Grand Valley State University Proposed Wetland Complex Hydrologic and Hydraulic Analysis

Prepared For:
Grand Valley State University
Allendale, Michigan

October 17, 2008
Project No. G080331

Fishbeck, Thompson, Carr & Huber
engineers • scientists • architects • constructors

ftc&h

GRAND VALLEY STATE UNIVERSITY

PROPOSED WETLAND COMPLEX

HYDROLOGIC AND HYDRAULIC ANALYSIS

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LIST OF ABBREVIATIONS/ACRONYMS

BMP	Best Management Practice
FTC&H	Fishbeck, Thompson, Carr & Huber, Inc.
GVSU	Grand Valley State University
NWL	Normal Water Level
NRCS	USDA Natural Resources Conservation Service
SWMPC	Southwest Michigan Planning Commission
USEPA	U.S. Environmental Protection Agency
SWMM	Storm Water Management Model
MDEQ	Michigan Department of Environmental Quality
SWAG	Storm Water Action Group

1.0 INTRODUCTION

FTC&H has completed a preliminary design for a proposed storm water wetland complex to be constructed by GVSU at the Allendale campus. The proposed 17-acre wetland complex consists of a north and south three-celled wetland system to detain and treat storm water diverted from discharging to the existing Grand River ravines. A preliminary drawing is provided in Figure 7. This design is the result of a cooperative effort between FTC&H and GVSU's Storm Water Action Group (SWAG), and is based on the conceptual recommendations made in the Storm Water Management Plan (SWMP) prepared by FTC&H and dated June 1, 2007. The results of the hydrologic and hydraulic analysis for preliminary design of the storm water wetland are presented here for use in regulatory review and for reference by the SWAG.

1.1 CAMPUS HISTORY

Historically, much of the land that is now occupied by GVSU's Allendale campus was wooded. The general topography of the area sloped to the west, away from the ravines leading to the Grand River. Soils throughout the area are primarily clays and loams, resulting in very poor drainage. As the campus was developed, storm water runoff was channeled into storm sewers which carried the runoff to the east, where it was discharged into the ravines along the eastern edge of the campus. As a result, good drainage was achieved in many areas of the campus, but significant erosion and degradation of the natural ravines occurred. Further details regarding the history of GVSU's campus are provided in the SWMP.

1.2 PROJECT GOALS

The development of the campus has resulted in significant increases in runoff, causing localized flooding and downstream erosion. Flood control and stream stability are therefore the primary goals of this project. The constructed wetland complex is also intended to meet several other goals as outlined in the Wetland Design Matrix provided in Appendix 1. This report discusses the hydrology and hydraulics of the proposed wetland, focusing on the following:

- Flood Control
- Stream Stability
- Water Quality
- Water Budget
- Public Safety

Flood control will be achieved by reducing peak flow rates through the wetland complex, since a large amount of storm water runoff will be diverted from the east to restore presettlement drainage patterns. Detention up to and including the 10% chance (10-year) storm, with no negative impacts during storms exceeding the 10% chance will be provided by the wetland forebay. Stream stability goals will be met by ensuring that no net increase in discharge occurs during the 50% chance (2-year) storm, for any downstream watercourse.

In addition, water quality improvements will be made by ensuring the wetland system can treat the first flush, or first 1-inch of runoff from the watershed. Additional water quality benefits will be realized by reducing erosion in the ravines to the east of campus. The water budget, which is crucial to the successful establishment of the wetland ecosystem, will be discussed in detail later in the report. Additionally, public safety concerns will be taken into account in the grading and layout of the complex.

2.0 BASIS OF DESIGN

2.1 SITE CONDITIONS

The site of the proposed wetland, located just north of Pierce Street and east of 48th Avenue, is currently open meadow that slopes gently to the northwest. There are two existing communication towers at the site, that will remain in place. An existing anemometer is planned to be removed. There is a 15-inch CMP culvert under Pierce Street that conveys water to the south, toward the Curry Drain. Another culvert under Campus Drive conveys water to the north through The Meadows Golf Course, toward the Jacobs Drain. An existing conditions plan is shown in Figure 1.

Soils in the area are primarily Kawkawlin loams, with small pockets of Belding sandy loams and Sims loams, based on the NRCS Web Soil Survey (see Figure 2). Saturated hydraulic conductivity of these soils is very low, with rates at or below a depth of 24 inches, primarily in the range of 0.06 inch to 0.20 inch per hour. A geotechnical study done in 1971 by Grand Rapids Testing Service for installation of the television broadcasting tower indicated predominantly stiff brown and grey clays in the area. Where encountered, groundwater was at depths of 12.5 feet or more.

In addition to the Curry and Jacobs Drains mentioned above, there is a third watercourse that is not a county drain that crosses under Lake Michigan Drive, north of campus. These watercourses historically took runoff from the campus area prior to its development. All three watercourses discharge to Ottawa Creek, which is a county drain.

2.2 METHODOLOGY

A hydrologic and hydraulic model was developed using the Storm Water Management Model (SWMM) Version 5.0, developed by the USEPA. This model was an extension of the one developed under the SWMP. The SWMP provides information regarding the background, development, and calibration of the model that applies here. Refinements and modifications were made to better define the characteristics, behavior, and design requirements of the proposed wetland complex.

In the development of this model, it was assumed that the three cells in each wetland (north and south) would not act independently. Control structures between the cells will be designed to ensure equal distribution of flows between them, such that during a storm event water would build up to approximately the same depth in all three cells. Therefore, the cells are combined into one basin in the model.

2.3 HYDROLOGY

Rainfall data was obtained from the *Rainfall Frequency Atlas of the Midwest*, Floyd A. Huff and James R. Angel, 1992. A Michigan Triangular Unit Hydrograph was used with the 24-hour rainfall amounts provided in Table 1. Complete 24-hour rainfall distributions for each of these storm events are provided in Appendix 2.

Table 1 – Rainfall Data

Storm Event	24-Hour Rainfall (inches)
50% (2-Year)	2.37
10% (10-Year)	3.52
4% (25-Year)	4.45
1% (100-Year)	6.15

Four site conditions were used in the analysis, as outlined in the SWMP. These conditions are:

- Presettlement
- Agricultural (prior to campus development)
- Existing
- Future

As part of the SWMP, Subcatchments were delineated based on topographic and utility maps.

- Subcatchment boundaries for each of the four conditions are provided in Figures 3 through 6.
- Drainage characteristics including acreage, percent slope, and percent impervious are provided in Appendix 2.

There are several recent and ongoing development projects that account for the differences between the existing hydrology and future hydrology. Those projects are:

- Recent development of the Movement Sciences & Indoor Recreation Facility (Subcatchment GC-6) with accompanying detention basin. This project also diverted runoff from Lot F (Subcatchment M45-6) and part of North Campus Drive (Subcatchment M45-7) away from the Ravine Apartments Ravine and directed the runoff to the golf course.

- Future development of 2010 Housing (Subcatchment C-3) and diversion of this runoff away from the South Ravine, toward the South Wetland.

- Future development of the Library (Subcatchment GC-4c) and diversion of this runoff away from Little Mac Ravine, toward the North Wetland.

- Future diversion of runoff from the Kirkhof Center and Performing Arts Center (Subcatchment A-2) and Lots K and H (Subcatchment A-1) away from Little Mac Ravine, toward the North Wetland.

- Future diversion of Lot P (Subcatchment C-5) runoff away from Calder Ravine, toward the North Wetland.

- Future diversion of runoff from Lot H (Subcatchment GC-4a) away from the golf course, toward the North Wetland.

- Future diversion of runoff from the land surrounding the proposed wetlands (Subcatchments GC-3 and Z-1) into each wetland.

Infiltration from the wetland complex was calculated using a design rate of 0.1 inch per hour, which is equal to one-half the rate provided in the NRCS Web Soil Survey for the predominant soil types. This was modeled as a constant flow rate, and was conservatively assumed to occur over the bottom area of the system at 0.5 foot below NWL. Infiltration from forebays is assumed to be zero, based on the expectation that sediment buildup will prevent infiltration from occurring. Calculations of this flow rate are included in Appendix 2.

2.4 WATER BUDGET THEORY

The water budget was developed based on concepts presented in *Planning Hydrology for Constructed Wetlands* by Gary J. Pierce (Wetland Training Institute, Inc., 1993). Inflows include precipitation, storm water runoff, and a baseflow contribution from perched groundwater entering the foundation drains of buildings. Due to heavy soil conditions and depth to groundwater, the contribution directly to the wetland from groundwater inflow is assumed to be zero. Outflows include infiltration, evapotranspiration, a low-flow discharge, and an overflow discharge following large storm events.

Rainfall data for the water budget was taken from a weather station near the 4th green of The Meadows Golf Course on the GVSU campus. This station has collected daily rainfall data since November 2002, though there are a few periods of missing data. Typically, the water budget analysis is done on a month-by-month basis. However, due to advances in computing and the capabilities of SWMM, as well as the availability of daily rainfall data, a more detailed daily water budget model was developed.

The water budget considers dry, average, and wet annual conditions. Year 2003 was considered an average year, with 31.2 inches of rainfall. Year 2005 was the driest year for which complete data was available, with 26.2 inches of rainfall. Year 2006 was the wettest year for which data was available, with 40.3 inches of rainfall. Annual rainfall data for each of these is included in Appendix 3.

An infiltration rate of 0.1 inch per hour was applied to the water budget model, as noted in the previous section. This rate was assumed to be constant over the course of the year. Although infiltration rates typically decrease in winter months, many of the deep marsh areas are sufficiently deep to prevent freezing. In a water budget, it is conservative to assume this loss occurs throughout the year.

Evapotranspiration was determined on a month by month basis, per the MDEQ Division Guidance Memo, *Calculating a Water Budget,* Admin-01-01, December 14, 2004, and is given in Table 2 below.

Table 2 – Monthly Evapotranspiration Rates

Month	Evapotranspiration (inches/day)
May	0.15
June	0.17
July	0.19
August	0.15
September	0.10
October	0.07

Though no measured base flow data is available, it is commonly known that some base flow does occur in the campus storm sewers as a result of foundation drain discharges. For the purpose of this analysis, a base flow of 0.35 cfs was assumed to occur into the north wetland, and a base flow of 0.15 cfs was assumed to occur into the south wetland.

3.0 WETLAND DESIGN

3.1 WETLAND DESCRIPTION

The proposed wetland complex is shown in Figure 7. The complex consists of two separate wetland systems, each accepting water from a different portion of the campus. The North Wetland takes water from Lots P, H, and K, the Laker Village Apartments, the Kirkhof Center, Performing Arts Center, and future Library site, discharging the water to the Jacobs Drain via The Meadows golf course. The South Wetland takes water from the 2010 Housing site, Pierce Street, and Lot J, discharging the water to the Curry Drain via an existing culvert under Pierce Street.

Each wetland is designed with a forebay for initial capture and detention of storm water. This forebay has the capacity to store a 10% chance storm prior to runoff overflowing into the wetland. This protects the wetland from frequent high flows that could be damaging to wetland habitat. The wetland itself consists of three wetland cells at progressively lower elevations. Table 3 provides data on the NWL at each location.

Table 3 – Normal Water Level Summary

Wetland Component	Normal Water Level (feet)	
	North Wetland	South Wetland
Forebay	690.00	695.00
Upper Cell	689.50	694.00
Middle Cell	689.00	690.00
Lower Cell	688.50	687.00

Each cell, in turn, has various wetland zones defined by varying water depths.

Table 4 provides a summary of the zones in each wetland.

Table 4 – Wetland Zones

Zone	Depth	North Wetland		South Wetland	
		Area (ac)*	Percentage	Area (ac)*	Percentage
Deep Marsh	18 to 72 inches Below NWL	0.85	8.0	0.28	4.5
Low Marsh	6 to 18 inches Below NWL	2.84	26.6	1.40	22.6
High Marsh	0 to 6 inches Below NWL	4.31	40.4	2.38	38.5
Semi-Wet	0 to 24 inches Above NWL	2.67	25.0	2.13	34.4
Total*		10.67	100%	6.19	100%

*Figures exclude forebay areas

Each wetland cell will have a multi-stage controlled outlet structure consisting of a low-flow discharge pipe, control weir, riser weir, and emergency overflow weir. The low-flow pipe will draw water from below the NWL and discharge it over a control weir, and will be the only means of discharge for events up to and including the 4% chance storm, with no more than 1.5 feet of water inundating the wetland. A riser weir will be utilized for additional discharge during the 1% chance storm, with no more than 2 feet of water inundating the wetland. Finally, an emergency overflow weir will be provided to control discharges in excess of the 1% chance storm. A drawing showing the outlet structure design is provided in Figure 8.

Side slopes within the wetlands above NWL are generally 15 horizontal to 1 vertical, while never exceeding 6 horizontal to 1 vertical. Side slopes below NWL to a depth of 1.5 feet are generally 20 horizontal to 1 vertical, while never exceeding 10 horizontal to 1 vertical. This creates the low and high marsh zones and provides for a safety ledge. Below that, a side slope of 10 horizontal to 1 vertical is used to achieve a suitable depth for the deep marsh zones.

Pump systems will be utilized for recirculation, improving water quality treatment, habitat stability, and aesthetic benefits.

3.2 HYDROLOGIC AND HYDRAULIC ANALYSIS

As stated in Section 1.2, several goals of this project include flood control, stream stability, and water quality. These goals will be addressed as part of the hydrologic and hydraulic analysis. Resulting hydrographs are found in Appendix 2.

3.2.1 FLOOD CONTROL

The SWMM model was used to determine peak discharge rates at each offsite discharge point. Table 5 provides a summary of these rates at all points affected by the proposed changes.

Table 5 – Existing and Future Peak Discharge Rates (cubic feet per second)

Receiving Watercourse	50% (2-Year)		10% (10-Year)		4% (25-Year)		1% (100-Year)	
	Existing	Future	Existing	Future	Existing	Future	Existing	Future
Curry Drain	1.0	0.6	3.1	0.8	5.7	1.0	12.4	1.6
Jacobs Drain	24.4	24.8	40.1	39.5	54.4	52.3	83.4	79.1
Ravine Apts. Ravine	54.5	39.8	92.1	67.3	125.4	91.6	188.2	136.3
Little Mac Ravine	57.7	31.5	99.6	55.0	139.8	77.2	196.4	126.4
Calder Ravine	21.3	19.2	39.0	35.4	57.2	52.1	96.7	88.8
South Ravine	9.8	8.4	18.2	15.9	26.9	23.7	46.9	42.1
Total Discharge	168.8	124.3	292.1	213.9	409.4	297.9	624.0	474.3

It is evident that peak discharge rates are reduced at all locations and for all storms, with one exception. The Jacobs Drain experiences a 0.4 cfs increase, or 1.6%, during the 50% chance storm event. This minor increase is offset by a 0.4 cfs decrease at the Curry Drain. The net result for peak flow in Ottawa Creek is therefore zero. Overall, the reduction in the total discharge from all points ranges from 23.8% for the 1% chance storm to 27.2% for the 4% chance storm. With no effective increase in flow rates for any receiving watercourse, flood control goals have been achieved.

3.2.2 STREAM STABILITY

In reviewing stream stability criteria, discharge volume rather than discharge rate, becomes the controlling factor. Discharge volumes are presented in Table 6.

Table 6 – Existing and Future Discharge Volumes (acre-feet)

Receiving Watercourse	50% (2-Year)		10% (10-Year)		4% (2-Year)		1% (100-Year)	
	Existing	Future	Existing	Future	Existing	Future	Existing	Future
Curry Drain	1.3	2.4	3.3	5.2	5.2	7.7	8.9	11.9
Jacobs Drain	18.9	21.7	39.9	47.0	56.8	69.9	84.2	111.0
Ravine Apts. Ravine	9.8	6.9	16.9	12.0	22.9	16.4	34.2	24.6
Little Mac Ravine	12.3	7.3	22.3	14.4	31.1	20.7	47.1	32.9
Calder Ravine	7.9	5.4	14.6	10.8	20.6	15.6	32.2	25.1
South Ravine	3.5	3.2	9.0	8.5	14.3	13.6	25.2	24.2
Total Volume	53.7	46.9	106.0	97.9	150.9	143.9	231.8	229.7

Discharge volume increases for all storms at the Jacobs and Curry Drains, while significant decreases occur at the four ravines. This is expected, given the project's intention to divert water back to the Jacobs and Curry Drains.

Typically, the 50% (2-year) storm is considered the "channel forming" flow. Smaller events do not contain enough energy to actively shape the channel, while larger events do not occur with enough frequency to consistently impact the channel's formation. In order to ensure the increases above do not compromise stream stability in the Jacobs, Curry, and Ottawa Creek Drains, it is appropriate to look at the discharge rates and volumes which occurred under historical conditions, during which much of the current stream channel formation occurred. These are given in Table 7.

Table 7 – Stream Stability Discharge Volumes

Receiving Watercourse	50% (2 Year) Rainfall Volume (acre-feet)			
	Pre-settlement	Agricultural	Existing	Future
Curry Drain	0.6	2.4	1.3	2.4
Jacobs Drain	4.5	24.4	18.9	21.7
Ottawa Creek (Total)	5.1	26.8	20.2	24.1

The reduction in volume from agricultural conditions to existing is a result of the diversion of runoff to the ravines east of the campus as it was developed. Correspondingly, the future discharge volumes are higher than existing as a result of runoff being diverted back to the west.

Agricultural conditions predominated for several decades prior to development of the campus, and they are indicative of the channel forming flows experienced by the Curry, Jacobs, and Ottawa Creek Drains. Since the future volume being discharged to Ottawa Creek reflects a 10% reduction from the agricultural discharge volume, stream stability goals have been met.

3.2.3 WATER QUALITY

To ensure water quality goals are met, the first 1-inch runoff, at a minimum, must be treated by a storm water BMP. Each forebay has the capacity to store the 10% chance event, ensuring the efficient capture of sediment during a lesser event producing a 1-inch runoff. Subsequently, each wetland has the capacity to hold up to the 4% chance event prior to bypass occurring via the riser weir, allowing significant filtration and nutrient uptake to occur. Therefore, it is anticipated that water quality goals are adequately addressed. It may be desirable to sample and monitor actual discharges into and out of the wetland complex to determine presence and adequate treatment of specific storm water pollutants. Additional treatment measures targeting certain pollutants could be implemented, depending on sampling and monitoring results.

3.3 WATER BUDGET ANALYSIS

For the water budget analysis, annual rainfall data, evapotranspiration, and groundwater base flow were incorporated into the USEPA SWMM model.

Graphs of water depth over time in each wetland system for the three years analyzed are included in Appendix 3. A depth of 0.0 foot represents the top of the deep marsh zones, with the top of the low marsh zones at 1.0 foot, and the top of the high marsh zones (and NWL) at 1.5 feet. Water is assumed to be at NWL at the start of the simulation. Extended dry periods were found to occur during September 2003, July and September 2005, and July 2006. Average water levels for each year are given in Table 8.

Table 8 – Average Water Depths

Year Analyzed	Average Water Depth (feet)	
	North Wetland	South Wetland
2003	1.5	1.1
2005	1.4	1.2
2006	1.6	1.3

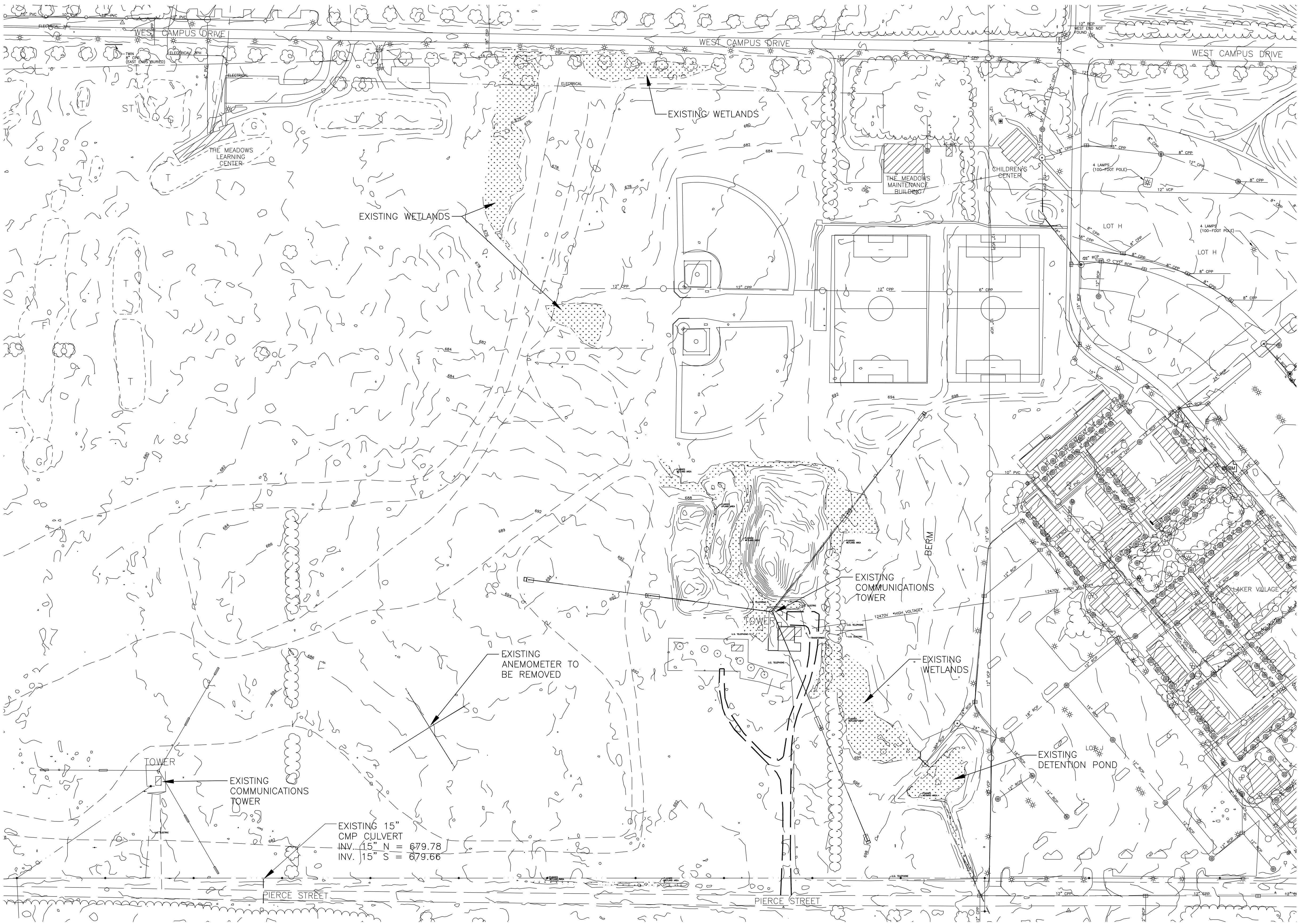
The water budget analysis generally shows that suitable hydrology will exist for successful establishment of the wetland. However, provisions for augmenting the inflow amounts may be worth considering, given that dry periods will certainly occur at times.

