Butterfield Rd. The common outlet is the 2-8'x8' RCB under Casement Rd. This area drains generally to the east and has an average slope of 0.3%.

LAND USE

There is a large agricultural area north of Butterfield Rd, about 130 acres (.20 mi^2), that accounts for 67% of the acreage in the Butterfield Rd. Area. This area is slated for development with single-family homes. Therefore, the entire Butterfield Area is single-family residential.

EXISTING DRAINAGE SYSTEM

The existing drainage system is composed of 26 reaches and 12 inlets. The dominating component is the 3700' long "Butterfield Channel" in the agricultural field from Butterfield Rd to Casement Rd. There is an enclosed system of pipes and inlets along Butterfield Rd. that discharge into a road ditch on the west side of Casement Rd. and eventually empty into the 2-8'x8' RCB of the Butterfield Channel located under Casement Rd. Slopes are very flat in this area so general problems of siltation, standing water (and mosquitoes), and flooding occur quite frequently.

SYSTEM PERFORMANCE

REACHES

On a whole, basically all of the drainage systems in this area are inadequate. There are 2 enclosed systems along Butterfield. One consists of area inlets (228-231) and conduits in the cul-de-sacs to the north of Butterfield Rd (the Cul-de-sac system). The other is a system of curb inlets (220-227) and conduits directly on Butterfield Rd (the East Butterfield system). The first inlet of the East Butterfield system is located at the east entrance of Brook Lane. This inlet is expected to handle stormwater flow from clear back at the 3-10'x3' RCB under Butterfield Rd, some 2000 feet of street away. The drainage area is just too large. The conduits at the top of the East Butterfield system (reaches B001-B004) are simply inundated and have levels of service <<2-yr. storm. Stormwater continues east on Butterfield and either finds it's way to the ditch on the west side of Casement or flows into the cul-de-sacs and incapacitates the Cul-de-Sac system. This is confirmed by residents on Nutmeg. Two residents report very high water in the Nutmeg cul-de-sac 3 times in the past 10 years. There was a small berm constructed on the north side of the cul-de-sacs to protect these

homes from flooding in the Butterfield Channel. The same residents request an overflow route through the berm to alleviate problems associated with high intensity rainfalls that come down Butterfield and swamp this street. Proposals to correct this problem upstream will make an overflow route unnecessary and keep the berm intact for flooding conditions. The Cul-de-Sac system is not recommended for replacement at this time. The last reach of it's system is a 24" CMP that rates >5-yr. storm. It is recommended that the Cul-de-Sac system be monitored after other proposals upstream are constructed.

The ditch along the west side of Casement Rd. performs adequately. However the 48" CMP (B018) under Butterfield Rd. and the 60" CMP (B016) at the north end of this ditch do not perform adequately. The 48" CMP has a 2-yr. storm Level of Service and the 60" CMP has a Level of Service just >5-yr. storm. The 60" CMP discharges stormwater flow into the 2-8'x8' RCB under Casement Rd. The pipe enters the box at a 90° angle. There are local observations that flow from the 60" CMP is causing a lot of turbulence upon discharge into the RCB and is disrupting flow from the Butterfield Channel. This most likely causes higher water depths on the upstream side of the 2-8'x8' RCB than normal hydraulic analysis can predict.

Reaches N009-N012 rate <<2-yr. storm. Reach N012 is the Butterfield Channel and N009-N011 are much shorter reaches that contribute to the top of the Butterfield Channel near the 3-10'x3' RCB under Butterfield Rd. The 3-10'x3' RCB is handling about 300 acres of drainage area. When stormwater comes down out of the Northfield Rd Area, whose average slope is about 3%, it goes through the 3-10'x3' RCB and hits the very flat (0.2-0.3%) vegetated area just east of the RCB and spreads out. The velocity decreases dramatically and the silt load drops out. Constant maintenance is required to remove the silt. There is a lot of standing water after any rainstorm and in a wet period, there is a tremendous mosquito problem. The flowline of N012 is not distinct. There just isn't enough fall in the channel to keep the water moving fast enough. The option of providing detention in this area north of Butterfield Rd. where the Butterfield Channel is located was studied and declined for various reasons. First, detention is most effective upstream in a watershed where the downstream facilities are inadequate to accommodate higher flows. In this scenario, detention would be placed at the downstream end of the watershed. The Butterfield Channel east of Casement Road (downstream facility) is quite adequate and has a Level of Service >100-yr. storm, so the problem is really just moving the water fast enough. Also, because it is at the downstream end of the watershed, the detention facility would have to cover approximately 20 acres to accommodate the large flows. Excavation would be costly not only because of the volume of soil that would be moved but also because the water table is quite high (approximately 3' below the surface) causing construction difficulties. Lastly, the area is already marshy with mosquito problems and the flat bottom of a detention facility would invariably create the same problems that local residents want solved.

Finally, the 2-8'x8' RCB under Casement will be discussed. This RCB has a Level of Service equal to a 50-yr. storm. Usually, design standards would not require improvement to this element given that it's Level of Service is quite high. However, in the event of a 100-yr. storm, this culvert will cause flooding to homes in the area. The lowest house is located immediately southwest of the culvert and has a finished floor elevation of 1018.34'. In a 100-yr. storm the elevation of the water is estimated to be at 1019.30'.

INLETS

Four inlets (220, 221, 222, and 224) have levels of service on the order of a 2-yr. storm and require replacement. All of these inlets are part of the East Butterfield system. Most of the reaches in that system will be replaced.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: **New West Butterfield**

PROJECT IDENTIFICATION NUMBER: **13**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **5**
Design Capacity: 42 cfs
Model Reach Designation(s): NEW11-NEW19
Map Reference Number: 7 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$120,935
E & I	$30,234
Total	$151,169

RECOMMENDED IMPROVEMENTS

This project will provide a system of conduits and inlets on Butterfield to the west of the existing system. It will head off a substantial portion of stormwater flow that would normally be going to the East Butterfield system and direct it north to the proposed Butterfield Channel. This project is somewhat contingent upon the completion of the proposed Butterfield Channel. Without the Butterfield Channel improvements, this project could direct its flow to the east to join up with the East Butterfield system (if enough fall is available). In this scenario, this project would be joined with the East Butterfield project and a new analysis done to size the conduits of the East system.

It is composed of approximately 1750' of RCP and 8 A-5 inlets. A set of A-5 inlets will be placed just prior to the intersections with Purcells Mill (North), Purcells Mill (South), Buttonwood Dr., and Brook Ln. A 36" RCP (or equivalent RCPHE) will take the stormwater north between Buttonwood Dr. and Brook Ln. to the proposed Butterfield Channel. An easement will be needed for the length of the 36" RCP and can be established at the time of development of that area. This improvement will help alleviate the problems in the cul-de-sacs on the north side of Butterfield and the general problems of high water all along Butterfield's east end and the surrounding streets.

PROJECT NAME: **East Butterfield Rd.**

PROJECT IDENTIFICATION NUMBER: **14**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **3**
Design Capacity: 41 cfs
Model Reach Designation(s): B001-B008, B018
Map Reference Number: 7 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:	
Const.	$173,000
E & I	$43,250
Total	$216,250

RECOMMENDED IMPROVEMENTS

This project is a replacement of the existing East Butterfield Rd. system. Even with the addition of the New West Butterfield Project, the existing East system is still inadequate. This project will replace all of the existing elements in the system except for inlets 225, 226, and 227. These 3 inlets will need to be reconstructed to accommodate the new pipe sizes and may need replaced. This project will also include the replacement of the 48" CMP, reach B018, under Butterfield Rd. with a 5'x4'RCB. The existing East Butterfield system discharges directly into the side of the existing 48" CMP, so it is natural to replace these components together. With this project and the West Butterfield Rd. Project, residents along Butterfield Rd. and it's collectors will see a substantial improvement in the storm drainage. Improved Levels of Service for all proposals in the Butterfield Rd. Area are included in Table 18 following this section of Capital Improvement Project Recommendations.

PROJECT NAME: **Butterfield/Casement RCP**

PROJECT IDENTIFICATION NUMBER: **15**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **7**
Design Capacity: 95 cfs
Model Reach Designation(s): B016
Map Reference Number: 7 and INDEX MAP C
Return Period: >25-yr.

Cost Estimate:	
Const.	$25,000
E & I	$6,250
Total	$31,250

RECOMMENDED IMPROVEMENTS

Reach B016 is currently a 60" CMP located at the north end of the ditch on the west side of Casement Rd. It discharges north, directly into the side of the 2-8'x8' RCB under Casement Rd. On it's own merits, the CMP's Level of Service (>5-yr. Storm) is cause for some further investigation. More importantly, the historical observation that the flow discharging from the CMP impedes the flow from the Butterfield Channel trying to make it's way through the 2-8'x8' RCB justifies replacement. This project will remove the 60" CMP and repair the wall of the 2-8'x8' RCB. A new 60" RCP will then be placed under Casement Rd. to direct discharge to the Northeast and into the Butterfield Channel on the east side of Casement Rd., totally bypassing the 2-8'x8' RCB. The 60" RCP has less friction losses due to it's smoothness (Manning's number) and the slight increase in slope, giving it a Level of Service >25-yr. Design Storm. The Butterfield Channel to the east of Casement Rd. is completely capable of handling the increased flow. This project will enhance the performance of both the 2-8'x8' RCB and the 60" RCP.

PROJECT NAME: **Butterfield Channel Alternate 1: Retaining Wall**

PROJECT IDENTIFICATION NUMBER: **16**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **4**
Design Capacity: 1396 cfs
Model Reach Designation(s): N012
Map Reference Number: 6 & 7 and INDEX MAP C
Return Period: 100-yr.

Cost Estimate:

Const.	$638,107
E & I	$159,526
Total	$797,633

RECOMMENDED IMPROVEMENTS

Option 1 is the construction of a 36' flat bottom earth channel with 6:1 side slopes for 18' feet on each side. From there, a 2' high modular retaining block wall will be placed on each side. The channel has been designed to handle a 100-yr. storm and maintain at least 1' of freeboard for all existing and future houses. An 8" wide concrete ditch check will span the channel at 100' intervals to prevent erosion and provide a guide as to what elevation the channel should be cleaned down to when silt is removed. The channel will be graded at 1.0% from the 3-10'x3' RCB under Butterfield to a point about 700' east. From there, the channel will be at 0.20% until it reaches the 2-8'x8' RCB under Casement Rd. This grade change is needed to deepen the existing channel, for about 5' of depth, so that it will be more readily accessible for underground conduits from future (and present) development to discharge into. This Project will greatly enhance storm drainage for the residents on the upstream end of this channel near Butterfield Rd. where all of the tremendous siltation and standing water problems occur. For any development to occur north of Butterfield, it is a must. Maintenance of the channel, namely mowing and occasional silt removal is required. Maintenance costs are not reflected in the construction cost of this project. It's Level of Service will leap from <<2-yr. storm to just >100-yr. storm even when accounting for increased flows from future development.

Since this project is altering an existing drainage path, the current landowner must request the determination of wetlands and/or streams of the U.S. by NRCS, the Natural Resource Conservation Service. A permit request will then be submitted to the Army Corps. of Engineers that reflects the NRCS evaluation and is accompanied by a full set of plans for the proposed channel improvements. At this time the Corps. of Engineers can decide that no permit is required or continue through the permit process.

PROJECT NAME: **Butterfield Channel Alternate 2: Concrete Ditch Liner**

PROJECT IDENTIFICATION NUMBER: **17**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **4**
Design Capacity: 1396
Model Reach Designation(s): N012
Map Reference Number: 6 & 7
Return Period: 100-yr.

Cost Estimate:

Const.	$635,341
E & I	$158,835
Total	$794,176

RECOMMENDED IMPROVEMENTS

Option 2 for the Butterfield Channel is a much simpler geometric design. It is a 16' flat-bottom concrete ditch liner with 2:1 sides. Again, the channel will provide 5' of depth and have the same longitudinal grade. This geometry provides the same hydraulic capacity and all of the benefits as discussed in Option 1. However, maintenance is greatly reduced.

Option 2 must also have the NRCS evaluation of wetlands and/or streams of the U.S. and the permit request to the Army Corps. of Engineers. Concrete ditch liner of Option 2 is less environmentally friendly than the earth channel with retaining walls of Option 1. Therefore, it is less likely that the Corps. of Engineers will approve Option 2.

PROJECT NAME: **Casement RCB**

PROJECT IDENTIFICATION NUMBER: **18**

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: **1**
Design Capacity: 1758 cfs
Model Reach Designation(s): 4000
Map Reference Number: 7
Return Period: 100-yr.

Cost Estimate:

Const.	$48,000
E & I	$12,000
Total	$60,000

RECOMMENDED IMPROVEMENTS

This project entails the addition of another 8'x8' barrel to the existing 2-8'x8' RCB. In a 100-yr. storm event, the elevation of the water has now decreased to 1017.2'. This is approximately 14" lower than the lowest finish floor elevation of 1018.34'.

