LAMP
RYNEARSON

9001 State Line Rd., Ste. 200
Kansas City, MO 64114
[P] 816.361.0440
[F] 816.361.0045
LampRynearson.com

Leaving a **Legacy**

Stormwater Preliminary Engineering Study

Raintree Lake Property Owners Association

City of Lee's Summit, Counties of Jackson and Cass, State of Missouri

Prepared for:

Raintree Lake Property Owners Association
825 SW Raintree Dr
Lee's Summit, MO 64082

Project No. 0322116.01

Date: January 6, 2023 (DRAFT)
Revised Date: July 19, 2023 (FINAL)

Leaving a Legacy of Enduring Improvements to Our Communities
Lamp Rynearson Purpose Statement

Engineer's Certification

I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Missouri.

Amy S. Bunnell

Amy S. Bunnell

2023-07-19

Date

SEAL

TABLE OF CONTENTS

SECTION 1.0 - INTRODUCTION 1

SECTION 2.0 - STUDY AREAS 1

2.1 BREEZY POINT 1
2.1.1 Existing Conditions 1
2.1.2 Alternative No. 1 2
2.1.3 Alternative No. 2 3
2.2 MARLINE/PENDANT/ROYALE 4
2.2.1 Existing Conditions 4
2.2.2 Alternative No. 1 5
2.2.3 Alternative No. 2 6
2.2.4 Alternative No. 3 (and French Drain) 7
2.3 RAINTREE PKWY TO SANDPIPER 9
2.3.1 Existing Conditions 9
2.3.2 Alternative No. 1 10
2.3.3 Alternative No. 2 11
2.4 SUNSET COVE 11
2.4.1 Existing Conditions 11
2.4.2 Alternative No. 1 12
2.4.3 Alternative No. 2 13
2.4.4 Assessments of Other Alternatives 14
2.5 WINDEMERE TO HIDDEN COVE 14
2.5.1 Existing Conditions 14
2.5.2 Alternative No. 1 14
2.5.3 Alternative No. 2 15

SECTION 3.0 - RECOMMENDATIONS 16

3.1 BREEZY POINT 16
3.2 MARLINE/PENDANT/ROYALE 16
3.3 RAINTREE PARKWAY TO SANDPIPER 17
3.4 SUNSET COVE 17
3.5 WINDEMERE 18
3.6 SUMMARY 18

LIST OF TABLES

Table 1. Breezy Point Hydrology 2
Table 2. Marline/Pendant/Royale Hydrology 4
Table 3. Raintree Pkwy to Sandpiper Hydrology 9
Table 4. Windemere to Hidden Cove Hydrology 14
Table 5. Summary of Recommendations by Priority 18

APPENDICES

Appendix A – Maps
Appendix B – Breezy Point
Appendix C – Marline/Pendant/Royale
Appendix D – Raintree Pkwy to Sandpiper
Appendix E – Sunset Cove
Appendix F – Windemere to Hidden Cove
Appendix G – Correspondence

SECTION 1.0 - INTRODUCTION

This preliminary engineering study identifies the existing stormwater issues, evaluates alternatives to correct these problems, and recommends improvements within the project limits.

Five locations were identified by the RLPOA as problem areas for stormwater within the neighborhood:

1. Breezy Point
2. Marline/Pendant/Royale
3. Raintree Pkwy to Sandpiper
4. Sunset Cove
5. Windemere to Hidden Cove.

The sites are located within the City of Lee's Summit, Jackson and Cass Counties, Missouri, Sections 06 and 31, Township 47 North, Range 31 West. An overall location map is shown in Appendix A.

A site visit was conducted on July 14, 2022, to take photographs at each of the locations and discuss the specific problems and concerns with the RLPOA management.

Design parameters for this study are based on Kansas City Metropolitan Chapter, American Public Works Association, Section 5600, Storm Drainage Systems & Facilities (2011), as well as Lee's Summit, Missouri's, supplement to Section 5600 (2020). Limited topographic survey of the five locations was completed in September and October 2022 and used in conjunction with Geographic Information System (GIS) data to perform a hydrologic and hydraulic investigation. A soils map showing hydrologic soil group designations within each of the watersheds can be found in Appendix A. Floodplain Maps can also be viewed in Appendix A.

A draft version of the study was provided to the RLPOA management on January 6, 2023. Appendix G includes questions provided by the Board at that time and subsequent responses from Lamp Rynearson.

SECTION 2.0 - STUDY AREAS

2.1 Breezy Point

2.1.1 Existing Conditions

Description

The Breezy Point site is located west of SW Raintree Dr, between SW Averio Ln and SW Breezy Point Ln. A Site Map can be viewed in Appendix B. The issues that were noted during the site visit included:

- Siltation/aggradation at the upstream culvert outfall and the concrete-lined channel section immediately downstream of the outfall.
- A minor failure of the interlocking blocks that line the channel at the lateral culvert outfall located approximately 200 feet downstream of the above location.
- A major failure of the interlocking blocks that line the drainage channel from the lake edge upstream approximately 25 feet.

Select site photos can be viewed in Appendix B.

The siltation/aggradation at the upstream culvert outfall can be cleared by RLPOA maintenance staff down to the concrete lining in the bottom of the channel. Re-establish turf vegetation on any disturbed soil along the adjacent side slopes.

Hydrology

Hydrologic analyses were performed using SCS Technical Release No. 55 (TR-55) methods. Three sub-watersheds were analyzed to estimate peak discharges at key locations. Subshed A includes drainage to the lateral culvert, Subshed B includes drainage contributing to channel flows at the lateral culvert outfall, and Subshed C accounts for additional runoff to the channel downstream of the lateral culvert to the confluence with the lake. Land use in the watershed consists of single family residential with areas of open space; soils are classified as hydrologic soil group C. A summary of the hydrologic analyses can be found in the table below. A Drainage Map and supporting calculations can be viewed in Appendix B.

Table 1. Breezy Point Hydrology

Location	Area (ac)	CN	Tc (hr)	Q 50% (cfs)	Q 10% (cfs)	Q 1% (cfs)
Subshed A	4.68	82	0.100	13	24	39
Subshed B	3.78	87	0.185	11	19	30
Subshed C	3.47	77	0.145	7	14	25
Outlet	11.93			30	56	91

Hydraulics

Manning's equation was used to analyze channel hydraulics and estimate shear stress in the channel assuming no backwater from the lake. The lateral culvert was modeled in FHWA's HY-8 software to estimate shear stress at the outfall. The most erosive shear stresses are at the lateral culvert outfall (3.7 lb/ft^2) and in the steepest portion of the channel (3.8 lb/ft^2), which also has the highest discharges, at the downstream end near the lake. These locations coincide with the concrete block failure locations. Hydraulic calculations can be viewed in Appendix B.

Utilities and Easements

Limited survey was obtained for this site, and utilities and easements were not located or identified. It should be noted that no utility pedestals were present in the open area where the channel is located—pedestals are present close to the adjacent backyards in this area. The channel is within common area owned by the RLPOA.

2.1.2 Alternative No. 1

Description

Alternative No. 1 consists of incorporating a tied concrete block mat, Flexamat, for scour/erosion control at the downstream end of the channel. Flexamat protects for shear stresses at least up to 24 lb/ft^2, which is well above expected shear stresses at this location and allows for a factor of safety if wave or wake action has contributed to the failure of the existing concrete blocks. Flexamat allows vegetation to grow between the blocks and can be easily maintained, as lawn mowers can travel over the surface. The optimal sized roll for this project would be 12 feet by 30 feet to be installed at the southern, downstream end of the channel. The northern location, at the lateral pipe outfall, would incorporate riprap to protect against scour. A conceptual plan showing the proposed layout can be found in Appendix B.

Roads & Traffic

The project location is not near any roads and should not have any effect on traffic other than for construction access to the site.

Utilities

With limited survey, utilities were not located in this area. Replacing the failing blocks in the channel with Flexamat will not require excavation, and replacing the failing blocks at the lateral culvert outfall with riprap will require minimal excavation, so if there are utilities in the area, conflicts are not anticipated.

Permits

A floodplain development permit will need to be obtained from the City of Lee's Summit for work in the floodplain to stabilize the downstream end of the channel. The improvements would be considered maintenance in nature and should not require other permits.

Easements

No easements are anticipated to be needed, since the channel and construction access from right-of-way are all within common area owned by RLPOA.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 1 is $18,118.00. A detailed cost estimate can be found in Appendix B.

2.1.3 Alternative No. 2

Description

Alternative No. 2 includes lining the southern, downstream end of the channel with riprap and placing a riprap apron at the lateral pipe outfall. The riprap will be placed where the current interlocking block channel lining has failed and will protect the channel from scour.

Roads & Traffic

The project location is not near any roads and should not have any effect on traffic other than for construction access to the site.

Utilities

Survey services did not locate any utilities in this area. Replacing the failing blocks with riprap will not require deep excavation, so if there are utilities in the area, there should not be any conflicts.

Permits

A floodplain development permit will need to be obtained from the City of Lee's Summit for work in the floodplain to stabilize the downstream channel. The improvements would be considered maintenance in nature and should not require other permits.

Easements

No easements are anticipated to be needed, since the channel and construction access from right-of-way are all within common area owned by RLPOA.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 2 is $18,712.00. A detailed cost estimate can be found in Appendix B.

2.2 Marline/Pendant/Royale

2.2.1 Existing Conditions

Description

The Marline/Pendant/Royale site is located south of SW Raintree Dr between SW Marline Dr, SW Pendant Dr, and SW Royale Ct. A Site Map can be viewed in Appendix C. The following items were noted during the site visit:

- There is a channel behind the homes on the east side of SW Marline Dr that appears stable at the upstream end but becomes unstable downstream, near the location of a rain garden that has failed. The RLPOA management requested that consideration be given to replacing the rain garden with a detention pond to reduce peak discharges downstream.
- There is a concrete flume for drainage behind the homes on the south side of SW Pendant Dr and the north side of SW Royale Ct. This flume has also been used by pedestrians as a sidewalk; however, the flume remains wet for prolonged periods of time in several locations and subsequently becomes slick due to algae growth—it is a pedestrian safety hazard and is not ADA compliant. There are voids and spalling present in the concrete flume at the upstream end, near the culvert outfall from SW Raintree Dr.
- The channel narrows and deepens downstream of the rain garden and where drainage from the Pendant/Royale flume joins the drainage from upstream. The channel runs across the 4080 SW Royale Ct backyard—they have a corner property line that extends to the east side of the sidewalk behind the SW Marline Dr homes; however, their fence line is offset just under 13 feet from the edge of this sidewalk. This is a pinch point for the channel. The downstream channel has been lined with small riprap, but the stones appear to be getting displaced, which suggests the riprap is undersized for channel flow conditions.
- The downstream channel eventually discharges to a concrete flume that drains to the lake—there were no issues noted at this concrete flume.

Select site photos can be viewed in Appendix C.

Hydrology

Hydrologic analyses were performed using TR-55 methods. Three sub-watersheds were analyzed to estimate peak discharges at key locations. Subshed A includes drainage upstream of the rain garden from north of SW Raintree Dr, the SW Marline Dr backyards, and the SW Pendant Dr cul-de-sac. Subshed B includes drainage to the Pendant/Royale concrete flume. Subshed C accounts for additional runoff to the channel downstream of the confluence of Subsheds A and B to the lake. Land use in the watershed consists of single family residential with areas of open space; soils are classified as hydrologic soil group C. A summary of the hydrologic analyses can be found in the table below. A Drainage Map and supporting calculations can be viewed in Appendix C.

Table 2. Marline/Pendant/Royale Hydrology

Location	Area (ac)	CN	Tc (hr)	Q 50% (cfs)	Q 10% (cfs)	Q 1% (cfs)
Subshed A	6.25	84	0.178	17	30	48
Subshed B	6.81	85	0.207	18	32	51
Subshed C	5.43	85	0.172	15	27	42
Outlet	18.49			49	88	140

Hydraulics

Manning's equation was used to analyze channel hydraulics and estimate maximum shear stress in the channels. The existing channel within Subshed A is susceptible to scour in the 1% storm, particularly at the downstream end. The channel within Subshed B is lined with concrete and protected from scour. For the channel in Subshed C, shear stresses range from 1.17 to 6.41 lb/ft^2, depending on channel slope and flow

depth, and scour and erosion are evident throughout this channel. At the pinch point in the channel (behind 4080 SW Royale Ct), it appears that the 50% storm begins to inundate the adjacent sidewalk, and in the 1% storm, flow will spread less than 40 feet (approximately 26 feet east of channel centerline and 13 feet west) with a maximum depth of flow within the channel of 2 feet. This suggests none of the adjacent homes are in danger of flooding in the 1% storm due to flow in this channel. Hydraulic calculations can be viewed in Appendix C.

Utilities and Easements

Survey has found that existing utilities at the Marline/Pendant/Royale location include energy, sanitary sewer, and cable. Energy and cable both run parallel to SW Marline Dr along the East side of the existing sidewalk located on the rear of SW Marline Dr homes. Along this stretch, cable and energy pedestals can be seen to help indicate their locations and are approximately 1.5 feet East of the sidewalk. Cable and energy also run parallel on the South side of the existing sidewalk located in between SW Pendant Dr and SW Royale Ct. Cable continues along this path until it connects to cable lines running South along the back of SW Marline Dr. Energy continues along this path until it splinters off into 4074 SW Royale's backyard. There is also a single sanitary sewer crossing within the project limits. The sanitary sewer line begins in the South corner of the SW Pendant Dr cul-de-sac and continues on the property lines between 4070 and 4069 SW Pendant Dr. The sanitary line then reaches a manhole along the property lines of 4074 and 4072 SW Royale Ct in their backyards. The sanitary sewer line has an estimated cover depth of 7 feet under the existing sidewalk, so it should not conflict with any alternatives for this location.

A permanent drainage easement will be needed in the rear of 4080 and 4082 SW Royale Ct. The existing channel is not entirely within the RLPOA common area, as it flows through and adjacent to private property. The drainage easement must extend at least 10 feet from the top of the channel bank per APWA 5607.2.

2.2.2 Alternative No. 1

Description

Alternative No. 1 includes construction of a detention basin at the intersection of the two northern channels, south of SW Pendant Dr. The detention basin would cover approximately 16,450 square feet and would be capable of holding approximately 78,000 cubic feet of storm water. The maximum height of the basin berms would be 4 feet above existing grade, and maximum depth of the basin would be 4 feet below existing grade. The embankment surrounding the basin would include a 6-foot-wide flat-top berm to allow maintenance access for smaller equipment. The basin would have two outlets to discharge the stored stormwater. The primary outlet is a 24" reinforced concrete pipe located at the bottom of the basin floor and extending approximately 321 feet downstream to an outfall location adjacent to the existing channel. The purpose of this pipe is to release flow downstream in the channel where the swale increases in width and has higher capacity. The secondary outlet from the basin, which also serves as an emergency overflow, is a 20-foot-long weir located in the South of the basin. The weir will discharge into the existing channel in storms exceeding the 10% storm.

The inflowing concrete flume/sidewalk channel from Subshed B will be removed and replaced with a grass swale. A riprap apron will be placed at the upstream pipe outfall in to the channel. The channel will then be diverted into the detention basin. The existing channel to the South of the proposed detention pond will be upgraded to handle the anticipated shear stress in the channel by lining it with turf-reinforced matrix (TRM), which protects against shear stresses up to approximately 8 lb/ft^2. TRMs are synthetic-based mats that protect against soil erosion and integrate with and support grass vegetation to resist scour.

A conceptual plan showing the proposed layout can be found in Appendix C.

Hydraflow Hydrographs Extension for Autodesk Civil 3D used to model the proposed detention pond. Peak discharges to the downstream channel would be reduced by 34%, 50%, and 15% for the 50%, 10%, and

1% storms, respectively. Upstream flows would be contained within the primary outlet pipe for storms up to the 10% frequency, and the sidewalk would no longer be inundated in the pinch point area during frequent storms The modeling outputs for the Alternative No. 1 detention pond analysis can be found in Appendix C, as can hydraulic calculations for the Subshed B (grass swale) channel and Subshed C (TRM) channel.

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

There are currently cable and energy crossings within this project that will need to be relocated. Cable crossings occur on the southern portion of the existing flume/sidewalk in Subshed B. Other cable and energy crossings are present, and exposed in some locations, along the channel south of the proposed detention pond. It is unclear at this time if they would have to be relocated or just re-buried in order to replace the existing riprap with TRM.

Permits

Permits for the improvements would need to be acquired from the City of Lee's Summit. Engineering Plan Review and Inspection Fees are 3% of project construction valuation. Approximately one acre of land may be disturbed, so a Land Disturbance Permit will need to be obtained from the City and a separate permit may be needed from the Missouri Department of Natural Resources (MDNR). Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

A permanent drainage easement will need to be acquired for the rear of 4080 and 4082 SW Royale Ct to comply with APWA 5600.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 1 is $251,880.00. A detailed cost estimate can be found in Appendix C.

2.2.3 Alternative No. 2

Description

Alternative No. 2 includes creating a detention pond with its bottom elevation at existing grade. The at-grade pond would have an estimated area of 16,451 square feet and would have a maximum storage volume of approximately 49,914 cubic feet. The primary outfall would be a 24" pipe that extends approximately 40 feet and discharges directly into the existing downstream channel, near the failed rain garden outlet. The primary outfall inverts would be located at-grade. A 20-foot-wide weir would be the secondary outfall, which also serves as an emergency overflow for the pond, and would release water into the channel in the vicinity of the proposed pipe outfall. The secondary weir operates in the 50% storm.

Alternative No. 2 will have the same channel layouts as Alternative No. 1. The channel flowing in from Subshed B, which is currently the flume/sidewalk will be removed and replaced with a grass swale. The existing channel to the South of the proposed detention pond will be upgraded to handle the anticipated shear stress in the channel by lining it with TRM, which protects against shear stresses up to approximately 8 lb/ft^2.

Hydraflow Hydrographs Extension for Autodesk Civil 3D used to model the proposed detention pond. Peak discharges to the downstream channel would be reduced by less than 20% for the range of storms

analyzed. As the primary outfall pipe releases flows into the pinch point, the sidewalk would still be inundated in frequent storm events. The modeling outputs for the Alternative No. 2 detention pond analysis can be found in Appendix C.

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

There are currently cable and energy crossings within this project that will need to be relocated. Cable crossings occur on the southern portion of the existing flume/sidewalk in Subshed B. Other cable and energy crossings are present, and exposed in some locations, along the channel south of the proposed detention pond. It is unclear at this time if they would have to be relocated or just re-buried in order to replace the existing riprap with TRM.

Permits

Permits for the improvements would need to be acquired from the City of Lee's Summit. Engineering Plan Review and Inspection Fees are 3% of project construction valuation. Approximately one acre of land may be disturbed, so a Land Disturbance Permit will need to be obtained from the City and a separate permit may be needed from the Missouri Department of Natural Resources (MDNR). Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

A permanent drainage easement will need to be acquired for the rear of 4080 and 4082 SW Royale Ct to comply with APWA 5600.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 2 is $182,754.00. A detailed cost estimate can be found in Appendix C.

2.2.4 Alternative No. 3 (and French Drain)

Description

Alternative No. 3 includes construction of a concrete-lined channel. The channel will begin as a rectangular channel with a width of 4-feet and a depth of 2.5 feet, then transition into a trapezoidal, riprap-lined channel with a bottom width of 4-feet and 3:1 side slopes. The rectangular concrete-lined channel will extend 315 feet, starting at the failed rain garden and following the existing channel's flow path. It will then transition to a 54-foot-long trapezoidal channel which flows to the existing concrete flume south of 4082 SW Royale Court. The rectangular concrete channel will have a maximum flow depth of 1.8 feet in the 1% storm. The trapezoidal, riprap-lined channel will have a maximum flow depth of 1.8 feet in the 1% storm event. The concrete-lined channel would contain discharges from the 1% storm without overtopping into adjacent yards.

Sidewalk will be removed on the east end of the concrete flume/sidewalk from SW Raintree Dr to the sidewalk's intersection with the flume/sidewalk downstream of the existing storm pipe outfall. A portion of the inflowing concrete flume/sidewalk from Subshed B will be removed and replaced with sod. A grass swale, lined with TRM, will be graded in the common area to route flows to the upstream end of the rectangular, concrete-lined channel. The extents of concrete flume/sidewalk removal will be from near the South property corner of 4070 SW Pendant Drive to the west where it intersects the sidewalk behind the

Marline homes. TRM would also be added downstream of the concrete flume extending from SW Pendant Drive.

A conceptual plan showing the proposed layout can be found in Appendix C.

French Drain

Per request by the RLPOA, a French drain running along the rear of SW Marline Drive homes was evaluated. The RLPOA indicated that sump pumps are present for homes on the east side of Marline from 4063 to 4073 SW Marline Drive. The French drain would consist of a 6" perforated PVC pipe embedded in clean rock. The flow path would be along the West side of the fence line and would connect to the concrete-lined channel as an outfall. An estimated 370 linear feet of 6" Perforated PVC pipe would be needed. The estimated cost of this pipe and installation would be $12,950. There is not currently enough room to run the 6" Perforated PVC pipe on the East side of the fence line without removing and replacing the entire section of sidewalk or all fences. Running the pipe along the West side of the fence line would result in small sections of fence needing to be removed and reset with minimal impact. An estimated 45 linear feet of 6" PVC pipe per home would be needed to connect existing sump pumps to the French drain line. Two connections per home would be needed with cleanouts (one connecting the existing sump pump outflow pipe to the new PVC pipe, and one connecting the PVC pipe to the French Drain line). The estimated cost per home for connections, cleanouts, and PVC pipe is $2,465. The addition of a French drain, and home sump pump connections to any alternative can result in higher lump sum costs (Mobilization, Erosion Control, and Clearing, Grubbing and Demolition).

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

There are currently cable and energy crossings within this project that will need to be relocated. Cable crossings occur on the southern portion of the existing flume/sidewalk in Subshed B. There is also a cable line running along the Northern side of the existing flume/sidewalk that will potentially have to be relocated. The anticipated utility conflicts are called out in the concept drawing in Appendix C.

Permits

Permits for the improvements would need to be acquired from the City of Lee's Summit. Engineering Plan Review and Inspection Fees are 3% of project construction valuation. Less than 1 acre of land will be disturbed so a state land disturbance permit would not be needed. More than 2,000 square feet of land would be disturbed so a City of Lee's Summit land disturbance permit would be needed. Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

A permanent drainage easement will need to be acquired for the rear of 4080 and 4082 SW Royale Ct to comply with APWA 5600.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 3 is $198,182.00. A detailed cost estimate can be found in Appendix C.

2.3 Raintree Pkwy to Sandpiper

2.3.1 Existing Conditions

Description

The Raintree Pkwy to Sandpiper site is located south of SW Raintree Pkwy, just east of SW Sandpiper Dr. A Site Map can be viewed in Appendix D. The primary concern at this location is flooding. There is a 4-ft x 4-ft reinforced concrete box culvert that conveys drainage from the south, under SW Raintree Pkwy to the lake. The culvert has a drop structure on its upstream end with a debris catcher that has frequently clogged in the past. The street has flooded on occasion as has the basement garage of the house located east of the channel, upstream of the culvert, at 5271 SW Raintree Pkwy. Since the garage last flooded in 2015, the retaining wall adjacent to the driveway was extended closer to road, which appears to have raised the low spot (to approximately 969.3 ft elevation) where flood waters were previously overflowing onto the driveway down to the garage. The debris catcher was replaced in the latter half of 2022, which could reduce clogging issues and help alleviate flooding. The channel downstream of the culvert outlet is lined with gabion baskets along the banks to the lake. Selected site photos can be viewed in Appendix D.