It is recommended that each of the wetlands be constructed in three phases, with the upper cell constructed first, followed by the middle cell and ultimately the lower cell. These phases can be timed to correspond with the various development projects and storm sewer diversions planned by GVSU. This will ensure that an adequate water supply exists as each cell is constructed, and will allow efforts to be focused on the successful establishment of one cell in each wetland at any given time.

4.0 CONCLUSIONS

The proposed wetland complex, with design parameters as outlined in this report, will reduce overall discharge rates and volumes from GVSU's Allendale campus, thereby reducing flooding and erosion in downstream watercourses. Construction of the wetland complex and planned storm sewer modifications will allow significant amounts of runoff to be diverted away from the ravines. Water quality is expected to improve as a result of the sediment removal, nutrient uptake, and filtration occurring in the system. Adequate protection of downstream channels will be provided by decreasing 50% (2-year) runoff volumes over historic, agricultural conditions.

Figures



NORTH

EXISTING CONDITIONS PLAN

SCALE: 1" = 250'

0 125 250

fTC&H

engineers
scientists
architects
constructors

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Allendale, Michigan

Proposed Storm Water Wetland Complex

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FIGURE NO.
1

PLOT INFO: U:\CADD\080331\CD\FIG 1 - EXISTING TOPO.DWG DATE: 10/1/2008 TIME: 2:11:57 PM USER: AJS
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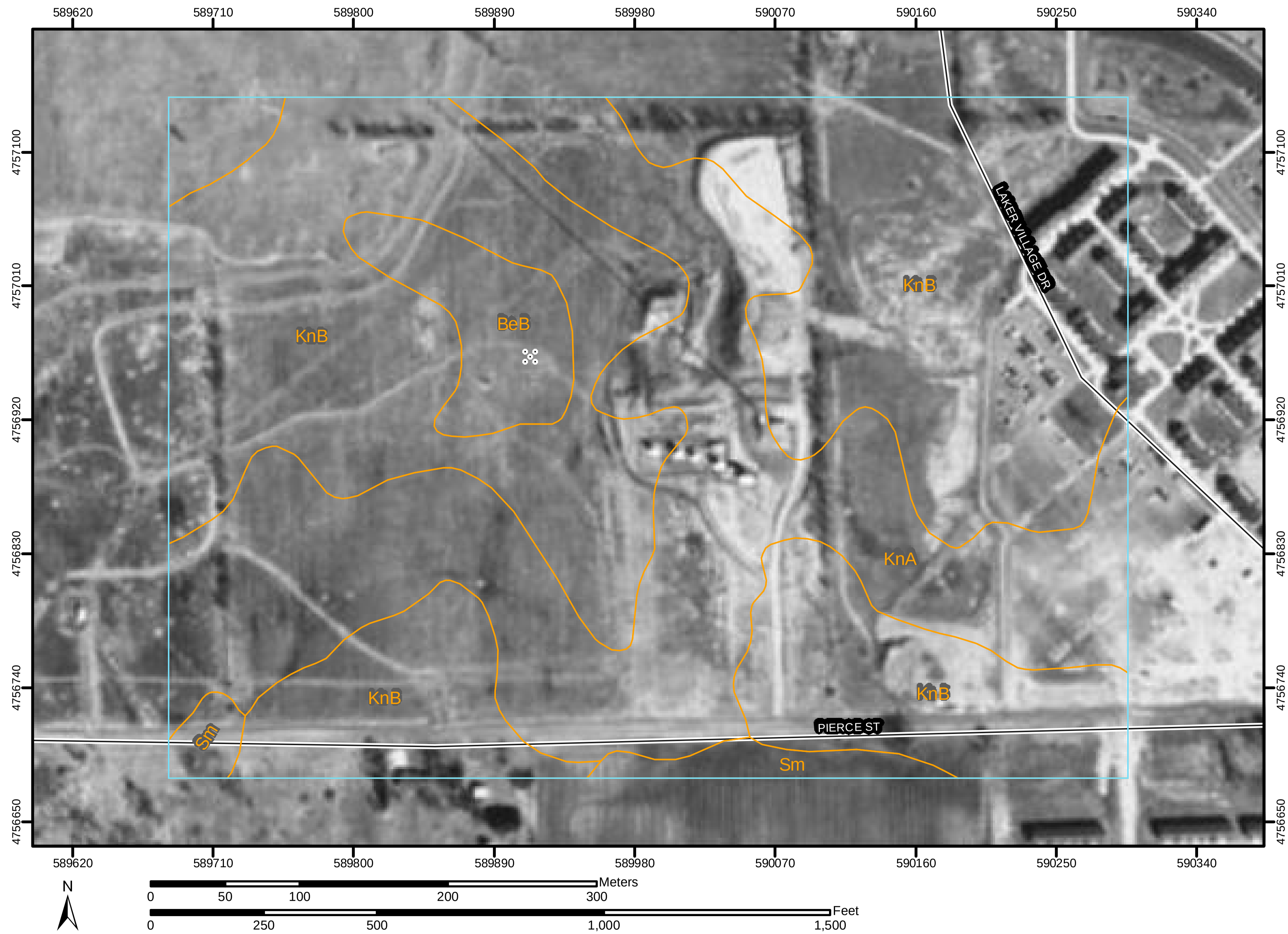
Soil Map–Ottawa County, Michigan
(GVSU Wetland Complex Site)



Natural Resources
Conservation Service

Web Soil Survey 2.0
National Cooperative Soil Survey

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

Municipalities

- Cities
- Urban Areas

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails

Roads

- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

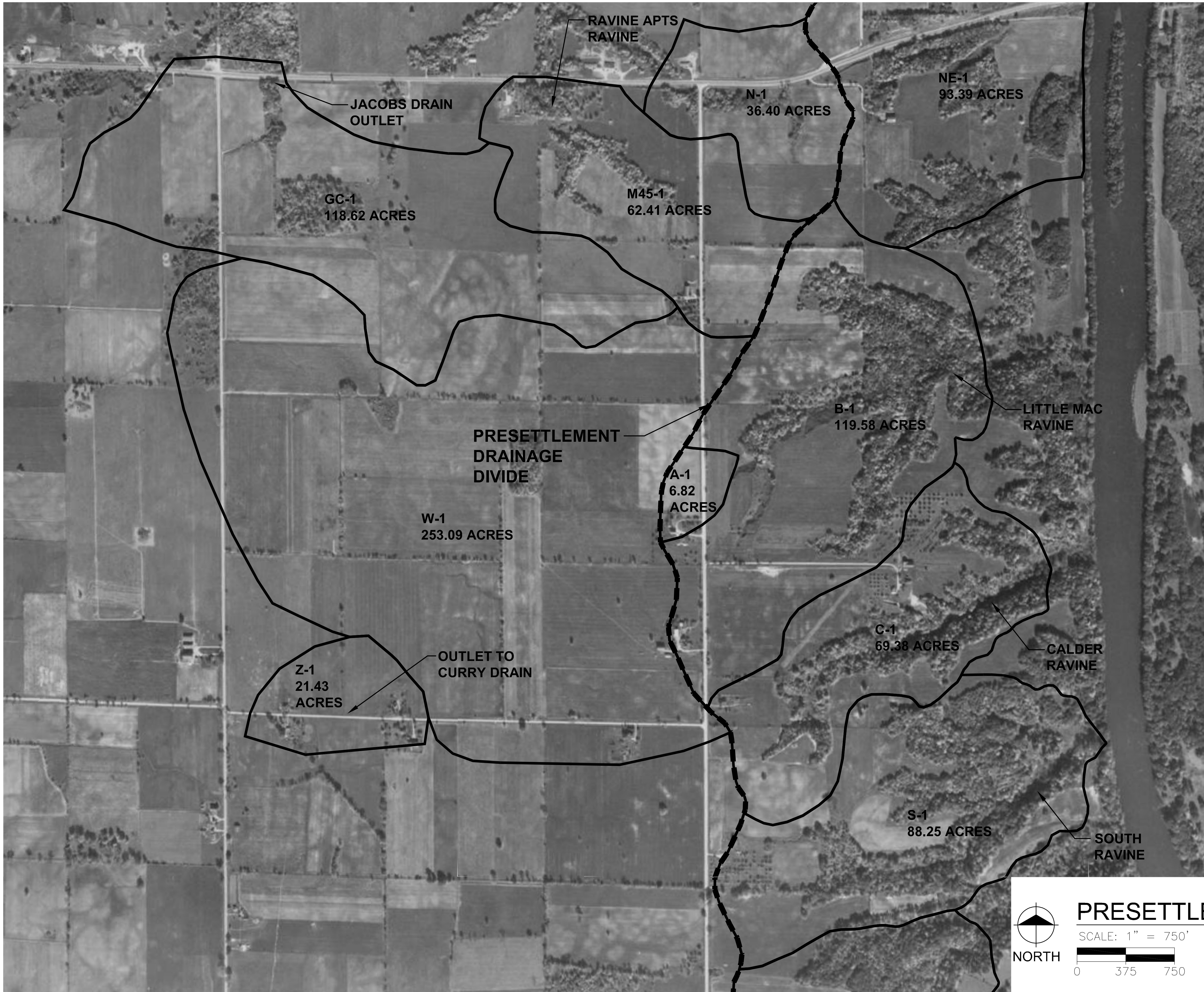
Soil Survey Area: Ottawa County, Michigan
Survey Area Data: Version 4, Jan 16, 2007

Date(s) aerial images were photographed: 3/27/1999

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Ottawa County, Michigan (MI139)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BeB	Belding sandy loam, 2 to 6 percent slopes	3.0	4.1%
KnA	Kawkawlin loam, 0 to 2 percent slopes	24.3	33.3%
KnB	Kawkawlin loam, 2 to 6 percent slopes	44.1	60.4%
Sm	Sims loam	1.6	2.2%
Totals for Area of Interest (AOI)		73.0	100.0%



NOTE: AERIAL PHOTO CIRCA 1955.

PRESETTLEMENT HYDROLOGY

SCALE: 1" = 750'

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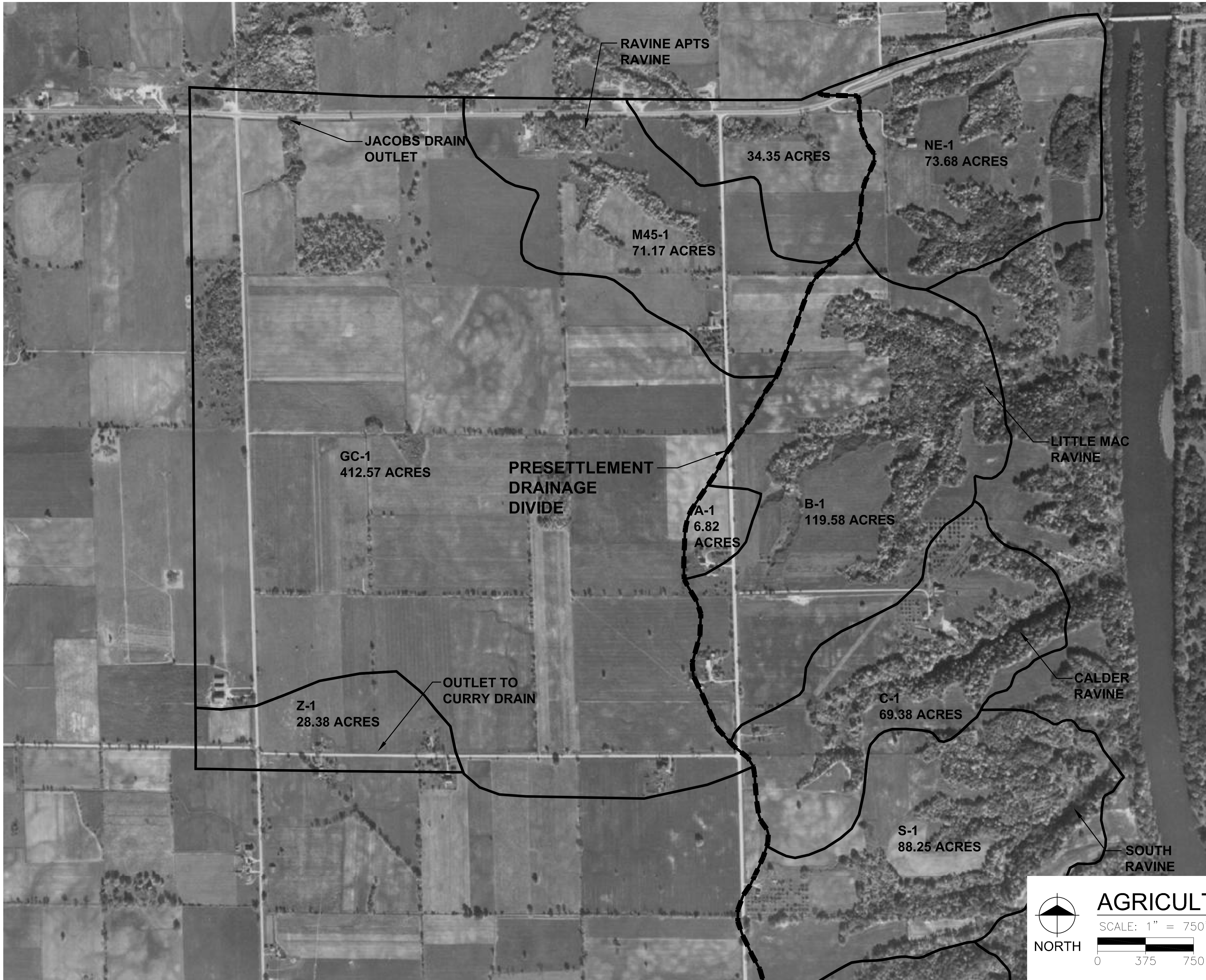
3

PLOT INFO: U:\CADD\080331\CD\FIG 3 - PRESETTLE AERIAL.DWG DATE: 9/30/2008 TIME: 1:52:40 PM USER: AJS

U:\CADD\080331\RASTER\GVSU 1955.JPG



NOTE: AERIAL PHOTO CIRCA 1955

NORTH

AGRICULTURAL HYDROLOGY

SCALE: 1" = 750'

0 375 750

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4

PLOT INFO: U:\CADD\080331\CD\FIG 4 – AGRICULTURAL AERIAL.DWG DATE: 9/30/2008 TIME: 1:53:10 PM USER: AJS
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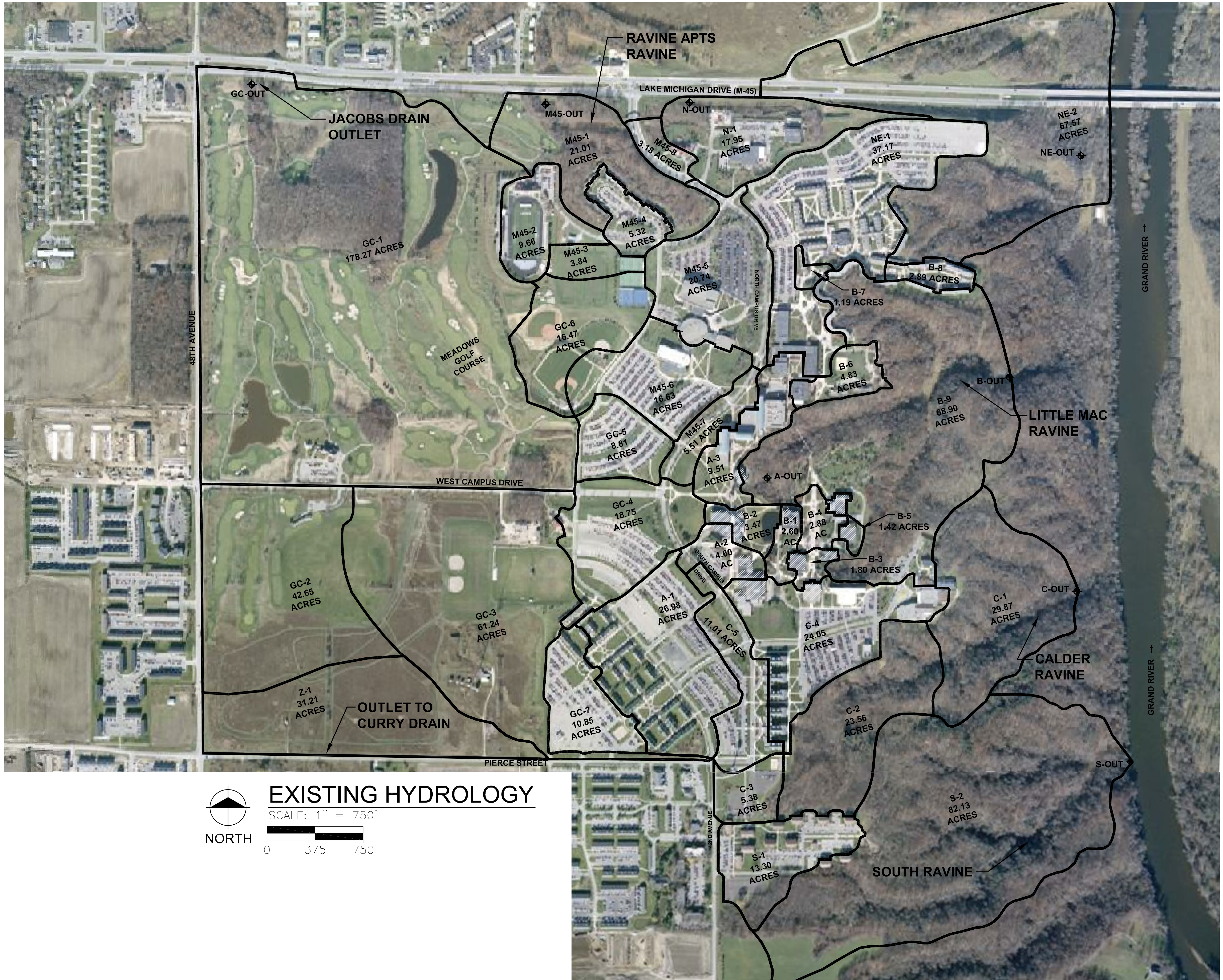

EXISTING HYDROLOGY

SCALE: 1" = 750'

NORTH

0 375 750

ftc&h

engineers
scientists
architects
constructors

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FIGURE NO.
5

PLOT INFO: U:\CADD\080331\CD\FIG 5 - EXISTING AERIAL.DWG DATE: 10/1/2008 TIME: 1:49:25 PM USER: AJS

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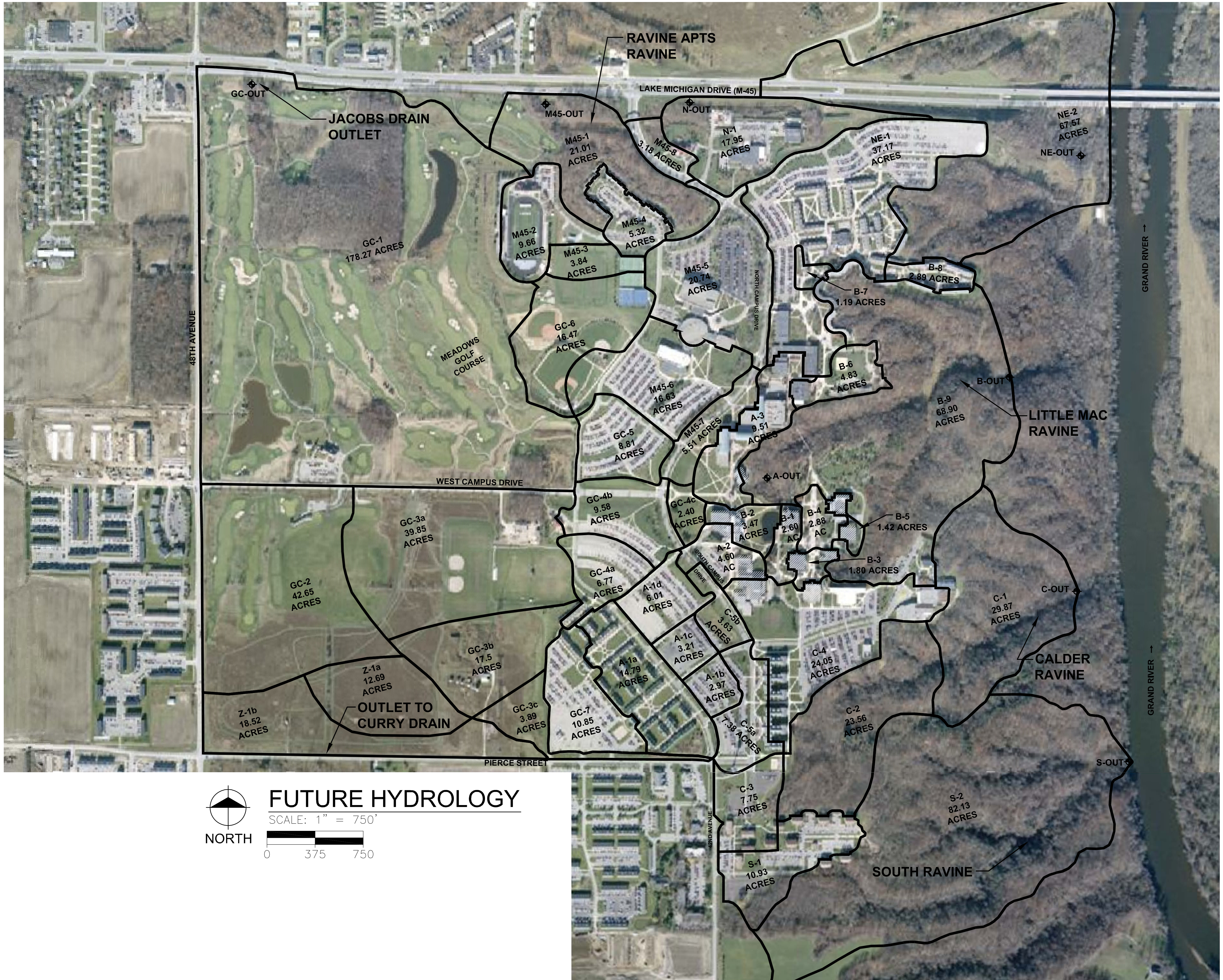

FUTURE HYDROLOGY

SCALE: 1" = 750'

NORTH

0 375 750

ftc&h

engineers

scientists

architects

constructors

fishbeck, thompson, carr & huber, inc.