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHEX

BUTTERFIELD ROAD AREA (MAP NO. 7)

Table 16: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
B001*	15" RCP: inlet 220 - 221	3.5	9	15	19	26	31	36	<<2
B002*	24" CMP: inlet 221 - 222	8	18	28	36	48	58	68	<<2
B003*	30" CMP: inlet 222 - 223	14.5	20	32	41	55	66	77	<<2
B004*	30" CMP: inlet 223 - 224	14	21	33	43	57	68	80	<<2
B005	15" RCP: inlet 225 - 224	3.5	0	0	1	1	1	1	>100
B006*	30" CMP: inlet 224 - 227	14	24	37	48	64	76	89	<<2
B007	15" RCP: inlet 226 - 227	3.5	1	1	1	2	2	2	>100
B008*	30" CMP: inlet 227-B018	14.2	26	41	52	69	83	97	<<2
B009	15" RCP: inlet 228 - 229	3.5	1	2	3	4	5	5	>10
B010	24" RCP: inlet 229-Charolais Ln.	10.5	2	3	3	4	5	6	>100
B011	15" RCP: inlet 230 - B010	3.5	2	3	4	5	6	7	>5
B012	24" RCP: Charolais Ln.- inlet 231	10.5	3	5	7	9	11	13	>25
B013	24" RCP: inlet 231 -E. Csmt ditch	10	6	9	12	15	18	22	>5
B014	5' earth ditch: Elem. School to Butterfield	216	12	21	28	39	48	58	>100
B015	5' earth ditch – Butterfield to N. Kgdm Hall	216	36	58	76	102	124	146	>100
B016	60" CMP – N. Kgdm. Hall to 2-8'x8' RCB	76	41	66	87	116	141	166	>5
B017	15" RCP from inlet 231	3.5	2	3	4	6	7	8	>5
B018*	48" CMP under Butterfield Rd.	37	36	58	76	102	124	146	2
N007	Approx. 10' earth ditch to N010	56	19	31	40	53	64	74	>25
N008	Approx. 10' earth ditch to N010	56	2	2	3	3	3	4	>100
N009S*	Approx. 10' earth ditch from 3-10'x3' to N004	56	130	206	264	351	420	489	<<2
N009N*	Approx. 10' earth ditch from N004 to N010	56	158	251	322	428	513	598	<<2
N010*	Approx. 10' earth ditch to N012	75	174	275	354	471	565	658	<<2
N011*	Approx. 10' earth ditch to N012	75	153	242	312	413	494	580	<<2
N012*	"Butterfield Channel" – 10' earth ditch from Butterfield Rd. to Csmt Rd.	110	309	496	642	857	1030	1209	<<2
4000	2-8'x8' RCB under Casement	1140	343	555	722	967	1164	1369	<50

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHEX

BUTTERFIELD ROAD AREA (MAP NO. 7) CONTINUED

Table 16: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
220*	Area Inlet 2.5'x1.5'	5.1	9	15	19	26	31	36	<<2
221*	2.5'x5" sump	3.6	9	14	19	25	30	35	<<2
222*	3'-9"x6" 0.5% grade	3	3	5	6	8	9	11	2
223	2.5'x5" 0.5% grade	2.3	1	2	3	3	4	5	>5
224*	1'x9" sump	4.2	3	5	6	9	10	12	>2
225	1'x9" sump	4.2	0	0	1	1	1	1	>100
226	2'x9" sump	4.8	1	1	1	2	2	2	>100
227	Area Inlet 2'-5"x1'-5.5"	4.7	2	4	5	6	8	9	10
228	Area Inlet 2'-4"x2'-5"	7.7	1	2	3	4	5	5	>100
229	Area Inlet 4'-5"x4'-5"	20.5	0	0	0	1	1	1	>100
230	Area Inlet 2'-4"x2'-5"	7.7	2	3	4	5	6	7	>100
231	Area Inlet 2'-4"x2'-5"	7.7	2	3	4	6	7	8	100

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHFUT

BUTTERFIELD ROAD AREA (MAP NO. 7)

Table 17: *Existing* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
N012*	"Butterfield Channel" – 10' earth ditch from Butterfield Rd. to Csmt Rd.	110	354	561	721	955	1143	1335	<<2
4000	2-8'x8' RCB under Casement	1140	388	620	800	1064	1276	1493	>25

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHPRO

BUTTERFIELD ROAD AREA (INDEX MAP C)

Table 18: *Future* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
NEW11$^{\Phi}$	18" RCP : inlet 11-12	6	1	2	2	3	4	4	>100
NEW12$^{\Phi}$	18" RCP : inlet 12-14	8	3	6	7	10	12	13	>10
NEW13$^{\Phi}$	18" RCP : inlet 13-14	6	1	2	2	3	3	4	>100
NEW14$^{\Phi}$	24" RCP : inlet 14 -16	14	6	10	13	17	21	24	>10
NEW15$^{\Phi}$	18" RCP : inlet 15-16	6	1	2	3	4	5	5	>100
NEW16$^{\Phi}$	30" RCP : inlet 16-MH	20	10	15	20	26	32	37	10
NEW17$^{\Phi}$	18" RCP : inlet 17-18	6	2	3	4	6	7	8	25
NEW18$^{\Phi}$	24" RCP : inlet 18-MH	13	4	6	8	10	12	14	>50
NEW19$^{\Phi}$	36" RCP : MH–Butterfield Chan.	42	13	21	27	37	44	51	<50
B001	18" RCP: inlet 220 - 221	6	3	5	6	8	10	12	10
B002	30" RCP: inlet 221 - 222	22	7	10	14	18	22	26	50
B003	30" RCP: inlet 222 - 223	24	9	15	19	25	30	35	25
B004	30" RCP: inlet 223 - 224	24	10	17	21	28	33	39	>10
B005	18" RCP: inlet 225 - 224	6	0	0	1	1	1	1	>100
B006	36" RCP: inlet 224 - 227	35	13	21	27	36	43	50	25
B007	18" RCP: inlet 226 - 227	6	1	1	1	2	2	2	>100
B008	36" RCP: inlet 227-B018	41	16	25	32	42	51	59	25
B016	60" RCP – N. Kgdm. Hall to E. Butterfield Channel	95	30	50	65	88	107	127	>25
B018	5'x4' RCB under Butterfield Rd.	85	25	42	55	74	90	106	>25
N012	"Butterfield Channel" 16' Bottom Concrete-lined 36' Bottom earth w/ ditch checks	1503	375	593	765	1015	1217	1424	>100
4000	3-8'x8' RCB under Casement	1758	375	593	765	1015	1217	1424	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
11$^{\Phi}$	A-5 0.5% grade : Purcells Mill N.	3.9	1	2	2	3	4	4	100
12$^{\Phi}$	A-5 0.5% grade : Purcells Mill N.	3.9	2	4	5	7	8	9	5
13$^{\Phi}$	A-5 0.5% grade : Purcells Mill S.	3.9	1	2	2	3	3	4	100
14$^{\Phi}$	A-5 0.5% grade : Purcells Mill S.	3.9	2	3	4	5	6	7	10
15$^{\Phi}$	A-5 0.5% grade : Buttonwood Dr.	3.9	1	2	3	4	5	5	25
16$^{\Phi}$	A-5 0.5% grade : Buttonwood Dr.	3.9	2	3	4	5	6	7	10
17$^{\Phi}$	A-5 0.5% grade : Brook Lane	3.9	2	3	4	6	7	8	10

$^{\Phi}$ New Proposed Elements

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHPRO

BUTTERFIELD ROAD AREA (INDEX MAP C) CONTINUED

Table 18: *Future* Elements/*Future* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
18[Φ]	A-5 0.5% grade : Brook Lane	3.9	2	3	3	4	5	6	25
220	A-5 sump	12	3	5	6	8	10	12	100
221	A-5 sump	12	4	6	7	10	12	14	50
222	A-7.5 0.5% grade	6	3	5	6	8	9	11	10
223	A-5 0.5% grade	3.9	1	2	3	3	4	5	50
224	A-5 sump	12	3	5	6	9	10	12	100

[Φ] New Proposed Elements

BLUE HILLS WATERSHED

PARKER DRIVE AREA (MAP NO. 5 &8)

LOCATION

The Parker Dr. Area is approximately 115 acres (.18 mi^2). The west border is Casement Rd. and the east border is the Big Blue River. The south border runs between Parker Dr. and Knox Ln. while the north border runs through an agricultural area between Marlatt and Butterfield channel. The common outlet is the Butterfield Channel as it discharges into the Big Blue River. The average slope is approximately 0.5%.

LAND USE

The Parker Dr. Area is mostly agricultural at approximately 83 acres (.13 mi^2). The remaining 32 acres are single-family residential.

EXISTING DRAINAGE SYSTEM

The drainage system is composed of 17 reaches and 8 inlets. The Butterfield Channel is the main component of the system. There is a roadside ditch on the east side of Casement and an enclosed system of pipes and inlets along Parker Drive and in the north Cul-de-Sac's that drain into the Butterfield Channel.

SYSTEM PERFORMANCE

REACHES

There are two enclosed reaches in the Parker Dr. Area requiring replacement. These reaches, P004 and P006, are 15" RCP's and are crossroad pipes under Parker Dr. between curb inlets. These reaches have Levels of Service <2-yr. storm when considering the future flows from the proposed development south of Parker Dr. (south of Willow Lane and Butternut Lane). Flow from some of the new development will flow in the curbs along Willow Lane to inlet 194. In large storm events the water will cross the crown of the road and inlet 195 will share some of the flow to inlet 194. Inlets 194 and 195 are on each end of P004 and are sump inlets. A clear overflow route was not identified. Therefore, based on the Level of Service (future flow) of P004, stormwater is expected to be detained in this area frequently. Flow from some of the new development will also travel in the curbs along Butternut Lane to inlet 196. There will also be a channel in the backyards between Knoxberry Dr. and Butternut Ln. directing stormwater into a knock-out in the back of inlet 196. If P006 is not replaced, water is expected to back up in the backyards between Knoxberry Dr. and Butternut Ln. The overflow route would be for water to travel over inlet 196, onto Parker Dr, north on Knoxberry Dr., and west to inlets 198 and 199 at the dead end of Hackberry Avenue. Currently, inlets 198 and 199 have high Levels of Service and can accommodate higher flows. It is expected that sometime in the future the area west of inlets 198 and 199 will be developed. Stormwater flow will increase and the Level of Service will

decrease for these inlets, so it is not prudent to assume that inlets 198 and 199 will always be available to accept overflow from inlet 196. To replace reaches P004 and P006 is reasonably inexpensive when considering the benefit it will have on the efficiency of this particular stormwater system and the success it will have in lessening the occurrence of standing water for the surrounding residents.

Reaches N014-N018 make up the Butterfield Channel east of Casement Rd. The hydraulic capacity of this channel is great. It has a Level of Service >100-yr. storm. In the occurrence of a 100-yr. storm, the water surface elevation is estimated to be at 1014.21, some 4' below the lowest finish floor elevation, 1018.36, of the lowest home in the area located at 101 Knoxberry Circle. However, there is a lot of concern about erosion in the channel. Residents report that the channel has substantially deepened and widened. There is a general uncomfortable feeling about the channel's continued encroachment into the backyards of the residents who live at the end of the Cul-de-Sac's on Knoxberry, Raspberry, and Strawberry.

INLETS

One inlet requires replacement. Inlet 196, an A-5 inlet on the south side of Parker Dr. has a Level of Service of a 2-yr. storm in future flow conditions. The storm drainage for the development south of Parker Dr. calls for constructing a knock-out in the back of this inlet to consume flow from the additional 2 acres of drainage it will be contributing to the inlet. Even with a portion of the flow being taken in at the back of the inlet, it is felt that the A-5 on the front is still inadequate and needs replaced.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Parker Dr. Area

PROJECT IDENTIFICATION NUMBER: 19

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: Discretionary
Design Capacity: 24" RCP – 12 cfs, A-7.5 inlet – 6 cfs
Model Reach Designation(s): P004 and P006
Model Inlet Designations(s): 196
Map Reference Number: 8 and INDEX MAP C
Return Period: varies – see text below

Cost Estimate:

Const.	$8,345
E & I	$2,086
Total	$10,431

RECOMMENDED IMPROVEMENTS

This project will replace the two 15" RCP crossroad pipes under Parker Dr. and one inlet. The pipes will be replaced with 24" RCP's that will elevate the Levels of Service to >25-yr. for P004 and >100-yr. for P006. The 10-year storm requirement for the inlet is 7 cfs. The new A-7.5 inlet has a maximum capacity of 6 cfs, which is slightly less than what is required. However, it is expected that a portion of the flow will be taken in at the knock-out in the back of the inlet.

PROJECT NAME: East Butterfield Channel

PROJECT IDENTIFICATION NUMBER: 20

PERTINENT DATA SUMMARY
Watershed: Blue Hills
Priority No.: Discretionary
Design Capacity: N/A
Model Reach Designation(s): N014-N018
Map Reference Number: 8 and INDEX MAP C
Return Period: N/A

Cost Estimate:

Const.	$75,000
E & I	$18,750
Total	$93,750

RECOMMENDED IMPROVEMENTS

This project is a total erosion control project for the Butterfield Channel east of Casement. A major ditch check with rip rap is recommended towards the bottom of the channel, approximately 400-500 feet from the Big Blue River. Three minor ditch checks are recommended where the channel is next to the residences at the end of the Knoxberry, Raspberry, and Strawberry Circle. Bank stabilization is also recommended along this stretch of the channel on the south bank. These measures will stop the channel from encroaching into the backyards of the residences any further.