Hydrology

Hydrologic analyses were performed using TR-55 methods. This site was modeled with a single upstream watershed. Land use consists of large lot single family residential, crops and woods; soils are classified as hydrologic soil group C, C/D, and D. A summary of the hydrologic analyses can be found in the table below. A Drainage Map and supporting calculations can be viewed in Appendix D.

Table 3. Raintree Pkwy to Sandpiper Hydrology

Location	Area (ac)	CN	Tc (hr)	Q 50% (cfs)	Q 10% (cfs)	Q 1% (cfs)
Watershed	66.18	78	0.283	123	239	403

An "As Constructed" plan sheet was obtained from the City of Lee's Summit for the box culvert under SW Raintree Pkwy. The plan sheet is included in Appendix D. The culvert was designed to convey the 10% storm flows, which is consistent with current stormwater design criteria; however, the peak discharge estimated via Rational Method for the 10% storm (144 cfs) appears to have been underestimated or did not account for development—it is approximately 40% lower than current estimates using TR-55 methods. There is a note on the plan sheet that indicates the adjacent lot (at 5271 SW Raintree Pkwy) should be raised to an elevation of 968 ft or above. Due to the age of the plans, this elevation is likely based on NGVD29, which would convert to approximately 968.36 ft in NAVD88. The ground elevation at the home's basement garage is at approximately 966.5 ft (NAVD88).

Hydraulics

The culvert hydraulics were analyzed with the Hydraflow Hydrographs Extension for Autodesk Civil 3D to account for storage that occurs upstream of the culvert within the channel. Results of the analysis suggest the culvert is undersized for the 10% storm, as there are potentially 6 inches of ponding in the street above the low-crown elevation of 969.16 ft. The 1% storm is estimated to pond to almost 12 inches deep at the low-crown elevation. This does not meet APWA 5600 criteria for storm drainage design. This assumes the debris catcher is not clogged, so actual ponding and overtopping may exceed these estimates.

Utilities and Easements

Limited survey was obtained for this site, and easements were not identified at this time. Survey picked up buried energy, telephone, and cable lines on the south side of SW Raintree Pkwy, both parallel to the channel on its west side and parallel to the street. On the North side, cable, gas, water, and telephone are located parallel to the street. The approximately 180 feet of channel immediately upstream of the culvert

are within RLPOA common area. There is a sanitary sewer line that parallels the channel to the west at an elevation approximately equal to the channel flowline elevation. There are utility pedestals in the street right-of-way and behind the backyards of the homes that front SW Raintree Pkwy.

2.3.2 Alternative No. 1

Description

Alternative No. 1 includes upsizing the box culvert from a 4'x4' reinforced concrete box to a 7'x4' reinforced concrete box. The existing drop inlet will be replaced with a 7'X6' drop inlet with a debris catcher. The box will extend 103.58 feet as the existing box does and will gain the additional 3 feet in span to the East. This will result in only one side of the gabion wall being removed and reset at the downstream end. Southwest Raintree Parkway will need full depth trenching to remove the existing box culvert, and to replace it with the upsized box. An estimated 12-foot-wide trench will be made in the street extending down to the bottom of the culvert. The larger box culvert will have the capacity to convey the 10% storm without overtopping and appears to eliminate street ponding for the 1% storm if the debris catcher is not clogged. A conceptual plan and hydraulic modeling outputs can be viewed in Appendix D.

As it appears the culvert is undersized for existing conditions, and there has been flooding in the adjacent home, the City of Lee's Summit may consider funding this alternative as a capital improvement project to help alleviate flooding.

Roads & Traffic

Southwest Raintree Parkway will have to be closed during construction of the new box culvert. Local traffic will have to be diverted on alternative routes.

Utilities

Existing utilities along this segment of SW Raintree Pkwy will have to be relocated as a result of the upsized box culvert. Buried energy, telephone, and cable lines may be in conflict on the south side of SW Raintree Pkwy. On the North side, cable, gas, water, and telephone may be in conflict. Some of the utilities may lie within Lee's Summit right-of-way and could be relocated at the cost of the utility companies if the project is deemed a City of Lee's Summit infrastructure project.

Permits

If the City does not consider funding the improvements, and RLPOA intends to proceed with final design and construction, permits for the improvements would need to be acquired from the City. Engineering Plan Review and Inspection Fees are 3% of project construction valuation. Land disturbance will exceed 2,000 square feet, so a Land Disturbance Permit will need to be obtained from the City. As the land disturbance would be less than one acre, a separate permit would not be needed from the Missouri Department of Natural Resources (MDNR). A floodplain development permit will need to be obtained from the City for work in the floodplain on the north side of SW Raintree Pkwy. Right-of-Way and Temporary Traffic Control Permits will also be required. Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

No easements will be needed for this project as construction is contained within right-of-way or RLPOA common area.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 1 is $252,085.40. A detailed cost estimate can be found in Appendix D.

2.3.3 Alternative No. 2

Description

Alternative No. 2 includes grading and excavation in the channel on the south side of SW Raintree Pkwy in order to gain more storage volume upstream of the undersized culvert. Grading was limited to maintain minimum cover and avoid the need to relocate the existing sanitary sewer line that runs along the western side of the channel. All side slopes were also kept at a maximum of 4:1 side slope to ensure that maintenance for the channel can be done safely. The increase in storage volume from grading will not decrease flooding in the street enough to meet APWA standards, as there would still be over 5 inches of ponding in the street in the 10% storm, and the adjacent home is still in danger of flooding. Hydraulic modeling outputs can be found in Appendix D.

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

Proposed grading was designed to avoid conflicts with existing utilities.

Permits

Land disturbance will exceed 2,000 square feet, so a Land Disturbance Permit will need to be obtained from the City. As the land disturbance would be less than one acre, a separate permit would not be needed from the Missouri Department of Natural Resources (MDNR). Additional, miscellaneous permits may be needed from the City, but associated costs are anticipated to be nominal.

Easements

No easements will be needed for this project as construction is contained within RLPOA common area.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 2 is $15,834.00. A detailed cost estimate can be found in Appendix D.

2.4 Sunset Cove

2.4.1 Existing Conditions

Description

The Sunset Cove site is located near the southeast corner of Ward Rd and Hwy 150, just south of the Raintree Village Shopping Center. A Site Map can be viewed in Appendix E. There is an unmaintained detention or sediment pond upstream of the cove that serves the shopping center and is not owned by the RLPOA. Design data were requested from the City of Lee's Summit for this detention facility; however, they indicated they did not retain records for this private pond. Debris and trash are not adequately captured by the pond and subsequently enter Raintree Lake. The RLPOA management have indicated they would like to be able to isolate debris, trash, and sediment for easier removal and to allow for a smaller scale algal treatment area. Select site photos can be viewed in Appendix E.

Hydrology

A runoff volume was estimated for the water quality storm (1.37 inches in the Kansas City Metro Area) using TR-55 methods. The drainage area to a point within the cove that is around 1,200 feet downstream of the private detention/sediment pond is approximately 656 acres. Land use in the watershed varies and includes commercial, multifamily residential, high to low density single family residential, and crops/fields; soils are classified as hydrologic soil group C, C/D, and D. The runoff curve number (CN) is estimated to be 85. The runoff volume for the above parameters is estimated to be 20.33 acre-feet. Peak flows were estimated using the United States Geological Survey StreamStats web application. The 1% storm discharge is expected to be approximately 1,800 cubic feet per second. A Drainage Map and supporting calculations can be viewed in Appendix E.

Hydraulics

No existing conditions hydraulics calculations were performed.

Utilities and Easements

No survey was obtained at this location. There is a sanitary sewer main west of the cove's shoreline. The cove is located on RLPOA property.

2.4.2 Alternative No. 1

Description

Alternative No. 1 includes creating a larger sediment forebay within Sunset Cove by constructing an earthen embankment. The forebay would be located approximately 1,200 feet South of the unmaintained detention pond. The forebay embankment would span approximately 245 feet across the cove. An earthen weir overflow, 150 feet in length, would be constructed in the embankment at an elevation of 957.00 feet. The weir would be 1.64 feet higher than the normal pool elevation (955.36 ft) in order to trap sediment, debris, and trash before it enters the lake. The embankment would extend to a maximum elevation of 961.00 feet, then would tie into the existing ground at this elevation on both ends. In order to construct this alternative, the lake would likely need to be drained at least 8 feet below normal pool. This will allow the contractor to excavate muck and develop a stable base for the embankment. Approximately 10,000 cubic yards of engineered soil would be placed to create the embankment. The embankment would be seeded with grass above the normal pool elevation and would be covered with TRM from 2 vertical feet below the normal pool to an elevation of 959.00 feet. Transporting material from roads to be able to place the embankment would disturb an estimated 1,115 square yards of vegetation and would require restoration. A conceptual plan can be viewed in Appendix E.

The location of the embankment and elevations were determined based on design guidance in the MARC, Manual of Best Management Practices for Stormwater Quality (a.k.a., the "BMP Manual"), for sediment forebays. The volume of water that would be captured in the forebay is at least 10% of the runoff volume from a water quality storm (1.37 inches). The weir overflow was designed to pass the 1% storm at an elevation below the FEMA-published base flood elevation. Calculations can be found in Appendix E.

Roads & Traffic

In order to haul in soils for the embankment and haul out excavated material, trucks would likely access the site from SW Ward Rd but should have a minimum effect on traffic and would not require road closures.

Utilities

At this time, it is not anticipated that any utilities would be in conflict or affected.

Permits

A floodplain development permit will need to be obtained from the City of Lee's Summit for work in the floodplain.

Lamp Rynearson contacted the US Army Corps of Engineers, who indicated this alternative may qualify for a Nationwide Permit (NWP) if the footprint of the fill for the embankment is less than 1/2 of an acre. NWP 29 is specific for residential subdivisions and requires a delineation to identify and locate aquatic resources (including wetlands) on the property. The Corps also indicated mitigation may not be required, because the area is currently open water. It should be noted that wetlands are likely to form in this upper arm of the lake if sediment is not removed. If wetlands do form, and dredging is subsequently proposed, costly mitigation may be required for the loss of those wetlands.

Easements

It is not anticipated that any easements will be needed for this alternative.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No 1 is $571,348.00. A detailed cost estimate can be found in Appendix E.

2.4.3 Alternative No. 2

Description

Alternative No. 2 includes creating a sediment forebay in the same location and configuration as Alternative No. 1 but would use rock for the embankment. Clean rock has the advantage of not requiring extensive permitting to be placed within waterways, but it is more expensive. The rock embankment would create the same shape as Alternative No. 1 and have the same elevations for weir, maximum height, and dredging depths. An estimated 3,530 cubic yards of clean rock would be placed as the base of the forebay. Then two sequential layers of 1.5 foot D50 riprap would be placed at the embankment surface. Over time, sediment would be trapped within the rock and creating the sediment forebay, and preventing trash from entering Raintree Lake.

Roads & Traffic

In order to haul in rock for the embankment and haul out excavated material, trucks would likely access the site from SW Ward Rd but should have a minimum effect on traffic and would not require road closures.

Utilities

At this time, it is not anticipated that any utilities would be in conflict or affected.

Permits

Permits are anticipated to be the same as Alternative No. 1.

Easements

It is not anticipated that any easements will be needed for this alternative.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No 2. is $1,365,640.00. A detailed cost estimate can be found in Appendix E.

2.4.4 Assessments of Other Alternatives

The RLPOA management and Board had questions about other Alternatives at this location. No formal alternatives were prepared; however, assessments were performed and are discussed in correspondence that can be found in Appendix G. Maintaining the existing detention/sediment pond upstream could provide some benefit. The fact that it appears to be silting in over time suggests it is collecting some sediment and preventing it from entering the lake. It would be recommended that four to six feet of depth be maintained in the pond (from normal pool elevation to pond bottom).

2.5 Windemere to Hidden Cove

2.5.1 Existing Conditions

Description

The Windemere to Hidden Cove site is located east of SW Hidden Cove Dr and north of SW Hidden Cove Ct. A Site Map can be viewed in Appendix F. There is a concrete-lined channel downstream of a pipe outfall conveying drainage from the adjacent Windemere subdivision. The concrete-lined channel ends at the RLPOA property where it becomes a grass-lined channel until it reaches the culvert under SW Hidden Cove Dr. There appears to be minor scour at the end of the concrete-lined channel. The grass-lined channel has a flat slope and tends to remain wet for prolonged periods of time. There was a small amount of flow in the channel at the time of the site visit, but it was unclear whether it might be due to a groundwater seep, drainage from upstream irrigation of yards, or some other source. At the outlet end of the culvert under SW Hidden Cove Dr, the concrete apron appears to be failing due to scour. Select photos can be viewed in Appendix F.

Hydrology

Hydrologic analyses were performed using the Rational Method and assumed a single upstream watershed. Land use consists of single family residential. A summary of the hydrologic analyses can be found in the table below. A Drainage Map and supporting calculations can be viewed in Appendix F.

Table 4. Windemere to Hidden Cove Hydrology

Location	Area (ac)	"C"	Tc (hr)	Q 50% (cfs)	Q 10% (cfs)	Q 1% (cfs)
Watershed	49.94	0.51	0.083	138	187	329

Hydraulics

Manning's equation was used to analyze channel hydraulics and estimate maximum shear stress in the channel. The calculations (included in Appendix F) suggest shear stresses are high enough to scour the grass-lined channel.

Utilities and Easements

Limited survey was obtained for this site, and utilities and easements were not located or identified. It should be noted that no utility pedestals were present in the open area where the channel is located. The channel is within common area owned by the RLPOA.

2.5.2 Alternative No. 1

Description

Alternative No. 1 proposes re-grading the channel to establish a constant slope and prevent water ponding, as well as placing a riprap apron at the end of the concrete flume where it transitions to a vegetated channel

and at the upstream end of the culvert under SW Hidden Cove Dr. The maximum slope achievable between the existing concrete flume and the culvert invert is 1.73%, which should be adequate for conveying flows in the channel. After grading is completed, topsoil will be placed, and the channel will be seeded with grass then overlaid with TRM to protect the channel from potential scour. A conceptual plan can be viewed in Appendix F.

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

Limited survey was obtained for this analysis, so no utilities were identified. It is unlikely that any utilities will run under the channel where grading will occur.

Permits

Land disturbance will exceed 2,000 square feet, so a Land Disturbance Permit will need to be obtained from the City. As the land disturbance would be less than one acre, a separate permit would not be needed from the Missouri Department of Natural Resources (MDNR). Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

Easements will not be required, since the improvements would be contained within RLPOA common area.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 1 is $55,325.00. A detailed cost estimate can be found in Appendix F.

2.5.3 Alternative No. 2

Description

Alternative No. 2 includes installing intermittent infiltration trenches along the channel. The channel would be re-graded as in Alternative No. 1, but infiltration trenches about 30 feet in length would be placed about 30 feet apart along the length of the channel to encourage infiltration of stormwater. The trenches would be composed of a bottom layer of aggregate clean rock, which would be overlaid by a filter fabric, then covered by an amended soil (for water permeability) and seeded with grass. The segments of channel between the infiltration trenches would be covered with topsoil and seeded with grass, then the entire channel would be overlaid with TRM, as in Alternative No. 1, to protect it from potential scour. This alternative also includes placing a riprap apron at the end of the concrete flume where it transitions to a vegetated channel and at the upstream end of the culvert under SW Hidden Cove Dr.

Roads & Traffic

This alternative does not require any roads to be closed during construction and should not have any impact on traffic other than for construction access to the site.

Utilities

Limited survey was obtained for this analysis, so no utilities were identified. It is unlikely that any utilities will run under the channel where grading and trenching will occur.

Permits

Land disturbance will exceed 2,000 square feet, so a Land Disturbance Permit will need to be obtained from the City. As the land disturbance would be less than one acre, a separate permit would not be needed from the Missouri Department of Natural Resources (MDNR). Additional, miscellaneous permits may be needed from the City, but costs are anticipated to be nominal.

Easements

Easements will not be required, since the improvements would be contained within RLPOA common area.

Preliminary Opinion of Probable Construction Costs

Estimated total cost for final design and construction of Alternative No. 2 is $70,469.20. A detailed cost estimate can be found in Appendix F.

SECTION 3.0 - RECOMMENDATIONS

3.1 Breezy Point

Recommended Improvements

In order to repair failures in the interlocking blocks lining portions of the Breezy Point channel, Lamp Rynearson recommends incorporating Flexamat for the southern portion of the channel and riprap at the lateral pipe outfall. Flexamat is a tied concrete block mat and is recommended because it allows vegetation to grow between the blocks and can be easily maintained, since lawn mowers can travel over the surface. Flexamat can protect against shear stresses greater than the anticipated channel shear stresses and should be more than adequate to resist scour. Riprap is the optimal choice for the lateral pipe outfall, since it will reduce outfall velocities and shear stresses as stormwater leaves the pipe and enters the channel. This alternative is also estimated to be marginally less expensive than the all riprap alternative.

Conclusions

Breezy Point has the smallest land disturbance of all the provided sites and is the least expensive. It may be possible for RLPOA maintenance staff to complete construction in-house and save further costs. Breezy Point has been deemed a medium priority project.

3.2 Marline/Pendant/Royale

Recommended Improvements

In order to decrease peak stormwater flows and scour in the Marline/Pendant/Royale location, it is recommended to implement the deeper detention pond that requires excavation below the existing grade. The pond significantly reduces stormwater discharges in the downstream channel, and the longer pipe releases discharges further downstream in the channel where there is more capacity for flows. Lining the downstream channel with TRM will adequately protect against scour and allow there to be a more aesthetically pleasing grass-lined channel instead of a riprap-lined channel. The TRM channel can be easily maintained by mowing. Removing the concrete flume/sidewalk and establishing a grass swale will eliminate the safety hazard of the slick, algae-covered walkway and the future costs to maintain the degrading

concrete.

Conclusions

While there is minor flooding in the Marline/Pendant/Royale location, it does not appear to endanger any homes and is a temporary nuisance issue. The channel scour and erosion issues are a bigger problem, and if not addressed, could become much worse over time; because of this, it is recommended this be considered a high priority project.

3.3 Raintree Parkway to Sandpiper

Recommended Improvements

In order to meet APWA 5600 criteria, the existing culvert should be removed and replaced with an 84"x48" reinforced concrete box culvert. The current culvert is significantly undersized and other options will not adequately address the recurring flooding issues. The culvert is an asset of City of Lee's Summit, so there is the possibility that the City would program culvert replacement into their capital improvement plan.

Conclusions

RLPOA should consider providing the City with the analyses performed by Lamp Rynearson to gauge their interest in programming a culvert replacement project at this location into their capital improvement plan. If the City is not receptive, they may consider sharing the costs with RLPOA. This has been deemed a high priority project. RLPOA noted that since the debris catcher on top of the drop inlet has been replaced, the home to the East has not flooded, but analyses suggest that the home still has potential to flood, even in a 10% storm with the debris catcher clear of any clogging. Additionally, the significant roadway flooding that occurs here is a danger to the public.

3.4 Sunset Cove

Recommended Improvements

It is not recommended that either of the options for a larger sediment forebay be pursued at this time. Performing an analysis to assess sediment capture efficiency of a forebay at this location is outside of the scope of this study; however, the contributing drainage area to this location is only about 14% of the total area draining to the lake—this is somewhat insignificant and likely will not be worth the cost. The funding required to construct the embankment for a larger sediment forebay may be better utilized by establishing a new or improving upon an existing sediment management and removal plan for the lake as a whole and implementing less costly and more beneficial improvements to address sedimentation.

Conclusions

This improvement is considered a low priority. The existing boom appears to be helping to capture debris and trash, but more robust apparatuses are available and could be considered if needed. Algae are less likely to thrive with deeper water or by aerating the water. Application of barley straw is an alternative method to control algal growth—guidance for its use can be found on-line.

3.5 Windemere

Recommended Improvements

In order to decrease standing water and address minor scour throughout the channel, it is recommended to re-grade the channel and line it with TRM and to place riprap at the upstream concrete flume outfall at the pipe downstream pipe entrance. The combination of TRM and selectively located riprap will protect against scour, and re-grading the channel to a constant slope should keep water moving through the channel more efficiently. The low maintenance of TRM channel lining is a major advantage, and it also has high capacities to withstand shear stresses. Overall aesthetic should be almost identical to the existing grass channel so residents who backyards overlook the channel will not be affected in any way. The option to integrate intermittent infiltration trenches into the channel could be implemented later if needed. It is recommended the concrete apron at the outlet end of the culvert under SW Hidden Cove Dr be monitored. The city should be notified if conditions worsen or the culvert itself begins to be undermined.

Conclusions

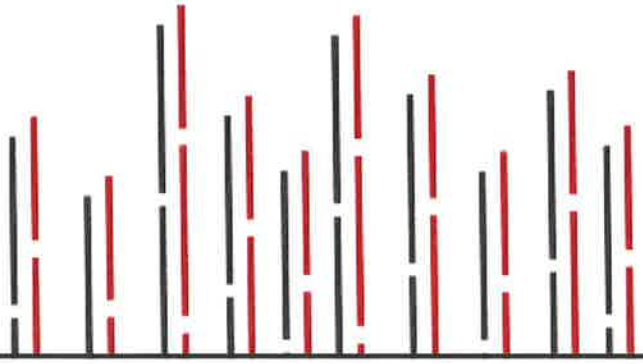
Current issues along the channel are not severe and are more a nuisance, so a project at this location would be considered a medium priority for repair.