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Proposed Storm Water Wetland Complex

PROJECT NO.

G080331

FIGURE NO.

6

PLOT INFO: U:\CADD\080331\CD\FIG 6 – STORM SEWER.DWG DATE: 10/1/2008 TIME: 1:21:26 PM USER: AJS

:\REF\B-11X17
U:\CADD\080331\RASTER\ALLENDALE CAMPUS AERIAL 295313 KM.JPG
U:\CADD\080331\SUPPORT\GVSUBASE2007_COPY.DWG

LEGEND

- DEEP MARSH 18–72" DEEP
- LOW MARSH 6–18" DEEP
- HIGH MARSH 0–6" DEEP
- SEMI WET/DRY 0–24" TO WATER
- UPLAND
- EXISTING WETLANDS

CONCEPTUAL LAYOUT PLAN

SCALE: 1" = 250'

0 125 250

NORTH

ftc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

Grand Valley State University
Allendale, Michigan

Proposed Storm Water Wetland Complex

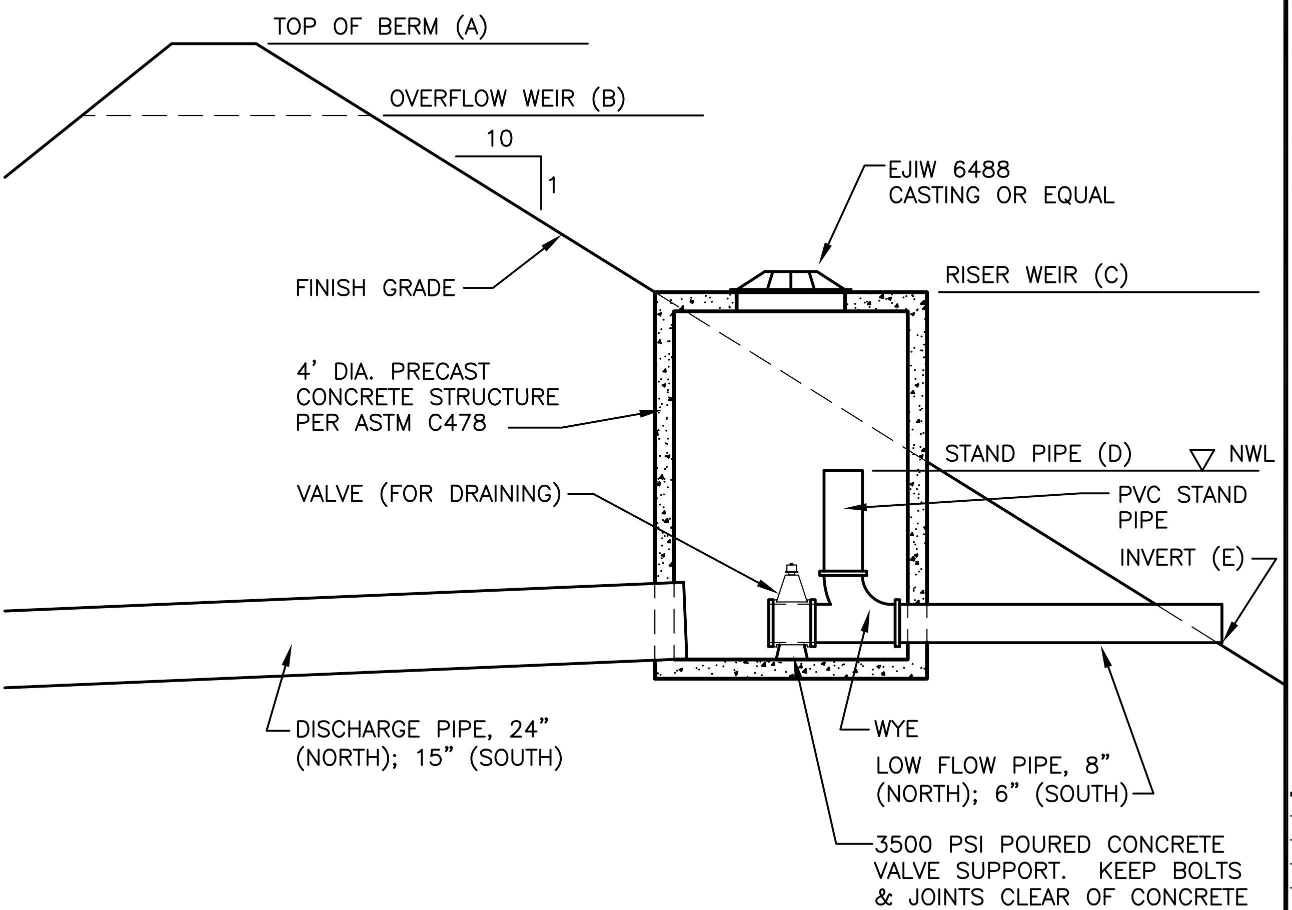
PROJECT NO.
G080331

FIGURE NO.
7

PLOT INFO: U:\CADD\080331\CD\FIG 7 CONCEPT LAYOUT.DWG DATE: 9/30/2008 TIME: 12:10:35 PM USER: AJS
..\REF\CDGN080331.DWG ..\REF\CTOPO080331.DWG ..\SUPPORT\GVSU UTILITIES-F&V_COPY.DWG ..\SUPPORT\GVSUBASE2007_COPY.DWG

ELEVATION DATA

	NORTH WETLAND	SOUTH WETLAND
A	691.5 (MIN)	690.0 (MIN)
B	690.5	689.0
C	690.0	688.5
D	688.5	687.0
E	687.0	685.5



OUTLET CONTROL STRUCTURE
NO SCALE

ftc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

Grand Valley State University
Allendale, Michigan

Proposed Stormwater Wetland Complex

PROJECT NO.
G080331

FIGURE NO.
8

Appendix 1

Table A1. DESIGN CONSIDERATION FOR STORM WATER WETLANDS BY FUNCTION

	Storm Water Management			**Hydrology**		**Vegetation**	**Aesthetics/Layout**	**Habitat**	**Maintenance and Public Safety**
Function	**Flood Control**	**Water Quality**	**Stream Stability**	**Water Budget**	**Groundwater Impacts**				
Priority	PRIMARY IMPORTANCE	MEET OBJECTIVES	MUST ACHIEVE	MUST ENSURE	N/A	IMPORTANT	IMPORTANT	SECONDARY BENEFIT	MUST ACHIEVE
Objectives	Proper size and storage volume? Rises in water level acceptable for vegetation and habitat?	Understanding of influent quality? Target pollutant and/or removal goal? Proper size and zones selected for treatment? Soil amendment necessary? Downstream watercourse temperature and oxygen considerations?	Volume control and/or extended detention provided?	Determine if wetland hydrology is sustainable.	Connected to groundwater? Seasonal fluctuations in groundwater understood? Wetland (impoundment) impacts that may increase groundwater levels?	Wetland soils? Proper vegetation selected for different zones? Appropriate vegetation selected to meet aesthetic objectives? Invasive species control? Algae control?	Ideal look visualized? Adequate circulation? Are bottom grades and slopes optimized for hydrology, cost and aesthetics?	Wildlife priorities identified? Proper zones and vegetation for desired habitat? Habitat structures?	Side slopes acceptable? Safety ledges? Adjustable water level controls? Cleanouts? Access routes? Staging area? Widest location allows for equipment reach?
Approach	Detain the 10-year rainfall event (capacity of incoming storm sewers flowing full) from impacting the wetland (determined by acceptable water level fluctuations) and the 100-year event from impacting downstream offsite properties.	GVSU faculty sample storm water outfalls for nutrients, heavy metals, oils/grease, salt. Review any pertinent Watershed Management Plans for TMDLs or priority pollutants. Treat the first 1-inch of runoff from the contributing drainage area. Follow guidelines in *Design of stormwater wetland systems : guidelines for creating diverse and effective stormwater wetlands in the mid-Atlantic Region* by the Metropolitan Council of Governments. Get input from FTC&H process engineers for advanced treatment. Continue influent and effluent sampling after construction.	Provide no net increase in runoff volume for the 2-year rainfall event, or mitigate any increase with 24-hour extended detention of the 1-year storm.	Identify existing/proposed ditches and tiles that would impact hydrology. Perform Water Budget analysis per *Planning Hydrology for Constructed Wetlands* by Gary J. Pierce; MDEQ Division Guidance Memo *Calculating A Water Budget,* Admin-01-01	Soil borings and, if necessary, installation of piezometers during preliminary design, and again following construction.	If existing wetland has high quality seed bank, stockpile and reuse wetland topsoil. If invasive species are present, remove wetland topsoil and use upland topsoil in constructed wetland. Ensure establishment of intended hydraulic regimes through establishing water budget and installing adjustable weirs. Identify invasive species of concern. Implement a maintenance plan to control water levels and eradicate invasive species. Install unmowed upland buffer around perimeter of wetland. Utilize chemical controls, if necessary, to remove algae.	Obtain photographs of typical “types” of wetlands and wetland features. Consider the placement of the wetland in relationship to the surrounding topography, and perform earthwork calculations. Review normal water levels and depths. Grade to avoid water flow short-circuiting and sharp corners creating stagnant areas. Wetland shape should contain undulating lines – avoid rectangular basins. Rough grade to create variable microclimates. Consider viewscapes and placement of paths, viewing decks, and boardwalks. Place larger plant material in focused plantings that accentuate the viewscape and in high access areas. Install focal points (trees around perimeter, habitat structures, water features at inlet or outlet).	Identify both desired and undesired wildlife species. Provide appropriate habitat for desired species (food, water, shelter, and territory). Deter undesired wildlife with barriers, if necessary. Install grid system to prevent waterfowl from decimating new plantings. Installed an unmowed buffer around wetland perimeter. Install habitat structures, in accordance with MDEQ guidance for mitigation areas.	Follow MDEQ BMP guidelines for “Constructed Storm Water Wetlands”; *Stormwater Pond and Wetland Maintenance Guidebook* by Center for Watershed Protection.

Functions of “Public Access & Recreation” and “Soil Erosion and Sedimentation Control” not included in matrix.

Appendix 2

Table A2. SCS Type II Rainfall Distributions
Michigan Region 8
from Rainfall Frequency Atlas of the Midwest, Huff & Angel, 1992

	Cumulative Rainfall (Inches)			
Elapsed Time	50% (2 Year)	10% (10 Year)	4% (25 Year)	1% (100 Year)
0:00:00	0.000	0.000	0.000	0.000
0:30:00	0.013	0.019	0.024	0.034
1:00:00	0.026	0.039	0.049	0.068
1:30:00	0.039	0.058	0.073	0.101
2:00:00	0.052	0.077	0.098	0.135
2:30:00	0.068	0.100	0.127	0.175
3:00:00	0.083	0.123	0.156	0.215
3:30:00	0.098	0.146	0.185	0.255
4:00:00	0.114	0.169	0.214	0.295
4:30:00	0.133	0.197	0.249	0.344
5:00:00	0.152	0.225	0.285	0.394
5:30:00	0.171	0.253	0.320	0.443
6:00:00	0.190	0.282	0.356	0.492
6:30:00	0.211	0.313	0.396	0.547
7:00:00	0.232	0.345	0.436	0.603
7:30:00	0.258	0.384	0.485	0.670
8:00:00	0.284	0.422	0.534	0.738
8:30:00	0.315	0.468	0.592	0.818
9:00:00	0.348	0.517	0.654	0.904
9:30:00	0.386	0.574	0.725	1.002
10:00:00	0.429	0.637	0.805	1.113
10:30:00	0.483	0.718	0.908	1.255
11:00:00	0.557	0.827	1.046	1.445
11:30:00	0.671	0.996	1.259	1.740
12:00:00	1.571	2.334	2.950	4.077
12:30:00	1.742	2.587	3.271	4.520
13:00:00	1.830	2.717	3.435	4.748
13:30:00	1.894	2.812	3.556	4.914
14:00:00	1.943	2.886	3.649	5.043
14:30:00	1.979	2.939	3.716	5.135
15:00:00	2.015	2.992	3.783	5.228
15:30:00	2.050	3.045	3.849	5.320
16:00:00	2.086	3.098	3.916	5.412
16:30:00	2.107	3.129	3.956	5.467
17:00:00	2.128	3.161	3.996	5.523
17:30:00	2.150	3.193	4.036	5.578
18:00:00	2.171	3.224	4.076	5.633
18:30:00	2.192	3.256	4.116	5.689
19:00:00	2.214	3.288	4.156	5.744
19:30:00	2.235	3.319	4.196	5.799
20:00:00	2.256	3.351	4.236	5.855
20:30:00	2.270	3.372	4.263	5.892
21:00:00	2.285	3.393	4.290	5.929
21:30:00	2.299	3.414	4.317	5.966
22:00:00	2.313	3.436	4.343	6.002
22:30:00	2.327	3.457	4.370	6.039
23:00:00	2.342	3.478	4.397	6.076
23:30:00	2.356	3.499	4.423	6.113
24:00:00	2.370	3.520	4.450	6.150

Table A3. Subcatchment Input Parameters - Presettlement Hydrology
Grand Valley State University, Allendale Campus

Subcatchment	Area (acres)	Width (feet)	%Impervious	%Slope
A-1	6.82	250	0.0	7.0
B-1	119.58	900	0.0	2.8
C-1	69.38	690	0.0	3.8
D-1	59.62	710	0.0	4.0
GC-1	118.62	925	0.0	1.2
M45-1	62.41	715	0.0	2.6
N-1	36.40	600	0.0	2.8
NE-1	93.39	1200	0.0	4.0
S-1	88.25	815	0.0	3.8
W-1	253.09	1375	0.0	1.0
Z-1	21.43	700	0.0	1.4

Table A4. Subcatchment Input Parameters - Agricultural Hydrology
Grand Valley State University, Allendale Campus

Subcatchment	Area (acres)	Width (feet)	%Impervious	%Slope
A-1	6.82	250	0.0	7.0
B-1	119.58	900	0.0	2.8
C-1	69.38	690	0.0	3.8
D-1	59.62	710	0.0	4.0
GC-1	412.57	1500	0.0	1.0
M45-1	71.17	790	0.0	2.3
N-1	34.35	565	0.0	2.8
NE-1	73.68	900	0.0	4.0
S-1	88.25	815	0.0	3.8
Z-1	28.38	780	0.0	1.2

Table A5. Subcatchment Input Parameters - Existing Hydrology
Grand Valley State University, Allendale Campus

Subcatchment	Area (acres)	Width (feet)	%Impervious	%Slope
A-1	26.98	590	58.3	1.0
A-2	4.60	225	60.0	0.3
A-3	9.51	210	57.3	0.4
B-1	2.60	140	45.0	1.3
B-2	3.47	205	54.2	2.5
B-3	1.80	180	58.3	1.8
B-4	2.88	160	46.2	0.2
B-5	1.42	190	70.4	0.8
B-6	4.83	220	42.0	4.2
B-7	1.19	82	37.8	0.1
B-8	2.89	135	60.2	0.4
B-9	68.90	900	6.1	4.3
C-1	29.87	610	0.3	7.0
C-2	23.56	370	1.2	4.4
C-3	5.38	230	7.8	1.6
C-4	24.05	440	58.6	0.6
C-5	11.01	330	56.3	1.0
D-1	59.62	710	0.0	4.0
GC-1	178.27	945	6.4	0.6
GC-2	42.65	690	0.0	1.3
GC-3	61.24	900	9.2	1.2
GC-4	18.75	565	39.0	1.5
GC-5	8.81	390	68.2	2.2
GC-6	16.47	565	7.3	1.2
GC-7	10.85	450	74.4	2.0
M45-1	21.01	510	2.4	2.5
M45-2	9.66	400	37.7	0.8
M45-3	3.84	160	13.3	1.3
M45-4	5.32	250	59.0	1.1
M45-5	20.74	675	60.2	1.4
M45-6	16.63	390	47.5	0.6
M45-7	5.51	210	29.0	0.7
M45-8	3.18	300	43.4	2.2
N-1	17.95	325	21.1	1.8
NE-1	37.17	350	63.3	0.5
NE-2	67.57	790	0.0	3.3
S-1	13.30	640	42.7	0.5
S-2	82.13	750	0.0	3.7
Z-1	31.21	570	0.0	1.2

Table A6. Subcatchment Input Parameters - Future Hydrology
Grand Valley State University, Allendale Campus

Subcatchment	Area (acres)	Width (feet)	%Impervious	%Slope
A-1a	14.79	590	58.3	1.0
A-1b	2.97	200	58.3	1.0
A-1c	3.21	200	58.3	1.0
A-1d	6.01	400	58.3	1.0
A-2	3.89	225	60.0	0.3
A-3	9.51	210	57.3	0.4
B-1	2.60	140	45.0	1.3
B-2	3.47	205	54.2	2.5
B-3	1.80	180	58.3	1.8
B-4	2.88	160	46.2	0.2
B-5	1.42	190	70.4	0.8
B-6	4.83	220	42.0	4.2
B-7	1.19	82	37.8	0.1
B-8	2.89	135	60.2	0.4
B-9	68.90	900	6.1	4.3
C-1	29.87	610	0.3	7.0
C-2	23.56	370	1.2	4.4
C-3	7.75	230	60.0	1.6
C-4	24.05	440	58.6	0.6
C-5a	7.28	330	56.3	1.0
C-5b	3.81	100	56.3	1.0
D-1	59.62	710	0.0	4.0
GC-1	178.27	945	6.4	0.6
GC-2	42.65	690	0.0	1.3
GC-3a	39.85	585	9.2	1.2
GC-3b	17.50	315	18.0	1.2
GC-3c	3.89	200	40.0	1.0
GC-4a	6.77	205	39.0	1.5
GC-4b	9.68	360	39.0	1.5
GC-4c	2.40	360	39.0	1.5
GC-5	8.81	390	68.2	2.2
GC-6	16.47	565	7.3	1.2
GC-7	10.85	450	74.4	2.0
M45-1	21.01	510	2.4	2.5
M45-2	9.66	400	37.7	0.8
M45-3	3.84	160	13.3	1.3
M45-4	5.32	250	59.0	1.1
M45-5	20.74	675	60.2	1.4
M45-6	16.63	390	47.5	0.6
M45-7	5.51	210	29.0	0.7
M45-8	3.18	300	43.4	2.2
N-1	17.95	325	21.1	1.8
NE-1	37.17	350	63.3	0.5
NE-2	67.57	790	0.0	3.3
S-1	10.93	640	42.7	0.5
S-2	82.13	750	0.0	3.7
Z-1a	12.69	570	0.0	1.2
Z-1b	18.52	570	0.0	1.2

Flow Rate from Wetland due to Infiltration

Project #: G080331
Prepared by: JT
Date: 9/17/2008

1. Determine Coefficients for Darcy's Law

Q = A*h^B
Set B = 0
Therefore h^0 = 1
Therefore Q = A
A = Discharge Rate = Area (sft) * Infiltration Rate (ft/s)

2. Per NRCS Web Soil Survey, Infiltration Rate = 0.20 to 0.63 in/hr.

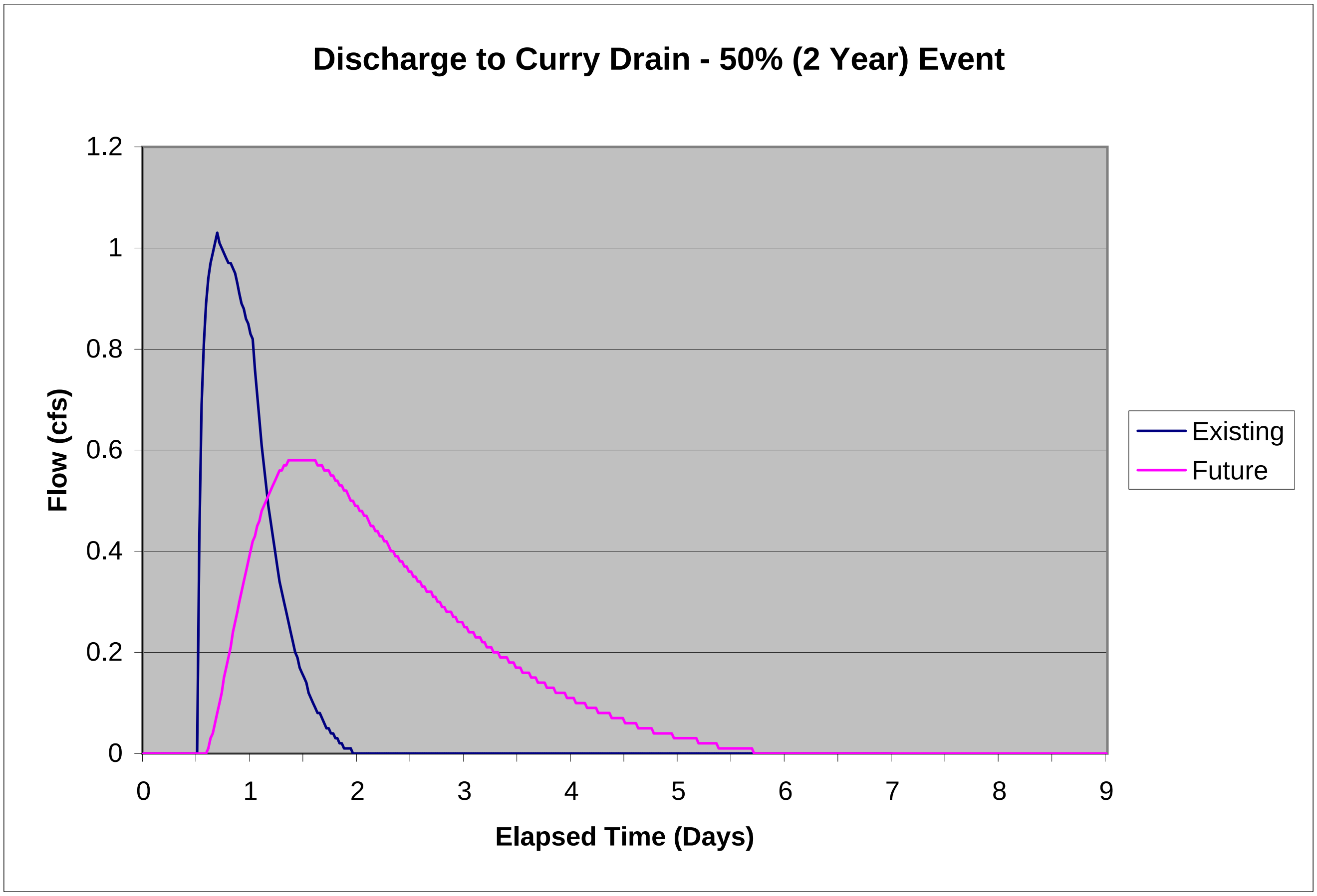
Design Rate = 0.20 in/hr * 0.5 = 0.10 in/hr