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHEX

PARKER DRIVE AREA (MAP NO. 8)

Table 19: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
EC001	24" CMP across Casement Road	12	3	5	7	10	13	16	>25
EC002	24" CMP across Casement Road	12	1	1	2	3	3	4	>100
EC003	4' Roadside ditch East of Casement Road	53	1	2	2	3	4	5	>100
P002	15" RCP to ditch	8.5	5	8	11	14	17	20	5
P003	15" RCP to ditch	7.5	4	7	9	12	14	17	5
P004*	15" RCP from inlet 194 to 195	3.5	4	7	9	12	15	18	<2
P005	24" RCP from inlet 195 to 197	11	6	10	13	17	21	25	>5
P006*	15" RCP from inlet 196 to 197	3.5	2	4	5	7	9	10	>2
P007	30" RCP from inlet 197 to 199	15	9	15	20	26	32	38	5
P008	30"x36" RCPHE from inlet 198 to 199	24	12	20	26	35	42	50	<10
P009	30"x36" RCPHE from inlet 199 to outlet	24	17	28	36	48	58	68	<5
N014	Butterfield Channel East of Casement Rd.	1408	306	504	660	892	1081	1275	>100
N015	Butterfield Channel East of Casement Rd.	1408	296	489	643	873	1061	1255	>100
N016	Butterfield Channel East of Casement Rd.	1496	293	485	638	867	1054	1247	>100
N017	Butterfield Channel East of Casement Rd.	1750	275	455	599	816	994	1179	>100
N018	Butterfield Channel East of Casement Rd.	2268	290	488	649	894	1098	1310	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
194	A-5 sump	12	4	7	9	12	15	18	25
195	A-5 sump	12	2	3	4	5	6	7	>100
196	A-5 0.5% grade	3.9	2	4	5	7	9	10	5
197	A-2.5 0.5% grade	2.4	1	2	2	2	3	3	>25
198	A-7.5 sump	18	3	5	6	9	10	12	>100
199	Area Inlet 8'x2'-9"	25	5	8	10	14	16	19	>100
201	A-10 sump	24	5	8	11	14	17	20	>100
202	Area Inlet 4'-6"x2'-4"	14.3	4	7	9	12	14	17	50

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHFUT

PARKER DRIVE AREA (MAP NO. 8)

Table 20: *Existing* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
P004*	15" RCP from inlet 194 to 195	3.5	5	8	10	14	17	19	<2
P005	24" RCP from inlet 195 to 197	11	6	9	12	16	19	23	10
P006*	15" RCP from inlet 196 to 197	3.5	4	6	7	10	12	14	<2
P007	30" RCP from inlet 197 to 199	15	10	16	20	27	32	38	5
P008	30"x36" RCPHE from inlet 198 to 199	24	12	19	24	33	39	46	10
P009	30"x36" RCPHE from inlet 199 to outlet	24	16	25	33	44	53	62	5
N014	Butterfield Channel East of Casement Rd.	1408	353	570	740	991	1194	1403	>100
N015	Butterfield Channel East of Casement Rd.	1408	347	563	733	986	1191	1402	>100
N016	Butterfield Channel East of Casement Rd.	1496	344	559	728	980	1185	1395	>100
N017	Butterfield Channel East of Casement Rd.	1750	324	527	688	928	1123	1324	>100
N018	Butterfield Channel East of Casement Rd.	2268	340	561	738	1006	1226	1455	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
194	A-5 sump	12	5	8	10	14	17	19	>10
196*	A-5 0.5% grade	3.9	4	6	7	10	12	14	2

BLUE HILLS WATERSHED REACH ANALYSIS – 2BHPRO

PARKER DRIVE AREA (INDEX MAP C)

Table 21: *Future* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
P004	24" RCP from inlet 194 to 195	12	5	8	10	14	17	19	>10
P006	24" RCP from inlet 196 to 197	12	4	6	7	10	12	14	50

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
196	A-7.5 0.5% grade	6	4	6	7	10	12	14	5

MARLATT WATERSHED

MARLATT WATERSHED

(MAP NO. 9, 10, & 11)

LOCATION

The Marlatt watershed is approximately 3,150 acres (4.92 mi^2). This watershed is mostly located west of Tuttle Creek Blvd. The 2-7'x7' RCB under Tuttle has a contributing drainage area of about 410 acres and the 4-10'x7' RCB under Tuttle Creek Blvd. has a contributing drainage area of about 1,965 acres. The area of concern for this study is the remaining 775 acres (1.21 mi^2) east of Tuttle. The north border of this area extends from Barnes Rd. just east of the Valleywood Addition southeasterly to Casement Rd. The west border is Tuttle Creek Blvd. and the east border is the Big Blue River. The south border runs between the Marlatt and Butterfield channels. Slopes of this watershed range between 0.20-0.50%. The common outlet is the Marlatt channel east of Casement Rd.

LAND USE

This watershed is mostly open space at 76%. Much of the open space is available for future development. The future development is assumed to be single-family residential. For this study, the future land use has been broken down as such: 7% school grounds, 5% mobile home trailer park, 23% open space, and 65% single family residential.

EXISTING DRAINAGE SYSTEM

The major component of this drainage system is the massive Marlatt Channel. There are two major RCB's under Tuttle Creek Blvd. that create the top of the Marlatt channel, the 2-7'x7' and the 4-10'x7'. At Tuttle, the Marlatt Channel has a drainage area of about 2, 375 acres. The channel flows easterly to the 2-12'x12' RCB under Casement Rd. There are many subsystems that discharge into the channel along the way. Most of them are overland flow, open channel systems from the large open areas. There are two enclosed systems. South of Marlatt in the Walters Dr. area is an enclosed system of 21 conduits and 20 inlets. North of Marlatt in the Colonial Gardens mobile home park is the other enclosed system of 8 conduits and 8 inlets. At the 2-12'x12' RCB under Casement Rd., this channel's drainage area has increased to approximately 3052 acres. The channel continues easterly to the Big Blue River.

Kansas State University owns land on the west side of Tuttle Creek Blvd. that has potential for future development. This land is upstream in the watershed and it is expected that if future development occurs, detention facilities will be required. Therefore, in this study the future flows do not reflect development west of Tuttle Creek Blvd.

SYSTEM PERFORMANCE

REACHES

Within the last five years, the Marlatt Channel was widened and deepened from about 500' east of Tuttle Creek Blvd. to the 2-12'x12' RCB under Casement Rd. For this stretch, it

is a 70' flat bottom earth ditch with 3:1 sides. For the most part, there is a lot of depth in the channel, 8' or greater. However, near Eisenhower Middle School (reach M027) the depth is greatly reduced and the Level of Service (for overbank flow) is <2-yr. storm. Overflow occurs over the south bank and encroaches upon the school. Flood elevations from a 2-yr. storm do not threaten property damage to the school buildings

The Marlatt channel has not been well maintained. There are trees and dense vegetation growing in it. Substantial erosion has cut some deep paths through the bottom and exposed a sanitary sewer manhole. The vegetation and erosion in the channel have created very swampy conditions. The channel is generally considered to be an eyesore. Complaints of these conditions are elevated with the middle school being so close.

There are 5 crossroad pipes carrying stormwater under Marlatt Ave. from drainage areas to the north. With the expected development in that area, these crossroad pipes deserve special attention. The 30" CMP, M021, that carries flow from Colonial Gardens mobile home park has a Level of Service <5-yr. storm. The future development north of Marlatt will not increase the existing stormwater flow to this reach. Even though it's Level of Service does not meet the 10-yr. storm design standard, historically this reach has not been a problem and there are no recommendations for improvement. The 32"x42" CMP (referred to as the Valleywood Drain), M033, located just east of Colonial Gardens rates >2-yr. storm. Upstream from the Valleywood Drain is reach CG012, a drainage ditch in the backyards between the Valleywood Addition and Colonial Gardens. CG012 is a special concern because it has little depth available (discussed later). To increase the Level of Service at M033 will, at the very least, decrease backwater problems upstream at CG012. Also, the two 18" RCP's , M036 and M037, on either side of Nelson's Landing rate poorly at <2-yr. and <5-yr. storm, respectively. Finally, the 36" CMP , M034, east of Nelson's Landing rates low at <<2-yr. storm.. The Levels of Service for most of the above mentioned reaches were calculated using a runoff coefficient for developed conditions but the drainage areas follow the existing topography (*Existing* Elements/*Future* Flow). To determine whether recommendations for improvement are truly needed for these reaches, an in-depth study of a comprehensive plan for storm drainage in the entire area slated for development north of Marlatt was performed. The results are shown in the table below (*Future* Elements/*Future* Flow) and discussed in the Capital Improvement Project Recommendations.

Reach M003 is a 15" RCP crossing Goodrich Dr. It routes stormwater from inlet 239, whose drainage area includes Goodrich Cir. and a portion of Mission Ave. to the west, approximately 4.2 acres. The inlet is adequate, but the 15" RCP is way too small for the amount of stormwater expected to pass through it. Inlet 239 is a sump inlet and so there is no opportunity for overflow to be caught at the next inlet. The rest of the system (reaches M002-M012) along Goodrich Dr. performs substantially better than this one isolated reach.

There have been many complaints by residents in Mission Cir. who say that the stormwater that runs into this cul-de-sac has nowhere to go. One resident has built a concrete flume on their property to facilitate the discharge of water. The slopes of the streets do drain off of Mission Ave. down into Mission Cir. Approximately 1.5 acres of drainage are going there. The concrete flume is the only outlet. Once this water travels east down the concrete flume, it basically just sits in the backyards between Mission Cir. and Russel Ct. until it infiltrates or evaporates. Including the area between Mission Cir. and Russel Ct., there appears to be approximately 3.8 acres of drainage that have nowhere to go.

The enclosed reaches within Colonial Gardens mobile home park have an average Level of Service <2-yr. storm. The conduits are simply undersized. Reach CG017, the 2'

earth ditch that carries water from the 3'x2' RCB (11200) under Tuttle Creek Blvd. to the 2-24" CMP's (CG016) under the drive to the back parking lot of the clubhouse, also has a Level of Service <5-yr. storm. This ditch needs widened and deepened to increase it's hydraulic capacity. The 2-24" CMP's would then also need adjusted to lower the west end of the pipes. All of this being said, the storm drainage within this area is privately owned and not maintainable by the City of Manhattan. Therefore, there will not be a capital improvement project recommendation in this report.

Special attention is given to reach CG012, the earth ditch between Valleywood and Colonial Gardens. A few years ago residents of Valleywood requested a study for possible solutions to the drainage problems in their subdivision. The area is very flat and stormwater basically doesn't have anywhere to go. There was neither an enclosed conduit nor open channel system to direct water out of this area. In 1995 an open channel system for this area was constructed to solve some of Valleywood's drainage problems. This open channel begins on the west side of the Valleywood Addition . It runs south and turns to the east between Valleywood and Colonial Gardens (CG012). From there, it turns back to the south (CG013N, CG013S, and M038) and runs, more or less, alongside Colonial Gardens to M033, the Valleywood crossroad pipe under Marlatt. The ditch between Valleywood and Colonial Gardens is a very critical area. The Valleywood homes on the north were built quite a bit lower than the mobile homes in Colonial Gardens on the south. The depth from the flowline of the ditch to the finish floor elevation of some of the Valleywood homes is less than 1'. A hydraulic study of the ditch found that it could handle flow from a 100-yr. storm with about 1" of freeboard to the lowest house. There are some obstructions in the ditch consisting of utilities and private fences that will affect the flow of water. This area should be kept as clear as possible.

INLETS

Inlets 253 and 254 on Walters Dr. perform poorly. These inlets are on grade and overflow from them will travel on to the east to sump inlets 251 and 252. Inlets 251 and 252 have high Levels of Service and can handle the additional flow. Replacement of 253 and 254 is, therefore, unnecessary.

In the Colonial Gardens mobile home park there are 3 inlets with low Levels of Service (304, 305, and 306). As stated earlier, the storm drainage there is privately owned. Though the inlets need replaced, there will not be a capital improvement project recommendation in this report.

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Marlatt Channel Wash Checks

PROJECT IDENTIFICATION NUMBER: 21

PERTINENT DATA SUMMARY
Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: N/A
Model Reach Designation(s): M027-M031
Map Reference Number: 9 & 10 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$233,000
E & I	$58,250
Total	$291,250

RECOMMENDED IMPROVEMENTS

This project addresses the erosion problems within the Marlatt Channel. Concrete wash checks will be constructed at 100' intervals. These wash checks will be at least 6' in height up the sides of the channel to be above the 10-yr. storm level. The wash checks will maintain the flowline of the channel and control the erosion. They will also serve as a guide for removing silt or filling in any future spots of erosion that may occur. Prior to placement of the wash checks, the channel will be cleared and grubbed to remove the trees and dense vegetation. The paths that have eroded down in the bottom of the channel will be filled in and graded. Finally, the channel will be seeded. Maintenance of the channel, mowing and grading, is required indefinitely after the wash checks have been constructed. Maintenance costs are not included in this project recommendation.

PROJECT NAME: Valleywood Drain

PROJECT IDENTIFICATION NUMBER: 22

PERTINENT DATA SUMMARY

Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: 220 cfs
Model Reach Designation(s): M033
Map Reference Number: 9 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$8,260
E & I	$2,065
Total	$10,325

RECOMMENDED IMPROVEMENTS

This reach, M033, is currently a 32"x42" CMP and has a Level of Service >2-yr. storm in future flow conditions. When future development occurs, it is expected that approximately 30 acres of additional drainage area will contribute to this crossroad pipe. Underground piping from the new development(s) can discharge into reach M038, the 12' ditch leading to the 32'x42" CMP. With the additional drainage, the Level of Service of M033 decreases to <2-yr. storm. The additional drainage would also compound backwater problems for the sensitive area between Valleywood Addition and Colonial Gardens. Replacement with a 66" RCP (or equivalent RCPHE or RCB) is recommended. The 66" RCP will increase the Level of Service to >10-yr. storm. Development should not be allowed without provisions for completion of this project.