3.6 Summary

Table 5. Summary of Recommendations by Priority

Location	Improvement	Description	Cost (2023 $$)	Priority
Marline/ Pendant/Royale	Detention Pond and Channel Improvements	Deeper detention pond alternative	$251,880.00	High
Raintree Pkwy to Sandpiper	Culvert Replacement	Remove and upsize existing culvert	$252,085.40	High
Breezy Point	Channel Improvement	TRM channel lining and riprap	$18,118.00.	Medium
Windemere to Hidden Cove	Channel Improvement	TRM Channel lining and riprap	$55,325.00	Medium
Sunset Cove	Larger Sediment Forebay	Sediment, trash, and debris capture	Not Recommended	Low

Appendix A

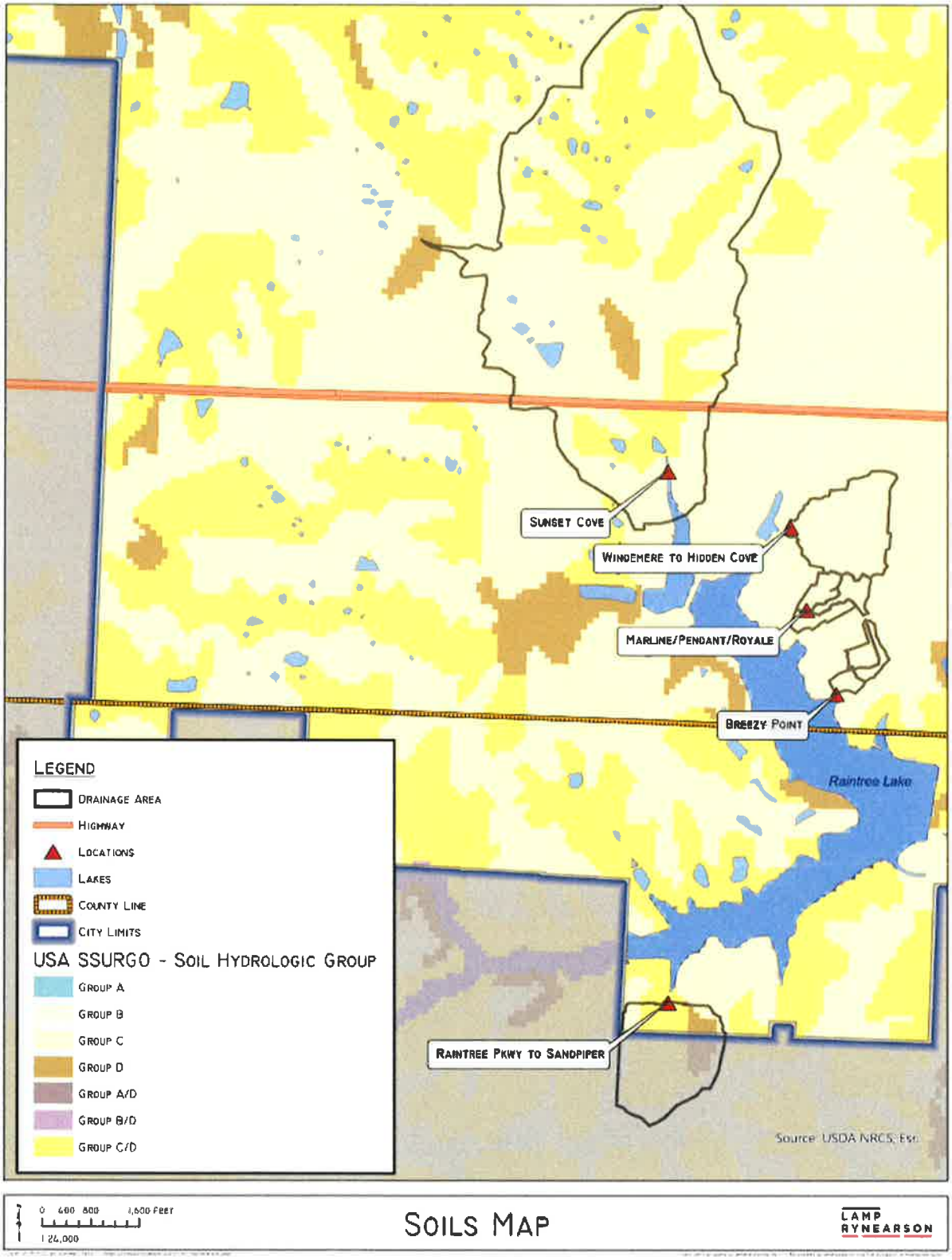


Maps

Overall Location Map

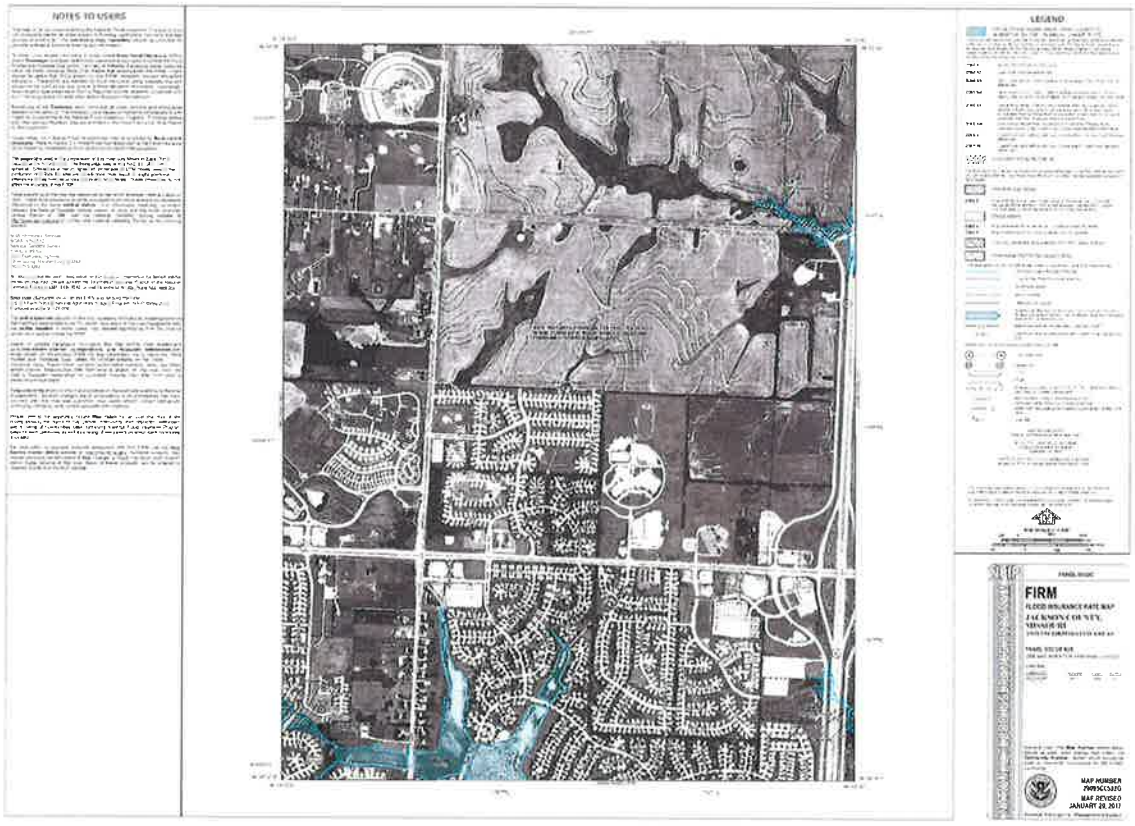
Appendix A

Soils Map

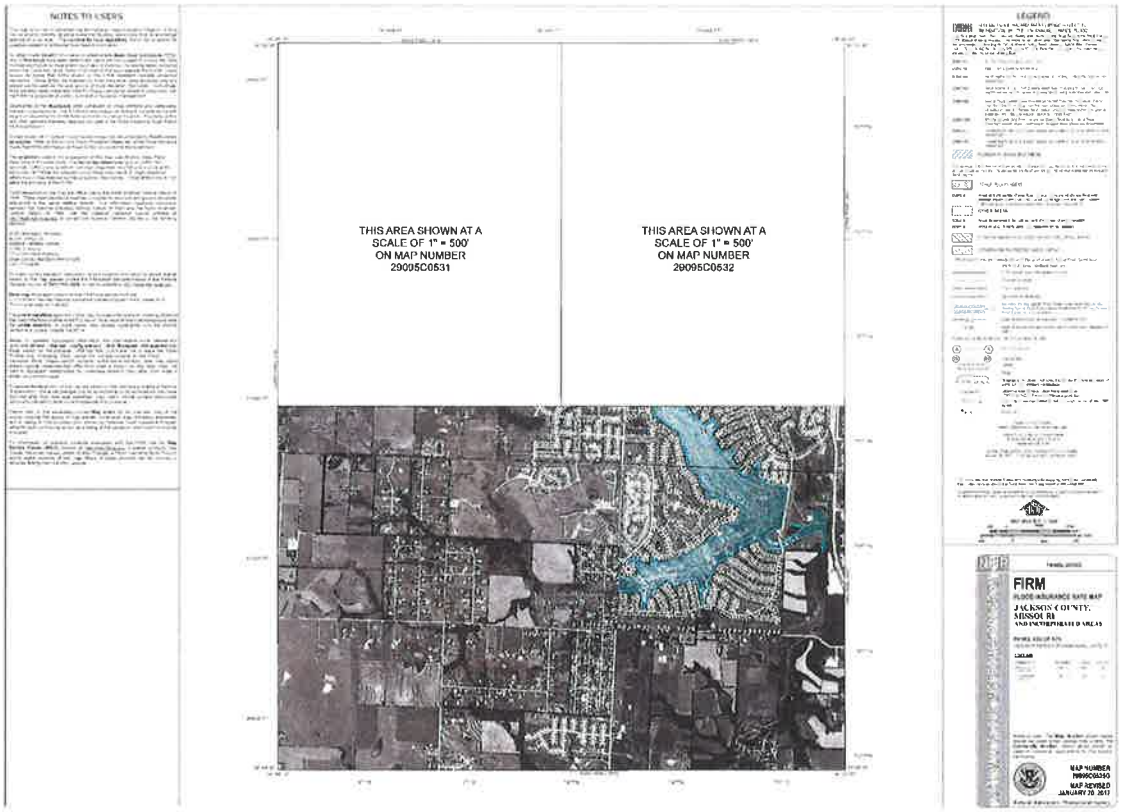


Appendix A

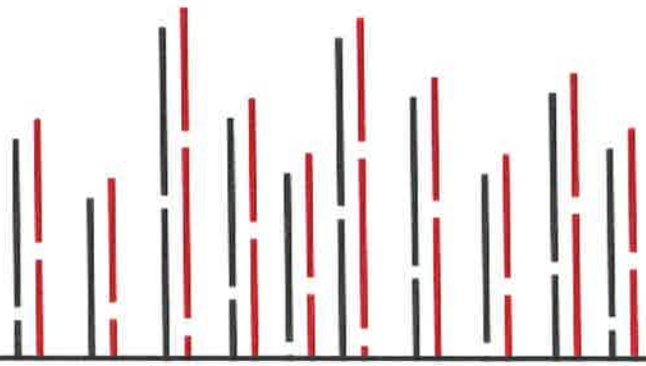
Floodplain Maps



Floodplain Maps



Appendix B

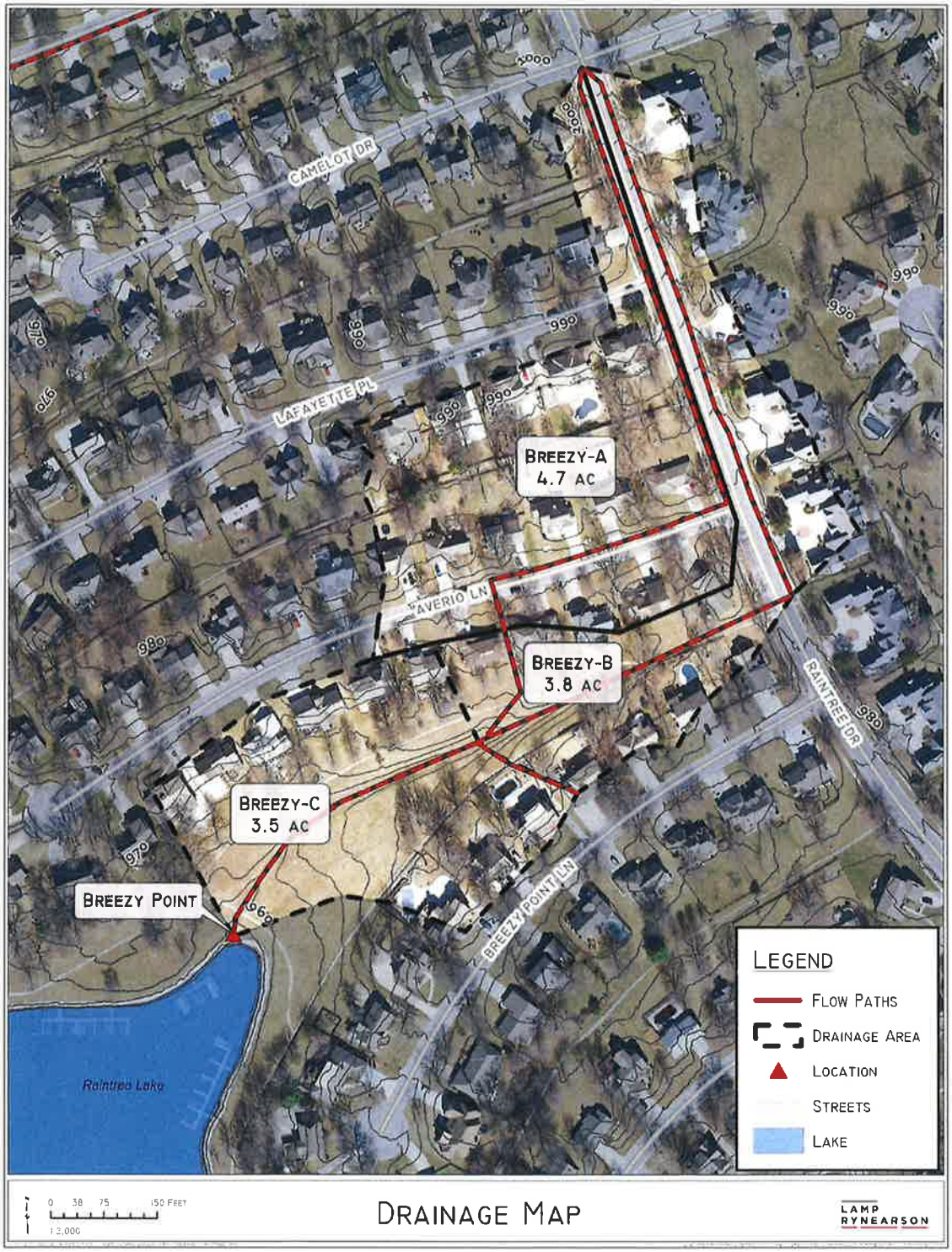


Breezy Point

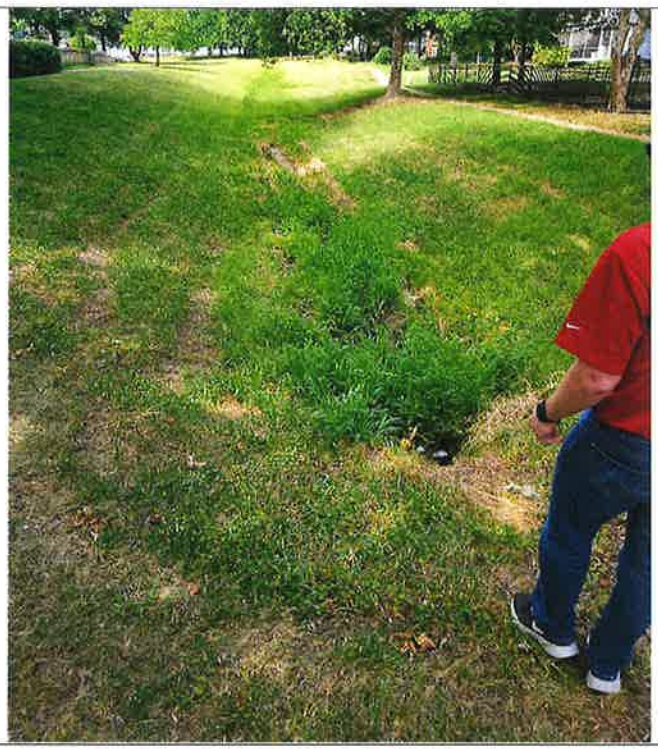
Site Map

Appendix B – Breezy Point

Drainage Map



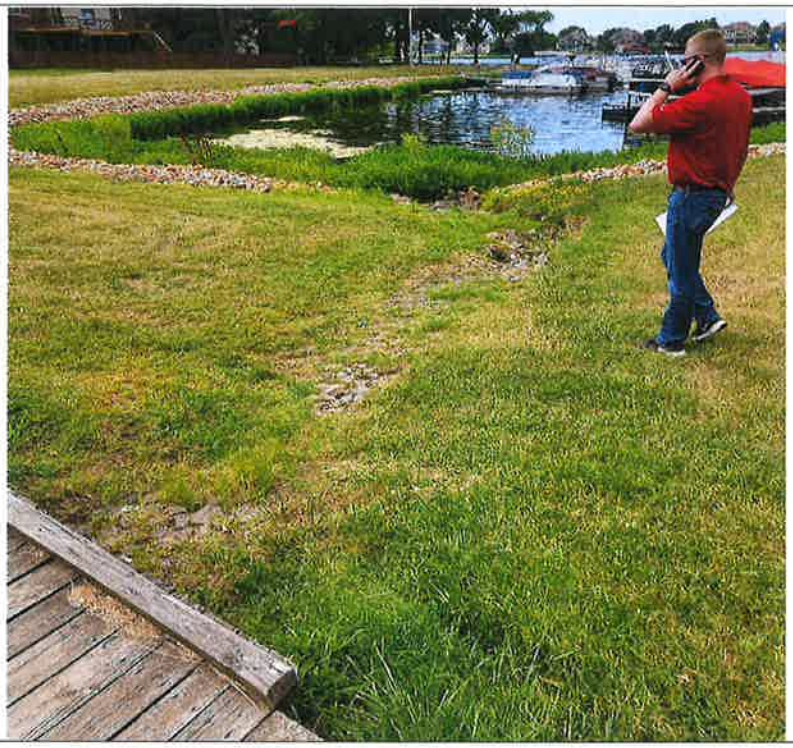
Site Photos



Siltation at upstream culvert outfall

Minor scour at lateral culvert outfall

Site Photos



Failure of interlocking blocks in downstream channel

Failure of interlocking blocks in downstream channel

WinTR-55 Current Data Description

--- Identification Data ---

User: TMM
Project: 0322116
SubTitle: Breezy Point 1
Areal Units: Acres State:
Missouri
County: Jackson
Filename: L:\Engineering\0322116 Raintree Lake Pes\DESIGN DATA\Rational Method\Breezy Point\TR-55 Current

Date: 12/22/2022
Units: English

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Breezy A	A	ab	4.68	82	0.1
Breezy B	B	ab	3.78	87	.185
Breezy C	C	Outlet	3.47	77	.145

Total area: 11.93 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
----------	3.5	4.6	5.3	6.2		
	6.9	7.7	3.0			

Storm Data Source: Jackson County, MO (NRCS)
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Watershed Peak Table

Sub-Area Rainfall Return Period or Reach Identifier	Peak Flow by 2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)
-------- SUBAREAS			
Breezy A	12.86	23.96	39.18
Breezy B	11.10	19.16	29.92
Breezy C	7.02	14.25	24.55
REACHES			
ab	23.03	41.54	66.55
Down	23.03	41.52	66.53
OUTLET	30.05	55.76	91.05

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Breezy A	4.68	0.100	82	ab	A
Breezy B	3.78	0.185	87	ab	B
Breezy C	3.47	0.145	77	Outlet	C

Total Area: 11.93 (ac)

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Breezy A							
SHEET	100	0.0300	0.011				0.016
SHALLOW	661	0.0383	0.025				0.046
CHANNEL	187	0.0241	0.013	1.76	4.71	8.657	0.006
			Time of Concentration				0.1
Breezy B							
SHEET	100	0.0250	0.011				0.018
SHALLOW	457	0.0433	0.025				0.030
CHANNEL	245	0.0126	0.013	2.40	5.49	7.562	0.009
CHANNEL	205	0.0206	0.130	0.70	4.95	0.445	0.128
			Time of Concentration				.185
Breezy C							
SHEET	100	0.0500	0.150				0.108
SHALLOW	57	0.1578	0.050				0.002
CHANNEL	437	0.0270	0.030	1.45	5.14	3.468	0.035
			Time of Concentration				.145

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Breezy A	Residential districts (1/4 acre)	C	3.7	83
	Residential districts (2 acre)	C	.98	77
	Total Area / Weighted Curve Number		4.68	82
Breezy B	Paved; curbs and storm sewers	C	1.15	98
	Residential districts (1/8 acre)	C	.93	90
	Residential districts (1 acre)	C	1.7	79
	Total Area / Weighted Curve Number		3.78	87
Breezy C	Residential districts (2 acre)	C	3.47	77
	Total Area / Weighted Curve Number		3.47	77

Reach Channel Rating Details

Reach Identifier	Reach Length (ft)	Reach Manning's n	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope
----------	ab	470	0.03		
	0.026	4	3 :1		

Reach Identifier	Stage (ft)	Flow (cfs)	End Area (sq ft)	Top Width (ft)	Friction Slope (ft/ft)
ab	0.0	0.000	0	4	0.026
	0.5	11.603	2.8	7	
	1.0	43.149	7	10	
	2.0	180.512	20	16	
	5.0	1459.167	95	34	
	10.0	7999.694	340	64	
	20.0	46846.833	1280	124	

Breezy - Upstream Reach (Subshed B)

Sideslope LT. =	4 :1
Sideslope RT. =	4 :1
n =	0.03
Bottom Width (ft) =	0
Flow Depth (ft) =	1.051
Channel Slope =	4.6000%

Area (ft^2) =	4.418404
WP (ft) =	8.667
R_H (ft) =	0.510

Q (cfs) =	30
V (Q/A) (ft/s) =	6.8

Top Width (free surface) = 8.41 ft

Hydraulic Depth, y_h = 0.53 ft

Fr = 1.65

Shear Stress, τ = 1.46 lb/ft^2

Breezy - Downstream Reach (Average)

Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	1.36
Channel Slope =	1.9700%

Area (ft^2) =	13.7088
WP (ft) =	14.601
R_H (ft) =	0.939

Q (cfs) =	91
V (Q/A) (ft/s) =	6.7

Top Width (free surface) = 14.16 ft

Hydraulic Depth, y_h = 0.97 ft

Fr = 1.20

Shear Stress, τ = 1.15 lb/ft^2

Breezy - Downstream Reach (Steep)

Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	1.01
Channel Slope =	6.0610%