3. North Wetland Area, at 0.5' below NWL = 160,670 sft

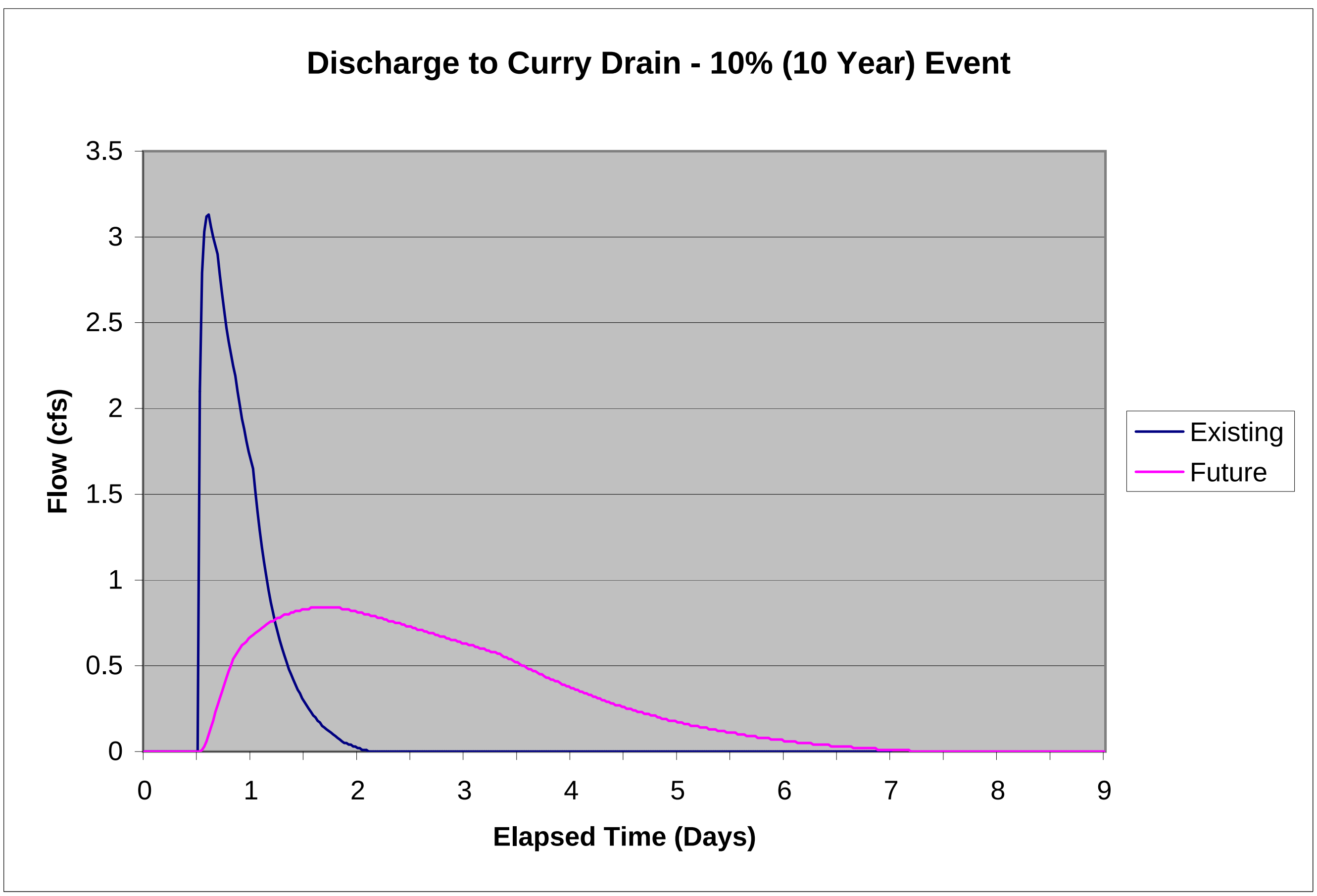
A = 160,670 sft * 0.10 in/hr * 1 ft/12 in * 1 hr/3600 sec = 0.37 cfs

4. South Wetland Area, at 0.5' below NWL = 73,452 sft

A = 73,452 sft * 0.10 in/hr * 1 ft/12 in * 1 hr/3600 sec = 0.17 cfs

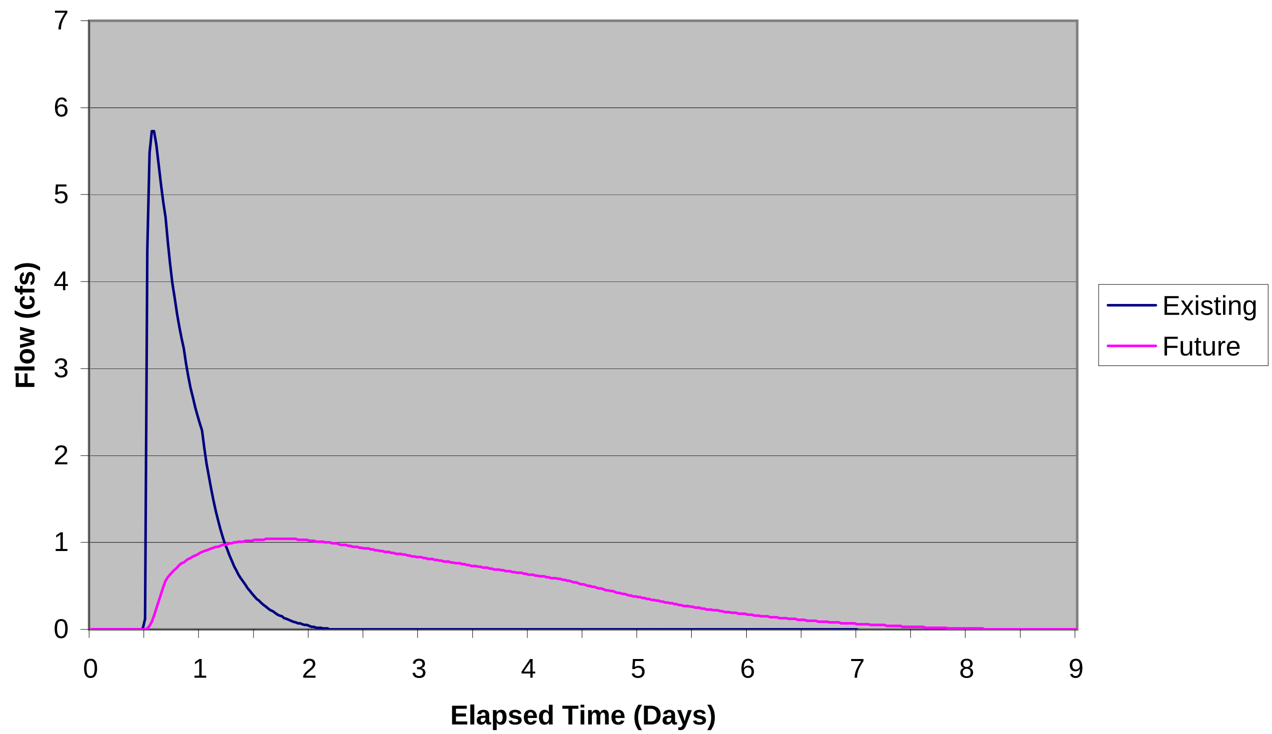


Discharge to Curry Drain - 50% (2 Year) Event
Flow (cfs)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

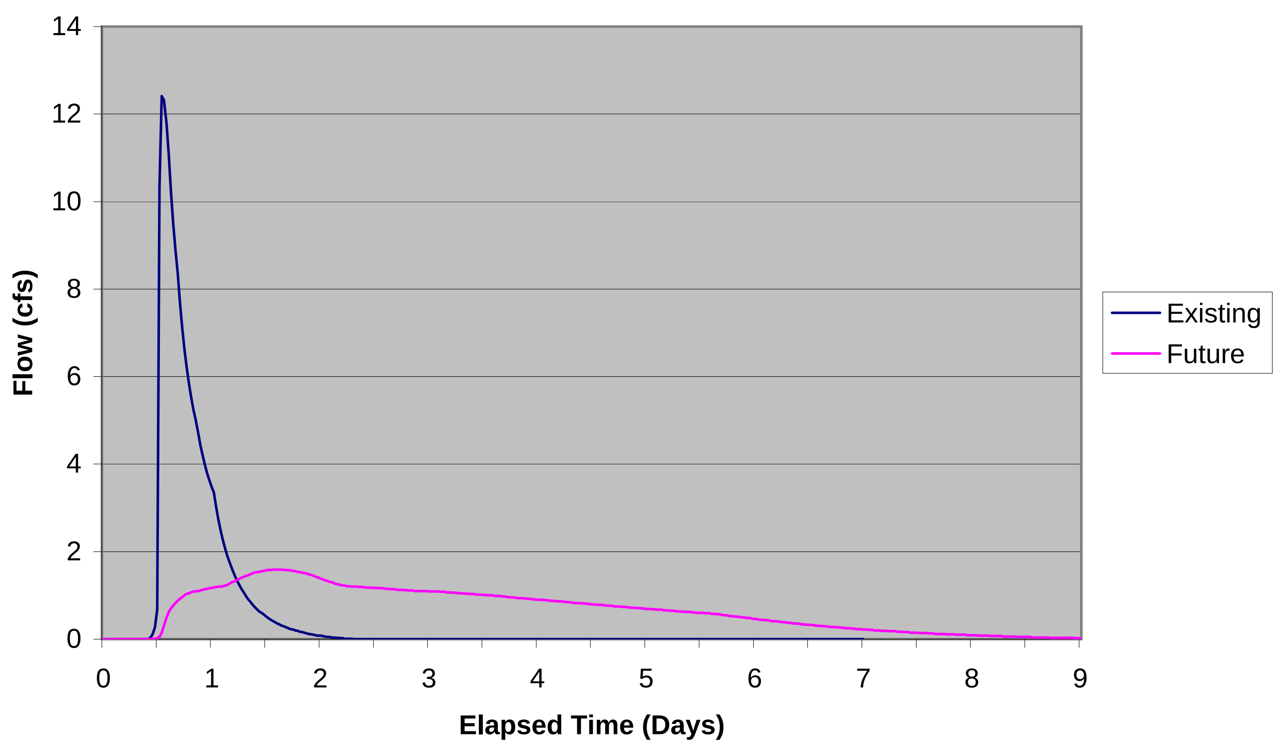


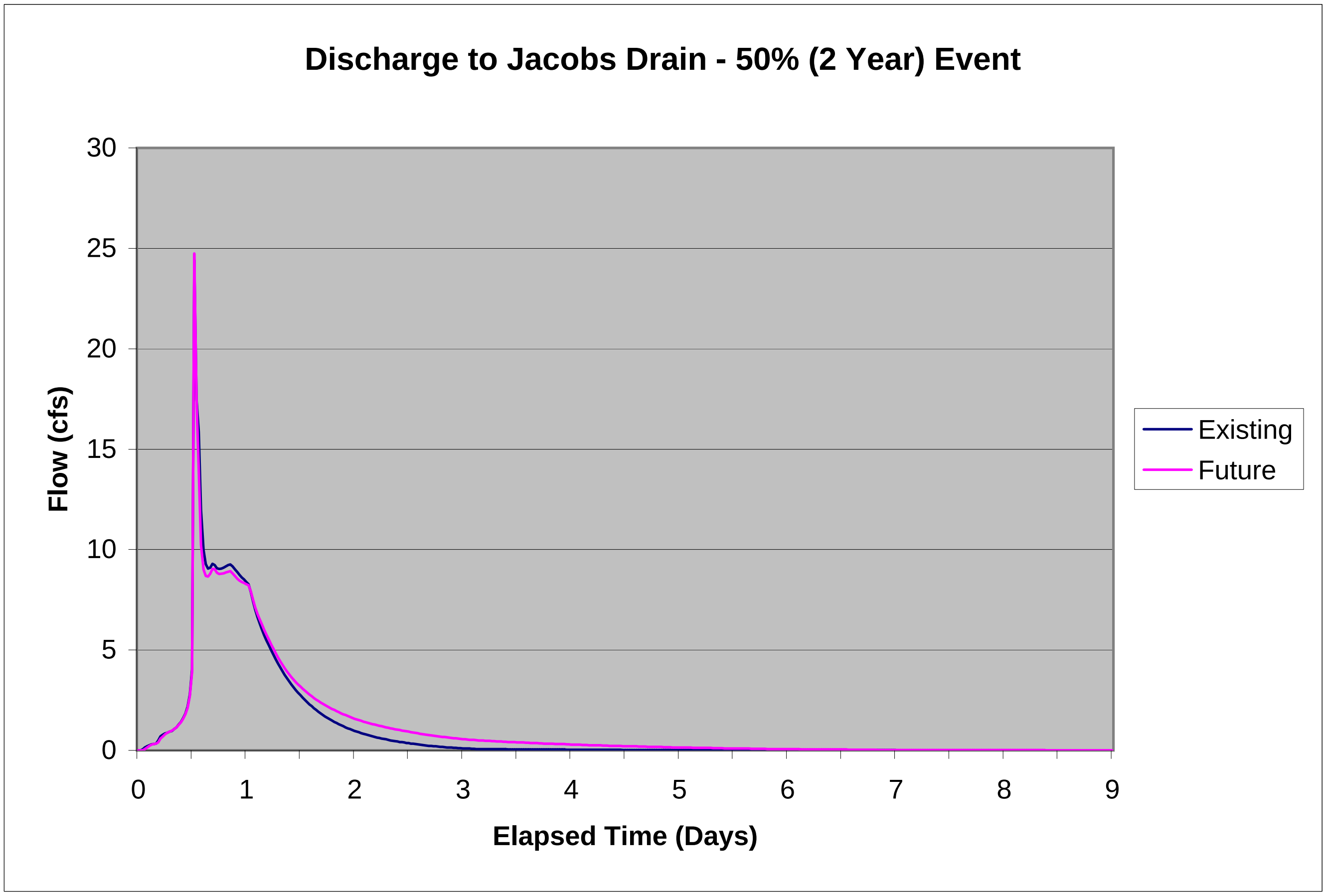
Discharge to Curry Drain - 10% (10 Year) Event
Flow (cfs)
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

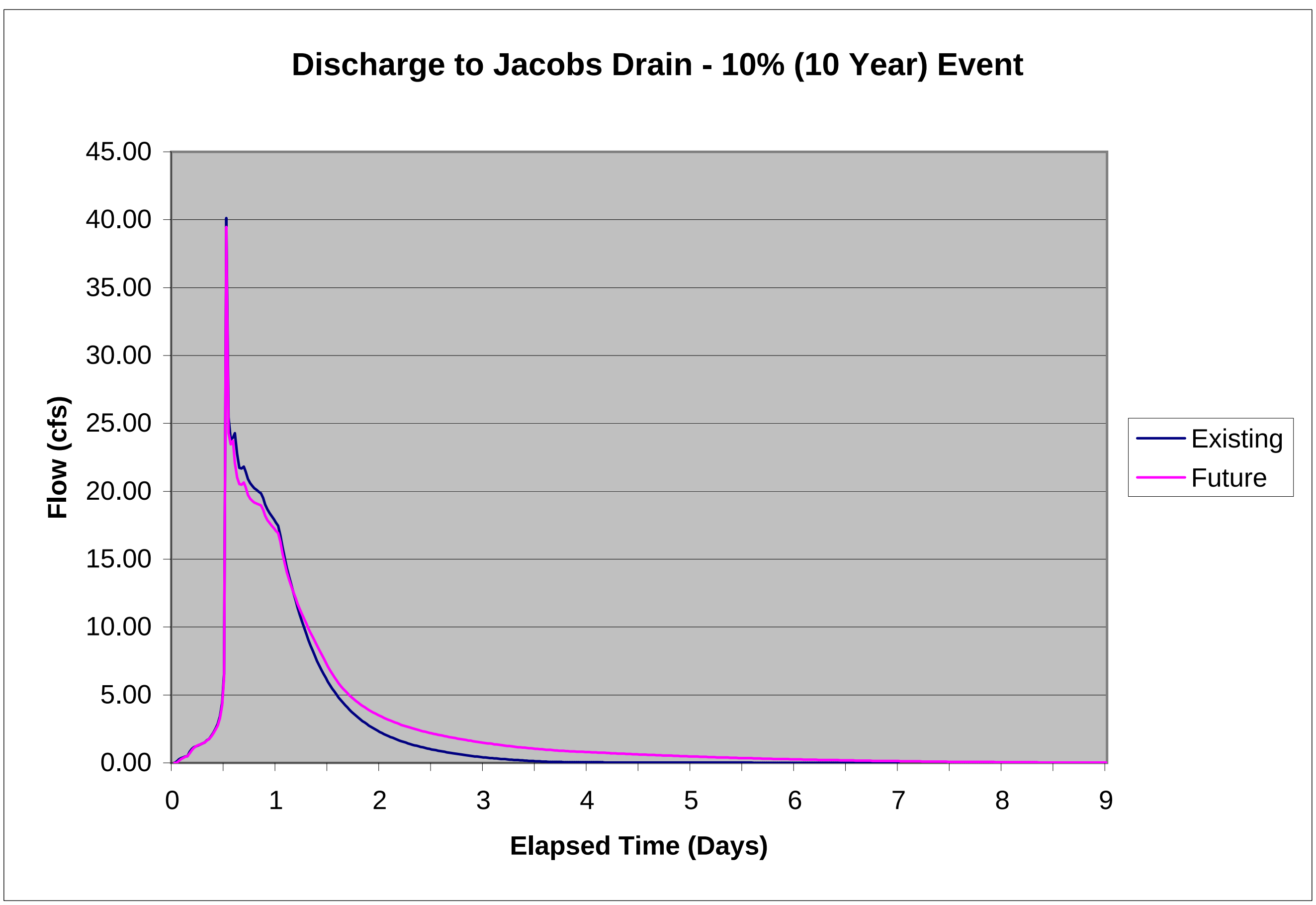
Discharge to Curry Drain - 4% (25 Year) Event