PROJECT NAME: North Marlatt New System 1

PROJECT IDENTIFICATION NUMBER: 23

PERTINENT DATA SUMMARY
Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: 151 cfs
Model Reach Designation(s): NM001 (new)
Map Reference Number: INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$90,300
E & I	$22,575
Total	$112,875

RECOMMENDED IMPROVEMENTS

This project is a new main line system to be located approximately halfway between the Valleywood Drain and the West Nelson's Landing Drain when development begins to occur there. It is approximately 900' of 54" RCP (or equivalent RCPHE or RCB) that will collect stormwater north of Marlatt and discharge south into the Marlatt Channel. Replacement of the 18" RCP, M036, that drains West Nelson's Landing is unnecessary with completion of this project. The 18" RCP has a current Level of Service of <<2-yr. storm. When the development to the west occurs, it is expected that the drainage area to the 18" RCP will decrease by about 80%. The future network to the proposed 54" RCP will pick up that portion of the area's runoff. Flows become lower to M036 and the Level of Service is expected to increase to <5-yr. storm. Refer to Index Map C to see the proposed drainage area division and location of the proposed 54" RCP.

PROJECT NAME: North Marlatt New System 2

PROJECT IDENTIFICATION NUMBER: 24

PERTINENT DATA SUMMARY
Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: 200 cfs
Model Reach Designation(s): M034
Map Reference Number: 10 and INDEX MAP C
Return Period: 25-yr.

Cost Estimate:

Const.	$110,760
E & I	$27,690
Total	$138,450

RECOMMENDED IMPROVEMENTS

This project replaces the 36" CMP, M034, with a 60" RCP (or equivalent RCPHE or RCB). The 60" RCP will extend approximately 1100' to the north. Future development can network to this main line. Since the 60" RCP is replacing an existing drainage pattern in an agricultural field, the proper permit must be obtained from the U.S. Army Corp. of Engineers. A representative of the Corp. has expressed optimism at having permit approval for this area during a previous consultation. Refer to Index Map C to see the proposed drainage area division and location of the proposed 60" RCP.

PROJECT NAME: Goodrich Drive

PROJECT IDENTIFICATION NUMBER: 25

PERTINENT DATA SUMMARY
Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: 12 cfs
Model Reach Designation(s): M003
Map Reference Number: 9 and INDEX MAP C
Return Period: >10-yr.

Cost Estimate:

Const.	$6,500
E & I	$1,625
Total	$8,125

RECOMMENDED IMPROVEMENTS

This project is a replacement of M003, a 15" RCP on Goodrich Dr., with a 30"x19" RCPHE. The 15" RCP is simply undersized and is located in a sump area, so there is no opportunity for overflow. The existing Level of Service is <<2-yr. storm and will increase to be >10-yr. storm with the 30"x19" RCPHE.

PROJECT NAME: Mission Circle

PROJECT IDENTIFICATION NUMBER: 26

PERTINENT DATA SUMMARY
Watershed: Marlatt
Priority No.: Discretionary
Design Capacity: 13 cfs
Model Reach Designation(s): NM002, NM003
Model Inlet Designations(s): 1, 2
Map Reference Number: 9 and INDEX MAP C
Return Period: 10-yr.

Cost Estimate:

Const.	$34,500
E & I	$8,625
Total	$43,125

RECOMMENDED IMPROVEMENTS

The Mission Circle project provides an enclosed stormwater system to facilitate drainage in that area. An A-5 inlet is recommended in the east portion of Mission Circle. An 18" RCP will then be installed between the east properties of the circle to replace the residentially-built concrete flume that is currently there. A 16' Drainage Easement has already been established there. A domed-grate area inlet will then be constructed at the back of the adjoining properties between Mission Cir. and Russel Ct. This area inlet is expected to be placed close to a line of trees. Grading into the new inlet may be a sensitive issue and will probably have to be minimized. Then a 24" RCP will carry the stormwater southeast to the 36" RCP along Goodrich Dr. A new manhole will be placed in the 36" line. There is also an existing 30' Utility Easement between Mission Cir. and Goodrich drive for the proposed area inlet and 24" RCP.

Taking the 24" RCP from the area inlet to the north and connecting to the system along Walters Dr. was explored. This option was ruled out because the existing Level of Service of the Walters Dr. system is quite low. The effects of this system on the Goodrich Dr. system is shown in the *Future* Elements/*Future* Flow table.

MARLATT WATERSHED REACH ANALYSIS – MARLATTEX (MAP NO. 9,10, & 11)

Table 22: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
M001	12" CMP to M002	2.5	1	2	2	3	4	4	>10
M002	36" RCP to inlet 240	70	23	40	54	76	93	112	>10
M003*	15" RCP: inlet 239 - 240	4.5	5	8	10	13	16	18	<2
M004	3'x5' RCPHE: inlet 240 - 241	110	32	56	75	103	126	150	>25
M005	18" RCP: inlet 242 - 241	6.5	1	1	2	2	2	3	>100
M006	3'x5' RCPHE: inlet 241 - 243	100	34	58	78	107	131	156	<25
M007	21" RCP: inlet 238 - 243	5.5	1	2	3	4	5	6	>50
M008	48" RCP: inlet 243 - 245	75	35	61	81	112	137	163	>5
M009	15" HDPE: inlet 237 - 236	2	1	1	1	2	2	2	100
M010	15" RCP: inlet 236 - 244	5.7	1	2	2	3	3	4	>100
M011	18" RCP: inlet 244 - 245	4.2	1	2	3	4	5	5	>25
M012	2-29"x45" RCPHE: inlet 245 - M023	80	38	64	86	118	144	171	<10
M013E	18"x22" RCPHE: inlet 247 - 246	11	5	8	10	13	16	19	>10
M013N	18"x22" RCPHE: inlet 246 - M023	15	5	8	10	13	16	19	<50
M014	15" RCP: inlet 248 - 247	4.5	3	5	6	8	9	11	<5
M015	18" RCP: inlet 250 - 249	6.5	2	3	4	5	6	7	>50
M016	19"x30" RCPHE: inlet 249 - 251	21	7	12	15	20	24	28	>25
M017	15" RCP: inlet 252 - 251	4.5	1	2	3	4	5	6	>25
M018	15" RCP: inlet 253 - 251	6.5	5	7	9	12	14	16	<5
M019	15" RCP: inlet 254 - 253	4.5	3	4	5	7	9	10	>5
M020	24" RCP: under Marlatt	15	6	10	13	17	21	24	>10
M021	30" CMP – Colonial Gardens Drain	40	29	43	53	67	79	90	<5
M022	19"x30" RCP: inlet 249 - outlet	22	11	17	22	29	34	40	10
M023	12" Concrete ditch East of Eisenhower MS	412	42	71	94	129	158	187	>100
M024	20' Earth ditch from 4-10'x7' RCB	3685	1132	1845	2486	3454	4242	5005	>25
M025	15' Earth ditch from 2-7'x7' RCB	1200	164	285	386	540	669	804	>100
M026	30' Earth ditch btwn M021 & M033	4581	1292	2107	2837	3968	4829	5644	<50
M027	70' Earth ditch btwn M033 & M023	1052	1357	2204	2965	4144	5038	5883	<2
M028	70' Earth ditch btwn M023 & M036	3586	1387	2242	3016	4212	5118	5972	>10
M029	70' Earth ditch btwn M036 & M037	5395	1404	2269	3052	4266	5183	6047	>50
M030	70' Earth ditch btwn M037 & M034	6442	1406	2272	3056	4270	5184	6052	>100
M031	70 Earth ditch btwn M034 & 12000	7585	1504	2446	3299	4625	5628	6581	>100
M032	15' Earth ditch btwn 12000 & Big Blue	5088	1529	2489	3361	4716	5743	6719	>25
M033	32"x42" CMP – Valleywood Drain	75	63	104	136	184	223	264	>2

MARLATT WATERSHED REACH ANALYSIS – MARLATTEX (MAP NO. 9,10, & 11)

CONTINUED

Table 22: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
M034*	36" CMP – Area 11360 Drain	50	78	144	199	285	357	433	<2
M035	Cross road pipe under Walters Dr.	15	0	1	1	1	2	2	>100
M036	18" RCP west of Nelson's Landing	15	24	41	55	76	93	111	<<2
M037	18" RCP east of Nelson's Landing	15	8	13	17	23	28	32	>5
M038	12' Earth ditch empties into M033	510	63	104	136	184	223	264	>100
CG001*	8"x4" opening under solid grate	.5	6	8	10	13	16	18	<<2
CG002*	12" CMP	3.7	8	12	14	19	22	25	<<2
CG003*	12" CMP	3.7	4	5	7	9	10	12	<2
CG004	18"x12" CMP from inlet 300 to 301	2.5	2	2	3	4	4	5	>2
CG005*	18"x12" CMP from inlet 301 to 302	2.5	4	6	7	9	10	12	<2
CG006*	18"x15" CMP from inlet 302 to 303	2.9	5	7	9	12	14	16	<2
CG007*	24"x15" CMP from inlet 303 to 304	5	8	12	15	20	23	27	<2
CG008*	21" CMP from inlet 304 to outlet	5.3	15	21	27	34	40	46	<<2
CG009*	18" CMP from inlet 305 to 306	3.6	8	12	14	18	21	24	<2
CG010*	18" CMP from inlet 306 to 307	4	14	20	25	31	37	42	<<2
CG011*	24" CMP from inlet 307 to outlet	10	15	21	26	34	39	45	<2
CG012	Earth ditch btwn Valleywd. & C.Gar.	120	22	39	53	74	92	110	>100
CG013N	8' Earth ditch east of Col. Gardens	54	22	39	53	74	92	110	10
CG013S	12' Earth ditch east of Col. Gardens	235	58	94	122	164	198	232	100
CG014	8' Concrete ditch in Col. Gardens	836	15	21	27	34	40	46	>>100
CG015	8' Concrete ditch in Col. Gardens	836	29	43	53	67	79	90	>>100
CG016	2-24" CMP in Col. Gardens	44	19	34	47	66	81	98	<10
CG017	2' earth ditch	13	9	16	21	30	38	45	<5
11000	4-10'x7' RCB under Tuttle Cr. Blvd.	3200	1130	1843	2485	3459	4235	4992	>10
11200	3'x2' RCB under Tuttle Cr. Blvd.	44	9	16	21	30	38	45	<100
12000	2-12'x12' RCB under Casement Rd.	3600	1504	2446	3299	4625	5628	6581	>10
12010	6'x5' RCB under Tuttle Cr. Blvd.	320	22	39	53	73	91	109	>100
12015	2-7'x7' RCB under Tuttle Cr. Blvd.	1100	163	284	385	539	667	801	>100

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
236	A-5 0.5% grade	3.9	0	1	1	1	1	1	>100
237	Area Inlet 27" Diam.	5.4	1	1	1	2	2	2	>100
238	Area Inlet 27" Diam.	5.4	1	2	3	4	5	6	>50
239	A-5 sump	12	5	8	10	13	16	18	>10
240	A-5 sump	12	6	9	12	16	19	23	10

MARLATT WATERSHED REACH ANALYSIS – MARLATTEX (MAP NO. 9,10, & 11)

CONTINUED

Table 22: *Existing* Elements/*Existing* Flow

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
241	A-5 0.64% grade	3.9	1	2	2	3	4	4	100
242	A-5 0.64% grade	3.9	1	1	2	2	2	3	>100
243	A-5 0.64% grade	3.9	1	1	1	1	2	2	>100
244	A-5 sump	12	0	1	1	1	2	2	>100
245	A-12.5 sump	30	1	2	3	3	4	5	>100
246	A-5 1% grade	3.7	0	0	0	0	0	0	>100
247	A-5 sump	12	2	3	4	6	7	8	>100
248	A-5 sump	12	3	5	6	8	9	11	>100
249	A-5 sump	12	1	2	3	4	5	5	>100
250	A-5 sump	12	2	3	4	5	6	7	>100
251	A-5 sump	12	2	3	4	5	6	7	>100
252	A-5 sump	12	1	2	3	4	5	6	>100
253	A-5 1.5% grade	3.6	2	3	4	5	6	7	>5
254	A-5 1.5% grade	3.6	3	4	5	7	9	10	>2
255	A-5 1% grade	3.7	1	2	2	3	4	4	>25
300	4'x8" sump	9.2	2	2	3	4	4	5	>100
301	4'x8" sump	9.2	2	3	4	5	6	7	>100
302	Area Inlet 3'-2"x3'-3"	14.4	1	2	2	3	4	4	>100
303	Sides 25"x8" : Front 46"x6.5"	17.6	4	5	6	8	10	11	>100
304	4'x7" sump	8.4	7	10	12	15	17	20	>2
305*	3'-6"x6" sump	7	8	12	14	18	21	24	<2
306	4'x8" sump	9.2	6	8	10	13	15	18	>5
307	4'-5"x11" sump	12.4	1	1	2	2	3	3	>100

MARLATT WATERSHED REACH ANALYSIS – MARLATTFUT (MAP NO. 9,10, & 11)

Table 23: *Existing* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
M027*	70' Earth ditch btwn M033 & M023	1052	1358	2205	2966	4144	5038	5883	<2
M028	70' Earth ditch btwn M023 & M036	3586	1388	2243	3017	4213	5117	5972	>10
M029	70' Earth ditch btwn M036 & M037	5395	1412	2277	3062	4277	5194	6058	>50
M030	70' Earth ditch btwn M037 & M034	6442	1413	2280	3065	4280	5195	6062	>100
M031	70 Earth ditch btwn M034 & 12000	7585	1583	2530	3399	4749	5755	6703	>100
M032	15' Earth ditch btwn 12000 & Big Blue	5088	1609	2572	3457	4835	5864	6829	>25
M033*	32"x42" CMP – Valleywood Drain	75	68	110	144	193	234	275	>2
M034*	36" CMP – Area 11360 Drain	50	159	252	325	432	519	609	<<2
M036*	18" RCP west of Nelson's Landing	15	35	55	71	94	113	133	<<2
M037	18" RCP east of Nelson's Landing	15	8	13	17	23	28	32	>5
M038	12' Earth ditch empties into M033	510	66	108	141	190	229	270	>100
12000	2-12'x12' RCB under Casement Rd.	3600	1583	2530	3399	4749	5755	6703	>10