Area (ft^2) =	9.1203
WP (ft) =	12.388
R_H (ft) =	0.736

Q (cfs) =	91
V (Q/A) (ft/s) =	10

Top Width (free surface) = 12.06 ft

Hydraulic Depth, y_h = 0.76 ft

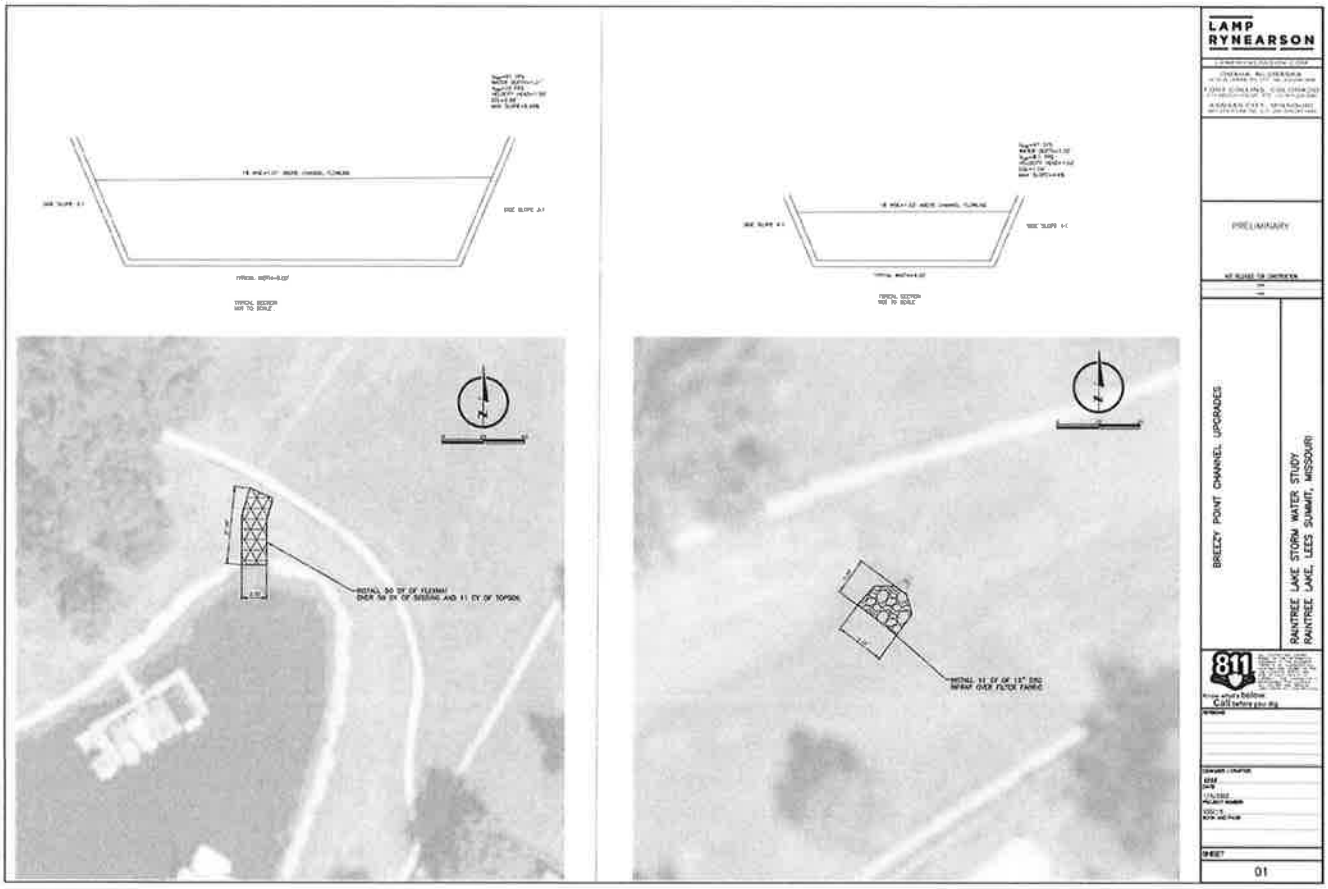
Fr = 2.03

Shear Stress, τ = 2.78 lb/ft^2

τ_{max} = 3.82 lb/ft^2

HY-8 - Lateral Culvert Outlet					
Storm	**Culvert Location**	**Depth (ft)**	**Velocity (ft/s)**	**Energy Slope (ft/ft)**	**Max Shear Stress (psf)**
50%	Outlet	1.003	10.358	0.0247	1.548
10%	Outlet	1.5	11.712	0.0388	3.634
1%	Outlet	1.5	11.822	0.0396	3.702

Alternative No. 1



Alternative No. 1

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Breezy Point Alternative 1: Flexamat					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$1,000.00	$1,000.00
2	Clearing Grubbing Demolition	LS	1	$750.00	$750.00
3	Site Restoration	LS	1	$500.00	$500.00
4	Flexamat or Equivilant	SY	50	$135.00	$6,750.00
5	Seeding and Fertalizing	SY	50	$3.00	$150.00
6	12" D50 Rip Rap Over Filter Fabric, 24" Depth	SY	11	$160.00	$1,760.00
7	Top Soil	CY	11	$55.00	$605.00

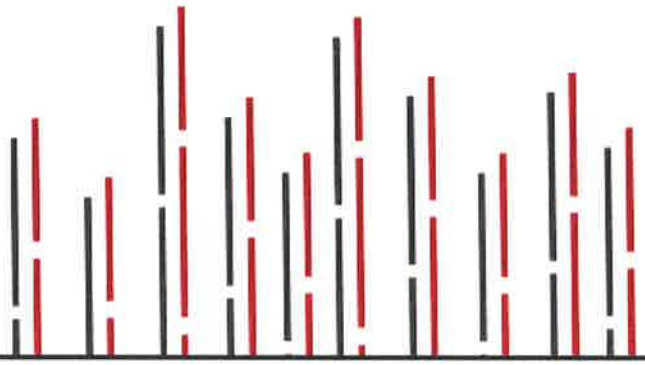
Subtotal	$11,515.00
Contingency(20%)	$2,303.00
Total Construction Cost	$13,818.00
Design Engineering	$3,000.00
Construction Administration	$1,000.00
Permitting	$300.00
Total Project Cost	$18,118.00

Alternative No. 2

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Breezy Point Alternative 2: Riprap					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$1,000.00	$1,000.00
2	Clearing Grubbing Demolition	LS	1	$750.00	$750.00
3	Site Restoration	LS	1	$500.00	$500.00
4	12" D50 Rip Rap Over Filter Fabric, 24" Depth	SY	61	$160.00	$9,760.00

Subtotal	$12,010.00
Contingency(20%)	$2,402.00
Total Construction Cost	$14,412.00
Design Engineering	$3,000.00
Construction Administration	$1,000.00
Permitting	$300.00
Total Project Cost	$18,712.00

Appendix C

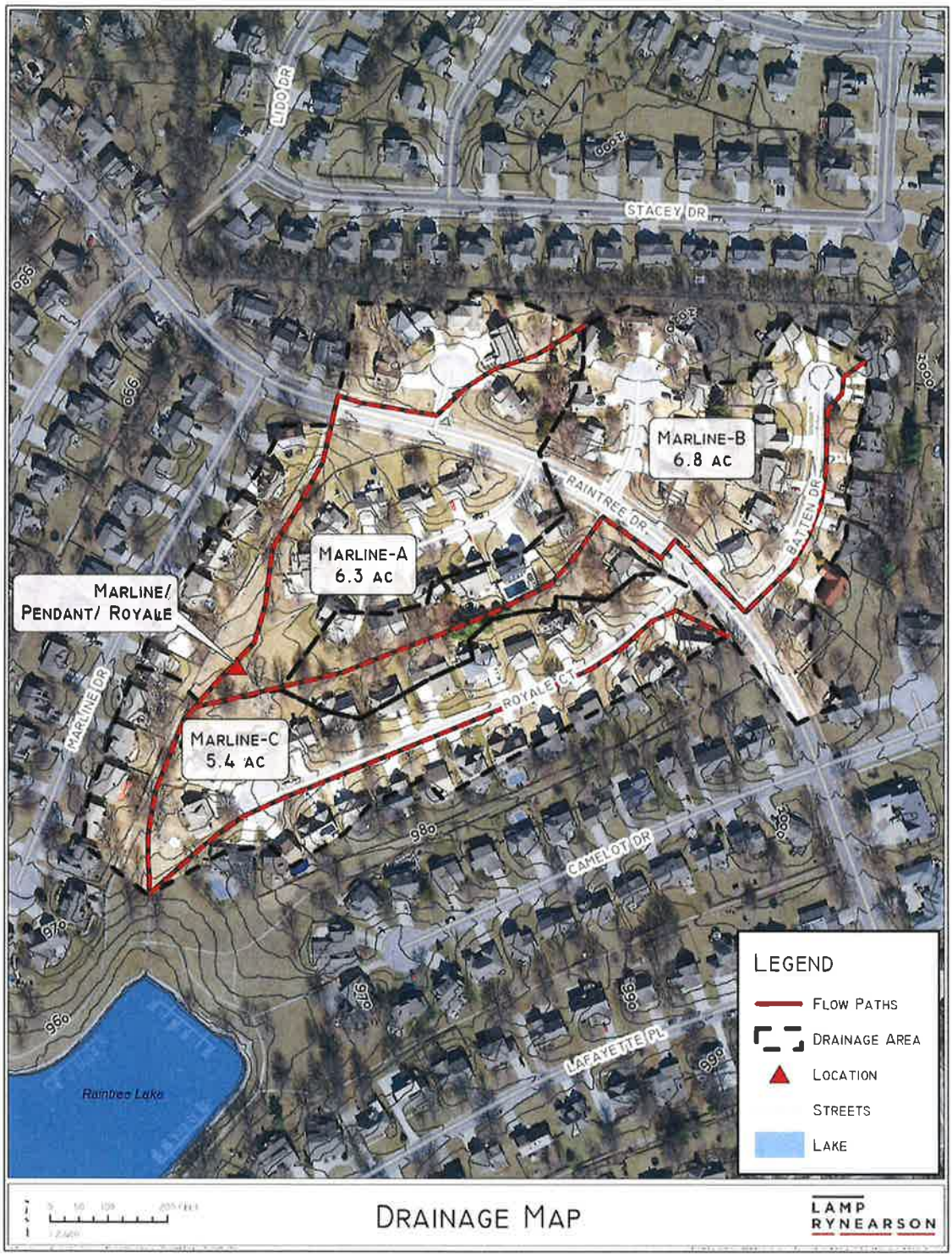


Marline/Pendant/Royale

Site Map

Appendix C – Marline/Pendant/Royale

Drainage Map



Appendix C – Marline/Pendant/Royale

Site Photos

Upstream channel behind SW Marline Dr homes, just downstream of culvert outfall

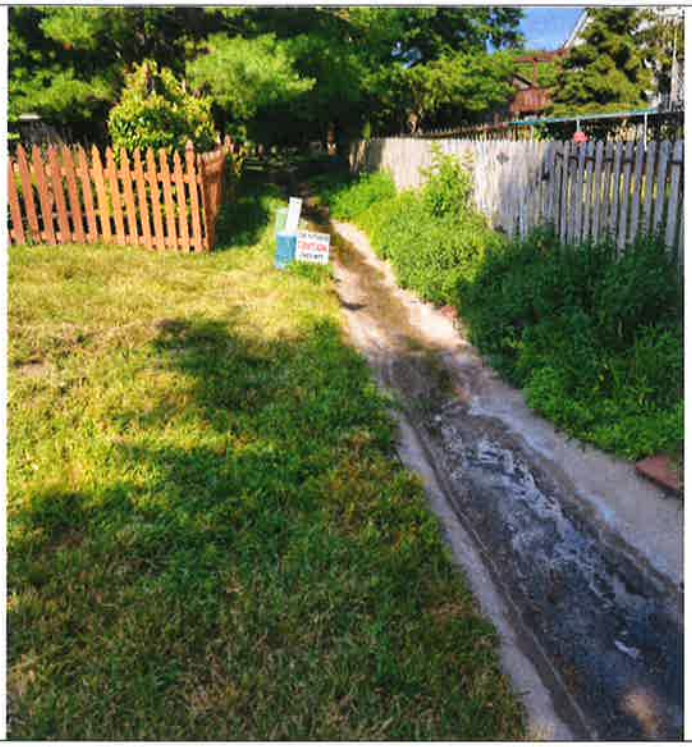
Marline channel upstream of rain garden, looking upstream

Site Photos

Marline channel upstream of rain garden, looking downstream

Sidewalk and flume between Pendant/Royale backyards at upstream end, looking downstream

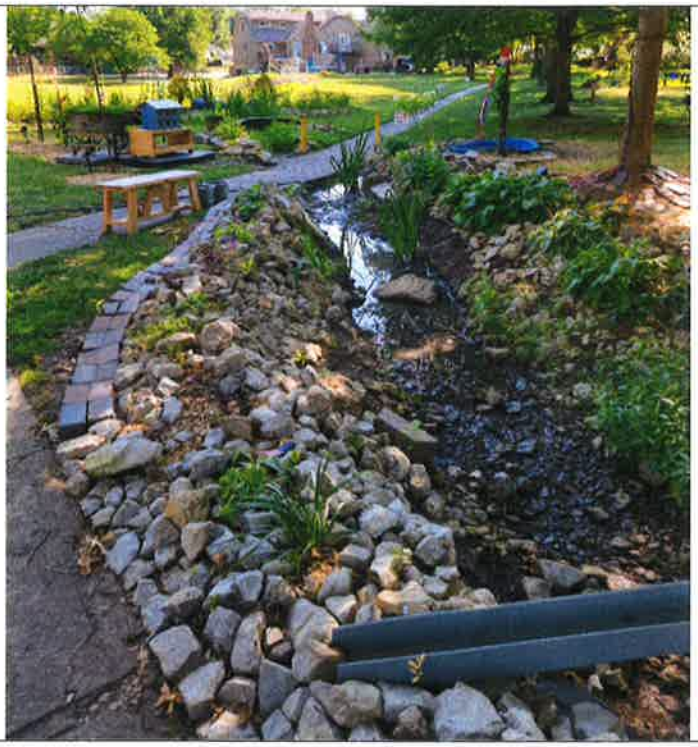
Site Photos



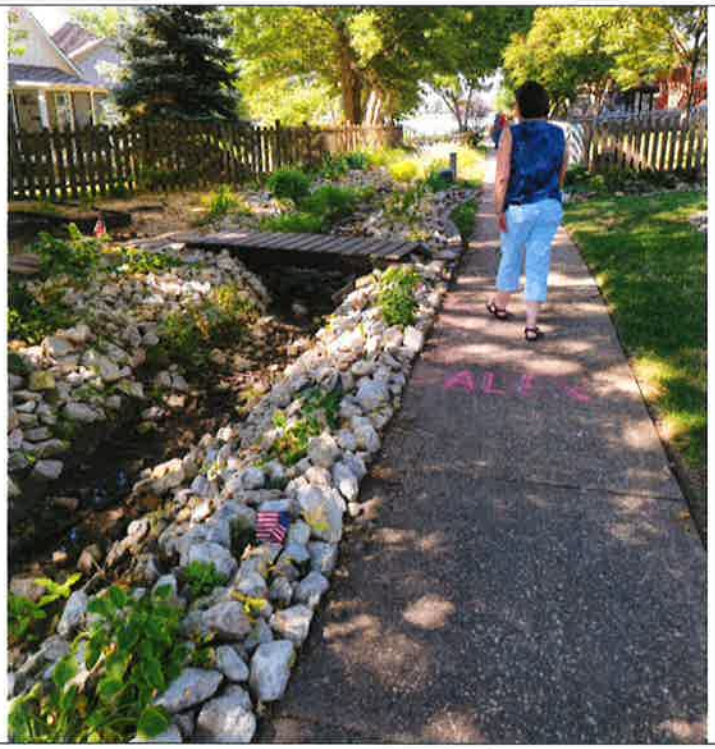
Wet concrete flume between Pendant/Royale backyards

Downstream end of concrete flume between Pendant/Royale backyards, looking upstream

Site Photos



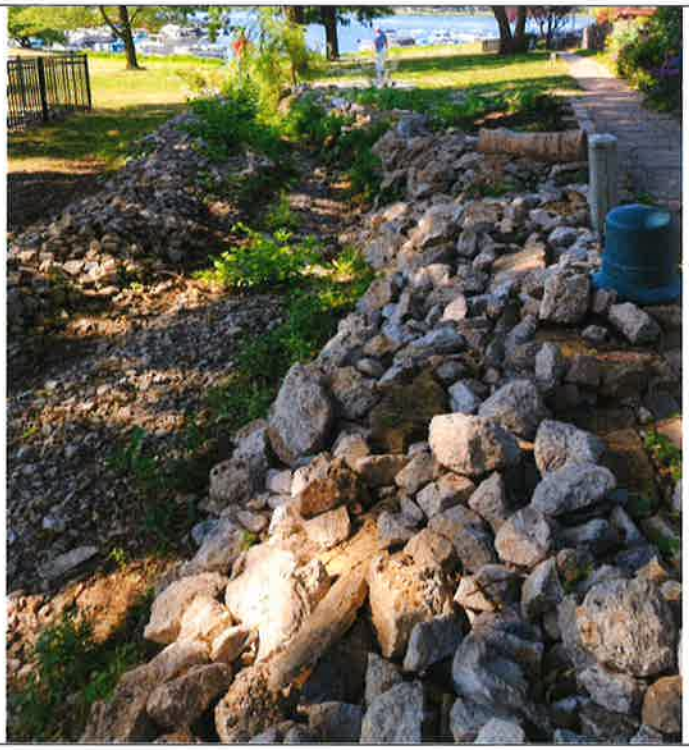
Channel downstream of rain garden, looking upstream



Channel downstream of rain garden looking downstream

Site Photos

Downstream channel, looking upstream; displaced riprap



Downstream channel, looking downstream

Site Photos

Downstream channel, looking downstream at concrete flume to lake

At downstream flume, looking upstream at channel

WinTR-55 Current Data Description

--- Identification Data ---

User: TMM
Project: 0322116
SubTitle: Marline/Pendant/Royale
State: Missouri
County: Jackson
Filename: L:\Engineering\0322116 Raintree Lake Pes\DESIGN DATA\Rational Method\Marline Pendent\Royale-Tr-55 (asb).w55

Date: 1/3/2023
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
A		ab	6.25	84	.178
B		ab	6.81	85	.207
C		Outlet	5.43	85	.172

Total area: 18.49 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.5	4.6	5.3	6.2	6.9	7.7	3.0

Storm Data Source: Jackson County, MO (NRCS)
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)
SUBAREAS			
A	16.54	29.84	47.83
B	18.04	32.09	50.94
C	15.03	26.73	42.48
REACHES			
ab	34.50	61.74	98.43
Down	34.48	61.69	98.36
OUTLET	49.30	88.09	140.21

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
A	6.25	0.178	84	ab	
B	6.81	0.207	85	ab	
C	5.43	0.172	85	Outlet	

Total Area: 18.49 (ac)

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
A							
SHEET	100	0.0300	0.150				0.133
SHALLOW	176	0.1037	0.025				0.007
CHANNEL	116	0.0069	0.013	1.76	4.73	4.603	0.007
CHANNEL	458	0.0259	0.030	3.77	10.41	4.104	0.031
					Time of Concentration		.178
B							
SHEET	100	0.0400	0.150				0.118
SHALLOW	610	0.0210	0.025				0.058
CHANNEL	204	0.0150	0.013	1.77	4.71	7.083	0.008
CHANNEL	544	0.0224	0.013	2.88	12.35	6.570	0.023
					Time of Concentration		.207
C							
SHEET	100	0.0500	0.150				0.108
SHALLOW	812	0.0333	0.025				0.061
CHANNEL	88	0.0454	0.013	1.24	5.01	8.148	0.003
					Time of Concentration		.172

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
A	Paved; curbs and storm sewers	C	.62	98
	Residential districts (1/4 acre)	C	5.63	83
	Total Area / Weighted Curve Number		6.25	84
B	Paved; curbs and storm sewers	C	.93	98
	Residential districts (1/4 acre)	C	5.88	83
	Total Area / Weighted Curve Number		6.81	85
C	Paved parking lots, roofs, driveways	C	.66	98
	Residential districts (1/4 acre)	C	4.77	83
	Total Area / Weighted Curve Number		5.43	85

Reach Channel Rating Details

Reach Identifier	Reach Length (ft)	Reach Manning's n	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope
ab	350	0.035	0.026	4	2 :1

Reach Identifier	Stage (ft)	Flow (cfs)	End Area (sq ft)	Top Width (ft)	Friction Slope (ft/ft)
ab	0.0	0.000	0	4	0.026
	0.5	9.305	2.5	6	
	1.0	32.636	6	8	
	2.0	126.159	16	12	
	5.0	918.960	70	24	
	10.0	4756.745	240	44	
	20.0	26866.530	880	84	

Existing Subshed A Channel - 1% Storm

Sideslope LT. =	5 :1
Sideslope RT. =	7 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	0.916171584
Channel Slope =	2.5983%

Area (ft^2) =	8.700908568
WP (ft) =	15.150
R_H (ft) =	0.574

Q (cfs) =	48.00
V (Q/A) (ft/s) =	5.6

Top Width (free surface) =	14.99 ft
Hydraulic Depth, y_h =	0.58 ft
Fr =	1.30
Shear Stress, τ =	0.93 lb/ft^2

Existing Subshed B Channel - 1% Storm

Sideslope LT. =	12 :1
Sideslope RT. =	12 :1
n =	0.013
Bottom Width (ft) =	4
Flow Depth (ft) =	0.56415857
Channel Slope =	2.2243%

Area (ft^2) =	6.075932981
WP (ft) =	17.587
R_H (ft) =	0.345

Q (cfs) =	51.00
V (Q/A) (ft/s) =	8.4

Top Width (free surface) =	17.54 ft
Hydraulic Depth, y_h =	0.35 ft
Fr =	2.52
Shear Stress, τ =	0.48 lb/ft^2

Existing Downstream Channel C - 1% Storm
(at upstream pinch point, just downstream of A & B)

Sideslope LT. =	2 :1
Sideslope RT. =	2 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.860360346
Channel Slope =	1.6100%

Area (ft^2) =	14.36332262
WP (ft) =	12.320
R_H (ft) =	1.166

Q (cfs) =	100.00
V (Q/A) (ft/s) =	7

Top Width (free surface) = 11.44 ft
Hydraulic Depth, y_h = 1.26 ft

Fr = 1.10
Shear Stress, τ = 1.17 lb/ft^2

Pinch Point - Composite Channel Geometry - 1% Storm (Existing)

Main Channel Flow

Sideslope LT. =	2.2 :1
Sideslope RT. =	1.8 :1
n =	0.03
Bottom Width (ft) =	3
Flow Depth (ft) =	1
Channel Slope =	1.6100%
Area (ft^2) =	5
WP (ft) =	7.475
R_H (ft) =	0.669
Q (cfs) =	24.03
V (Q/A) (ft/s) =	4.9

Top Width (free surface) = 7.00 ft

Overflow - Left Bank

Sideslope LT. =	24 :1
Sideslope RT. =	0 :1
n =	0.03
Bottom Width (ft) =	0
Flow Depth (ft) =	0.95
Channel Slope =	1.6100%
Area (ft^2) =	10.83
WP (ft) =	23.770
R_H (ft) =	0.456
Q (cfs) =	34.23
V (Q/A) (ft/s) =	3.2

Top Width (free surface) = 22.80 ft

Overflow - Right Bank

Sideslope LT. =	0 :1
Sideslope RT. =	10 :1
n =	0.03
Bottom Width (ft) =	0
Flow Depth (ft) =	0.95
Channel Slope =	1.1610%
Area (ft^2) =	4.5125
WP (ft) =	10.497
R_H (ft) =	0.430
Q (cfs) =	15.72
V (Q/A) (ft/s) =	3.5

Top Width (free surface) = 9.50 ft

Overflow - Center (above Main Channel Flow)

Sideslope LT. =	0 :1
Sideslope RT. =	0 :1
n =	0.03
Bottom Width (ft) =	7
Flow Depth (ft) =	0.95
Channel Slope =	1.1610%
Area (ft^2) =	6.65
WP (ft) =	8.900
R_H (ft) =	0.747
Q (cfs) =	29.23
V (Q/A) (ft/s) =	4.4

Existing Downstream Channel C - 1% Storm
(average channel slope)

Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.42942314
Channel Slope =	3.3000%

Area (ft^2) =	11.8474441
WP (ft) =	13.040
R_H (ft) =	0.909

Q (cfs) =	100.00
V (Q/A) (ft/s) =	8.5

Top Width (free surface) =	12.58 ft
Hydraulic Depth, y_h =	0.94 ft
Fr =	1.54
Shear Stress, τ =	1.87 lb/ft^2

Existing Downstream Channel C - 1% Storm
(steepest channel slope)