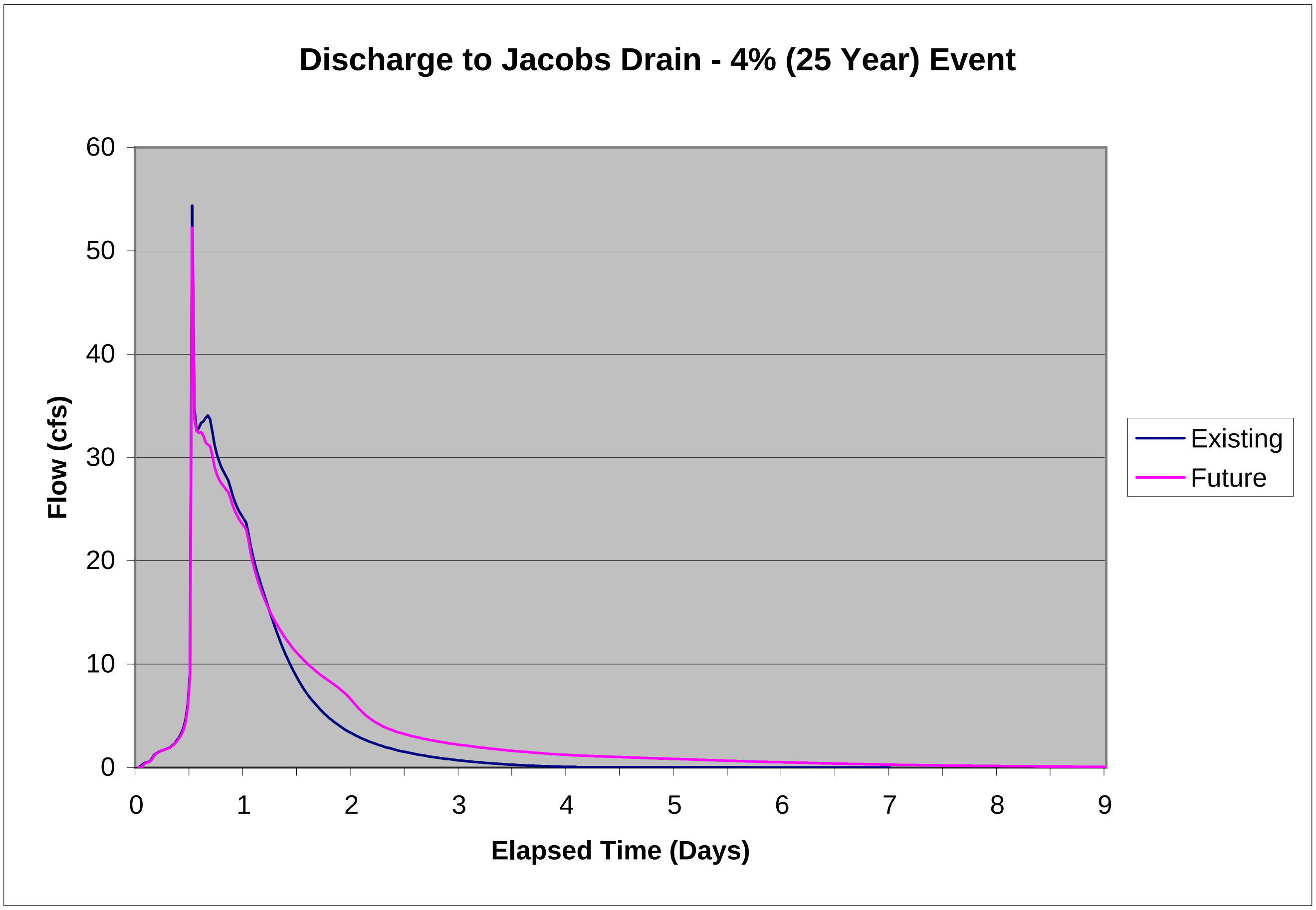


Discharge to Curry Drain - 1% (100 Year) Event

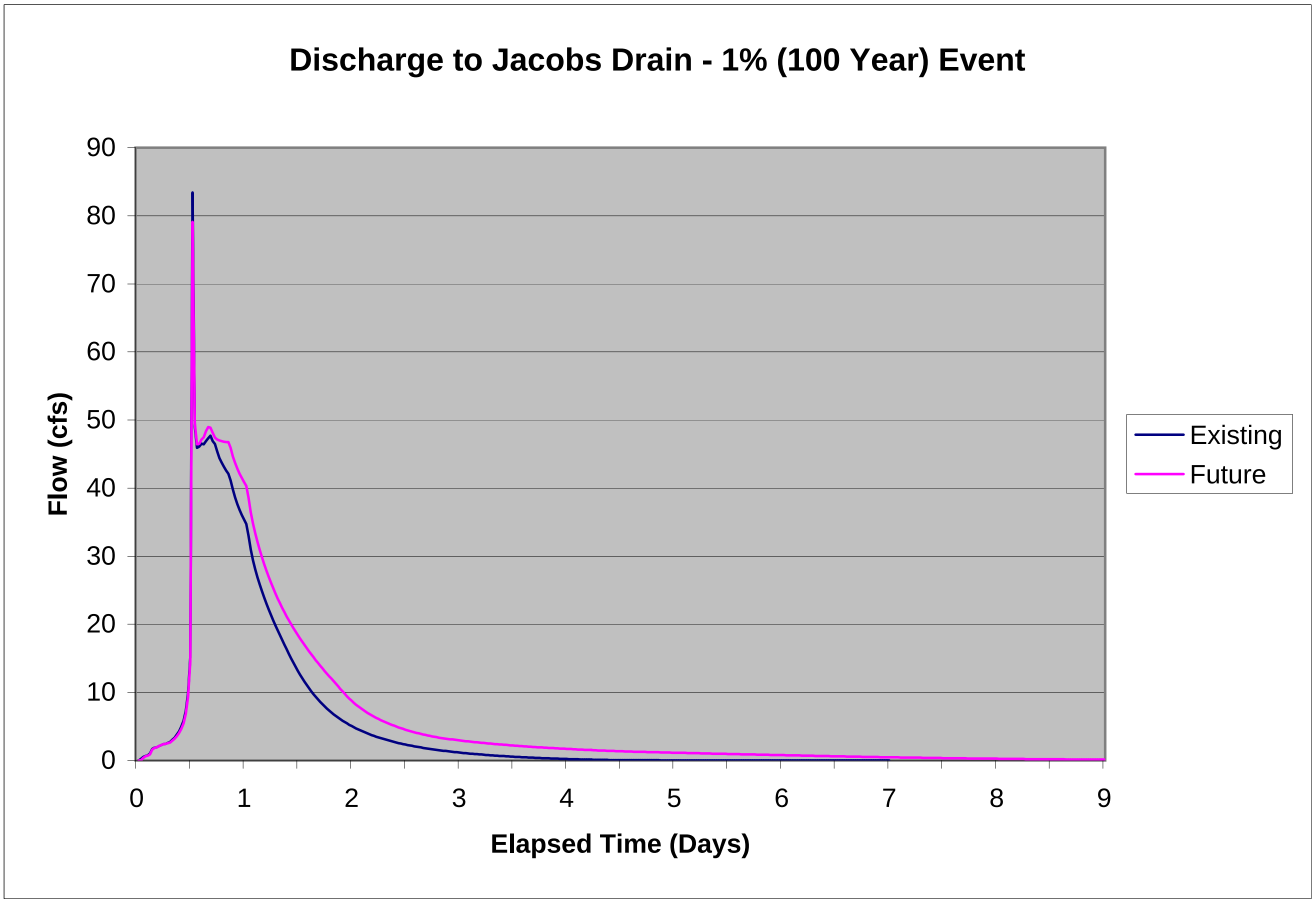



Discharge to Jacobs Drain - 50% (2 Year) Event
Flow (cfs)
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future


Discharge to Jacobs Drain - 10% (10 Year) Event
Flow (cfs)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

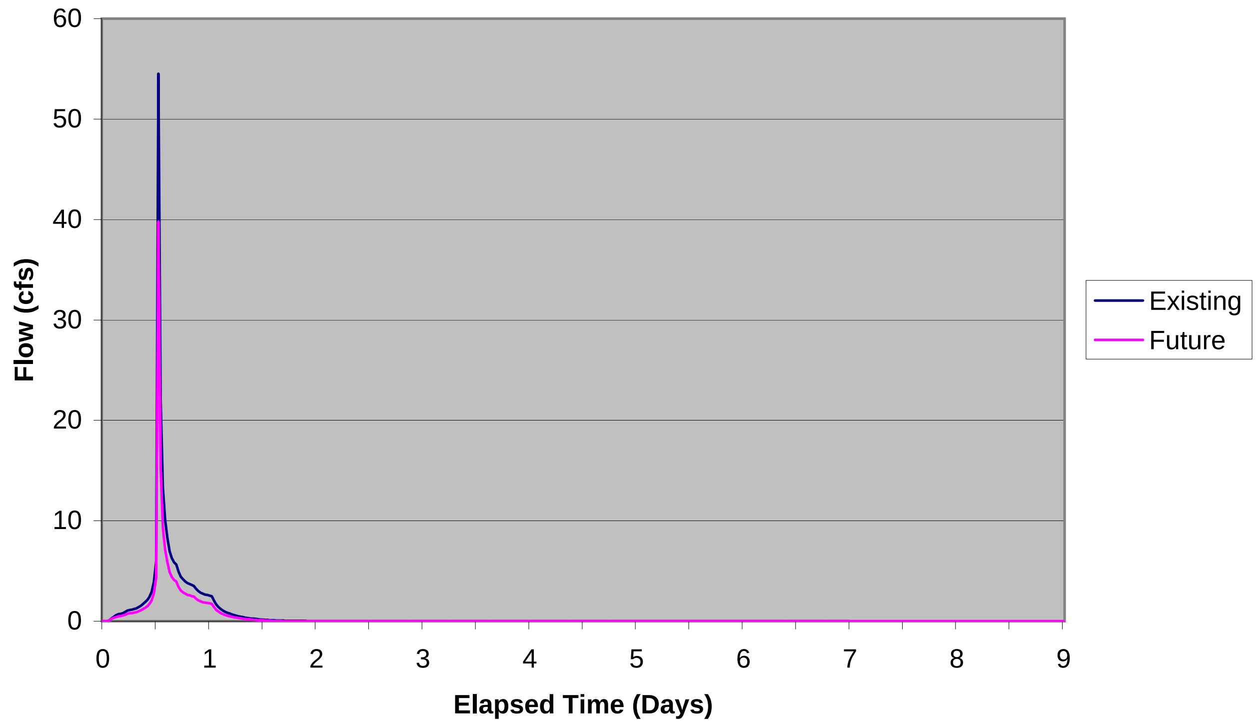


Discharge to Jacobs Drain - 4% (25 Year) Event
Flow (cfs)
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

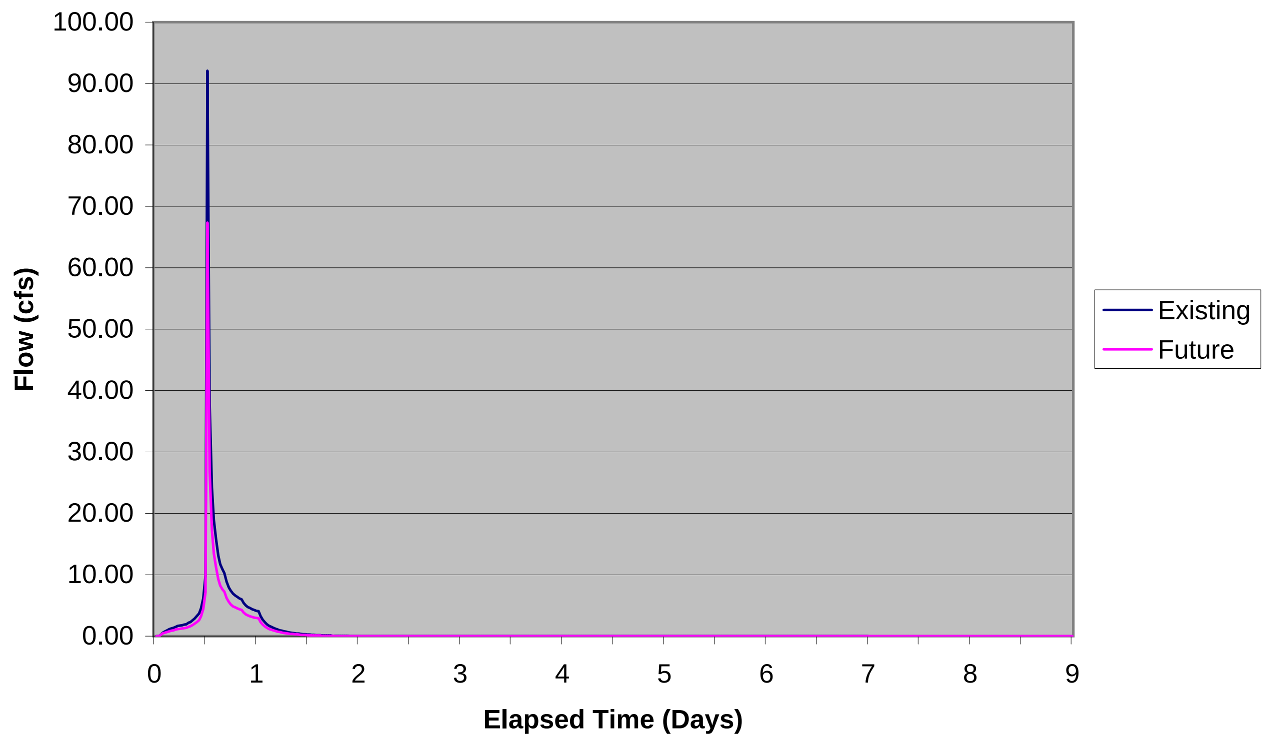


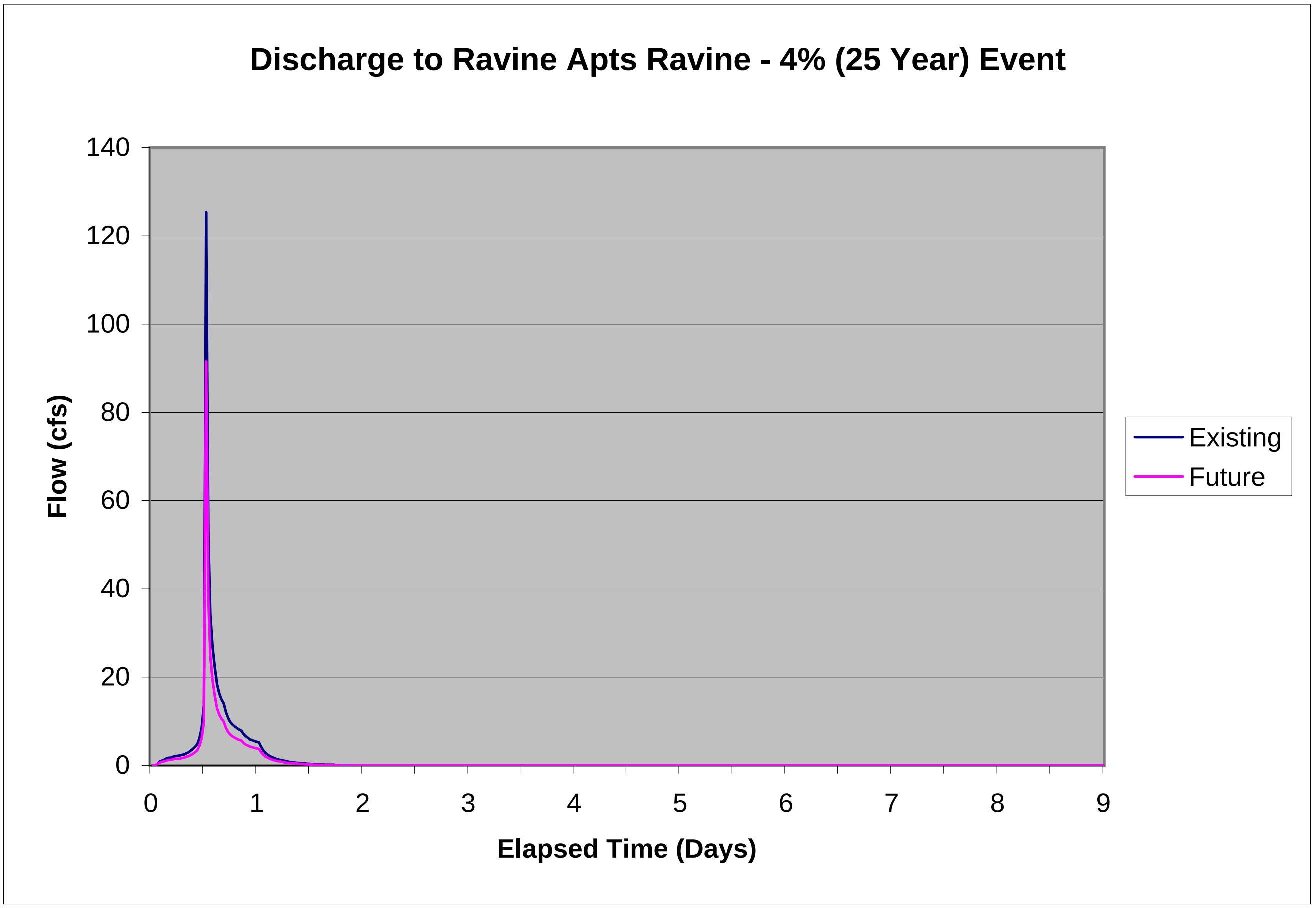
Discharge to Jacobs Drain - 1% (100 Year) Event
Flow (cfs)
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

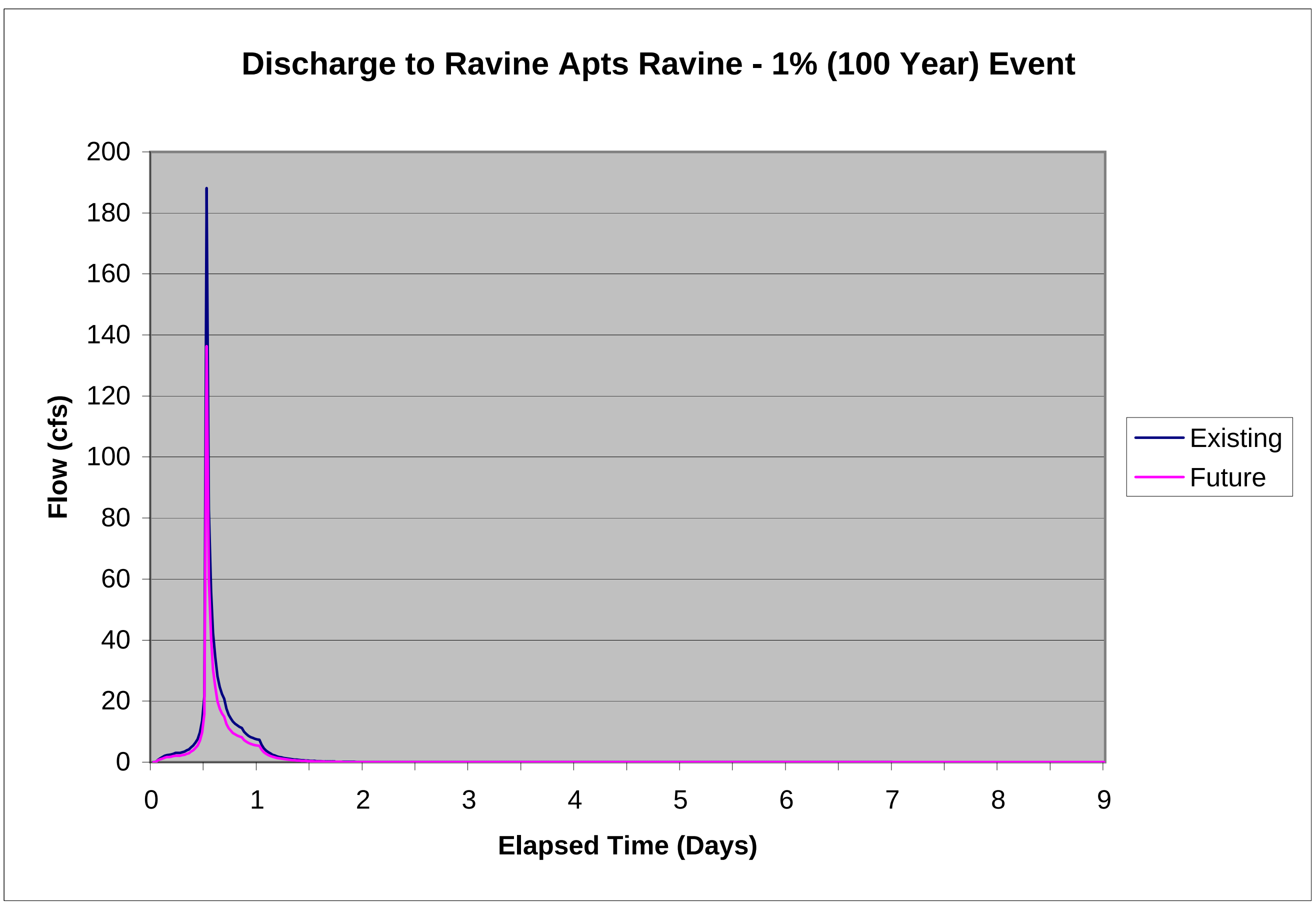
Discharge to Ravine Apts Ravine - 50% (2 Year) Event



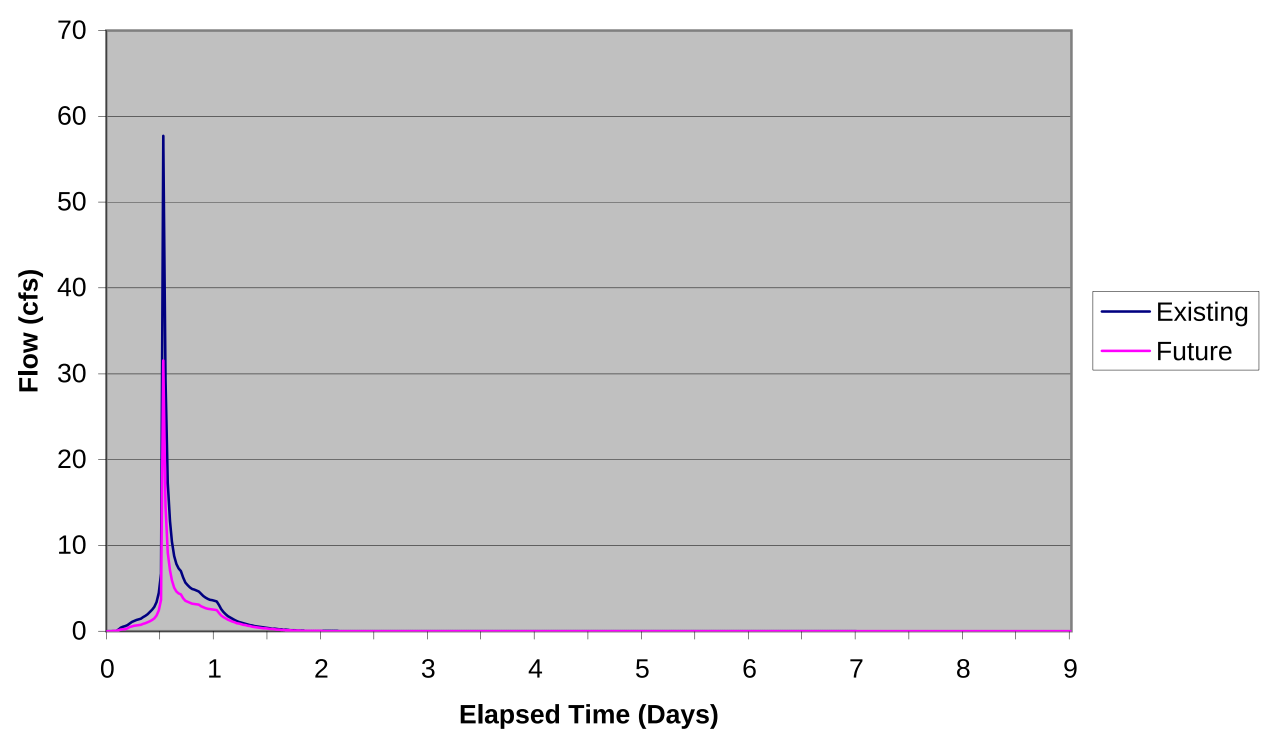
Discharge to Ravine Apts Ravine - 10% (10 Year) Event