MARLATT WATERSHED REACH ANALYSIS – MARLATTPRO (MAP NO. 9,10, & 11)

Table 24: *Future* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
NM001[Φ]	54" RCP – New System 1	151	59	94	122	162	195	228	>10
NM002[Φ]	18" RCP : inlet 1 – 2 (5% grade)	20	2	3	4	5	6	7	>100
NM003[Φ]	24" RCP : inlet 2 – M002	13	4	6	8	11	13	16	50
M002	36" RCP to inlet 240	70	26	46	62	86	106	126	>10
M003	30"x19" RCPHE: inlet 239 - 240	12	5	8	10	13	16	18	>10
M004	3'x5' RCPHE: inlet 240 - 241	110	36	62	82	113	139	165	<25
M006	3'x5' RCPHE: inlet 241 - 243	100	37	64	86	118	144	171	<25
M008	48" RCP: inlet 243 - 245	75	39	67	89	122	149	177	>5
M012	2-29"x45" RCPHE: inlet 245 - M023	80	41	70	93	128	157	186	<10
M023	12" Concrete ditch East of Eisenhower MS	412	45	77	102	140	170	202	>100
M027	70' Earth ditch btwn M033 & M023	3365	1370	2222	2989	4177	5077	5927	>10
M028E	70' Earth ditch btwn M023 & NM001	5365	1401	2262	3042	4249	5160	6019	>50
M028W	70' Earth ditch btwn NM001 & M036	5365	1422	2292	3081	4304	5226	6093	>50
M029	70' Earth ditch btwn M036 & M037	8479	1427	2299	3090	4316	5239	6110	>100
M030	70' Earth ditch btwn M037 & M034	10,123	1429	2301	3093	4319	5246	6112	>100
M031	70 Earth ditch btwn M034 & 12000	11,919	1495	2398	3224	4504	5465	6363	>100
M032	15' Earth ditch btwn 12000 & Big Blue	5088	1525	2447	3293	4606	5589	6510	>25
M033	66" RCP – Valleywood Drain	210	87	143	187	251	304	358	>10
M034	60" RCP – area 11360 (New Sys. 2)	200	73	117	151	201	241	282	25
M036	18" RCP west of Nelson's Landing	15	8	12	16	21	25	29	<5
M037	18" RCP east of Nelson's Landing	15	8	13	17	23	28	32	>5
M038	12' Earth ditch empties into M033	510	87	143	187	251	304	358	>100
12000	2-12'x12' RCB under Casement Rd.	3600	1495	2398	3224	4504	5466	6363	>10

INLET NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
1[Φ]	A-5 sump in Mission Cir.	12	2	3	4	5	6	7	>100
2[Φ]	Area Inlet – domed grate	5	2	3	5	6	8	9	10

[Φ] New Proposed Elements

BARNES WATERSHED

BARNES WATERSHED

(MAP NO. 11 & 12)

LOCATION

The Barnes Watershed is about 420 acres (0.65 mi^2). This watershed is located entirely east of Tuttle Creek Blvd and is, in general, the area south of Barnes Rd. The north border of this area follows along Barnes Rd. until it intersects with Casement Rd. At this intersection the north border travels southeasterly to the Big Blue River, which is the east border. The west border is just east of the Valleywood Addition and the south border extends from Valleywood to the Big Blue River. The common outlet is a natural earth channel from the double 32"x48" CMP's under Casement Rd. to the Big Blue River. The area is quite flat and slopes range from 0.20% to 0.50%.

LAND USE

Presently, this land is about 99% rowcrop farmland. There is one farmstead on the east side of Casement Rd. Future development is expected in the total watershed area, but this study is limited to improvements west of Casement Road.

EXISTING DRAINAGE SYSTEM

The existing drainage system is quite simple. Because the area is all farmland, there are only 3 reaches and no inlets. There is a roadside ditch, 11400, that directs flow east along Barnes Rd. and then south along Casement Rd. to two 32"x48" CMMAC culverts (11410). From the culverts under Casement east to the Big Blue River is a natural earth channel (11420).

SYSTEM PERFORMANCE

REACHES

This area is very flat and is also tilled farmland. These two factors combined are great conditions for low runoff and high infiltration rates. Once the ground is saturated, there is a lot of standing water that has to evaporate.

Recommendations for improvement would not be necessary if the area west of Casement Rd. was never developed. Reaches 11400 and 11410, the roadside ditch and the CMMAC culverts, have Levels of Service >25-yr. storm for existing runoff conditions. Reach 11420, from Casement Rd. to the Big Blue River, is a thickly vegetated, approximately 5' bottom, earth channel with trees growing on the channel side slopes. Its existing slope is approximately 0.003%. For existing flow, reach 11420 has a Level of Service >>100-yr. storm.

When development occurs, the Level of Service of the roadside ditch and the CMMAC culverts (11400 and 11410) drop to <<2-yr. storm. The Level of Service of the earth channel

from Casement Rd. to the River (11420) also decreases to <5-yr. storm. To make improvement recommendations for these three existing reaches, a comprehensive storm drainage plan was created. This plan also makes recommendations for the internal elements of the future development and for the problematic stormwater system in the Valleywood Addition. The results are shown in the *Future* Elements/*Future* Flow Table and discussed in Capital Improvement Project Recommendations .

CAPITAL IMPROVEMENT PROJECT RECOMMENDATION(S)

PROJECT NAME: Barnes Watershed

PROJECT IDENTIFICATION NUMBER: 27

PERTINENT DATA SUMMARY
Watershed: Barnes
Priority No.: Discretionary
Design Capacity: 817 cfs
Model Reach Designation(s): BA001-BA005 (new)
11400, 11410, 11420
Map Reference Number: 12 and INDEX MAP D
Return Period:>10-yr.

Cost Estimate:

Const.	$1,591,189
E & I	$397,797
Total	$1,988,986

RECOMMENDED IMPROVEMENTS

As a whole this project is a comprehensive plan for future development and future stormwater flow in the Barnes Watershed. For discussion, this project has been broken into 3 major, individual projects:

1.) In the area of development on the west side of Casement Rd, a system of open channels has been designed. Open channels were chosen over an enclosed system of pipes and/or RCB's due to the very flat slope and height constraints of the area. Please refer to the Capital Improvement Index Map D. The proposed slope was designed by estimating a need for at least 5' of depth at the Valleywood Addition (flowline = 1019). Five feet of depth was chosen to allow clearance for discharge from a 36" RCP from Valleywood into the proposed channel. Then, a proposed flowline for the outlet of reach 11420 at the Big Blue River (flowline = 1010) was determined. The slope is approximately 7' per mile or 0.0012%. With this slope, all of the proposed open channels must be lined with concrete to maximize the flow. Siltation will occur and the concrete lining will also provide something solid to clean down to. Valleywood would then have something to discharge stormwater into if they construct an enclosed system of pipes and inlets in the future. The option of constructing an enclosed stormwater system in Valleywood was ruled out in the Valleywood study of 1995. There simply wasn't anywhere to economically take the discharge pipe. This design provides Valleywood with a truly viable solution to their drainage problems. The new drainage area for the proposed network of channels in the Barnes Watershed has now increased to approximately 570 acres (.89 mi^2) with the addition of Valleywood and other surrounding areas. The open channel system has enough depth for all areas of future development to discharge underground stormwater pipes into, creating an attractive and orderly system of storm drainage. All proposed concrete ditch lining has a flat bottom with 3:1 sides. Height of the sides were determined by the height needed to convey a 10-yr. storm plus 6" in accordance with the City's 1995 Stormwater Management Master Plan. New reach BA001 from Valleywood to approximately 2000' to the east is proposed to be an 8' flat bottom with 2'-9" of height. New reach BA002 is approximately 1540'. It begins just below Barnes Rd. and flows southeast to join BA001. BA002 is proposed to be an 8' flat

bottom with 2'-4" of height. New Reach BA003 is a continuation of BA002 carrying flow to the southeast for approximately 2000'. BA003 is proposed to be an 8' flat bottom with 3'-9" of height. BA003 stops when the channel turns to the northeast. This northeast portion directs stormwater flow to the proposed RCB under Casement and is labeled BA004. It is proposed to be an 8' bottom with 4'-3" of height. The existing roadside ditch 11400 will be replaced only beside Casement Rd (not beside Barnes Rd.). It is proposed to be a 6' bottom with 2'-6" of height. Channels BA004 and 11400 will join together and will transition to match the width of the proposed RCB under Casement Rd. (reach 11410). Estimated construction cost for the aforementioned network of concrete channels is approximately $1,346,400. This is only for construction of the channel network and does not include any systems that may discharge into the channel.

2.) Reach 11410, the 2-48"x32" CMMAC culverts under Casement are projected to have Levels of Service <<2-yr. storm when future development occurs. It is recommended that these pipes be replaced with a 2-9'x5' RCB. The 2-9'x5' RCB will provide a Level of Service <25-yr.storm. Estimated individual cost for removal of the 2-48"x32" CMMACs and installation of the 2-9'x5' RCB is approximately $64,130.

3.) Finally, reach 11420, the earth channel from Casement Rd. to the Big Blue River will be discussed. In it's existing condition with future flow this channel has a Level of Service >10-yr. storm. To achieve the desired 5' of depth at Valleywood, the existing 0.003% slope of this channel must be altered to 0.0012%. If the slope of the channel did not need to be changed, there would be no recommendation for improvement. However, changing the slope to 0.0012% requires placement of concrete ditch liner. A 10' flat bottom with 4'-6" of height is recommended. The estimated construction cost for reach 11420 is $339,900.

BARNES WATERSHED – BARNEX (MAP NO. 12)

Table 25: *Existing* Elements/*Existing* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
11400	5' Roadside ditch along Casement	91	3	16	34	66	98	134	>25
11410	2-32"x48" CMMAC under Csmt. Rd.	84	3	16	34	66	98	134	>25
11420	5' Earth Ditch East of Casement	473	5	29	59	118	175	241	>>100

BARNES WATERSHED – BARNFUT (MAP NO. 12)

Table 26: *Existing* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
11400	5' Roadside ditch along Casement	91	144	230	297	394	474	555	<<2
11410	2-32"x48" CMMAC under Csmt. Rd.	84	144	230	297	394	474	555	<<2
11420	5' Earth Ditch East of Casement	473	156	266	357	495	611	732	>10

BARNES WATERSHED – BARNPRO (INDEX MAP D)

Table 27: *Future* Elements/*Future* Flow

REACH NO.	DESCRIPTION	CAPACITY (CFS)	PEAK FLOWS (CFS)						EXISTING LEVEL OF SERVICE (YR)
			2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	
BA001	8' Concrete Ditch Liner	269	80	127	164	218	262	307	>50
BA002	8' Concrete Ditch Liner	194	57	91	118	157	188	220	>50
BA003	8' Concrete Ditch Liner	530	190	304	393	524	630	739	>25
BA004	8' Concrete Ditch Liner	700	220	351	455	607	730	856	<50
11400	6' Concrete Ditch Liner	176	50	80	103	138	165	193	>50
11410	2-9'x5' RCB under Casement Rd.	720	270	431	558	744	895	1049	<25
11420	10' Concrete Ditch Liner	810	276	459	608	830	1014	1207	<25

PRIORITIZATION SUMMARY

PRIORITIZATION SUMMARY

In a manner similar to the Stormwater Management Master Plan of 1995, the Capital Improvement Projects of this study have been prioritized based on specific criteria: Cost Effectiveness, Safety, Property Damage, Inconvenience, and Future Development. Each project was analyzed and assigned points in each criteria. The points were totaled and projects scoring above a certain amount have been classified as Recommended Capital Improvement Projects. There are 7 projects that made the Recommended list. These projects should receive high priority as the City considers and plans storm drainage improvements.

In addition to the recommended improvement projects, a separate list of 27 potential improvement projects was compiled which have been identified as discretionary projects. These projects include drainage system elements identified by the analysis as being deficient in capacity but do not currently result in recurring or frequent adverse effects, or pose immediate problems for more than a few property owners due to remote locations or have a relatively small magnitude of deficiency. They are intended to be undertaken at the discretion of the City as the need arises and as funds are available. Several of the projects will not really be necessary until development in the existing drainage area occurs.

All projects have been summarized in the tables that follow.

RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

Priority No.	Proj. No.	Project Description	Const. $	Esmt. $	E & I $	Total $
1	18	Casement RCB	48,000		12,000	60,000
2	8*	Lincoln Dr. System	289,150	7,040	72,278	368,468
3	14	East Butterfield Rd.	173,000		43,250	216,250
4	16*	Butterfield Chan Alt 1:Ret. Walls	638,107		159,526	797,633
4	17*	Butterfield Chan Alt 2:ConcLiner	635,341		158,835	794,176
5	13	New West Butterfield	120,935		30,234	151,169
6	4	Knox Ln. Crossrd Pipe Replace.	20,000	2,000	5,000	27,000
7	15	Casement/Butterfield RCP	25,000		6,250	31,250
Grand Total with Project 16			1,314,192	9,040	328,538	1,651,770
Grand Total with Project 17			1,311,426	9,040	327,847	1,648,313

* Projects that were also recommended for improvement in the 1995 SWMMP.