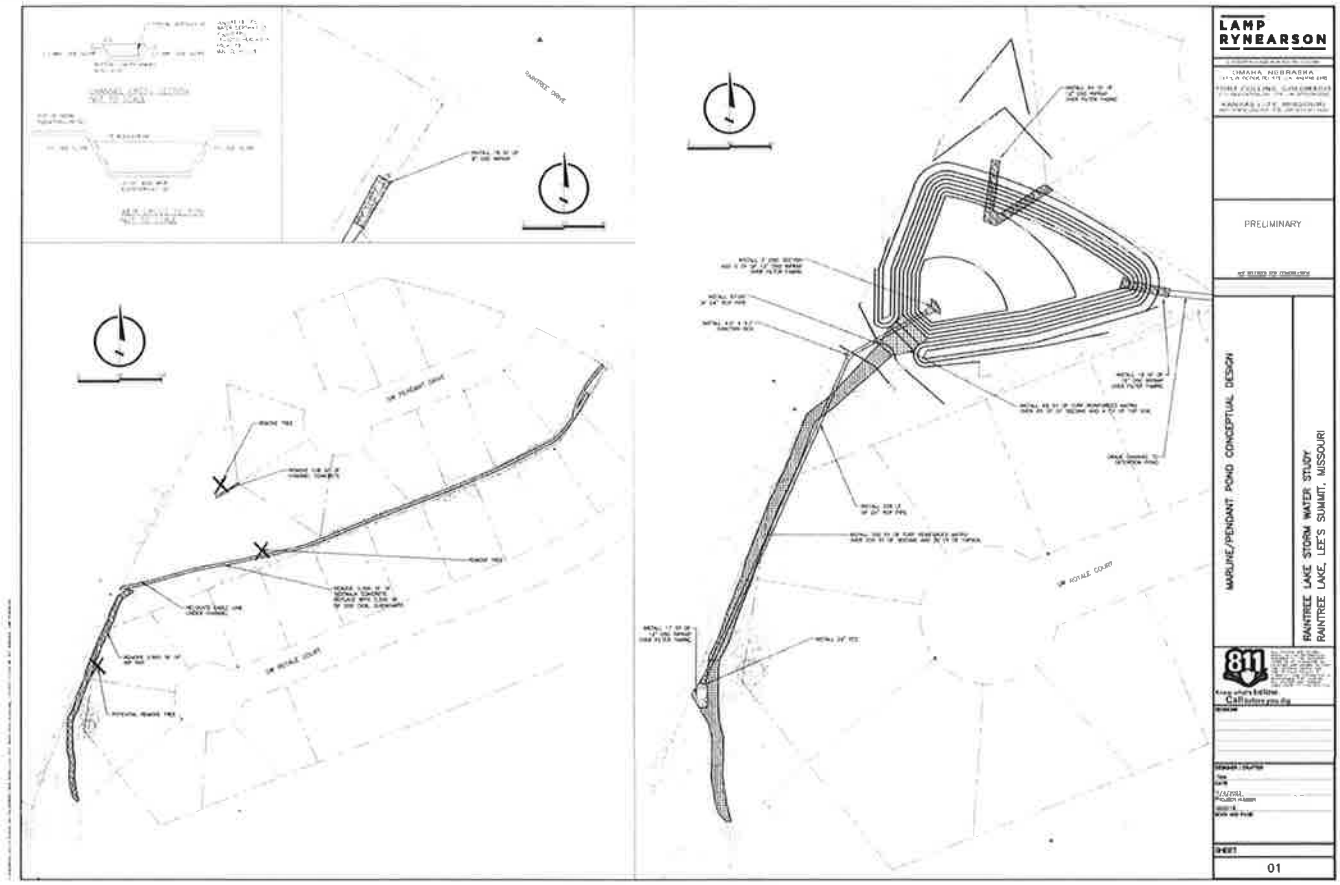
Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.108994789
Channel Slope =	9.2600%

Area (ft^2) =	8.125587479
WP (ft) =	11.014
R_H (ft) =	0.738

Q (cfs) =	100.00
V (Q/A) (ft/s) =	12.4

Top Width (free surface) =	10.65 ft
Hydraulic Depth, y_h =	0.76 ft
Fr =	2.50
Shear Stress, τ =	4.26 lb/ft^2
τ_{max} =	6.41 lb/ft^2

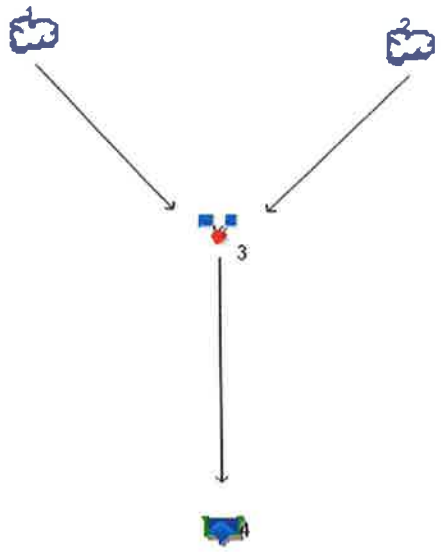
Alternative No. 1



Appendix C – Marline/Pendant/Royale

Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022



Legend

Hyd.	Origin	Description
1	SCS Runoff	Marline A
2	SCS Runoff	Marline B
3	Combine	Combined A and B
4	Reservoir	To pond

Alternative No. 1

2

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	------	17.47	------	------	31.59	------	------	50.65	Marline A
2	SCS Runoff	------	------	19.80	------	------	35.26	------	------	56.01	Marline B
3	Combine	1, 2	------	37.27	------	------	66.86	------	------	106.65	Combined A and B
4	Reservoir	3	------	22.81	------	------	31.16	------	------	82.81	To pond

50% Storm

3

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	17.47	2	720	45,307	------	------	------	Marline A
2	SCS Runoff	19.80	2	720	51,403	------	------	------	Marline B
3	Combine	37.27	2	720	96,710	1, 2	------	------	Combined A and B
4	Reservoir	22.81	2	728	96,709	3	975.03	14,011	To pond

10% Storm

10

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	31.59	2	720	82,963	------	------	------	Marline A
2	SCS Runoff	35.26	2	720	92,956	------	------	------	Marline B
3	Combine	66.86	2	720	175,919	1, 2	------	------	Combined A and B
4	Reservoir	31.16	2	730	175,918	3	977.02	35,836	To pond

Alternative No. 1

1% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	50.65	2	720	135,878	------	------	------	Marline A
2	SCS Runoff	56.01	2	720	151,023	------	------	------	Marline B
3	Combine	106.66	2	720	286,901	1, 2	------	------	Combined A and B
4	Reservoir	82.81	2	726	286,900	3	978.34	53,296	To pond

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022 — Wednesday, 12 / 21 / 2022

Pond No. 1 - Pond 1 Marline

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Beginning Elevation = 972.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	972.00	04	0	0
1.00	973.00	2,290	797	797
2.00	974.00	7,173	4,505	5,301
3.00	975.00	9,679	8,394	13,695
4.00	976.00	10,926	10,295	23,990
5.00	977.00	12,230	11,570	35,560
6.00	978.00	13,583	12,899	48,459
7.00	979.00	14,990	14,279	62,738
8.00	980.00	16,451	15,713	78,451

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	Inactive	0.00	0.00	0.00
Span (in)	= 24.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 972.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

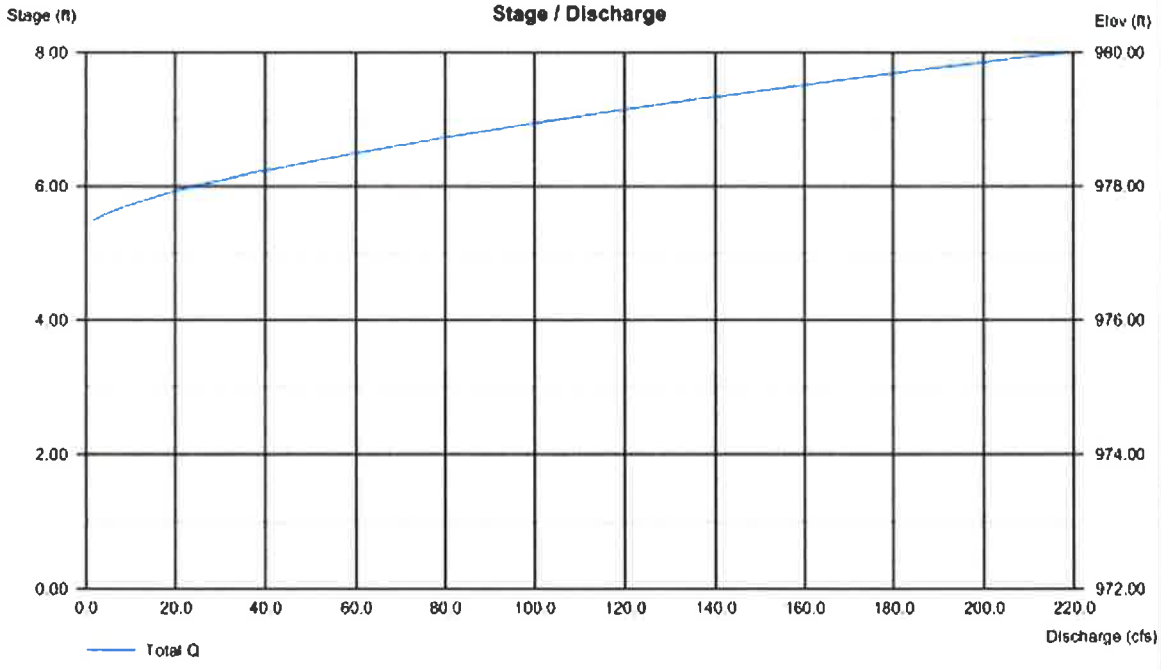
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	0.00	0.00	0.00
Crest El. (ft)	= 977.40	0.00	0.00	0.00
Weir Coeff.	= 2.60	3.33	3.33	3.33
Weir Type	= Broad	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (i) and outlet (o) control. Weir flows checked for orifice conditions (c) and submergence (s).



Alternative No. 1

Subshed B Channel Improvement

Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.130032648
Channel Slope =	2.2340%

Area (ft^2) =	8.351051952
WP (ft) =	11.147
R_H (ft) =	0.749

Q (cfs) =	51.00
V (Q/A) (ft/s) =	6.2

Top Width (free surface) = 10.78 ft

Hydraulic Depth, y_h = 0.77 ft

Fr = 1.24

Shear Stress, τ = 1.04 lb/ft^2

Channel C TRM

Sideslope LT. =	2 :1
Sideslope RT. =	2 :1
n =	0.03
Bottom Width (ft) =	5
Flow Depth (ft) =	1.449157798
Channel Slope =	3.0000%

Area (ft^2) =	11.44590564
WP (ft) =	11.481
R_H (ft) =	0.997

Q (cfs) =	98.00
V (Q/A) (ft/s) =	8.6

Top Width (free surface) = 10.80 ft

Hydraulic Depth, y_h = 1.06 ft

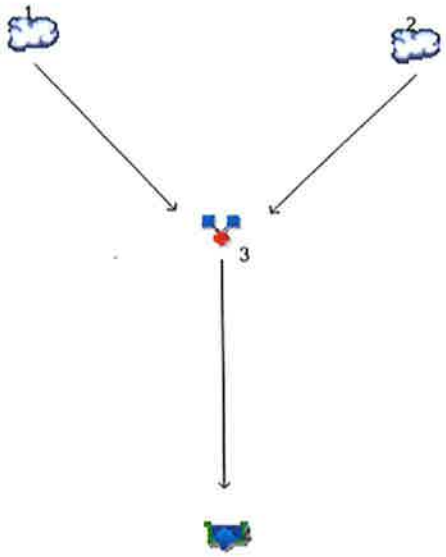
Alternative No. 1

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Marline/Pendant Alternative 1: Excavated Pond					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$15,000.00	$15,000.00
2	Erosion Control	LS	1	$3,000.00	$3,000.00
3	Site Restoration	LS	1	$5,000.00	$5,000.00
4	Clearing Grubbing Demolition	LS	1	$2,500.00	$2,500.00
4	8" D50 Rip Rap Over Filter Fabric, 16" Depth	SY	18	$140.00	$2,520.00
5	12" D50 Rip Rap Over Filter Fabric, 24" Depth	SY	99	$150.00	$14,850.00
7	4'X4' Junction Box	EA	1	$6,000.00	$6,000.00
8	24" RCP Pipe	LF	321	$180.00	$57,780.00
9	24" End Section (Concrete)	EA	1	$2,500.00	$2,500.00
10	Flared End Section 3' (Concrete)	EA	1	$2,500.00	$2,500.00
11	Earthwork Excavation	CY	2200	$5.00	$11,000.00
12	Earthwork Embankment	CY	250	$15.00	$3,750.00
13	Concrete Removal	SF	3408	$5.00	$17,040.00
14	Tree Removal	EA	3	$2,000.00	$6,000.00
15	Sodding	SF	3300	$5.00	$16,500.00
16	Turf Reinforced Matrix Lining	SY	415	$13.00	$5,395.00
17	Seeding and Fertilizing	SY	415	$3.00	$1,245.00
18	Spreading and Placing Top Soil (2")	CY	24	$55.00	$1,320.00

Subtotal	$173,900.00
Contingency(20%)	$34,780.00
Total Construction Cost	$208,680.00
Design Engineering and Easement Acquisition	$25,000.00
Construction Administration	$5,000.00
Utility Relocation	$3,000.00
Testing Services	$3,000.00
Permitting	$7,200.00
Total Project Cost	$251,880.00

Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022



Legend

Hyd.	Origin	Description
1	SCS Runoff	Marline A
2	SCS Runoff	Marline B
3	Combine	Combined A and B
4	Reservoir	To pond

Alternative No. 2

2

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc v2022

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	------	17.47	------	------	31.59	------	------	50.65	Marline A
2	SCS Runoff	------	------	19.80	------	------	35.26	------	------	56.01	Marline B
3	Combine	1, 2	------	37.27	------	------	66.86	------	------	106.66	Combined A and B
4	Reservoir	3	------	30.00	------	------	60.96	------	------	99.97	To pond

50% Storm

3

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	17.47	2	720	45,307	------	------	------	Marline A
2	SCS Runoff	19.80	2	720	51,403	------	------	------	Marline B
3	Combine	37.27	2	720	96,710	1, 2	------	------	Combined A and B
4	Reservoir	30.00	2	726	96,709	3	977.78	14,565	To pond

10% Storm

8

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	31.59	2	720	82,963	------	------	------	Marline A
2	SCS Runoff	35.26	2	720	92,956	------	------	------	Marline B
3	Combine	66.86	2	720	175,919	1, 2	------	------	Combined A and B
4	Reservoir	60.96	2	724	175,918	3	978.25	20,537	To pond

Alternative No. 2

1% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	50.65	2	720	135,878	------	------	------	Marline A
2	SCS Runoff	56.01	2	720	151,023	------	------	------	Marline B
3	Combine	106.66	2	720	286,901	1, 2	------	------	Combined A and B
4	Reservoir	99.97	2	722	286,900	3	978.71	27,106	To pond

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022 — Thursday, 01 / 5 / 2023

Pond No. 1 - Pond 1 Marline

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 975.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	975.00	02	0	0
1.00	976.00	2,483	852	852
2.00	977.00	8,460	5,175	6,026
3.00	978.00	13,583	10,920	16,946
4.00	979.00	14,990	14,279	31,225
5.00	980.00	16,451	15,713	46,938

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 19.00	0.00	0.00	0.00
Span (in)	= 24.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 975.00	0.00	0.00	0.00
Length (ft)	= 45.00	0.00	0.00	0.00
Slope (%)	= 0.75	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

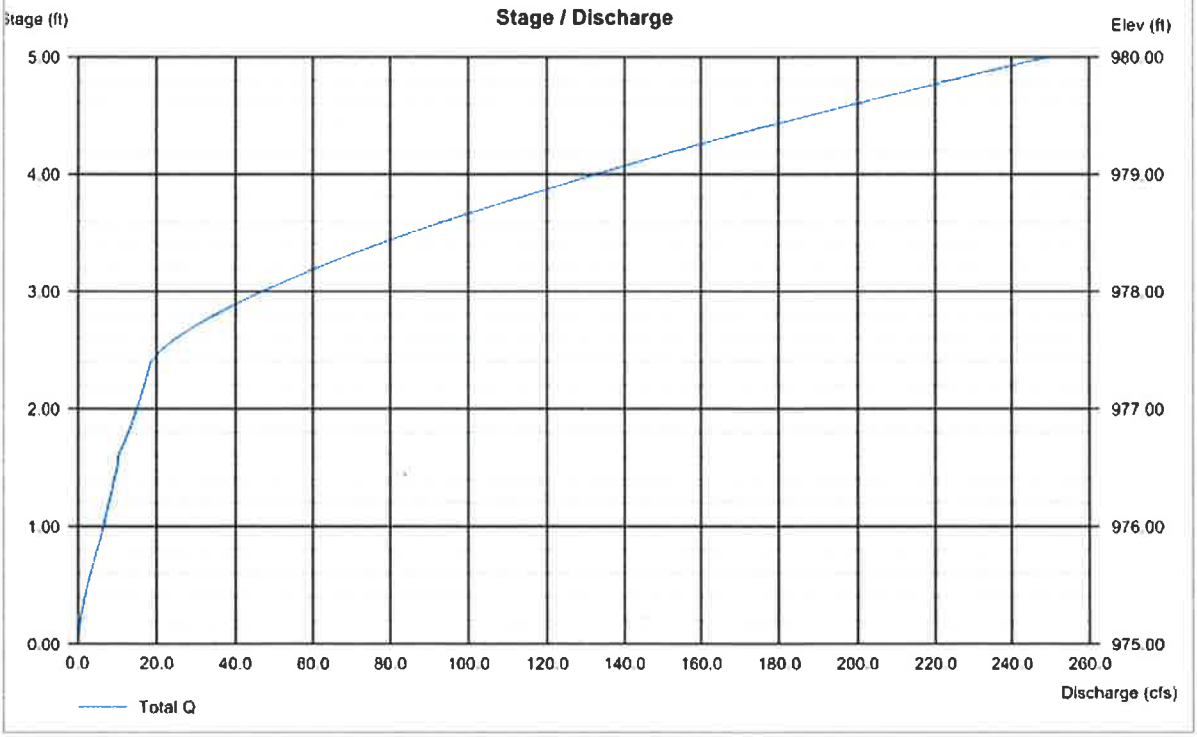
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	0.00	0.00	0.00
Crest El. (ft)	= 977.40	0.00	0.00	0.00
Weir Coeff.	= 2.60	3.33	3.33	3.33
Weir Type	= Broad	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (i) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

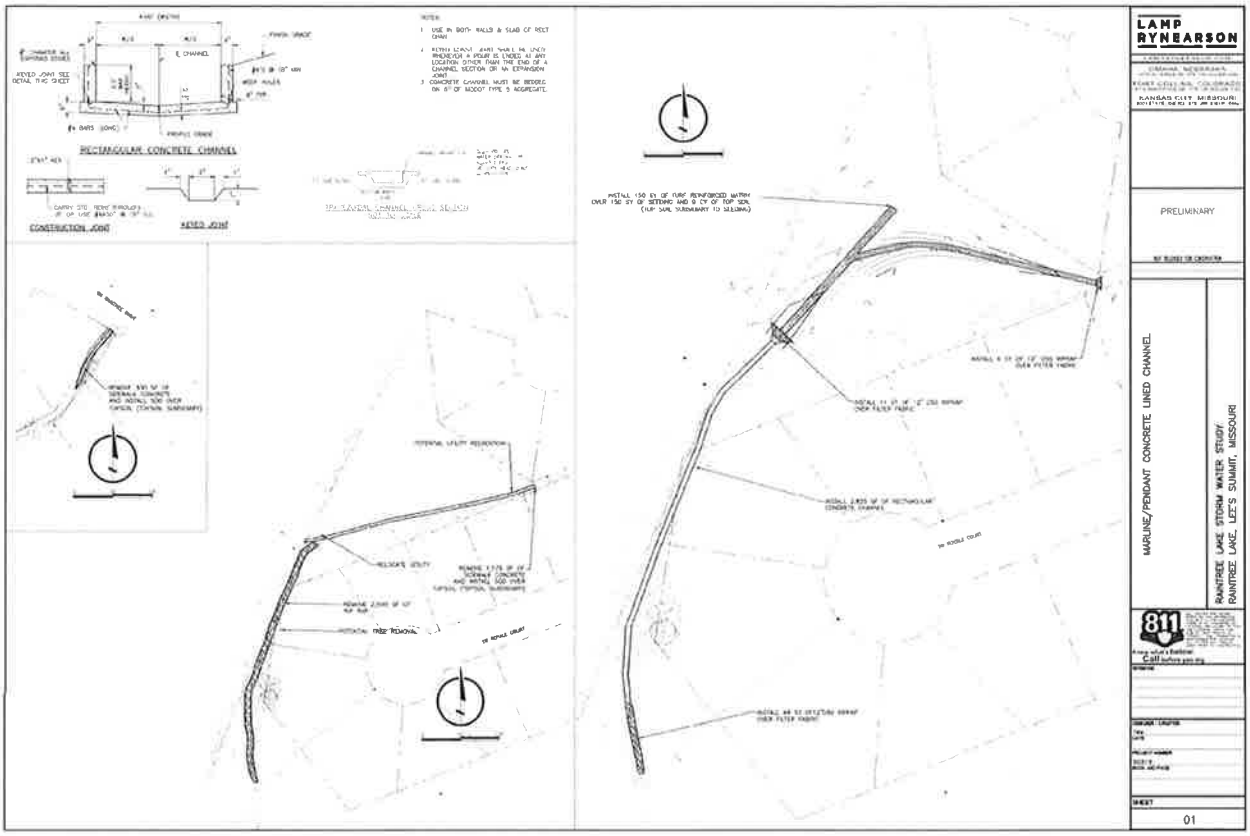


Alternative No. 2

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Marline/Pendant Alternative 2: Pond On Grade					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$15,000.00	$15,000.00
2	Erosion Control	LS	1	$3,000.00	$3,000.00
3	Site Restoration	LS	1	$5,000.00	$5,000.00
4	Clearing Grubbing Demolition	LS	1	$2,500.00	$2,500.00
5	12" D50 Rip Rap Over Filter Fabric, 24" Depth	SY	99	$160.00	$15,840.00
6	8" D50 Rip Rap Over Filter Fabric, 16" Depth	SY	18	$150.00	$2,700.00
7	24" RCP Pipe	LF	60	$180.00	$10,800.00
8	End Section 2' (Concrete)	EA	1	$2,500.00	$2,500.00
9	Flared End Section 2' (Concrete)	EA	1	$2,500.00	$2,500.00
10	Earthwork Excavation	EA	1035	$5.00	$5,175.00
11	Earthwork Embankment	CY	391	$15.00	$5,865.00
12	Concrete Removal	CY	3408	$5.00	$17,040.00
13	Tree Removal	SF	3	$2,000.00	$6,000.00
14	Sodding	EA	3300	$5.00	$16,500.00
15	Turf Reinforced Matrix Lining	SY	415	$13.00	$5,395.00
16	Seeding and Fertilizing	SY	24	$20.00	$480.00