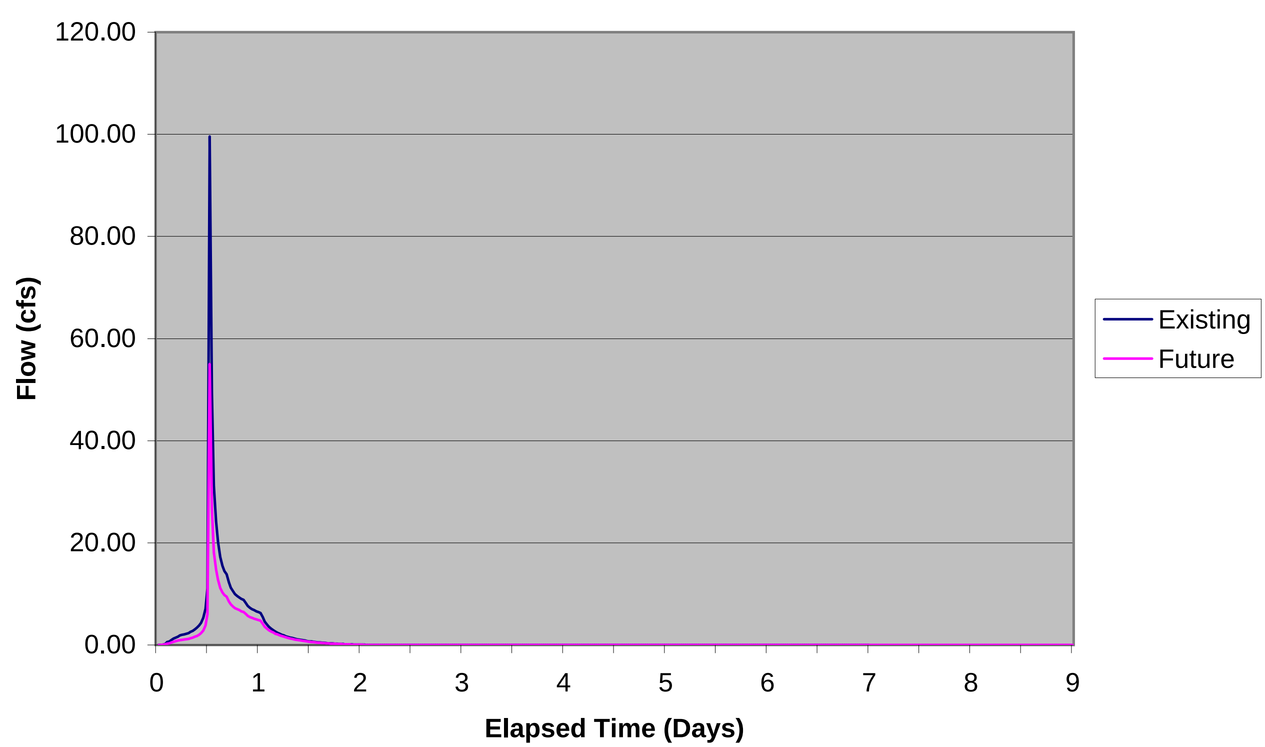

Discharge to Ravine Apts Ravine - 4% (25 Year) Event
Flow (cfs)
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

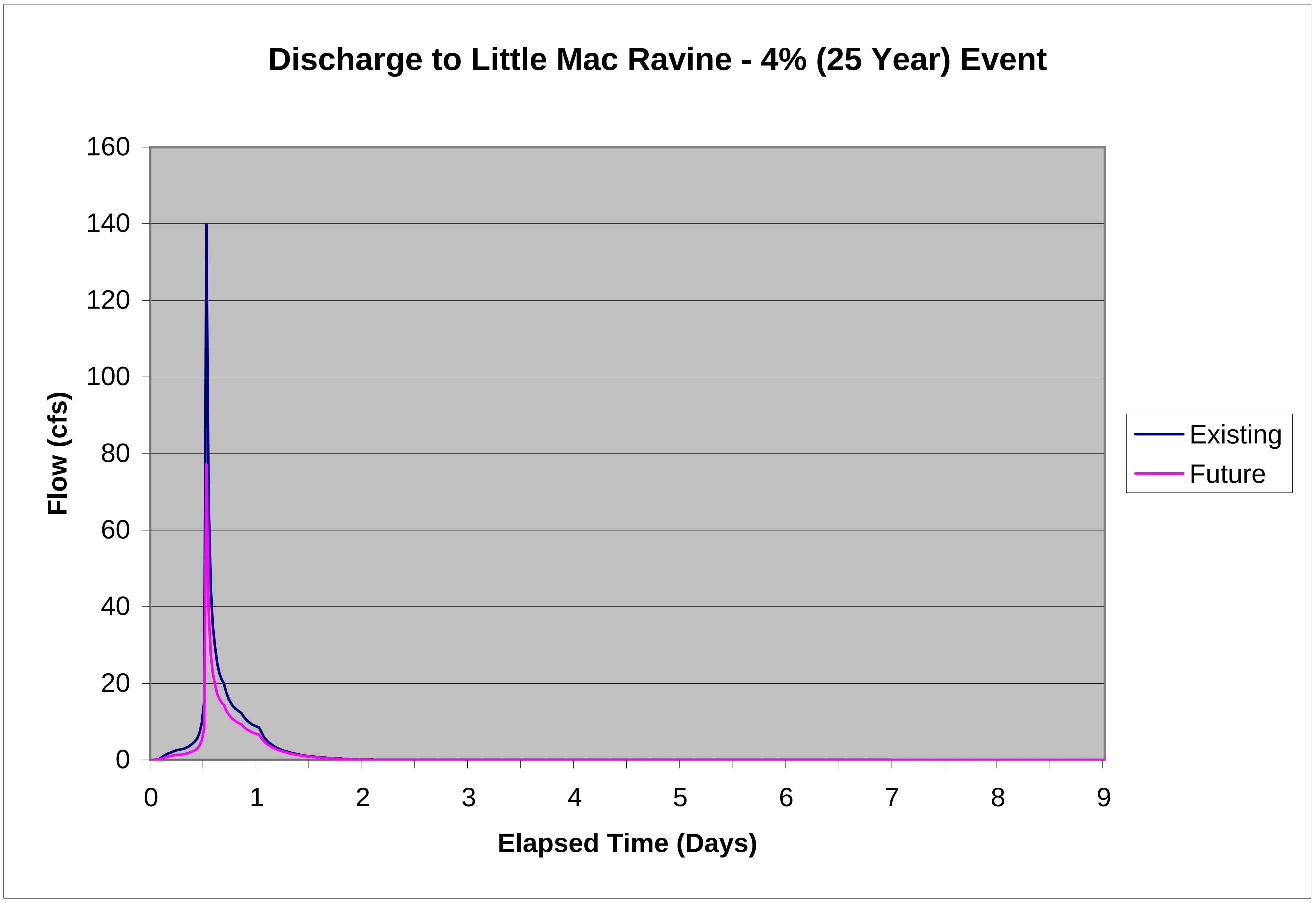

Discharge to Ravine Apts Ravine - 1% (100 Year) Event
Flow (cfs)
200
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

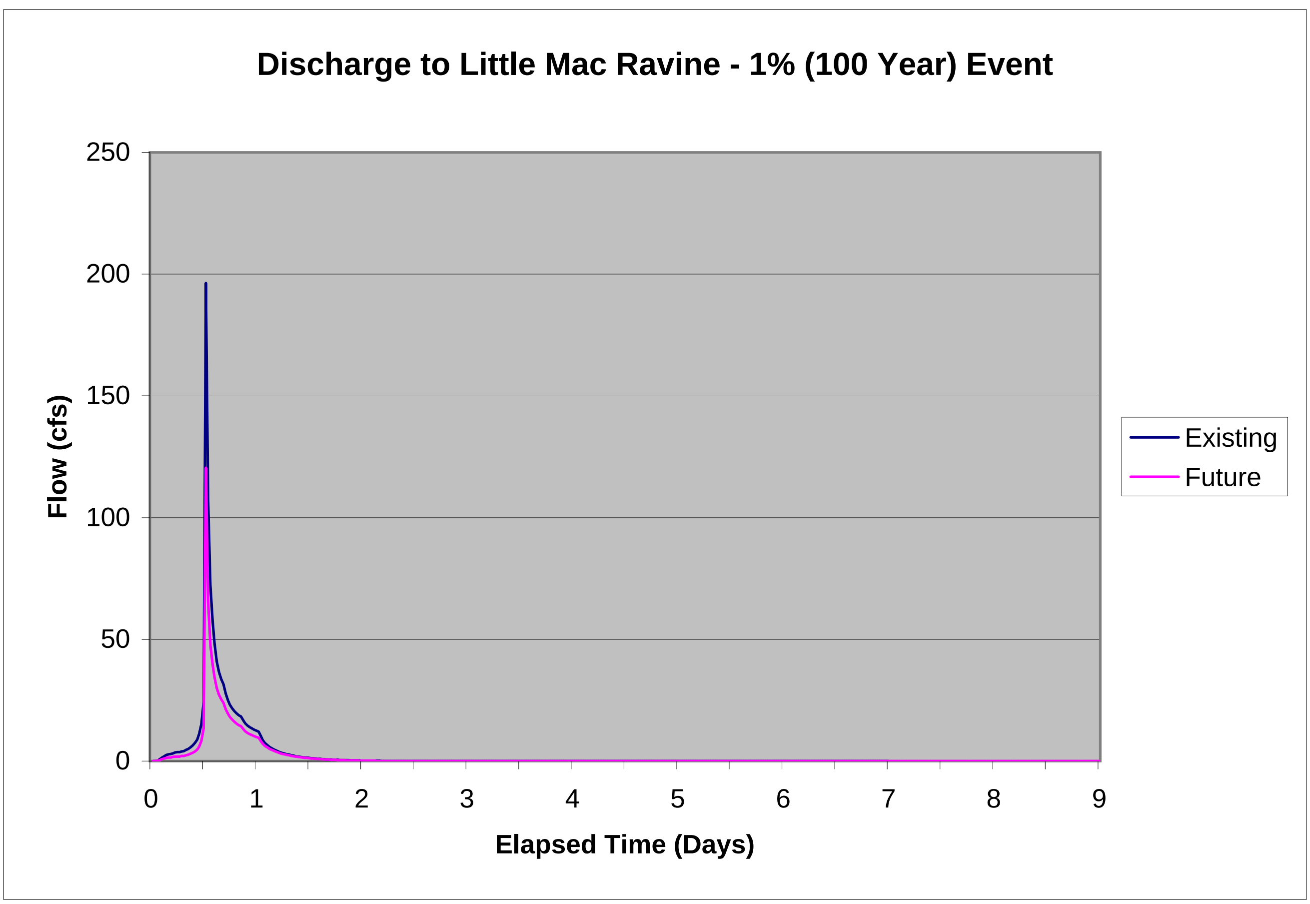
Discharge to Little Mac Ravine - 50% (2 Year) Event

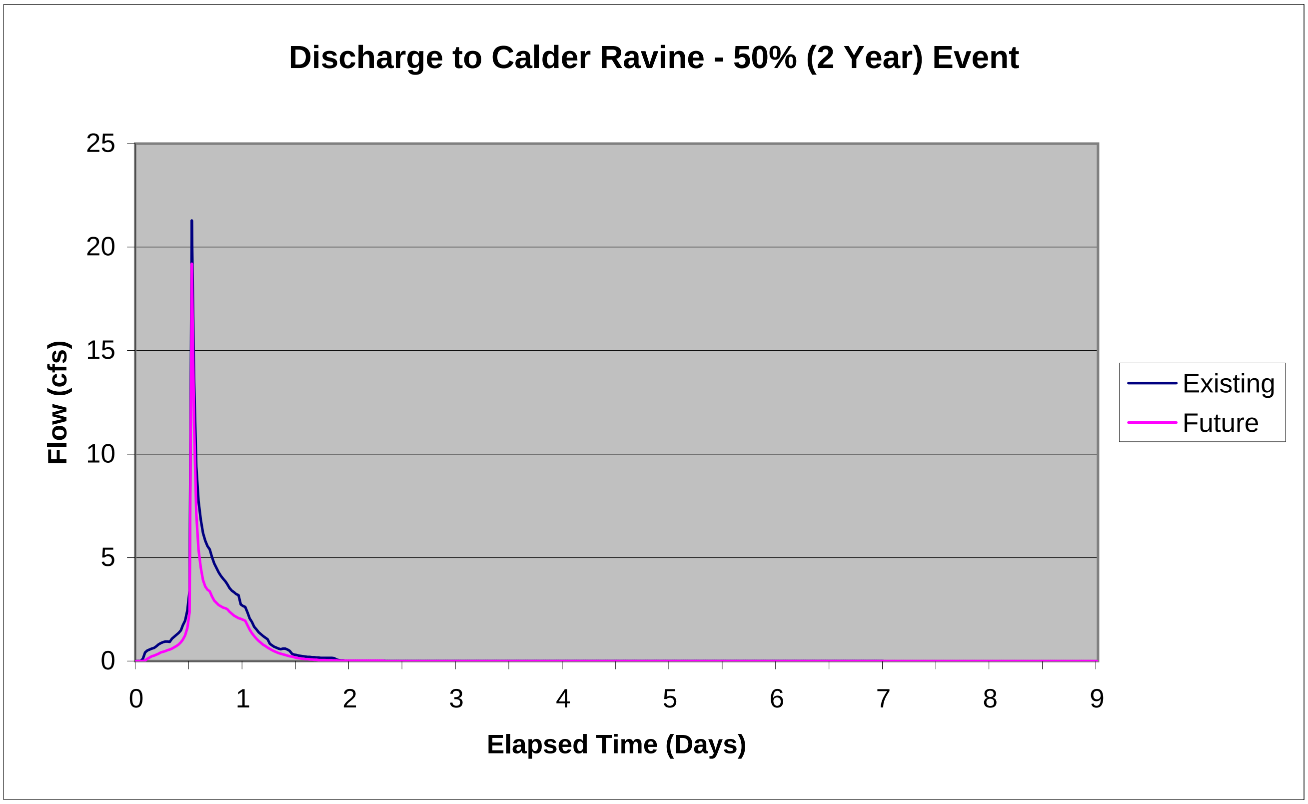


Discharge to Little Mac Ravine - 10% (10 Year) Event

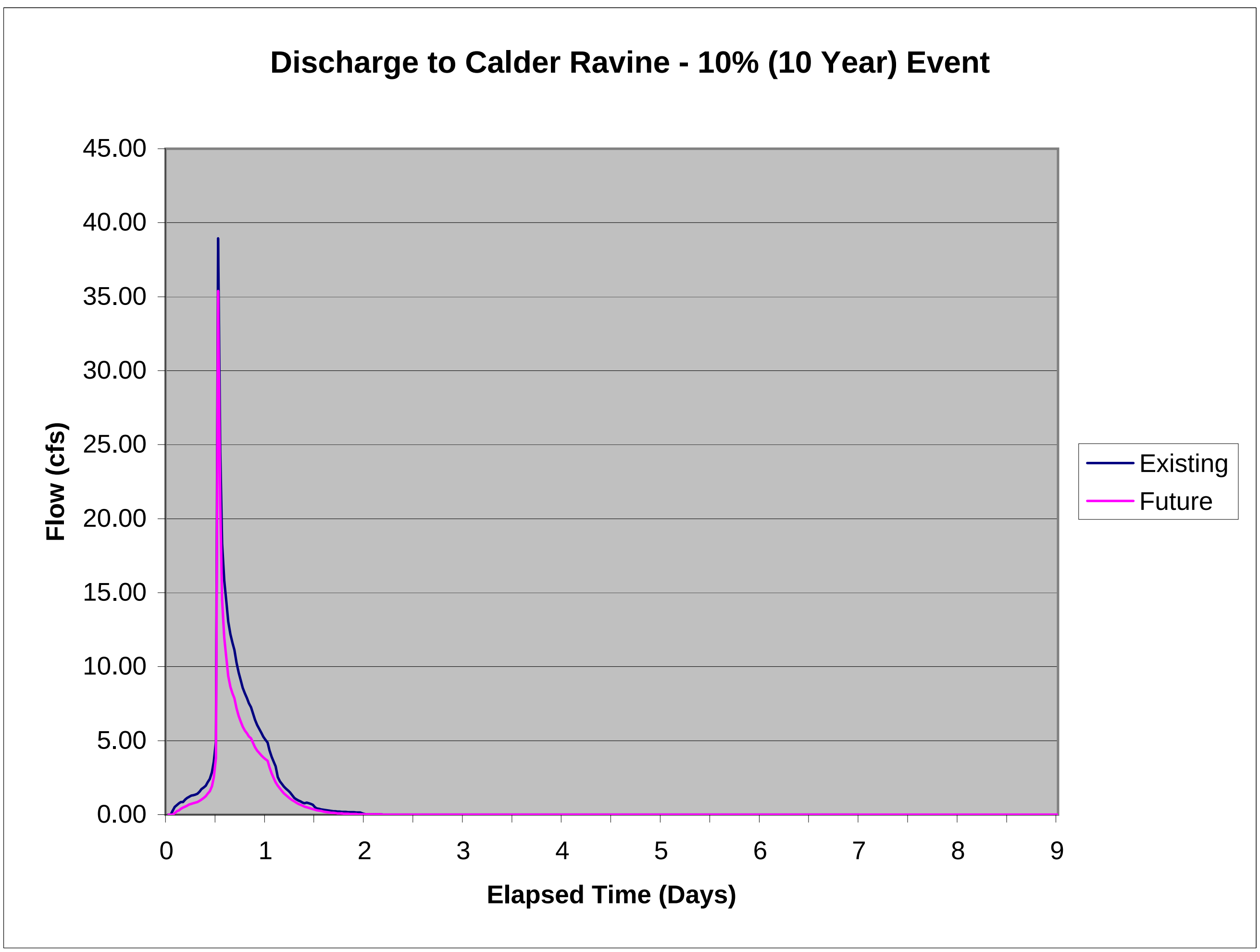



Discharge to Little Mac Ravine - 4% (25 Year) Event
160
140
120
100
80
60
40
20
0
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

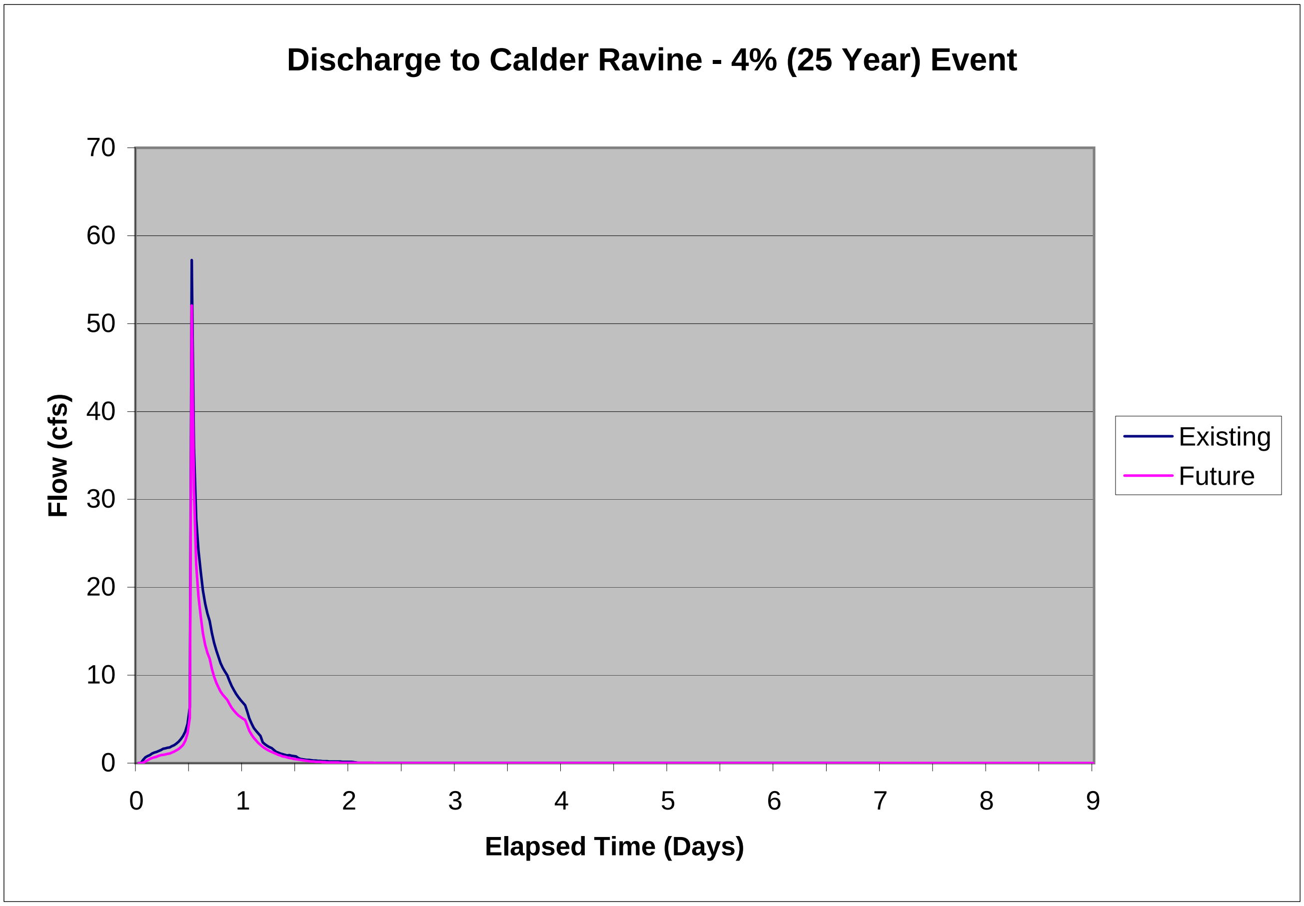

Discharge to Little Mac Ravine - 1% (100 Year) Event
250
200
150
100
50
0
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