DOES NOT INCLUDE CONTINGENCIES. PER PHONE CONVERSATION W/ KAREN WEATHERS (BG) 7-24-01

DISCRETIONARY CAPITAL IMPROVEMENT PROJECTS

Project No.	Project Description	Const. $	Esmt. $	E & I $	Total $
1	Dix Drive	80,000		20,000	100,000
2	Morning Gl. Dr. Alt. 1:Closed Conduit	45,500		11,375	56,875
3	Morning Gl. Dr. Alt. 2:Concrete Flumes	3,500		875	4,375
5	Knox Lane Alt. 1: Roadside Ditch	63,000	24,000	15,750	102,750
6	Knox Lane Alt. 2: Closed Conduit	24,240	16,960	6,060	47,260
7	Northeast Park Channel	300,000		75,000	375,000
9	Griffith Drive	2,136,250		534,063	2,670,313
10	Halls Landing	50,166		12,542	62,708
11*	Smith Street	80,000		20,000	100,000
12	Northfield Road	214,786		53,697	268,483
19	Parker Drive Area	8,345		2,086	10,431
20	East Butterfield Channel	75,000		18,750	93,750
21	Marlatt Channel Wash Checks	233,000		58,250	291,250
22	Valleywood Drain	8,260		2,065	10,325
23	North Marlatt New System 1	90,300		22,575	112,875
24	North Marlatt New System 2	110,760		27,690	138,450
25	Goodrich Drive	6,500		1,625	8,125
26	Mission Circle	34,500		8,625	43,125
27	Barnes Watershed	1,591,189		397,797	1,988,986
Grand Total with Projects 2 and 5		5,127,556	24000	1,281,890	6,433,446
Grand Total with Projects 3 and 6		5,046,796	16960	1,261,700	6,325,456

* Projects that were also recommended for improvement in the 1995 SWMMP.

WATERSHED MAPS

99-372M	Sheet No.	Total Sheets
	2	17

SEE INDEX MAP B

SEE INDEX MAP B

MARLATT AVE.

MARLATT CHANNEL

MARLATT WATERSHED 9

MARLATT WATERSHED 10

MAJOR WATERSHED LINE

NORTHEAST (EISENHOWER) MIDDLE SCHOOL

MANHATTAN CITY LIMITS

TUTTLE CREEK BLVD

MARLATT BLUE HILLS

EASEMENT ROAD

BLUE HILLS WATERSHED

BUTTERFIELD CHANNEL

BLUE HILLS WATERSHED

NORTHFIELD ROAD

MARLATT BLUE HILLS

TUTTLE CREEK BLVD

6 BLUE HILLS WATERSHED

BUTTERFIELD ROAD 7

8 BUTTER FIELD CHANNEL

BIG BLUE RIVER

BLUE HILLS NORTHVIEW

PURCELLS MILL

EASEMENT ROAD

PARKER DRIVE

BLUE HILLS NORTHVIEW

KIMBALL AVE

TUTTLE CREEK BLVD

GRIFFITH DRIVE

3

NORTHVIEW WATERSHED 4

SPAIN WATERSHED 5

BLUE HILLS SPAIN NORTH VIEW

SPAIN NORTHVIEW

NORTHVIEW

ALLEN ROAD

POWERLINE CHANNEL

NORTHVIEW

NORTHVIEW WATERSHED

MAJOR WATERSHED LINE

NORTHVIEW WATERSHED 1

DIX WATERSHED 2

DIX

TUTTLE CREEK BLVD

CASEMENT ROAD

CASEMENT WATERSHED

KEY MAP

	12	
	11	
9	10	
6	7	8
3	4	5
	1	2

SCALE 1 : 400

200' 0 400' 800'

Scale: 1" = 400'-0"

Northview Drainage Study
Manhattan, Kansas

MAP INDEX A
(South of Marlatt Rd.)
(Maps 1-10)

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

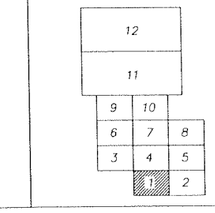
99-372M	Sheet No. 3	Total Sheets 17

NORTHVIEW WATERSHED

CASEMENT WATERSHED

LINCOLN DRIVE
GREEN AVENUE
STRONG AVE.
JUDSON ST.
HAYES DR.
BECK STREET
GROSS STREET
CASEMENT ROAD
TUTTLE CREEK BLVD. US 24 K13
STRONG AVENUE
JUDSON STREET
HAYES DRIVE
BECK STREET
ROAD
CASEMENT
LEVY STREAM
HAYES DRIVE
DOWNTOWN EAST
4'x 4' RCB
4'x 4' RCB
8' x 5' RCB
24"STEEL
84" CMP
72"
72"
LOT 23
LOT 10
LOT 9
3060
3060
3002
3000
1125
1130
1135
1127
1112
1113
4

KEY MAP



LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- (1125) – Drainage Area ('95 Study)
- (1127) – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Culverts
- Open Channels

NORTH

50' 0 100' 200'

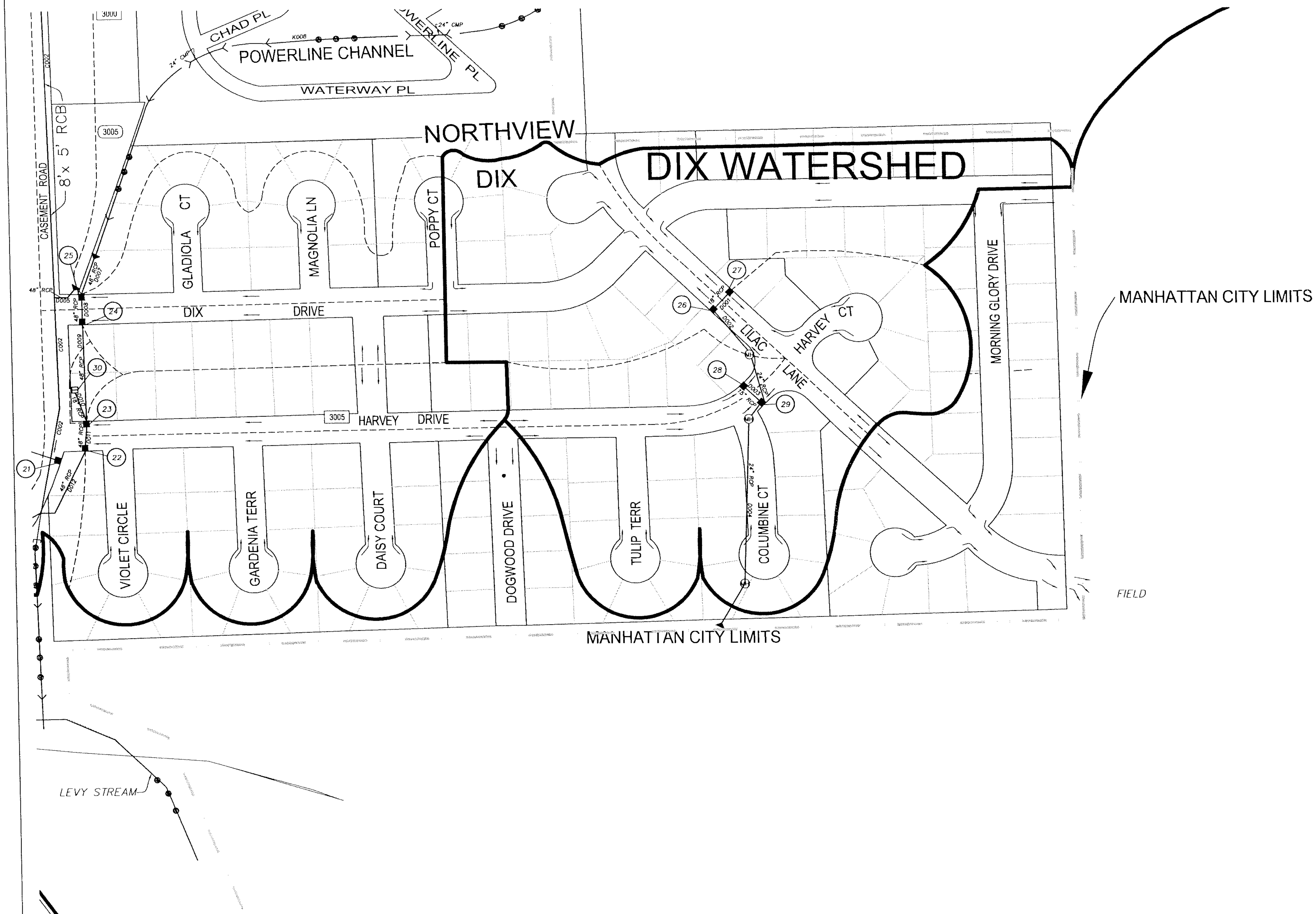
Scale: 1" = 100'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 1

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	4	17



KEY MAP

12		
11		
9	10	
6	7	8
3	4	5
	1	2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- 196 – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Culverts
- Open Channels

NORTH

50' 0 100' 200'

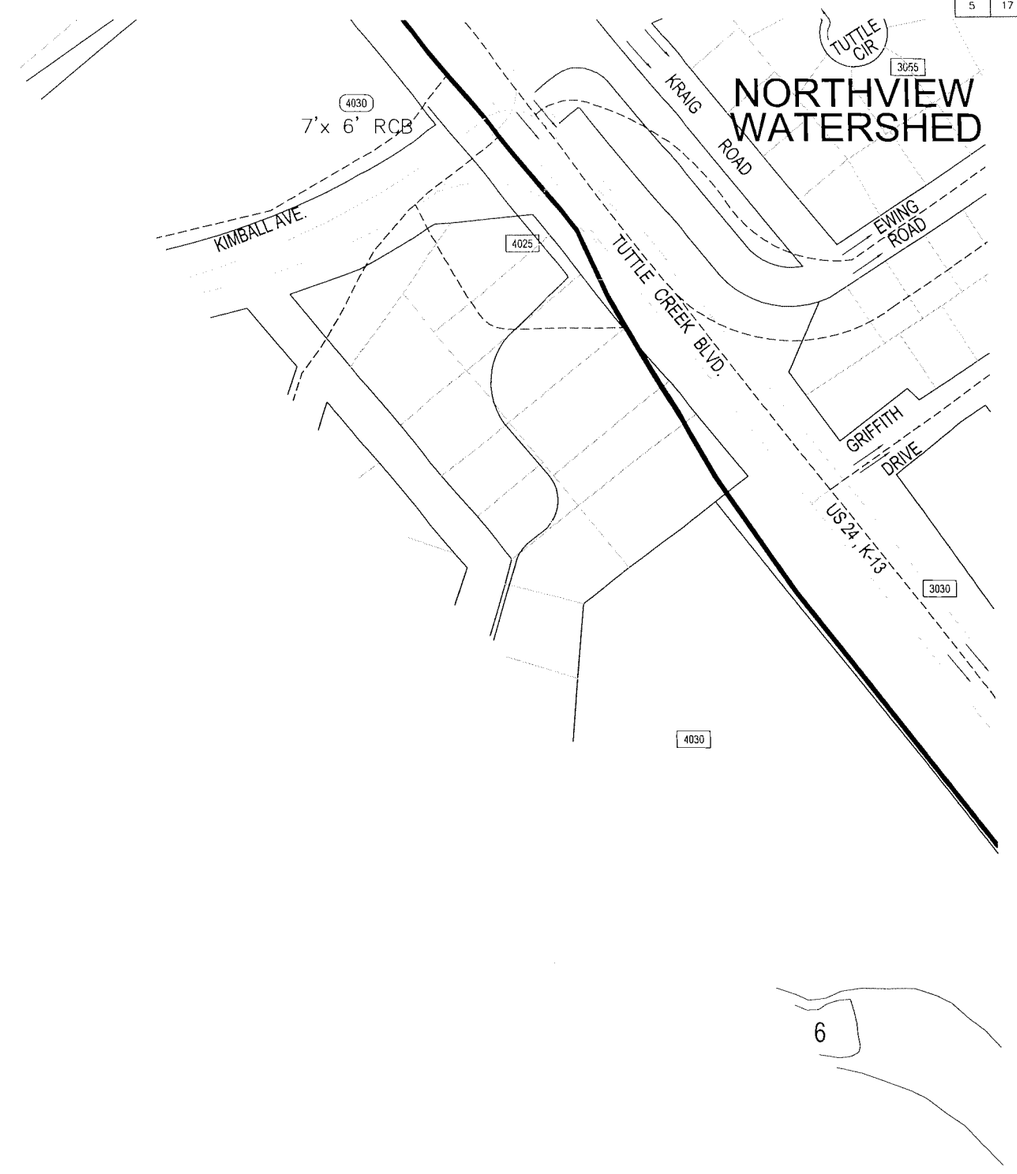
Scale: 1" = 100'-0"

Northview Drainage Study
Manhattan, Kansas

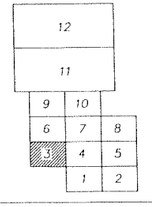
MAP 2

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	5	17



KEY MAP



LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- (1125) – Drainage Area ('95 Study)
- (1127) – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 3

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M.	Sheet No.	Total Sheets
	6	17

NORTHVIEW WATERSHED

NORTHVIEW

GRIFFITH DRIVE

GRIFFITH TERRACE

CASEMENT ROAD

EWING RD.