Subtotal	$116,295.00
Contingency(20%)	$23,259.00
Total Construction Cost	$139,554.00
Design Engineering and Easement Acquisition	$25,000.00
Construction Administration	$5,000.00
Testing Services	$3,000.00
Utility Relocation	$3,000.00
Permitting	$7,200.00
Total Project Cost	$182,754.00

Alternative No. 3



Appendix C – Marline/Pendant/Royale

Alternative No. 3

Subshed B Channel Improvement (TRM)	
1% Storm	
Sideslope LT. =	4 :1
Sideslope RT. =	4 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.028835986
Channel Slope =	2.6000%

Area (ft^2) =	8.349357894
WP (ft) =	12.484
R_H (ft) =	0.669

Q (cfs) =	51.00
V (Q/A) (ft/s) =	6.2

Top Width (free surface) = 12.23 ft

Hydraulic Depth, y_h = 0.68 ft

Fr = 1.32

Shear Stress, τ = 1.09 lb/ft^2

τ_{max} = 1.67 lb/ft^2

Subshed A Channel Improvement (TRM)	
1% Storm	
Sideslope LT. =	4 :1
Sideslope RT. =	4 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	0.998924858
Channel Slope =	2.6000%

Area (ft^2) =	7.987102922
WP (ft) =	12.237
R_H (ft) =	0.653

Q (cfs) =	48.00
V (Q/A) (ft/s) =	6.1

Top Width (free surface) = 11.99 ft

Hydraulic Depth, y_h = 0.67 ft

Fr = 1.32

Shear Stress, τ = 1.06 lb/ft^2

τ_{max} = 1.62 lb/ft^2

Alternative No. 3

Rectangular Concrete Channel	
1% Storm Min Slope	
Height (y)	2.5
Channel Height	2.5
n =	0.013
Bottom Width (ft) =	4
Flow Depth (ft) =	1.794444441
Channel Slope =	1.6000%

Area (ft^2) =	7.177777764
WP (ft) =	7.589
R_H (ft) =	0.946

Q (cfs) =	100.00
V (Q/A) (ft/s) =	14

Top Width (free surface) = 4.00 ft

Hydraulic Depth, y_h = 1.79 ft

Fr = 1.84

Shear Stress, τ = 0.94 lb/ft^2

τ_{max} = 1.79 lb/ft^2

Rectangular Channel 100 Year	
1% Storm Max Slope	
Height (y)	2.5
Channel Height	2.5
n =	0.013
Bottom Width (ft) =	4
Flow Depth (ft) =	0.959057531
Channel Slope =	9.2700%

Area (ft^2) =	3.836230123
WP (ft) =	5.918
R_H (ft) =	0.648

Q (cfs) =	100.00
V (Q/A) (ft/s) =	26.1

Top Width (free surface) = 4.00 ft

Hydraulic Depth, y_h = 0.96 ft

Fr = 4.70

Shear Stress, τ = 3.75 lb/ft^2

τ_{max} = 5.55 lb/ft^2

Subshed C Concrete Channel to Riprap Transition	
1% Storm Average Slope	
Sideslope LT. =	3 :1
Sideslope RT. =	3 :1
n =	0.04
Bottom Width (ft) =	4
Flow Depth (ft) =	1.895918477
Channel Slope =	1.7500%

Area (ft^2) =	18.36719452
WP (ft) =	15.991
R_H (ft) =	1.149

Q (cfs) =	99.00
V (Q/A) (ft/s) =	5.4

Top Width (free surface) = 15.38 ft

Hydraulic Depth, y_h = 1.19 ft

Fr = 0.87

Shear Stress, τ = 1.25 lb/ft^2

τ_{max} = 2.07 lb/ft^2

Subshed A and B Channel Improvement	
1% Storm (TRM at Pinch Point)	
Sideslope LT. =	4 :1
Sideslope RT. =	4 :1
n =	0.03
Bottom Width (ft) =	4
Flow Depth (ft) =	1.386346458
Channel Slope =	2.8000%

Area (ft^2) =	13.23321183
WP (ft) =	15.432
R_H (ft) =	0.858

Q (cfs) =	99.00
V (Q/A) (ft/s) =	7.5

Top Width (free surface) = 15.09 ft

Hydraulic Depth, y_h = 0.88 ft

Fr = 1.41

Shear Stress, τ = 1.50 lb/ft^2

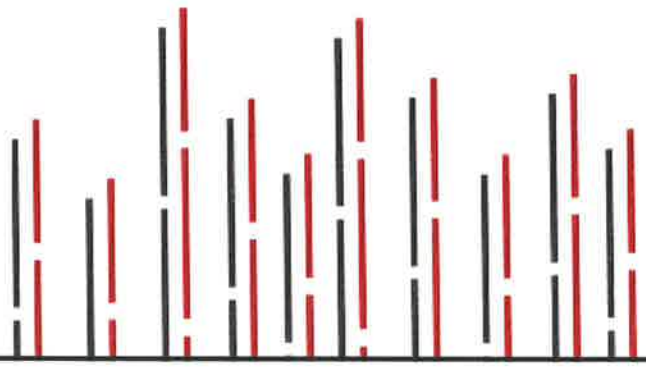
τ_{max} = 2.42 lb/ft^2

Alternative No. 3

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Marline/Pendant Alternative 3 Concrete Channel					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$10,250.00	$10,250.00
2	Erosion Control	LS	1	$2,500.00	$2,500.00
3	Site Restoration	LS	1	$5,000.00	$5,000.00
4	Clearing Grubbing Demolition	LS	1	$6,000.00	$6,000.00
5	12" D50 Rip Rap Over Filter Fabric, 24" Depth	SY	63	$160.00	$10,080.00
6	Rectangular Channel (Concrete, 4'x2.5')	SF	2835	$30.00	$85,050.00
8	Turf Reinforced Matrix Lining	SY	150	$13.00	$1,950.00
8	Earthwork Excavation	CY	171	$5.00	$855.00
9	Concrete Removal	SF	1505	$5.00	$7,525.00
10	Sodding	SF	1505	$5.00	$7,525.00
11	Seeding and Fertilizing	SY	150	$20.00	$3,000.00

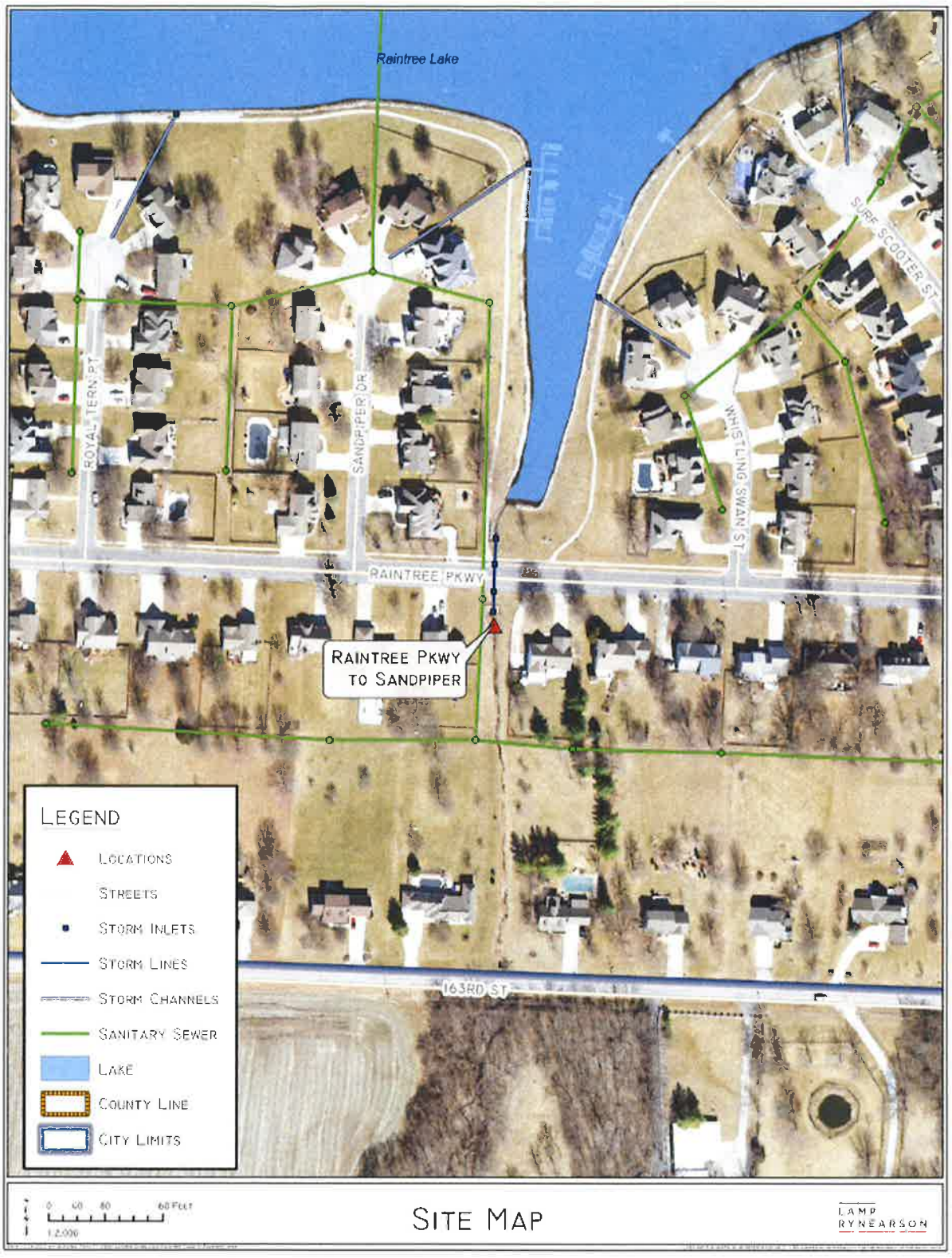
Subtotal	$139,735.00
Contingency(20%)	$27,947.00
Total Construction Cost	$167,682.00
Design Engineering and Easement Acquisition	$15,000.00
Construction Administration	$5,000.00
Testing Services	$3,000.00
Utility Relocation	$2,000.00
Permitting	$5,500.00
Total Project Cost	$198,182.00

Appendix D



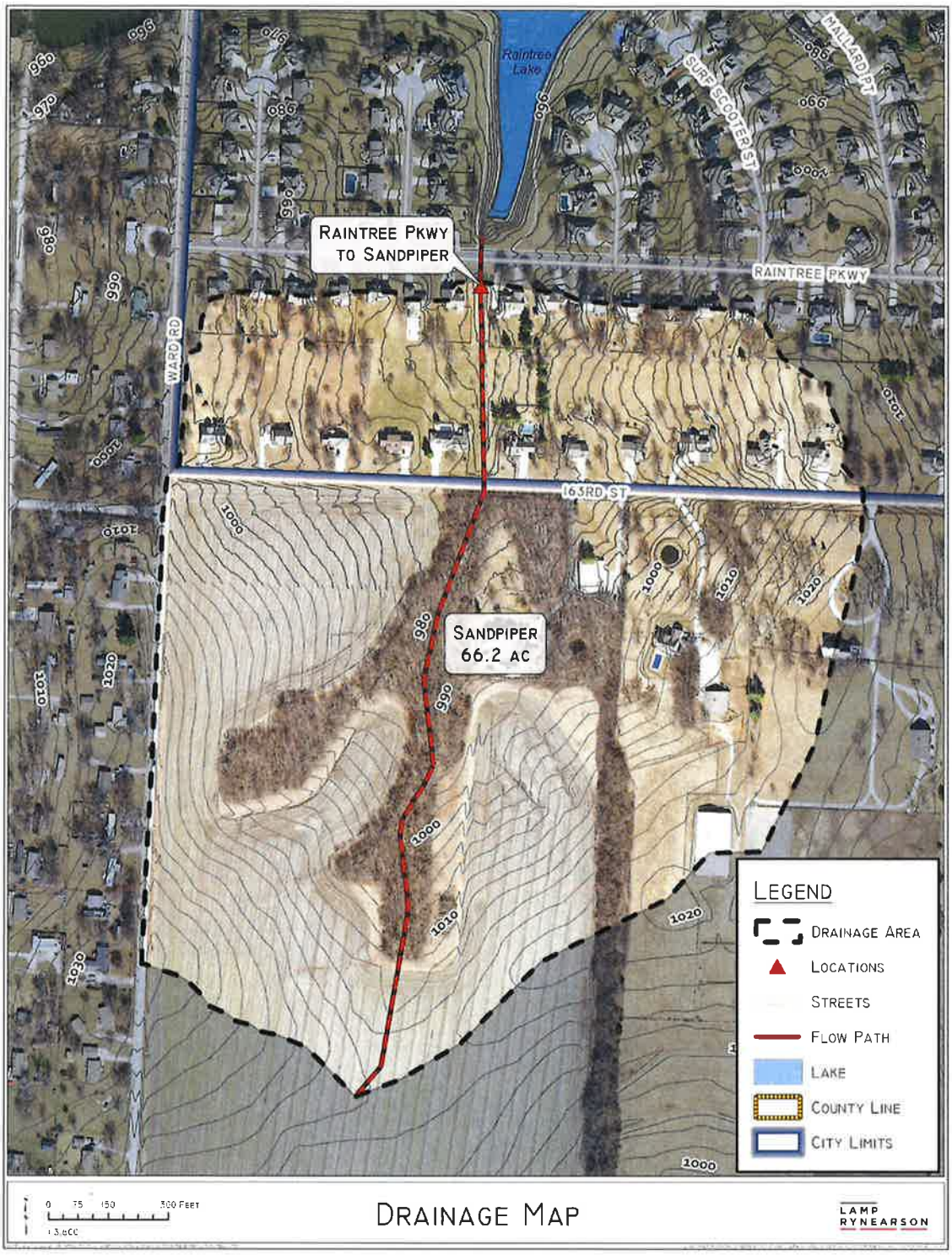
Raintree Pkwy to Sandpiper

Site Map



Appendix D – Raintree Pkwy to Sandpiper

Drainage Map



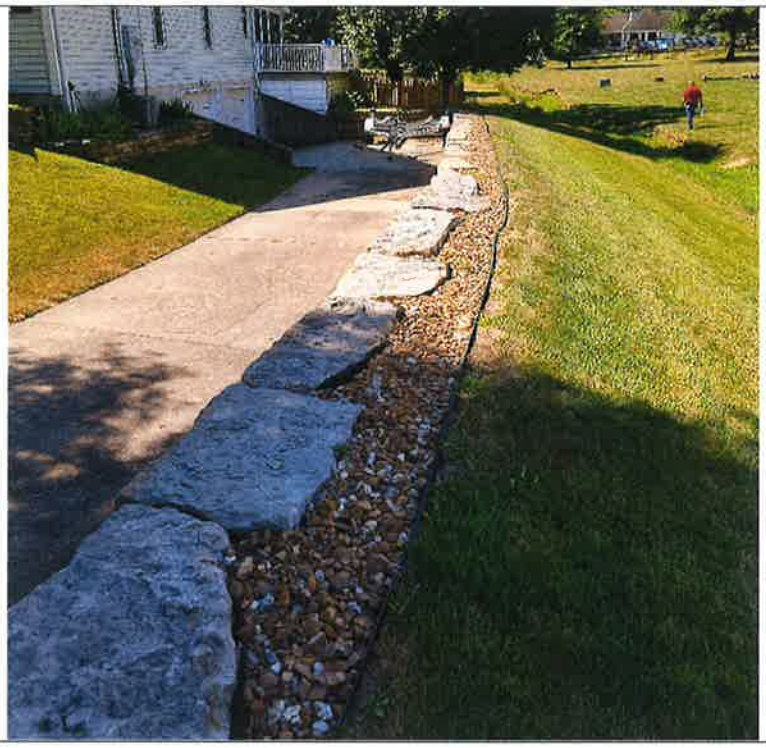
Appendix D – Raintree Pkwy to Sandpiper

Site Photos

Culvert inlet, drop structure, debris catcher (July 2022)

View of upstream channel, culvert inlet, drop structure, debris catcher (December 2022)

Site Photos



Retaining wall at 5271 SW Raintree Pkwy residence, upstream channel at right

View of area between street and retaining wall

Site Photos

Culvert outlet, looking upstream

Gabion baskets lining channel banks downstream of culvert outlet

WinTR-55 Current Data Description

--- Identification Data ---

User:
Project:
SubTitle:
State: Missouri
County: Cass
Filename: L:\Engineering\0322116 Raintree Lake Pes\DESIGN DATA\Rational Method\Raintree to Sandpiper\TR-55 RAINTREE TO SANDPIPER (ASB).w55

Date: 1/3/2023
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Raintree S		Outlet	66.18	78	.283

Total area: 66.18 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.6	4.7	5.4	6.3	7.0	7.8	3.0

Storm Data Source: Cass County, MO (NRCS)
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)
SUBAREAS			
Raintree S	122.70	239.27	403.18
REACHES			
OUTLET	122.70	239.27	403.18

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Raintree S	66.18	0.283	78	Outlet	

Total Area: 66.18 (ac)

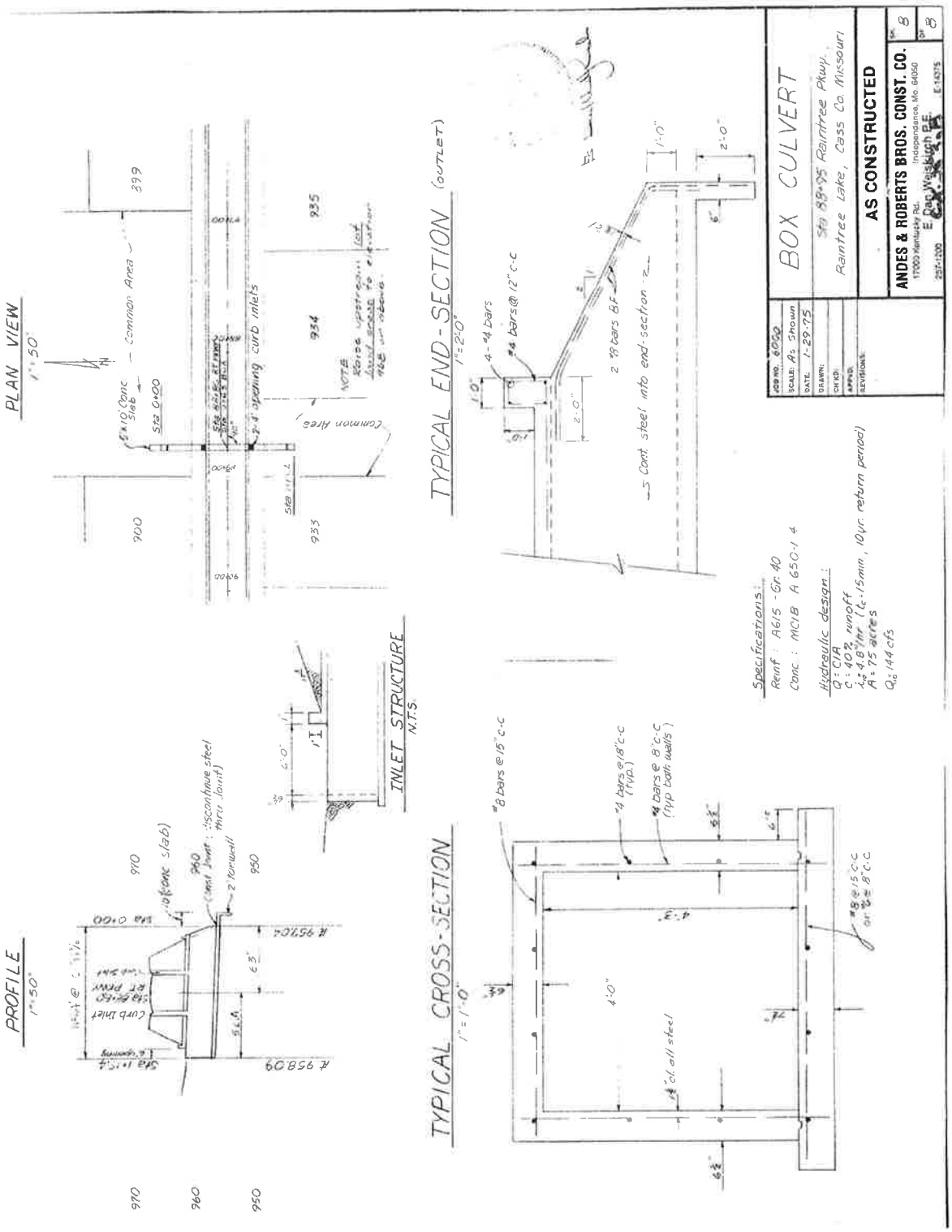
Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Raintree S							
SHEET	100	0.0200	0.150				0.154
SHALLOW	792	0.0316	0.050				0.077
CHANNEL	1237	0.0252	0.030	11.58	15.29	6.608	0.052
					Time of Concentration		.283

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Raintree S	Residential districts (1 acre)		D	10	84
	Residential districts (2 acre)		C	19.7	77
	Row Crop C + Crop residue	(good)	C	25	81
	Woods	(good)	C	11.48	70
	Total Area / Weighted Curve Number			66.18	78

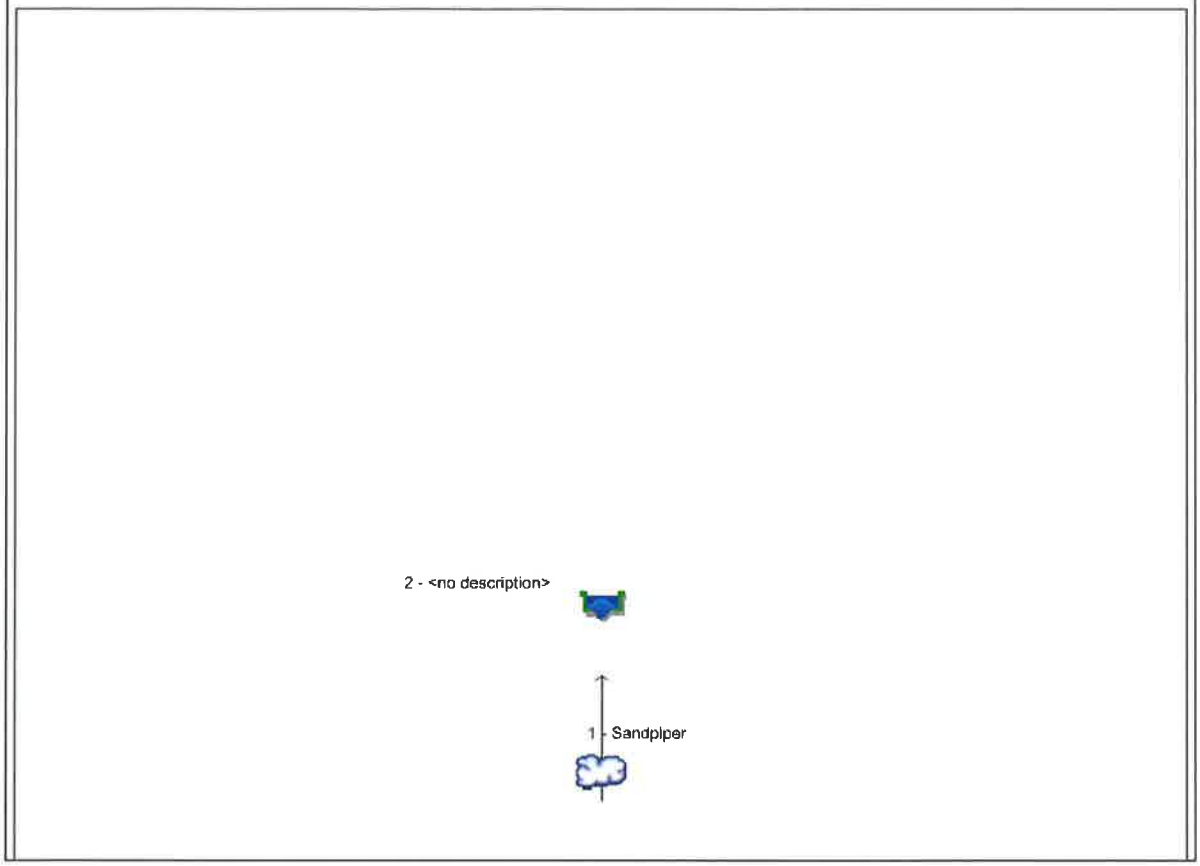
Plan Sheet for Existing Culvert



Appendix D – Raintree Pkwy to Sandpiper

Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022



Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	------	118.86	------	------	238.03	------	------	405.82	Sandpiper
2	Reservoir	1	------	118.74	------	------	230.14	------	------	405.53	<no description>