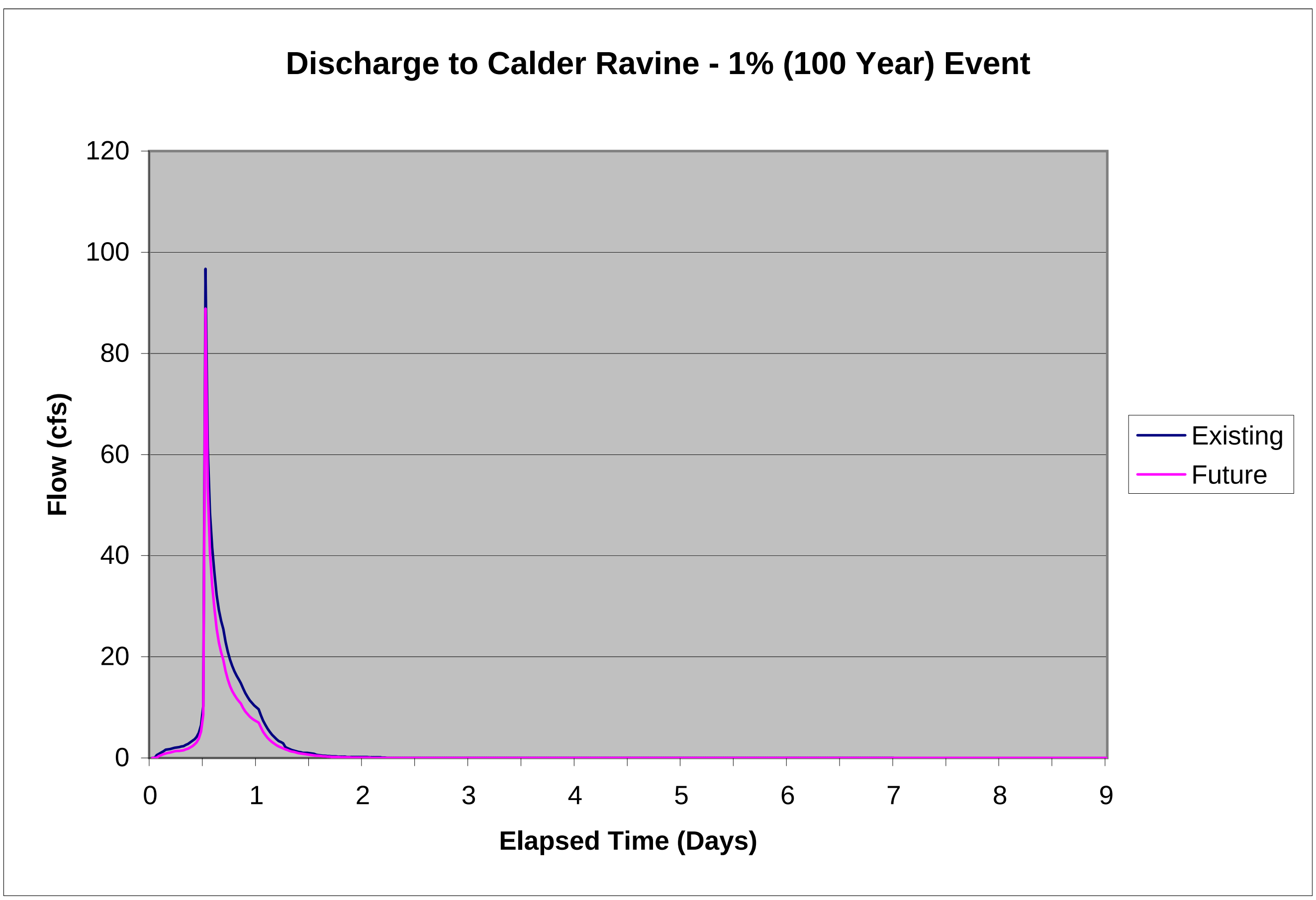


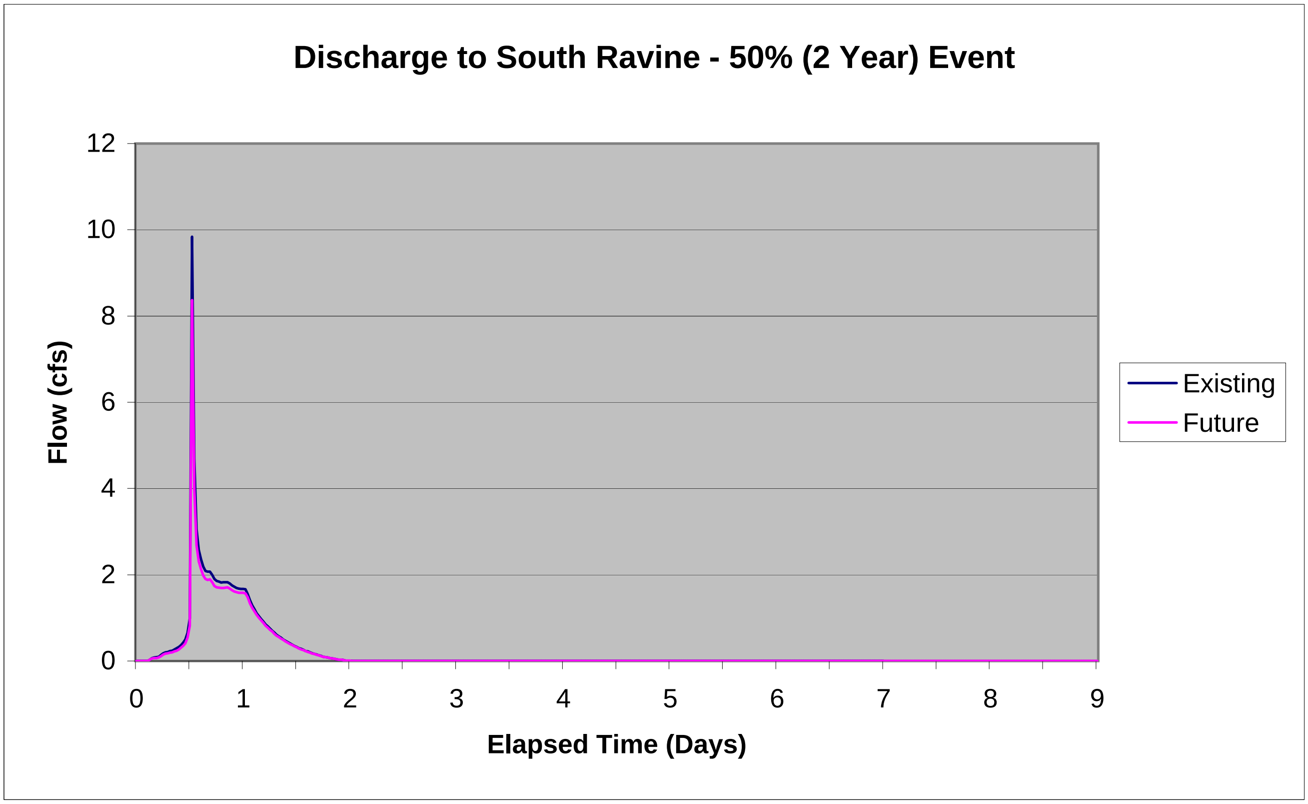
Discharge to Calder Ravine - 50% (2 Year) Event
Flow (cfs)
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future



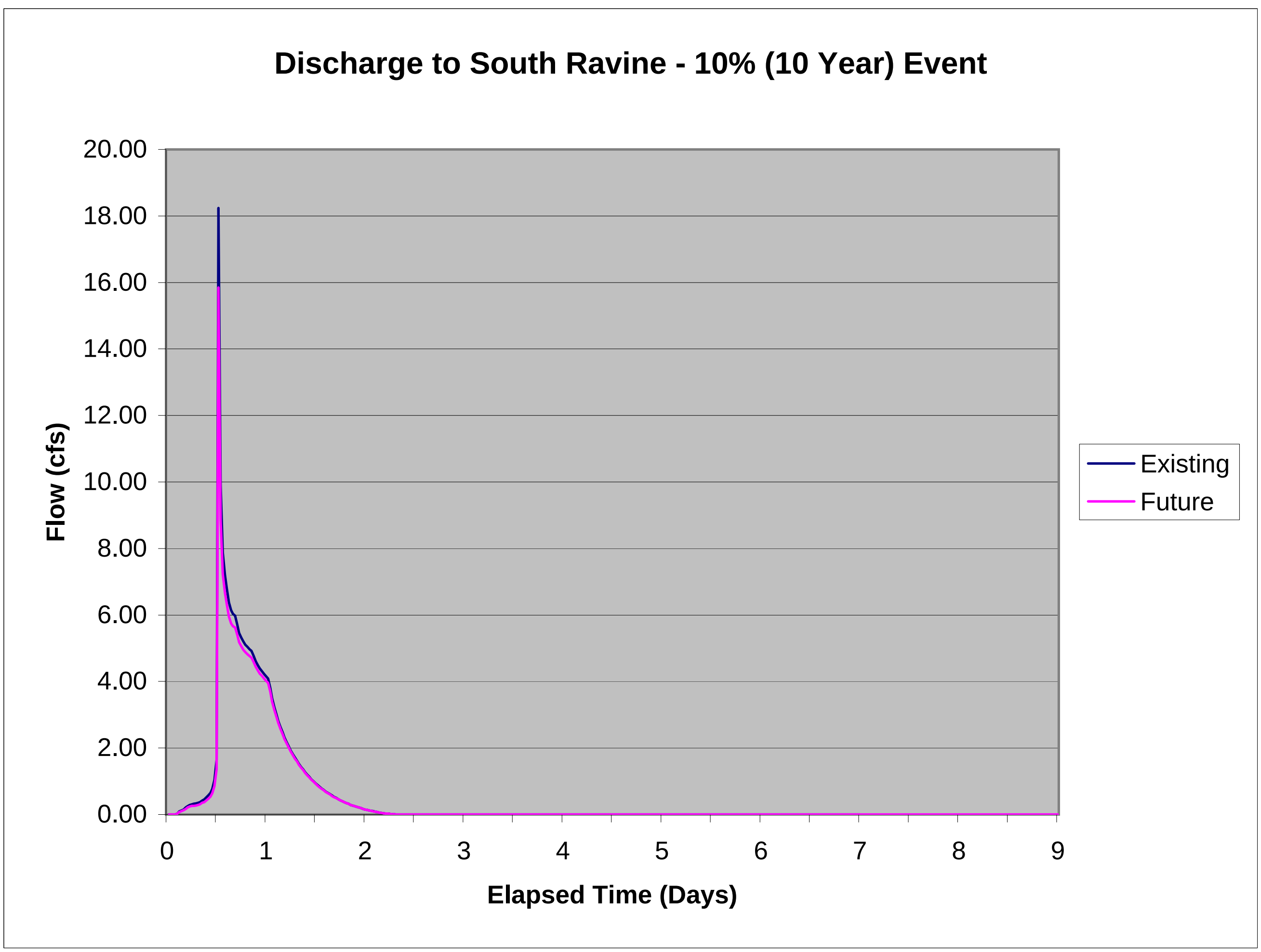
Discharge to Calder Ravine - 10% (10 Year) Event
Flow (cfs)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future


Discharge to Calder Ravine - 4% (25 Year) Event
Flow (cfs)
0
10
20
30
40
50
60
70
Elapsed Time (Days)
0
1
2
3
4
5
6
7
8
9
Existing
Future

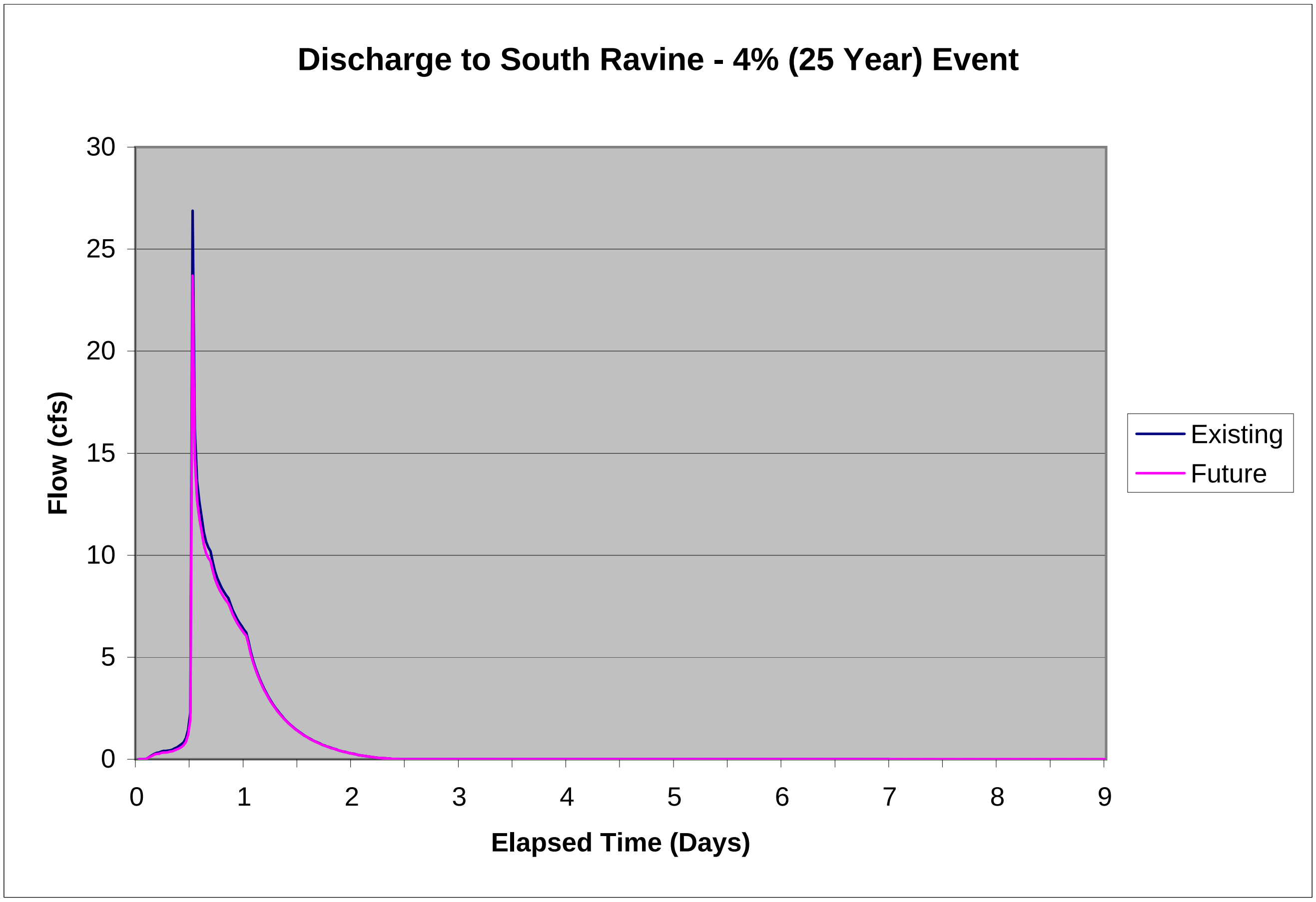

Discharge to Calder Ravine - 1% (100 Year) Event
Flow (cfs)
0
20
40
60
80
100
120
Elapsed Time (Days)
0
1
2
3
4
5
6
7
8
9
Existing
Future

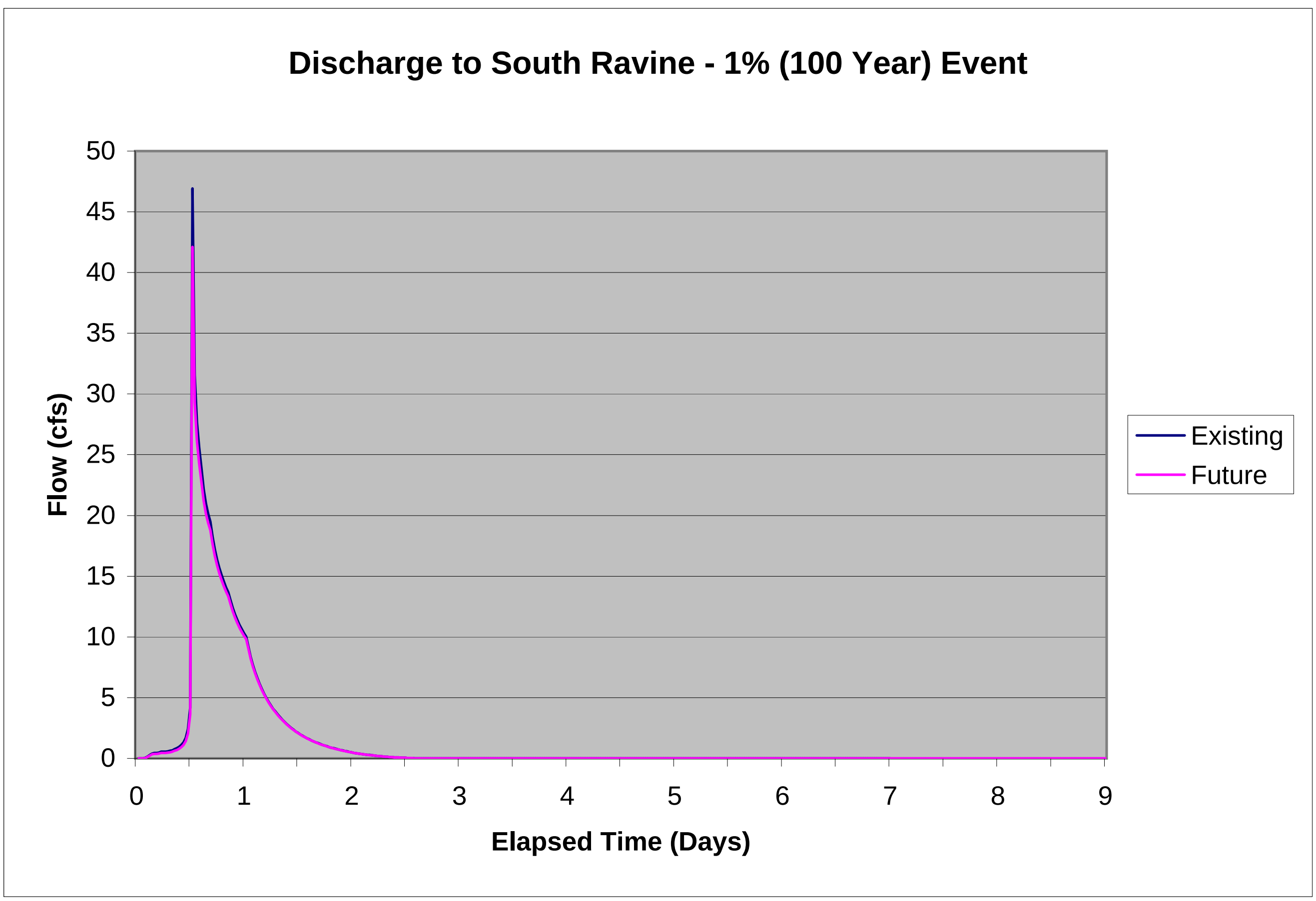


Discharge to South Ravine - 50% (2 Year) Event
12
10
8
6
4
2
0
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

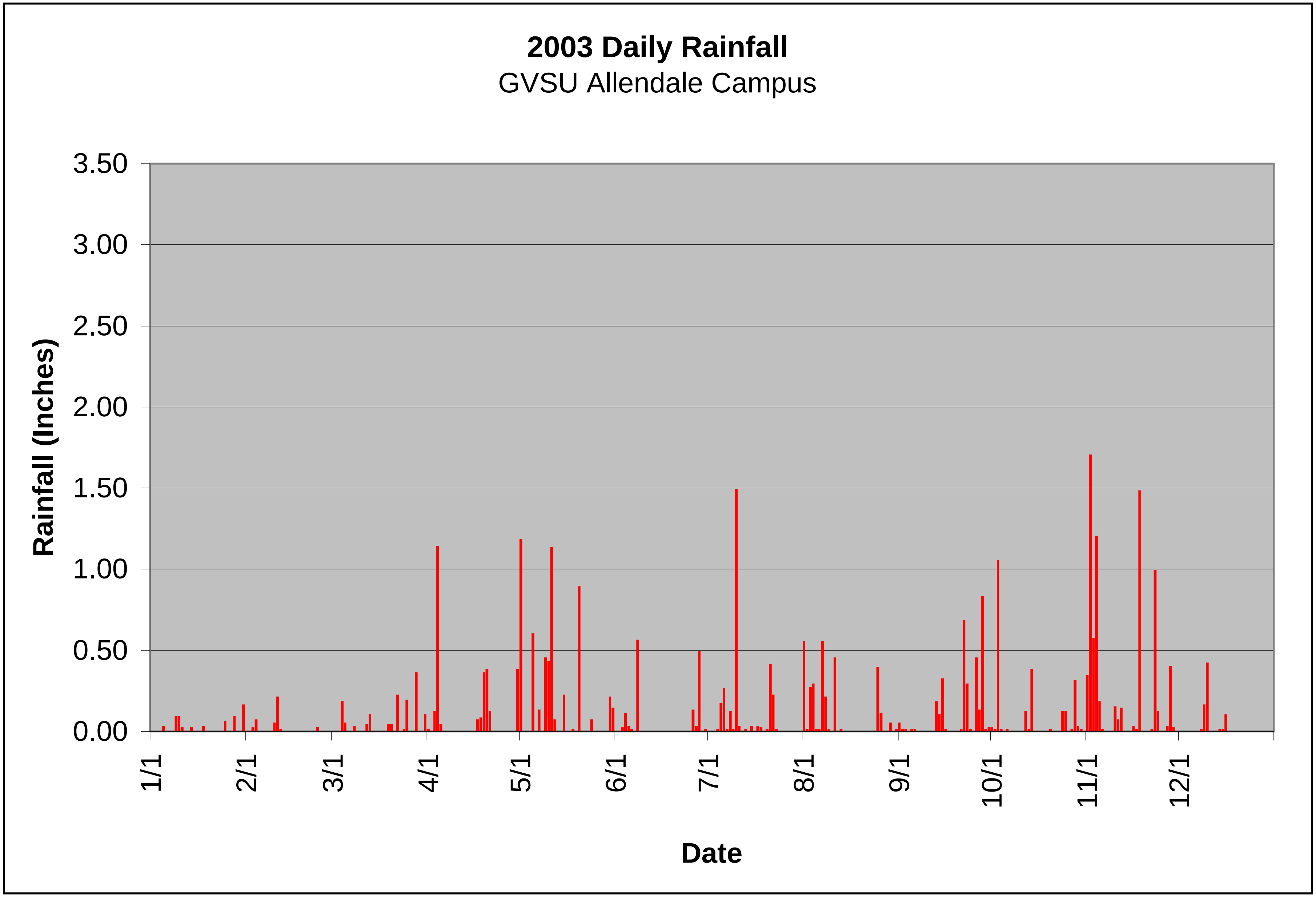


Discharge to South Ravine - 10% (10 Year) Event
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