BROCKMAN STREET

GRIFFITH DRIVE

TUTTLE CREEK BLVD. US24, K-13

HANLY STREET

SLOAN STREET

GREEN AVENUE

BLAKER DRIVE

NORTHVIEW DRIVE

PRAIRIE GLEN

PRAIRIE LEA PL

PRAIRIE FIELD PL

ALLEN ROAD

BECK STREET

HAYES DRIVE

JUDSON STREET

STRONG AVENUE

LINCOLN DR

LOT 15A

LOT 16

LOT 17

LOT 18

LOT 19

LOT 22

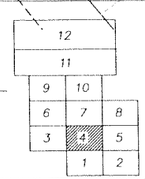
LOT 23

Overflow Route

3'x 2' RCB

BLOCKED

KEY MAP



LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- 196 – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

MAP 4

BG CONSULTANTS, INC.
ENGINEERS – ARCHITECTS – SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	7	17

SPAIN WATERSHED

NORTHVIEW WATERSHED

BLUE HILLS

SPAIN

NORTHVIEW

CASEMENT ROAD

WILLOW LN

BUTTERNUT LN

KNOXBERRY DRIVE

RASPBERRY DRIVE

STRAWBERRY CIRCLE

SPAIN DR

KNOXBERRY DRIVE

BLUEBERRY DR

Overflow Route

HALLS LANDING

SPAIN DRIVE

PLACE

SHERRY

PLACE

HOLLY

PLACE

PATRICIA

MIKE

REDWOOD CT

MAPLE CT

SPRUCE PLACE

POPLAR PL

KNOX LANE

MANHATTAN CITY LIMITS

COREY PL

WATERWAY

POWERLINE

EMERY PL

CODY PL

CHAD PL

REX

LN

POWERLINE CHANNEL

NORTHVIEW

KEY MAP

12		
11		
9	10	
6	7	8
3	4	5
	1	2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 5

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	8	17

BLUE HILLS WATERSHED

MARLATT

BLUE HILLS

6'x 5' RCB

12010

12005

4000

BROCK-MAN CIR

BROCKMAN STREET

NORTHFIELD ROAD

NORTHFIELD CIR

BUTTER FIELD ROAD

N005

N006

N007

N008

N009

N009A

N010

N012

N009B

N009S

4002

N011

N004

233

N003

25"x16" RCPHE

N010

(3) 10'x 3' RCB

4005

ROETS ADD

NORTHFIELD ADD. 1

MILLSTEAD CIR

MISSION AVENUE

232

12010

4005

CHURCH AVENUE

Conc. drainage ditch 9' wide at bottom

4010

N005S

4010

CHURCH CIRCLE

4005

3-6'x 4' RCB

4015

N001B

4015

TUTTLE CREEK BLVD.

US24, K13

4015

BROCKMAN STREET

4017

N001A

4020

BLUE HILLS NORTHVIEW

SMITH STREET

8'x 6' RCB

4020

4015

KRAIG ROAD

TUTTLE STREET

KEY MAP

	12	
	11	
9	10	
6	7	8
3	4	5
	1	2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- 196 – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

MAP 6

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	9	17

BLUE HILLS WATERSHED

BUTTERFIELD CHANNEL

R012

MANHATTAN CITY LIMITS

Approximate Location of End of Pipe

Critical Finish Floor Elevation = 1018.34

LOCKHART ADDITION

PURCELLS MILL

BUTTONWOOD DR.

BROOK LN.

BUTTERFIELD ROAD

BROOK LANE

BLUE HILLS

NORTHVIEW

PURCELLS MILL

BUTTONWOOD DRIVE

GALLOWAY DRIVE

UNIT 6

CHAROLAIS LANE

NUTMEG

KINGDOM HALL ADDITION

BUTTERFIELD ROAD

CASEMENT ROAD

TUTTLE STREET

SLOAN STREET

MANFAX AVENUE

FREY DRIVE

NORTHVIEW WATERSHED

BLUE HILLS

3045

3050

4000

KEY MAP

12		
11		
9	10	
6	7	8
3	4	5
	1	2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- (1127) – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

MAP 7

BG CONSULTANTS, INC.
ENGINEERS--ARCHITECTS--SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	10	17

BLUE HILLS WATERSHED

2-8'x8' RCB

4000

N014

MANHATTAN CITY LIMITS

Critical Finish Floor Elevation = 1018.36

KNOXBERRY

N015

BUTTER FIELD

UNIT 5

N017

N016

P003 30"X38" RCPHE

KNOXBERRY CIRCLE

199

P002 15" RCP

201 CIRCLE

P001 42" RCP

202 CIRCLE

P008 30"X38" RCPHE

198

P007 30" RCP

HACKBERRY AVENUE

KNOXBERRY DRIVE

RASPBERRY

STRAWBERRY

BLUE HILLS

SPAIN

195

197

PARKER DRIVE

P004 15" RCP

24" RCP P005

15" RCP P006

194

196

WILLOW LN

BUTTERNUT LANE

Previous Routes

Present Channel

CHANNEL

BIG BLUE RIVER

MANHATTAN CITY LIMITS

S022 45"X29" RCPHE

KEY MAP

	12	
	11	
9	10	
6	7	8
3	4	5
	1	2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- (1125) – Drainage Area ('95 Study)
- (1127) – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 8

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	11	17

MARLATT WATERSHED

MARLATT AVE.

(4) 10'x 7' RCB

(2) 7'x 7' RCB

MANHATTAN CITY LIMITS

WALTERS DRIVE

RUSSEL CT

MISSION AVENUE

MISSION CIR

LOT 30

LOT 29

Concrete Flume

GOODRICH

GOODRICH CIR

TUTTLE CREEK BLVD. US 24, K13

DRIVE

MARLATT BLUE HILLS

DOUGLAS WAY

KIRKWOOD

NORTHFIELD DRIVE

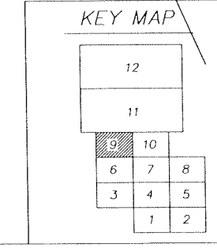
BROCKMAN STREET

BUTTERFIELD ROAD

NORTHEAST (EISENHOWER) MIDDLE SCHOOL

8' Flat Bottom Conc. Ditch

KEY MAP



LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- (127) – Line Numbers ('95 Study)
- (196) – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

Scale: 1" = 100'-0"

MAP 9

BG CONSULTANTS, INC.
ENGINEERS – ARCHITECTS – SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M

Sheet No.	Total Sheets
12	17

MARLATT AVE.

18" RCP M036

18" RCP M037

36" CMP M034

M028

M029

M030

MARLATT CHANNEL

MANHATTAN CITY LIMITS

11300

MARLATT WATERSHED

MARLATT BLUE HILLS

CASEMENT ROAD

12000

M031

M032

2-12'x12' RCB

BLUE HILLS WATERSHED

KEY MAP

12
11
9 10
6 7 8
3 4 5
1 2

LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- 196 – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

50' 0 100' 200'

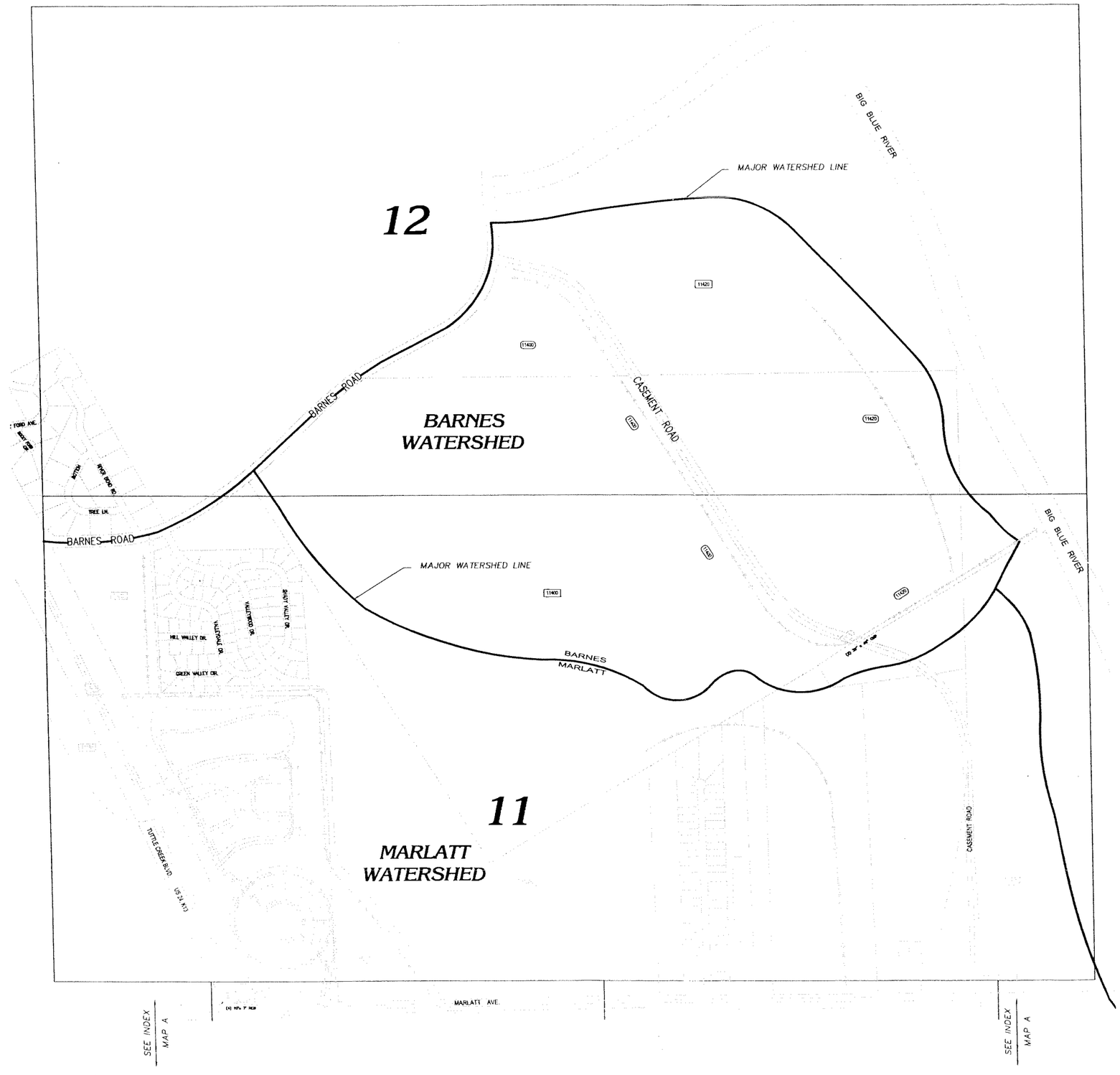
Scale: 1" = 100'-0"

MAP 10

BG CONSULTANTS, INC.
ENGINEERS-ARCHITECTS-SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M

Sheet No.	Total Sheets
13	17



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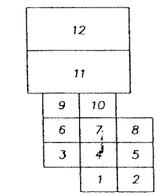


SCALE 1 : 400

200' 0 400' 800'

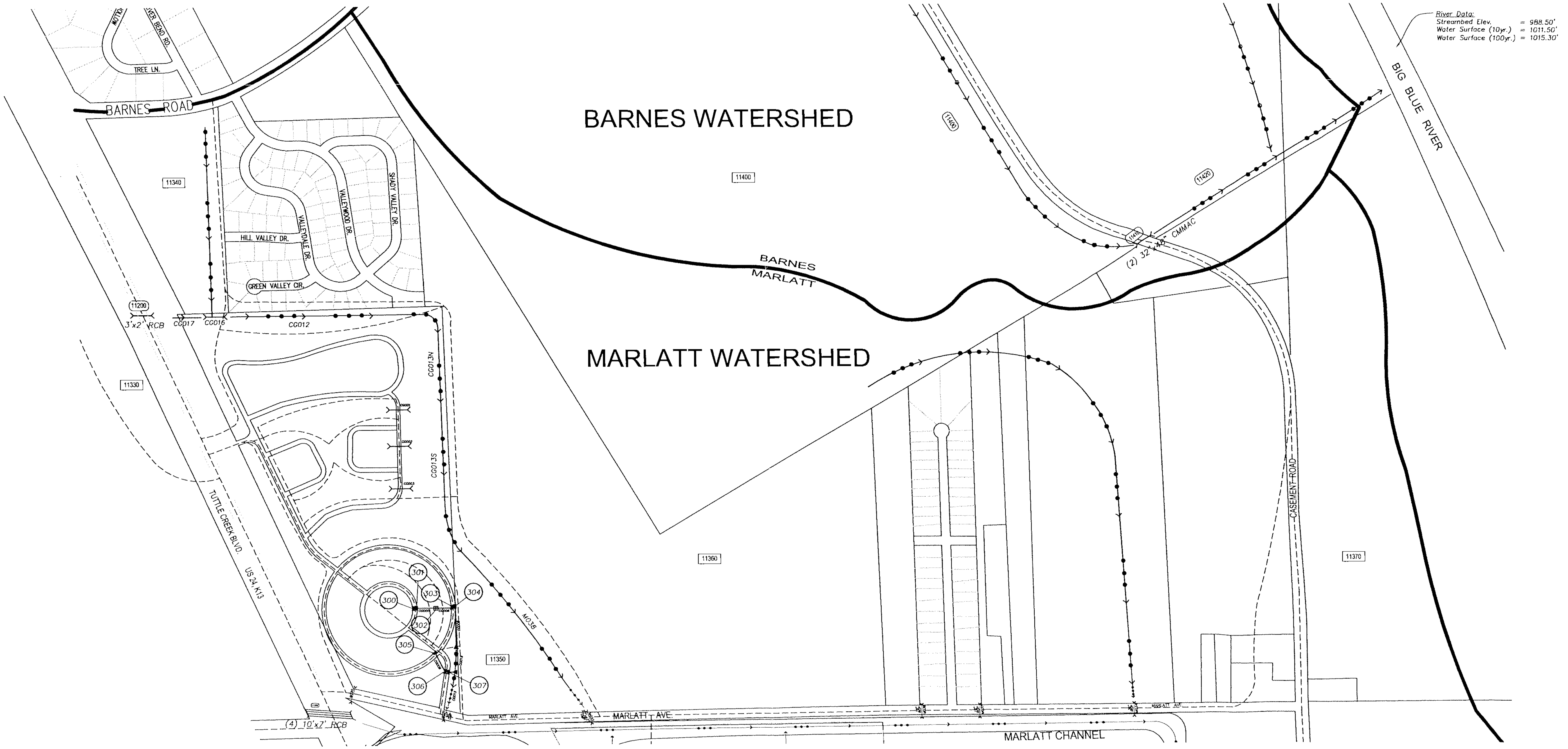
Scale: 1" = 400'-0"