Hydraulics

50% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	118.86	1	724	355,631	------	------	------	Sandpiper
2	Reservoir	118.74	1	725	355,631	1	964.77	664	<no description>

10% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	238.03	1	724	704,951	------	------	------	Sandpiper
2	Reservoir	230.14	1	726	704,951	1	969.66	26,059	<no description>

1% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	405.82	1	724	1,214,685	------	------	------	Sandpiper
2	Reservoir	405.53	1	724	1,214,687	1	970.11	31,770	<no description>

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022 — Tuesday, 01 / 3 / 2023

Pond No. 1 - SANDPIPER

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 958.82 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	958.82	24	0	0
4.00	962.82	24	96	96
4.18	963.00	77	9	105
5.18	964.00	246	153	258
6.18	965.00	880	531	789
7.18	966.00	1,745	1,288	2,077
8.18	967.00	3,086	2,384	4,461
9.18	968.00	5,639	4,299	8,759
10.18	969.00	12,680	8,924	17,683
11.18	970.00	12,680	12,679	30,362
12.18	971.00	12,680	12,679	43,041
13.18	972.00	12,680	12,679	55,720

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	0.00	0.00	0.00
Span (in)	= 48.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 958.82	0.00	0.00	0.00
Length (ft)	= 103.76	0.00	0.00	0.00
Slope (%)	= 0.81	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

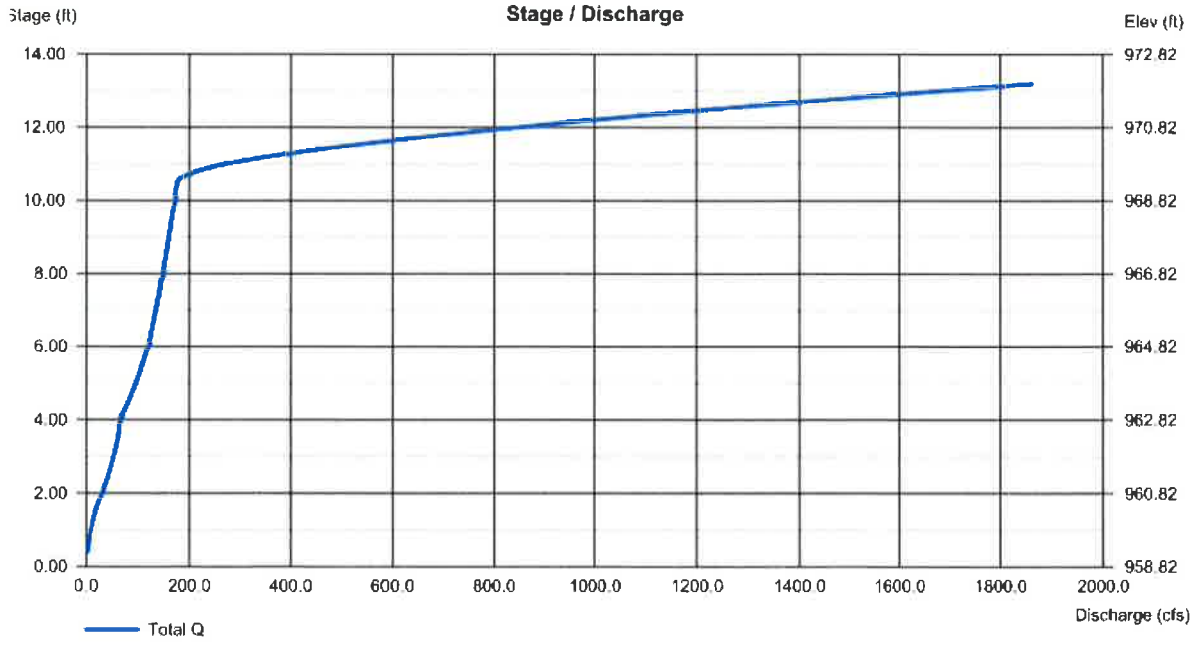
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	18.00	97.00	37.00
Crest El. (ft)	= 969.26	969.28	969.39	969.75
Weir Coeff.	= 2.60	2.60	2.60	2.60
Weir Type	= Broad	Broad	Broad	Broad
Multi-Stage	= No	No	No	No

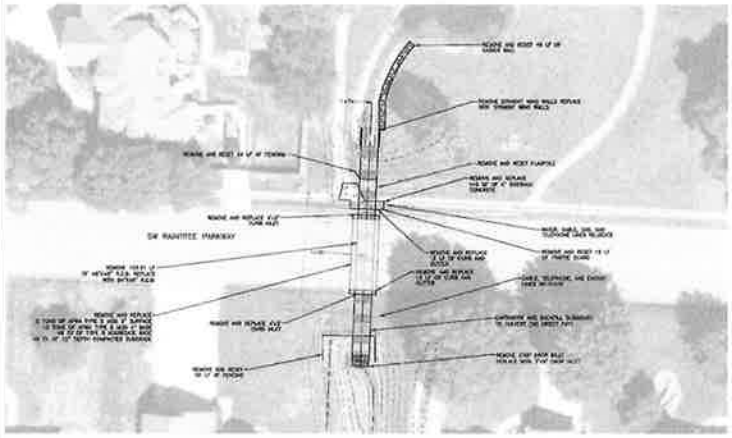
Exfil.(in/hr) = 0.000 (by Contour)

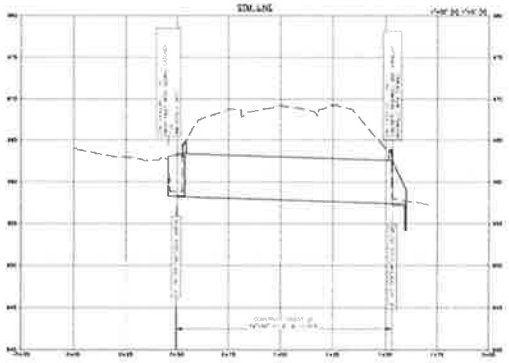
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Alternative No. 1





LAMP RYNEARSON

PRELIMINARY

SANDPIPER/RAINTREE PARKWAY CULVERT CONCEPTUAL DESIGN

RAINTREE LAKE STORM WATER STUDY
RAINTREE LAKE, LEE'S SUMMIT, MISSOURI

811 Know what's below. Call before you dig.

SHEET
01

Appendix D – Raintree Pkwy to Sandpiper

Alternative No. 1

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	------	118.86	------	------	238.03	------	------	405.82	Sandpiper
2	Reservoir	1	------	118.86	------	------	237.91	------	------	381.28	<no description>

50% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	118.86	1	724	355,631	------	------	------	Sandpiper
2	Reservoir	118.86	1	724	355,631	1	961.89	73.6	<no description>

10% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	238.03	1	724	704,951	------	------	------	Sandpiper
2	Reservoir	237.91	1	724	704,951	1	964.08	298	<no description>

1% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	405.82	1	724	1,214,685	------	------	------	Sandpiper
2	Reservoir	381.28	1	727	1,214,687	1	968.82	16,061	<no description>

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022 — Tuesday, 01 / 3 / 2023

Pond No. 1 - SANDPIPER

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 958.82 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	958.82	24	0	0
4.00	962.82	24	96	96
4.18	963.00	77	9	105
5.18	964.00	246	153	258
6.18	965.00	880	531	789
7.18	966.00	1,745	1,288	2,077
8.18	967.00	3,086	2,384	4,461
9.18	968.00	5,639	4,299	8,759
10.18	969.00	12,680	8,924	17,683
11.18	970.00	12,680	12,679	30,362
12.18	971.00	12,680	12,679	43,041
13.18	972.00	12,680	12,679	55,720

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	0.00	0.00	0.00
Span (in)	= 84.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 958.82	0.00	0.00	0.00
Length (ft)	= 103.76	0.00	0.00	0.00
Slope (%)	= 0.81	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

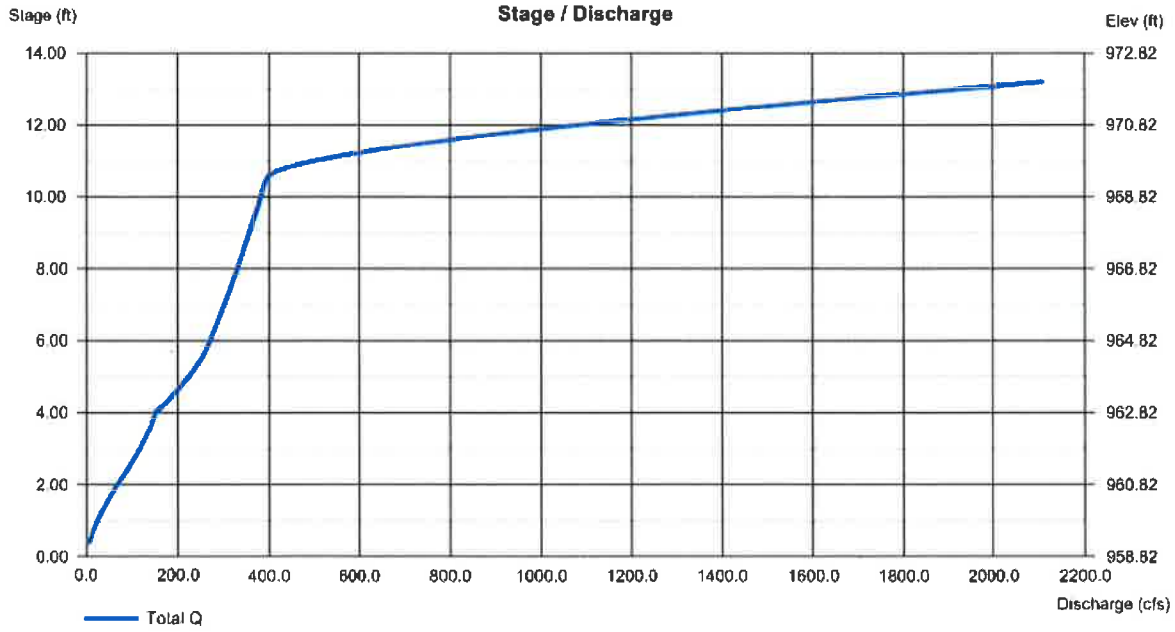
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	18.00	97.00	37.00
Crest El. (ft)	= 969.26	969.28	969.39	969.75
Weir Coeff.	= 2.60	2.60	2.60	2.60
Weir Type	= Broad	Broad	Broad	Broad
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Alternative No. 1

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Sandpiper/Raintree Parkway Box Culvert Upsize					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$20,000.00	$20,000.00
2	Erosion Control	LS	1	$3,000.00	$3,000.00
3	Clearing Grubbing and Demolition	LS	1	$10,000.00	$10,000.00
4	84"X48" RCB	LF	104	$1,000.00	$104,000.00
5	96" Wing Walls with Toe Wall and Headwall (Concrete)	EA	1	$12,000.00	$12,000.00
6	7'X6' Drop Inlet With Debris Catcher	EA	1	$12,000.00	$12,000.00
7	Type 5 Aggregate Base (6")	SY	49	$11.00	$539.00
8	Asphaltic Concrete Base (4")	TON	10	$100.00	$1,000.00
9	Asphaltic Concrete Surface (2")	TON	5	$110.00	$550.00
10	4'X3' Curb Inlet	EA	2	$4,000.00	$8,000.00
11	12" Depth Compacted Subgrade	SY	49	$12.00	$588.00
12	Remove and Replace 4" Concrete (KCMMB4K)	SF	145	$11.00	$1,595.00
13	Remove and Replace Curb and Gutter (Concrete) (KCMMB4K)	LF	24	$55.00	$1,320.00
14	Remove and Reset Gabion Wall	LS	1	$2,000.00	$2,000.00
15	Remove and Reset Fencing, Flagpole, Traffic Guard	LS	1	$1,500.00	$1,500.00

Subtotal	$178,092.00
Contingency(20%)	$35,618.40
Total Construction Cost	$213,710.40
Design Engineering and Survey	$16,775.00
Construction Administration	$6,000.00
Utility Relocation	$5,000.00
Testing Services	$3,500.00
Permitting	$7,100.00
Total Project Cost	$252,085.40

Alternative No. 2

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	------	118.86	------	------	238.03	------	------	405.82	Sandpiper
2	Reservoir	1	------	118.03	------	------	223.38	------	------	396.70	<no description>

50% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	118.86	1	724	355,631	------	------	------	Sandpiper
2	Reservoir	118.03	1	725	355,631	1	964.73	1,566	<no description>

10% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	238.03	1	724	704,951	------	------	------	Sandpiper
2	Reservoir	223.38	1	727	704,951	1	969.63	33,713	<no description>

1% Storm

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	405.82	1	724	1,214,685	------	------	------	Sandpiper
2	Reservoir	396.70	1	725	1,214,687	1	970.09	44,089	<no description>

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022 Friday, 01 / 6 / 2023

Pond No. 1 - SANDPIPER

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 958.82 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	958.82	24	0	0
4.00	962.82	24	96	96
4.18	963.00	269	22	118
5.18	964.00	769	497	616
6.18	965.00	1,914	1,298	1,914
7.18	966.00	4,029	2,906	4,820
8.18	967.00	5,319	4,658	9,479
9.18	968.00	7,147	6,210	15,688
10.18	969.00	12,865	9,866	25,554
11.18	970.00	12,865	12,864	38,418
12.18	971.00	128,665	60,732	99,150

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	0.00	0.00	0.00
Span (in)	= 48.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 958.82	0.00	0.00	0.00
Length (ft)	= 103.76	0.00	0.00	0.00
Slope (%)	= 0.81	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

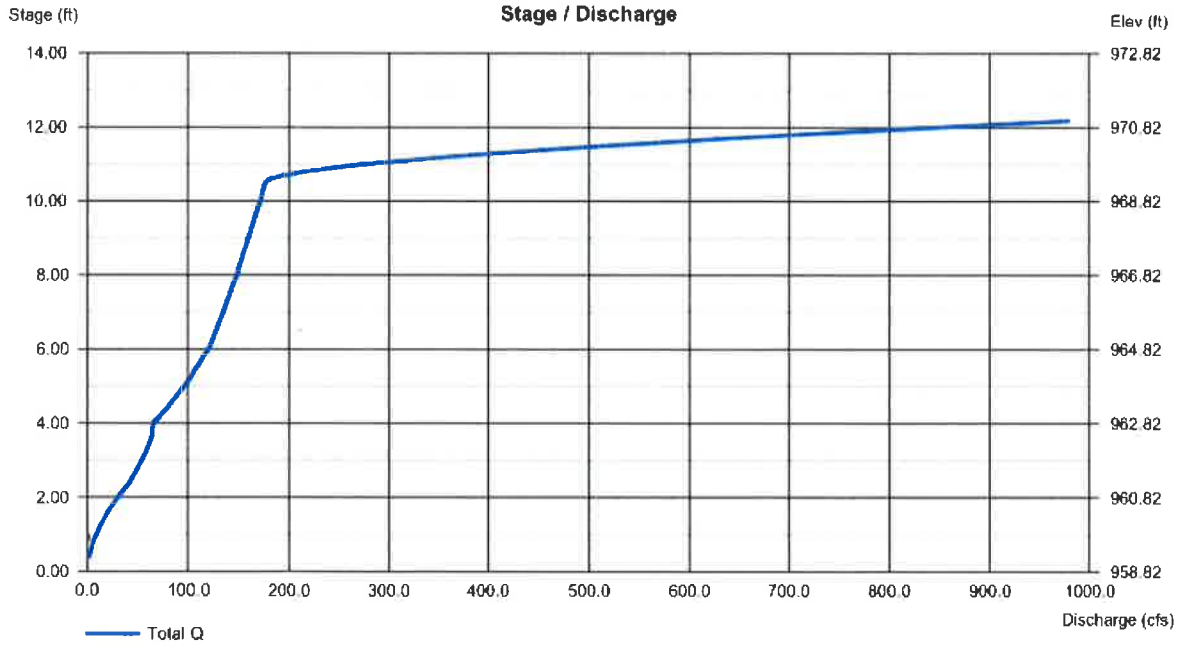
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	18.00	97.00	37.00
Crest El. (ft)	= 969.26	969.28	969.39	969.75
Weir Coeff.	= 2.60	2.60	2.60	2.60
Weir Type	= Broad	Broad	Broad	Broad
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

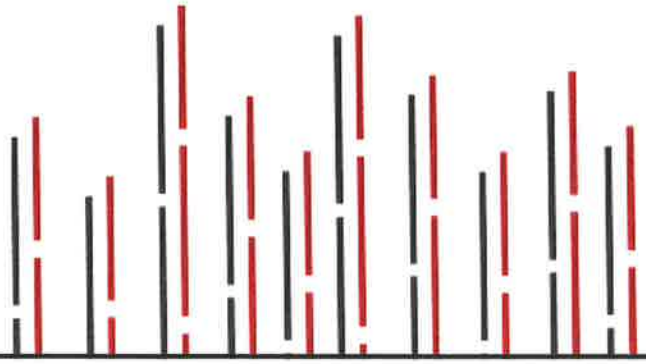


Alternative No. 2

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Sandpiper/Raintree Parkway Grading Swale Option					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$2,000.00	$2,000.00
2	Erosion Control	LS	1	$500.00	$500.00
3	Earthwork Excavation	CY	159	$5.00	$795.00
4	Sodding	SY	600	$9.00	$5,400.00
5	Grading	LS	1	$1,000.00	$1,000.00

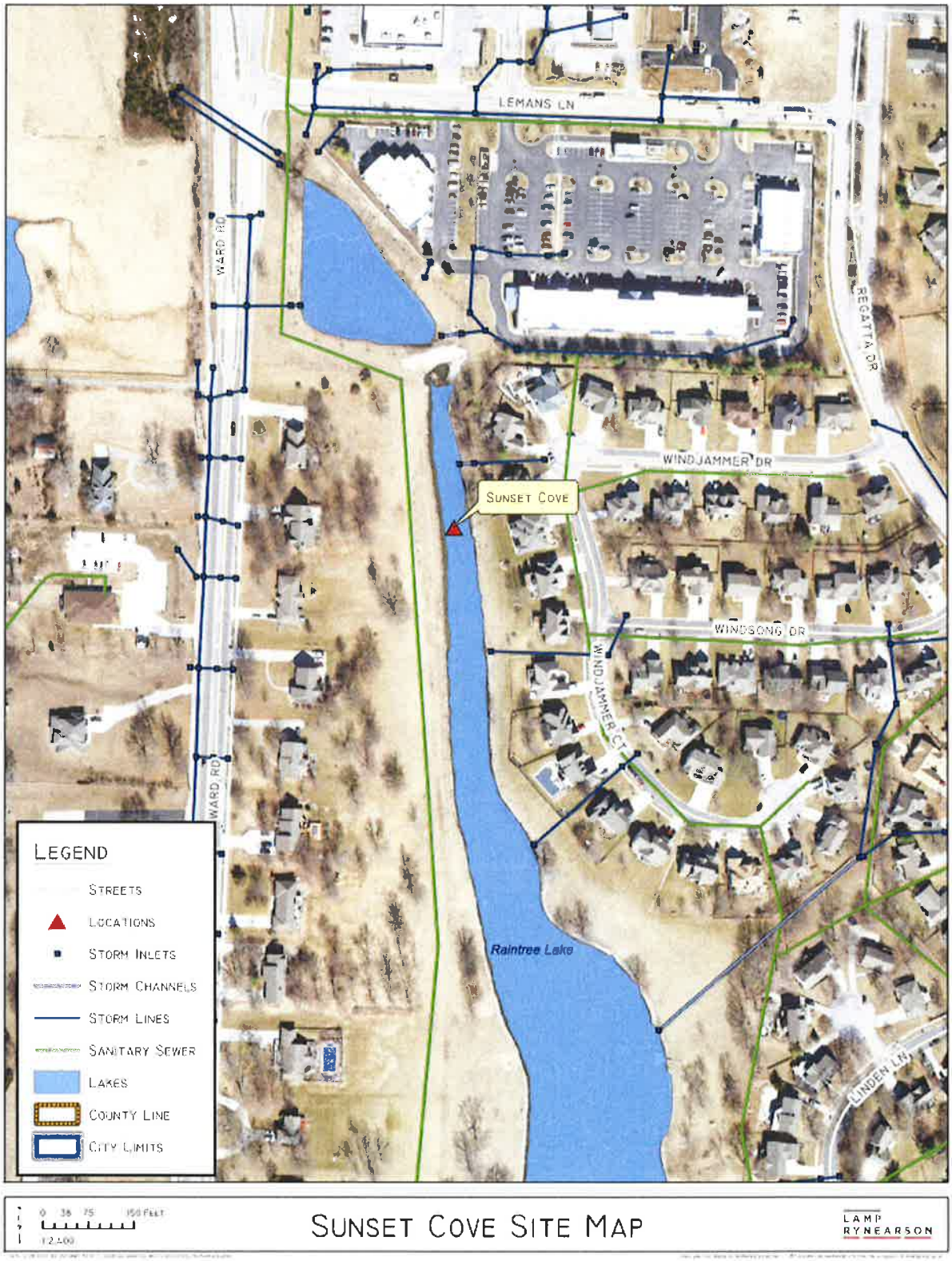
Subtotal	$9,695.00
Contingency(20%)	$1,939.00
Total Construction Cost	$11,634.00
Design Engineering	$3,000.00
Construction Administration	$1,000.00
Permitting	$200.00
Total Project Cost	$15,834.00