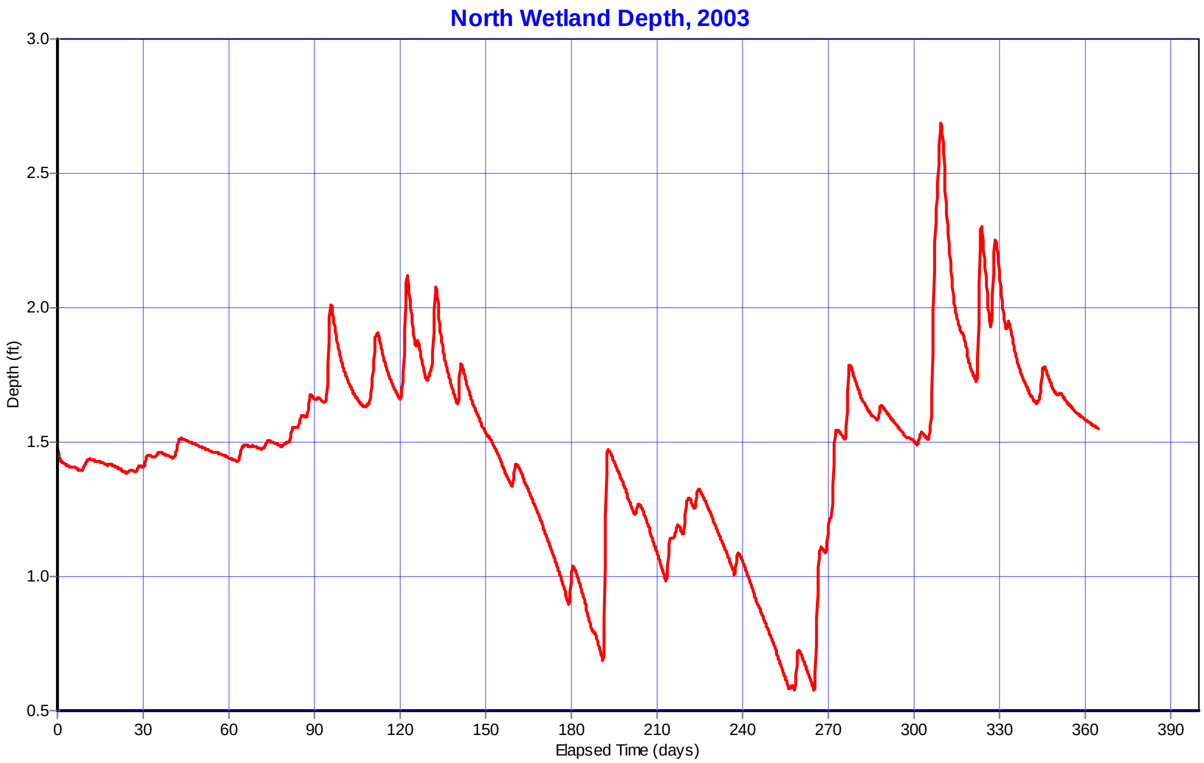

Discharge to South Ravine - 4% (25 Year) Event
Flow (cfs)
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future


Discharge to South Ravine - 1% (100 Year) Event
Flow (cfs)
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Elapsed Time (Days)
Existing
Future

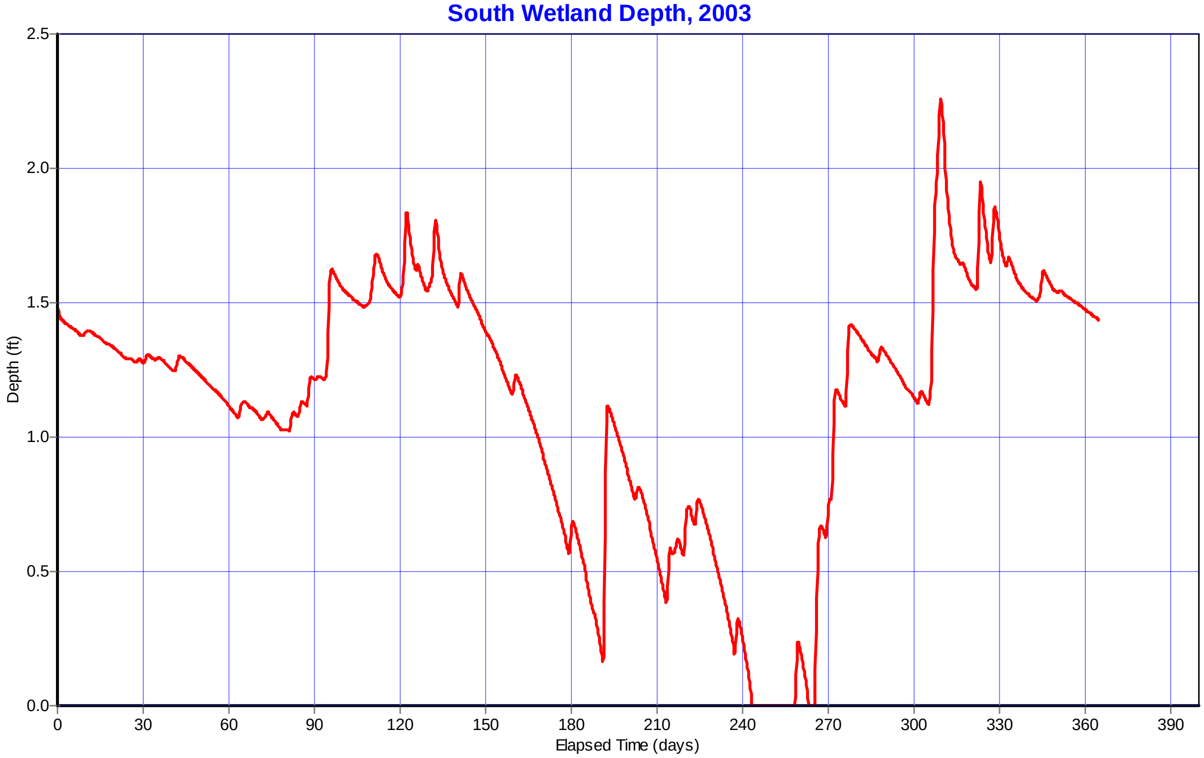
Appendix 3

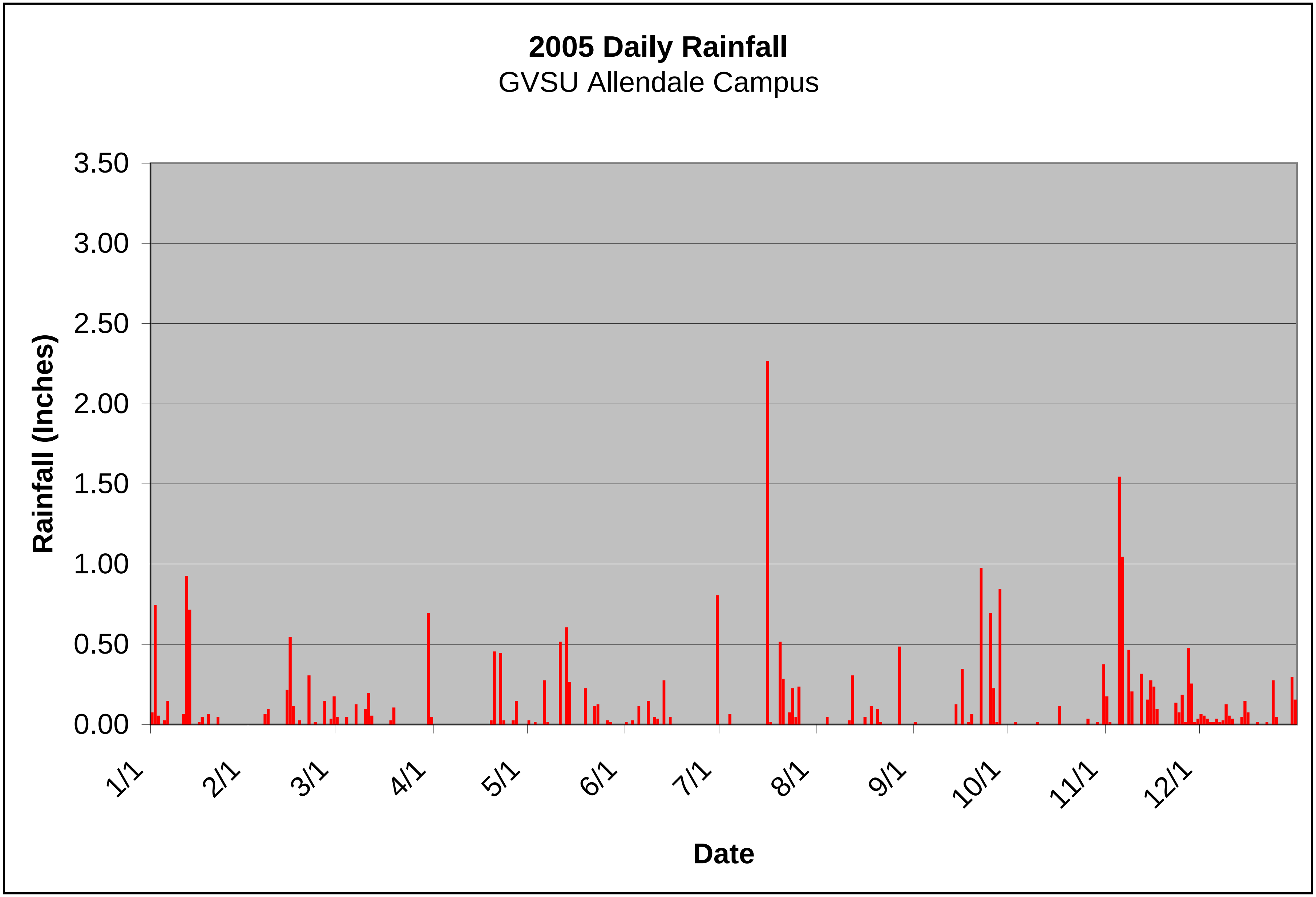

2003 Daily Rainfall
GVSU Allendale Campus
Rainfall (Inches)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Date

Grand Valley State University

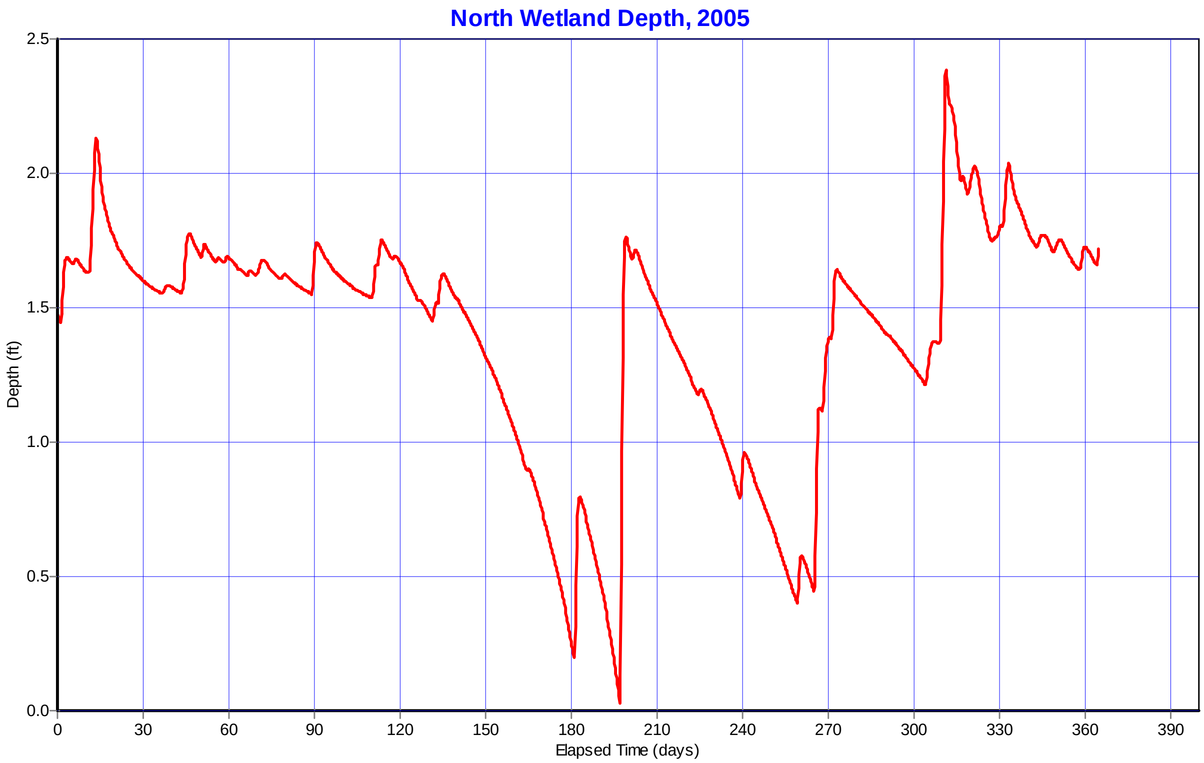


Grand Valley State University

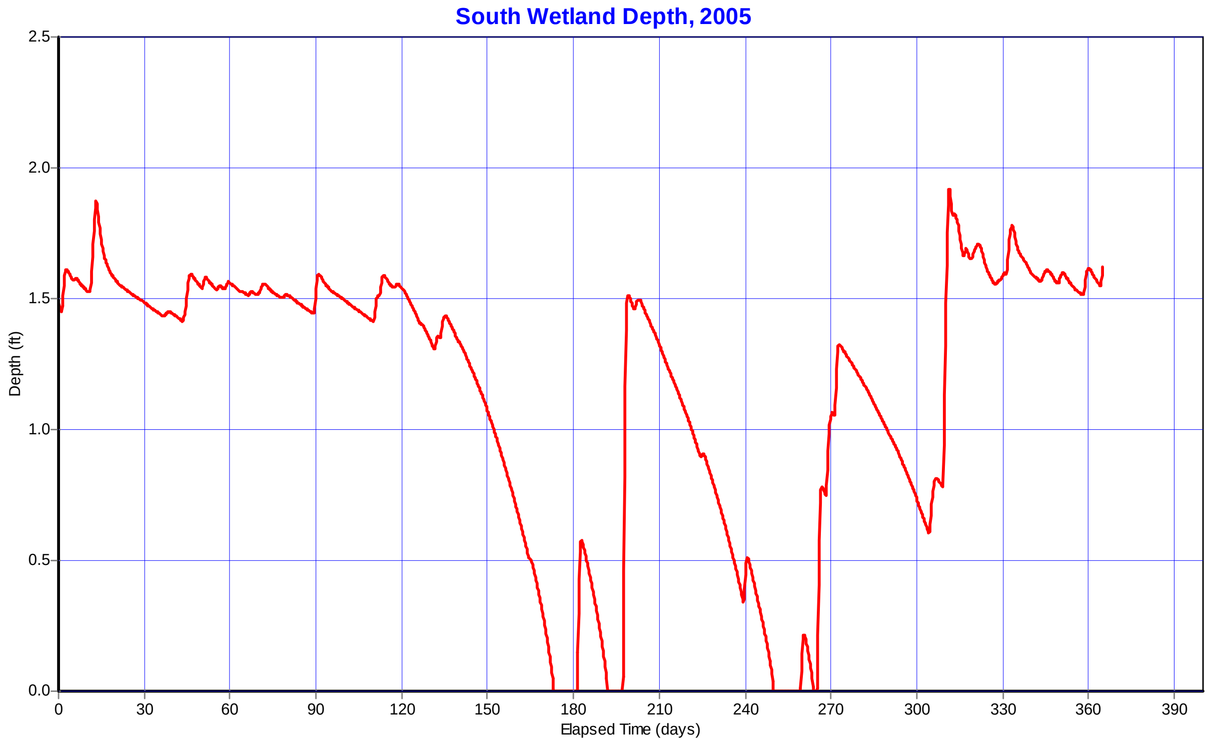


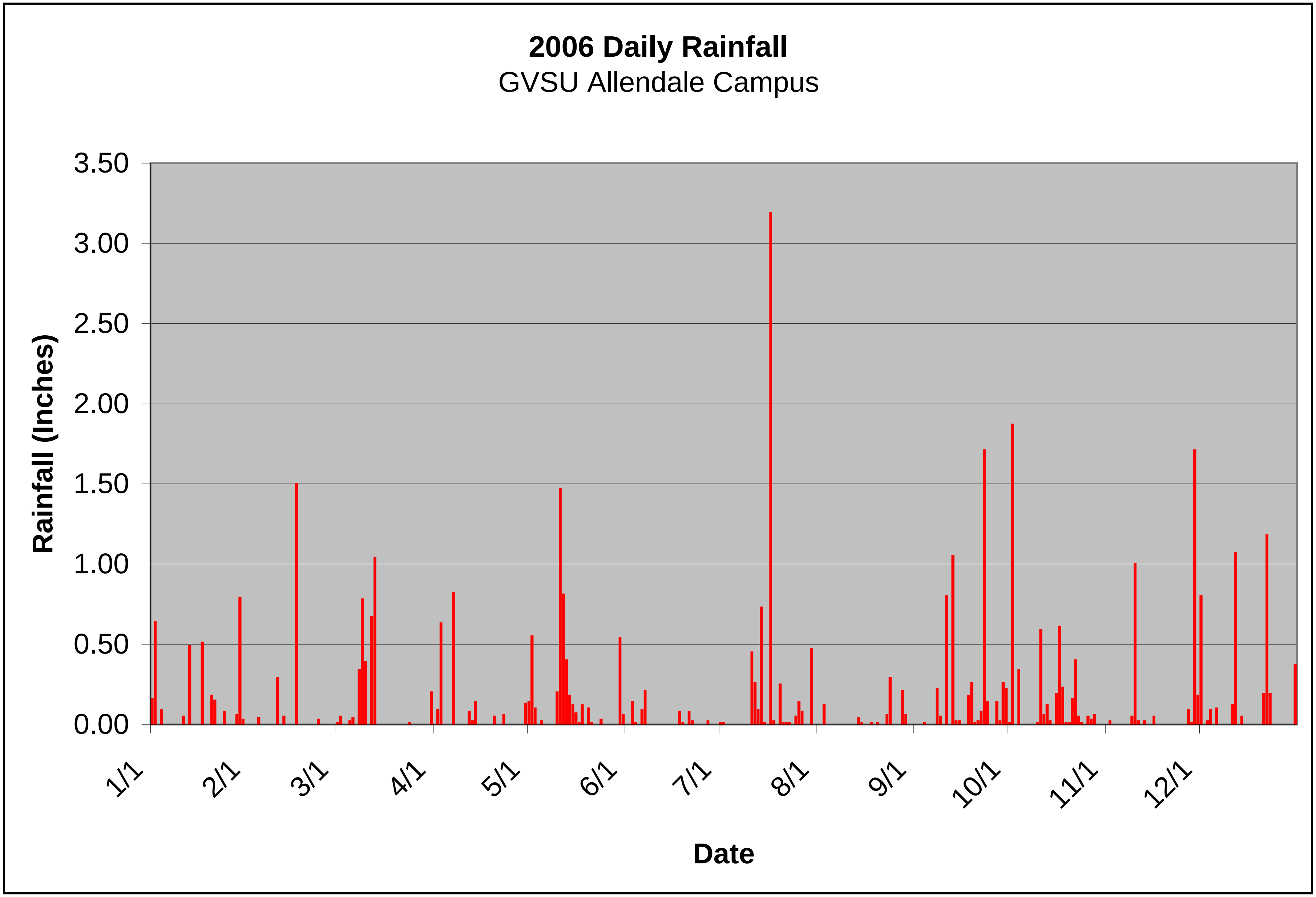

2005 Daily Rainfall
GVSU Allendale Campus
Rainfall (Inches)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Date

Grand Valley State University

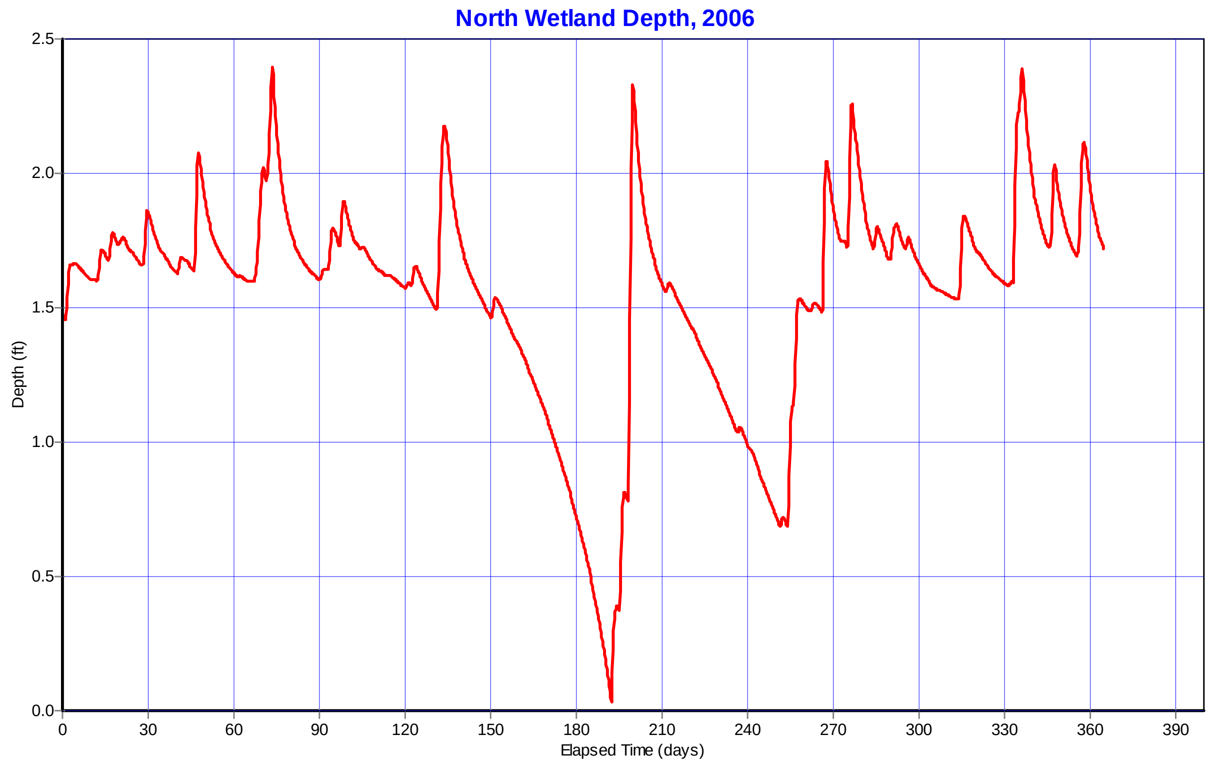


Grand Valley State University




2006 Daily Rainfall
GVSU Allendale Campus
Rainfall (Inches)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Date

Grand Valley State University



Grand Valley State University