Northview Drainage Study
Manhattan, Kansas

MAP INDEX B
(North of Marlatt Rd.)
(Maps 11 & 12)

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	14	17



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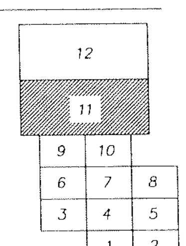


LEGEND

— Exist. Storm Sewer Pipe	(196) – Inlet Number	R001 – Reach Number
□ – Curb Inlet	▷ – Pipe End Section	Exist. Box Culverts
⊟ – Area Inlet	– Flow Direction	Open Channels
1125 – Drainage Area ('95 Study)	– Major Watershed Boundaries	
1127 – Line Numbers ('95 Study)	– Minor Watershed Boundaries	

NORTH

150' 0 300' 600'

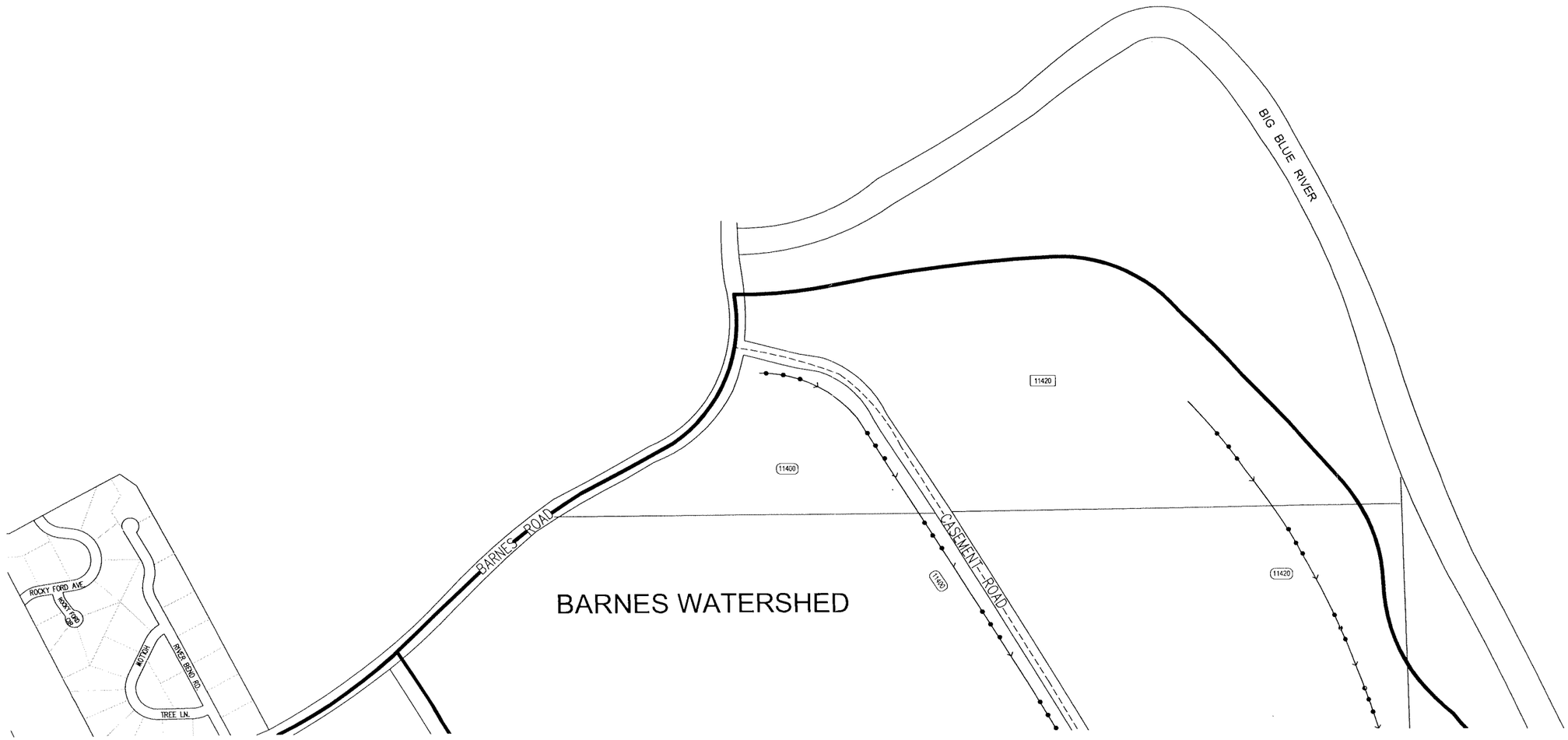
Scale: 1" = 300'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 11

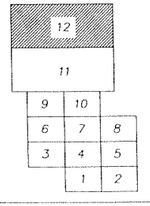
BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	15	17



BARNES WATERSHED

KEY MAP



LEGEND

- Exist. Storm Sewer Pipe
- Curb Inlet
- Area Inlet
- 1125 – Drainage Area ('95 Study)
- 1127 – Line Numbers ('95 Study)
- 196 – Inlet Number
- Pipe End Section
- Flow Direction
- Major Watershed Boundaries
- Minor Watershed Boundaries
- R001 – Reach Number
- Exist. Box Culverts
- Open Channels

NORTH

150' 0 300' 600'

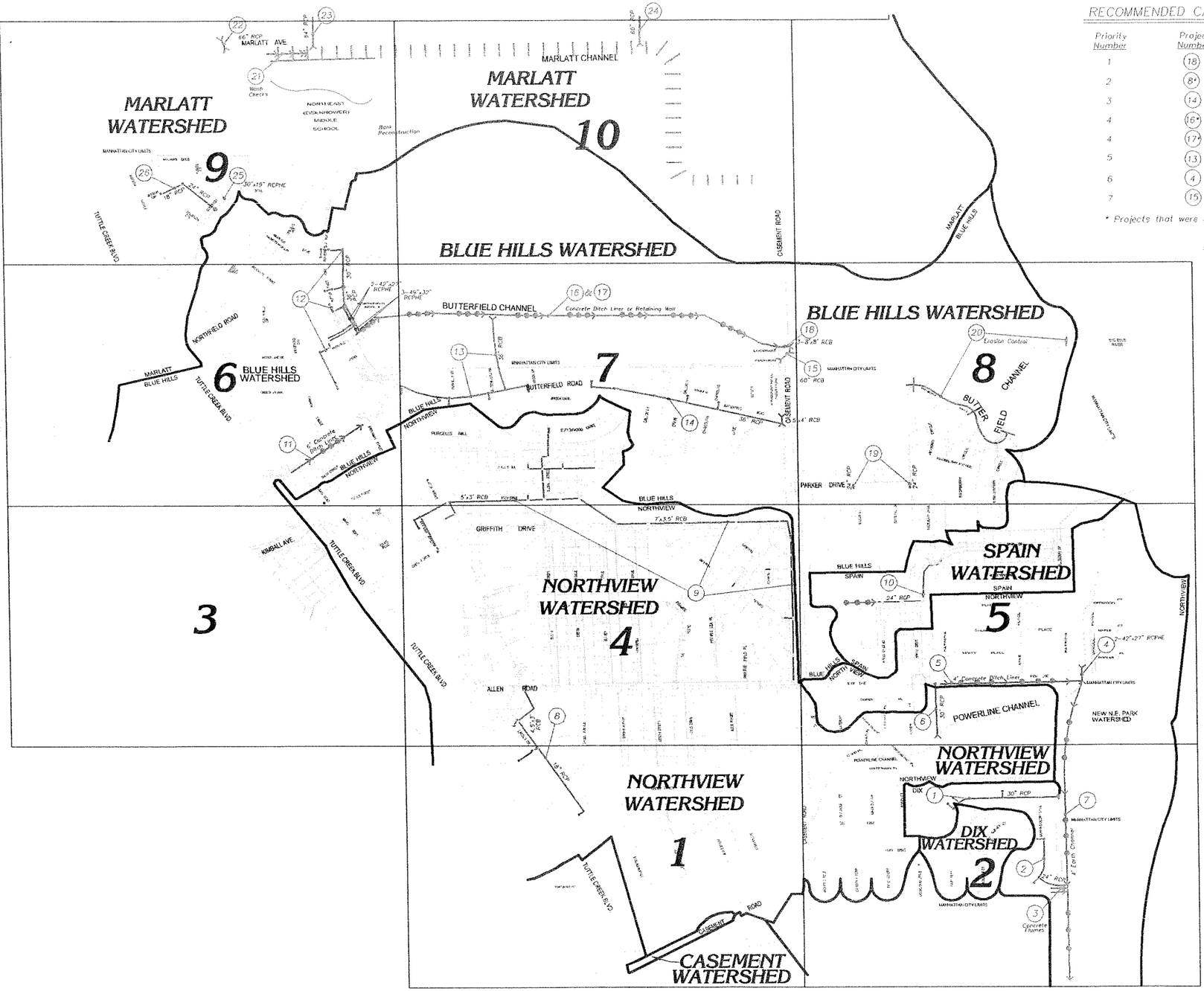
Scale: 1" = 300'-0"

Northview Drainage Study
Manhattan, Kansas

MAP 12

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

99-372M	Sheet No.	Total Sheets
	16	17



RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

Priority Number	Project Number	Project Description
1	(18)	Casement RCB
2	(8*)	Lincoln Dr. System
3	(14)	East Butterfield Rd.
4	(16*)	Butterfield Chan Alt 1: Ret. Walls
4	(17*)	Butterfield Chan Alt 2: Conc. Liner
5	(13)	New West Butterfield
6	(4)	Knox Ln. Crossrd Pipe Replace.
7	(15)	Casement/Butterfield RCP

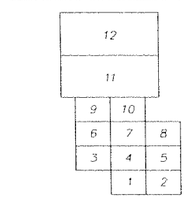
* Projects that were also recommended for improvement in the 1995 SWMMP.

DISCRETIONARY CAPITAL IMPROVEMENT PROJECTS

Project Number	Project Description
(1)	Dix Drive
(2)	Morning Glory Drive Alternate 1: Closed Conduit
(3)	Morning Glory Drive Alternate 2: Concrete Flumes
(5)	Knox Alternate 1: Roadside Ditch
(6)	Knox Alternate 2: Closed Conduit
(7)	Northeast Park Channel
(9)	Griffith Drive
(10)	Halls Landing
(11*)	Smith Street
(12)	Northfield Road
(19)	Parker Drive Area
(20)	East Butterfield Channel
(21)	Marlatt Channel Wash Checks
(22)	Valleywood Drain
(23)	North Marlatt New System 1
(24)	North Marlatt New System 2
(25)	Goodrich Drive
(26)	Mission Circle
(27)	Barnes Watershed

* Projects that were also recommended for improvement in the 1995 SWMMP.

KEY MAP



SCALE 1 : 400

200' 0 400' 800'

Scale: 1" = 400'-0"

Northview Drainage Study
Manhattan, Kansas

Capital Improvement Project
MAP INDEX C
(South of Marlatt Rd.)
(Maps 1-10)

BG CONSULTANTS, INC.
ENGINEERS–ARCHITECTS–SURVEYORS
MANHATTAN, KANSAS HUTCHINSON, KANSAS
LAWRENCE, KANSAS EMPORIA, KANSAS

HEC-1 INDEX

HEC-1 DATA FILE INDEX
Northview Drainage Study
Manhattan, KS

Watershed	Input File	Output file	Description
Casement	CMTEX.dat	CMTEX.out	Existing Elements/Existing Flow
Dix	DIXEX.dat	DIXEX.out	Existing Elements/Existing Flow
	DIXFUT.dat	DIXFUT.out	Existing Elements/Future Flow
	NEPARKPRO.dat	NEPARKPRO.out	Future Elements/Future Flow
Northview	2NOVEX.dat	2NOVEX.out	Existing Elements/Existing Flow
	2NOVPRO.dat	2NOVPRO.out	Future Elements/Existing Flow
Spain	SPAINEX.dat	SPAINEX.out	Existing Elements/Existing Flow
	SPAINPRO.dat	SPAINPRO.out	Future Elements/Existing Flow
Blue Hills	2BHEX.dat	2BHEX.out	Existing Elements/Existing Flow
	2BHFUT.dat	2BHFUT.out	Existing Elements/Future Flow
	2BHPRO.dat	2BHPRO.out	Future Elements/Future Flow
Marlatt	MARLATTEX.dat	MARLATTEX.out	Existing Elements/Existing Flow
	MARLATTFUT.dat	MARLATTFUT.out	Existing Elements/Future Flow
	MARLATTPRO.dat	MARLATTPRO.out	Future Elements/Future Flow
Barnes	BARNEX.dat	BARNEX.out	Existing Elements/Existing Flow
	BARNFUT.dat	BARNFUT.out	Existing Elements/Future Flow
	BARNPRO.dat	BARNPRO.out	Future Elements/Future Flow

Prepared By:
BG Consultants
206 Southwind Place
Manhattan, KS 66503
January 2001
99-372M