Appendix E



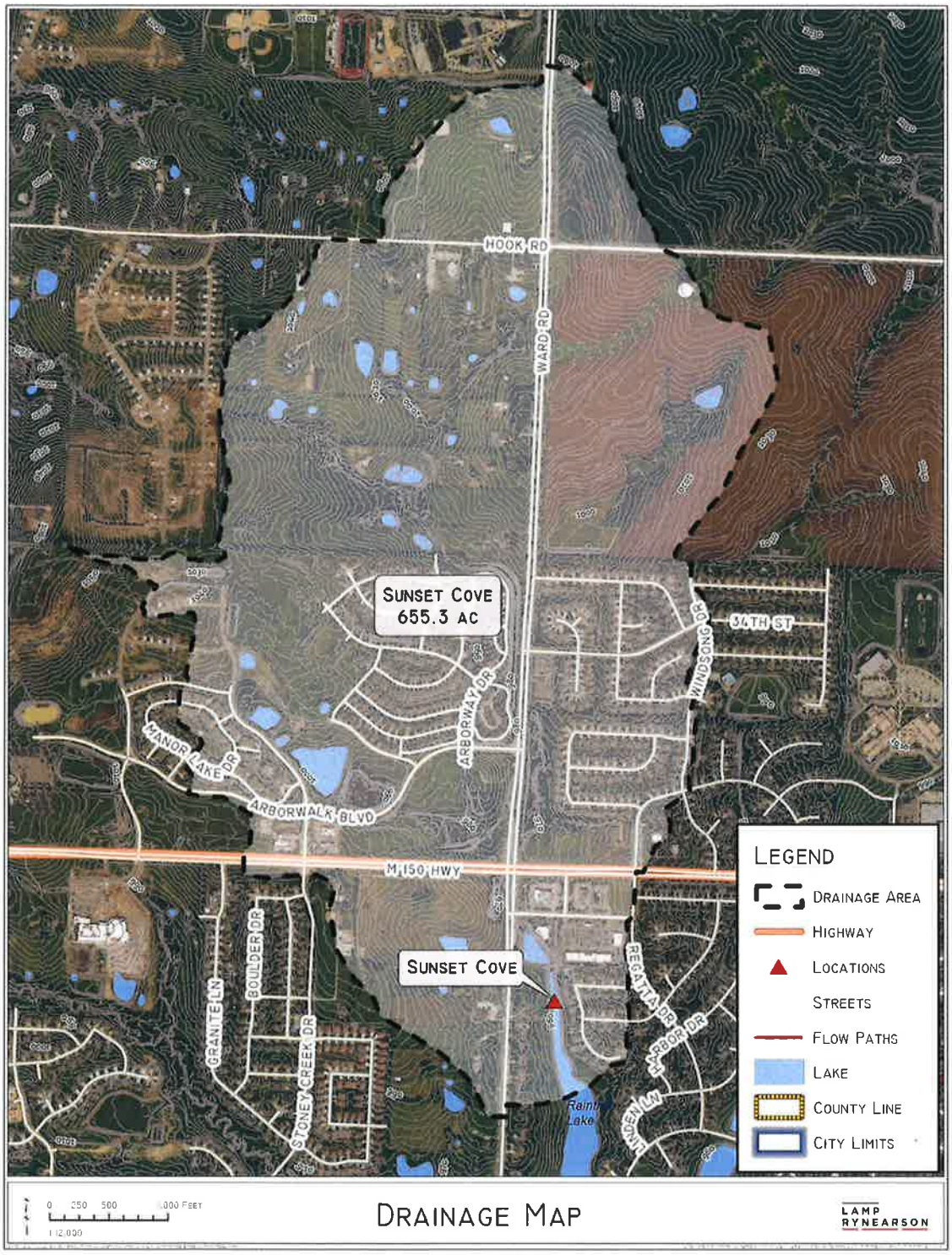
Sunset Cove

Site Map



Appendix E – Sunset Cove

Drainage Area Map



Appendix E – Sunset Cove

Site Photos

Standing on detention pond overflow structure looking upstream at pond

Standing on detention pond overflow structure looking downstream at lake

Site Photos

Standing at upstream end of Sunset Cove, looking downstream

Runoff Volume for Water Quality Storm

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \qquad P > I_a \qquad [10\text{–}11] \qquad CN = \frac{1000}{10+S} \qquad [10\text{–}12]$$

$$I_a = 0.2S \qquad [eq.\ 2\text{-}2]$$

$$Q = \frac{(P-I_a)^2}{(P-I_a)+S} \quad P > I_a \qquad Q = 0 \quad P \le I_a \qquad [10\text{–}1]$$

where:
- Q = depth of runoff, in inches
- P = depth of rainfall, in inches
- I_a = initial abstraction, in inches
- S = maximum potential retention, in inches

Area (ac)	CN	A*CN
170.59	92	15694.28
185.26	80	14820.8
32.2	83	2672.6
33.57	94	3155.58
72.45	85	6158.25
121.3	80	9704
39.97	84	3357.48
0	0	0
655.34	**84.7849818**	

CN = 85
P = 1.37 in

S = 1.76470588 in
I_a = 0.35294118 in
Q = 0.3718534 in

Area = 656 acres

Volume = 20.33 acre-ft = 885487 cu ft

StreamStats Report

Region ID: MO
Workspace ID: MO20221212175950317000
Clicked Point (Latitude, Longitude): 38.84835, -94.39700
Time: 2022-12-12 12:00:12 -0600

Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSHAPE	Basin Shape Factor for Area	3.43	dimensionless
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	42.2	feet per mi
DRNAREA	Area that drains to a point on a stream	1.01	square miles
IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	7.57	percent
LFPLENGTH	Length of longest flow path	1.86	miles
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	2.2547	percent
STREAM_VARG	Streamflow variability index as defined in WRIR 02-4068, computed from regional grid	0.53	dimensionless

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Rural Statewide Region 1 SIR 2014 5165]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.01	square miles	0.11	8212.38
BSHAPE	Basin Shape Factor	3.43	dimensionless	2.25	26.59

Peak-Flow Statistics Parameters [Peak Urban Statewide SIR 2010 5073]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.01	square miles	0.28	189
IMPNLCD01	Percent Impervious NLCD2001	7.57	percent	2.3	46

Peak-Flow Statistics Flow Report [Peak Rural Statewide Region 1 SIR 2014 5165]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other – see report)

Statistic	Value	Unit	ASEp
50-percent AEP flood	279	ft^3/s	38.4
20-percent AEP flood	526	ft^3/s	30.8
10-percent AEP flood	715	ft^3/s	29.1
4-percent AEP flood	977	ft^3/s	28.8
2-percent AEP flood	1180	ft^3/s	28.7
1-percent AEP flood	1390	ft^3/s	29.8
0.5-percent AEP flood	1590	ft^3/s	31
0.2-percent AEP flood	1870	ft^3/s	33.2

Peak-Flow Statistics Flow Report [Peak Urban Statewide SIR 2010 5073]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other – see report)

Statistic	Value	Unit	PII	Plu	ASEp
50-percent AEP flood	241	ft^3/s	151	384	26.7
20-percent AEP flood	429	ft^3/s	284	648	23.3
10-percent AEP flood	580	ft^3/s	393	855	22.1
4-percent AEP flood	776	ft^3/s	528	1140	22.1
2-percent AEP flood	955	ft^3/s	635	1440	23.3
1-percent AEP flood	1130	ft^3/s	720	1770	25.6
0.2-percent AEP flood	1590	ft^3/s	875	2890	35.2

Peak Flow Statistics Citations

Southard, R.E.,2010, Estimation of the Magnitude and Frequency of Floods in Urban Basins in Missouri: U.S. Geological Survey Scientific Investigations Report 2010-5073, 27 p. (http://pubs.usgs.gov/sir/2010/5073/)
Southard, R.E., and Veilleux, A.G.,2014, Methods for estimating annual exceedance-probability discharges and largest recorded floods for unregulated streams in rural Missouri: U.S. Geological Survey Scientific Investigations Report 2014-5165, 39 p. (http://pubs.usgs.gov/sir/2014/5165/)

Application Version: 4.11.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

V. Forebay — Normal Pool @ 955.36 ft

Step 1) Volume should equal at least 10% of WQv	Min Vol_{FB} (ac-ft) =	2.5
Step 2) Forebay depth, Z_{FB} (ft)	Z_{FB} (ft) =	1.5
Step 3) Minimum forebay surface area, A_{FB} (ac)	Min A_{FB} (ac) =	1.7
Step 4) Paved/hard bottom and sides?		

957

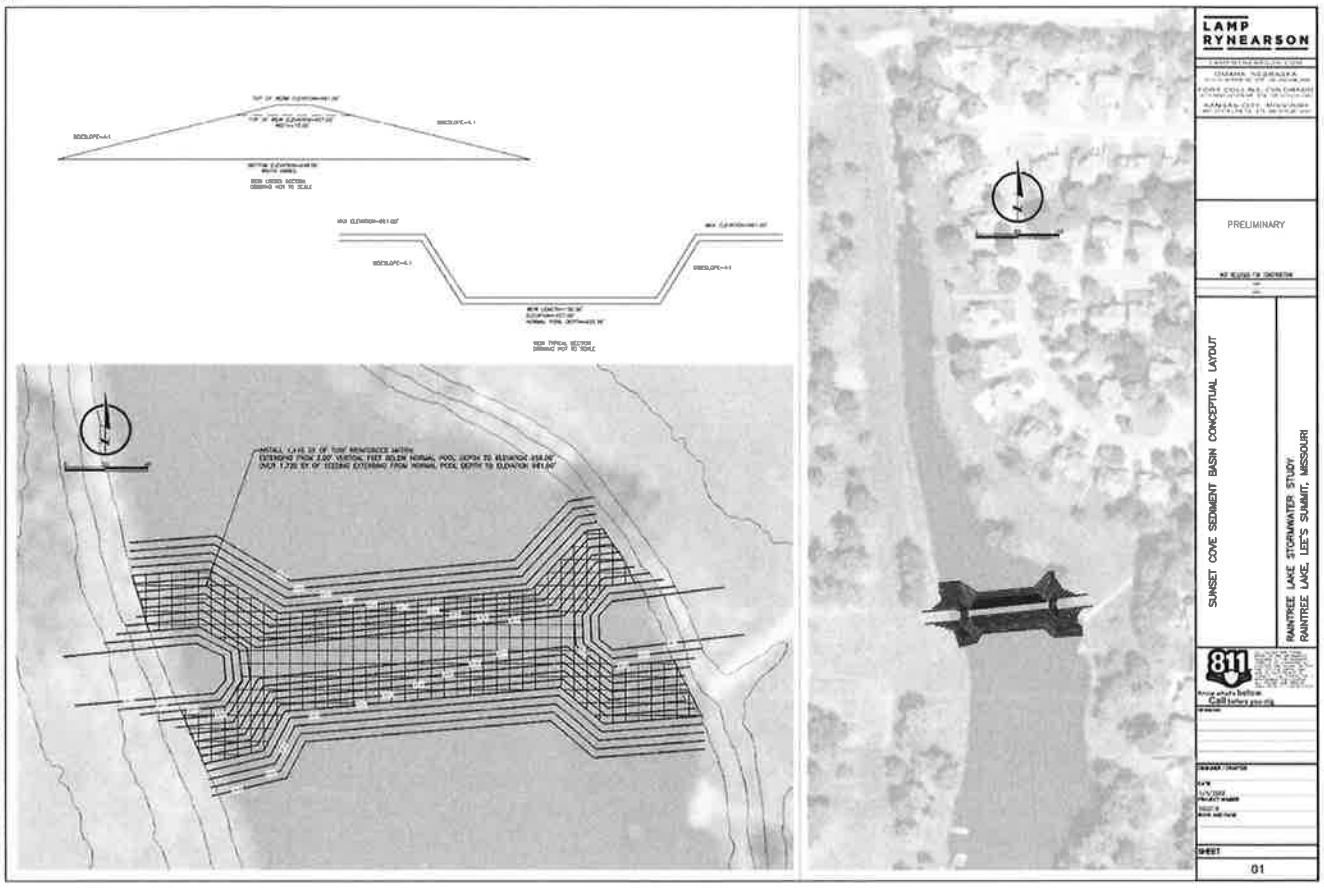
Broad-crested Weir ($Q = C_w b h^{3/2}$)

C_w =	2.63	$ft^{1/2}/s$
b =	150	ft
h =	2.8	ft
Q =	**1848.35**	**cfs**
V =	4.40	ft/s

Broad-crested Weir ($Q = C_w b h^{3/2}$)

C_w =	2.63	$ft^{1/2}/s$
b =	150	ft
h =	2.7	ft
Q =	**1750.22**	**cfs**
V =	4.32	ft/s

Alternative No. 1



Appendix E – Sunset Cove

Alternative No. 1

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Sunset Cove: Sediment Basin					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$55,000.00	$55,000.00
2	Site Restoration	LS	1	$10,000.00	$10,000.00
3	Erosion Control	LS	1	$10,000.00	$10,000.00
4	Earthwork Embankment	CY	10000	$30.00	$300,000.00
5	Earthwork Excavation	CY	2360	$5.00	$11,800.00
6	Turf Reinforced Matrix	SY	1410	$13.00	$18,330.00
7	Seeding and Fertilizing	SY	1720	$3.00	$5,160.00

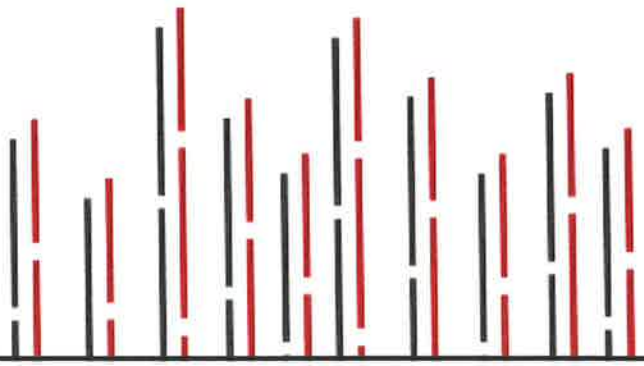
Subtotal	$410,290.00
Contingency(20%)	$82,058.00
Total Construction Cost	$492,348.00
Design Engineering and Survey	$22,000.00
Construction Administration/Observation	$12,000.00
Testing /Geotechnical Services	$25,000.00
Permitting	$20,000.00
Total Project Cost	$571,348.00

Alternative No. 2

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Sunset Cove: Rock Sediment Basin					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$75,000.00	$75,000.00
2	Site Restoration	LS	1	$20,000.00	$20,000.00
3	Erosion Control	LS	1	$10,000.00	$10,000.00
4	Clean Rock (Riprap) (Outer Embankment) (2 Layers)(1.5' D50)	SY	3235	$240.00	$776,400.00
4	Clean Rock (Aggregate) (Embankment)	CY	3530	$50.00	$176,500.00
5	Earthwork Excavation	CY	2360	$5.00	$11,800.00

	Subtotal	$1,069,700.00
	Contingency(20%)	$213,940.00
	Total Construction Cost	$1,283,640.00
	Design Engineering and Survey	$25,000.00
	Construction Administration/Observation	$12,000.00
1,258	Testing /Geotechnical Services	$25,000.00
	Permitting	$20,000.00
	Total Project Cost	$1,365,640.00

Appendix F



Windemere to Hidden Cove

Site Map

Appendix F – Windemere to Hidden Cove

Drainage Map

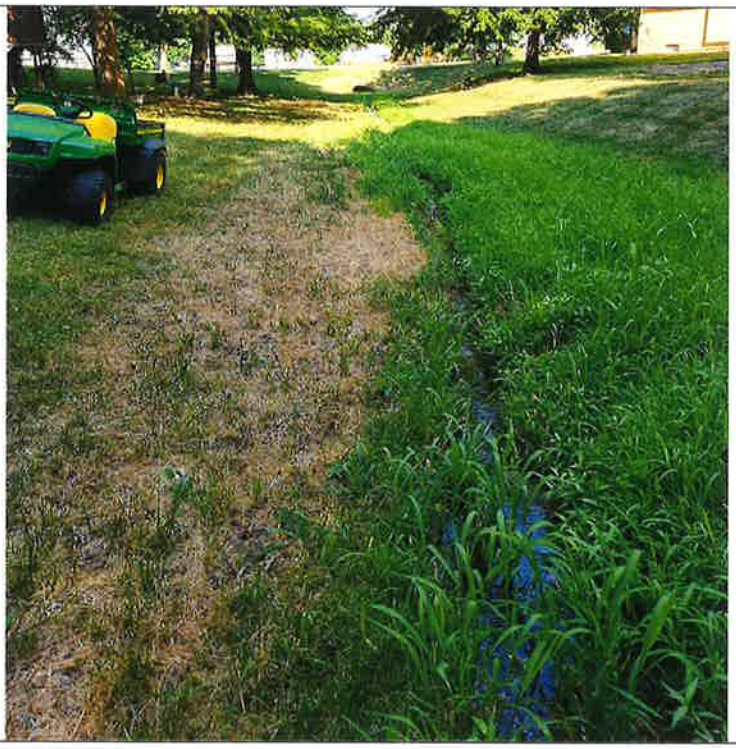
Appendix F – Windemere to Hidden Cove

Site Photos

Downstream end of concrete flume, looking upstream

Looking downstream at channel from end of concrete flume

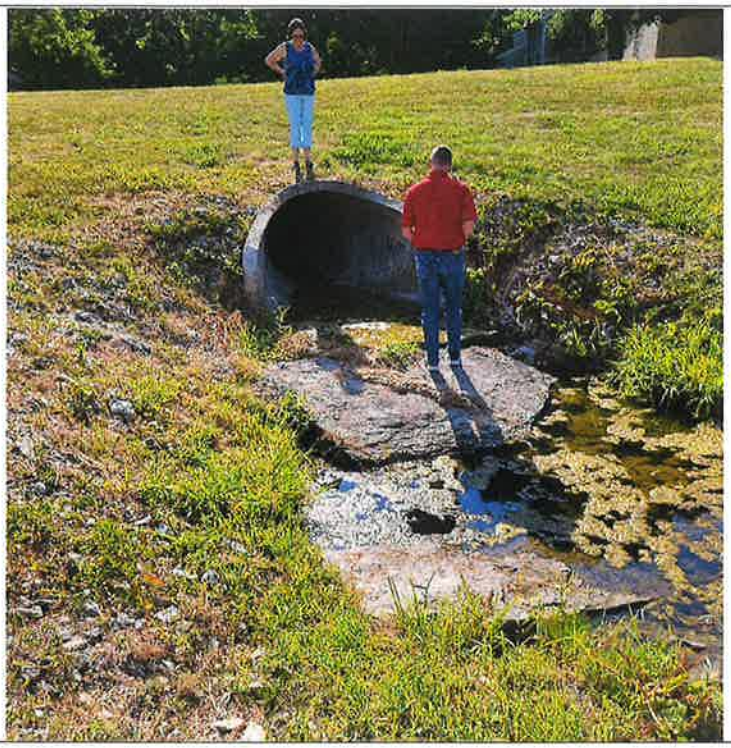
Site Photos



Channel, looking downstream at culvert under SW Hidden Cove Dr

Inlet end of culvert under SW Hidden Cove Dr

Site Photos



Outlet end of culvert under SW Hidden Cove Dr

Runoff Coefficient, "C" =	0.51	
Area, A =	49.94	acres
Time of Concentration, T_c =	5.00	minutes

Return Interval (yr)	Q (cfs)	k	k*C (≤ 1.0)	i (in/h)
WQ	**48.4**	1	0.51	1.90
2	**137.8**	1	0.51	5.41
5	**164.8**	1	0.51	6.47
10	**187.3**	1	0.51	7.35
25	**239.0**	1.1	0.561	8.53
50	**287.1**	1.2	0.612	9.40
100	**328.6**	1.25	0.6375	10.32

Existing Channel 1%

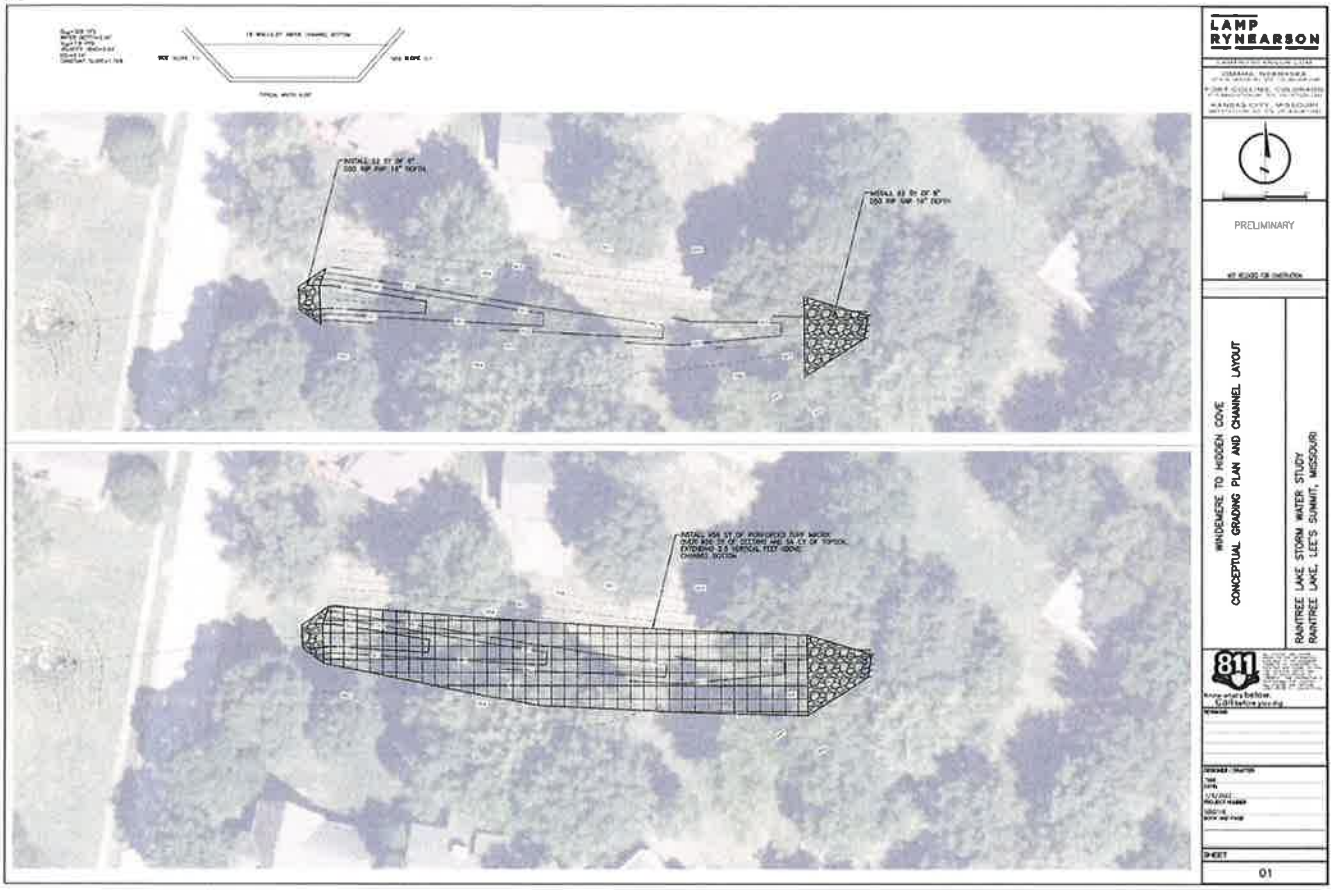
Sideslope LT. =	7 :1
Sideslope RT. =	5 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	2.206950256
Channel Slope =	1.7273%

Area (ft^2) =	42.46547812
WP (ft) =	32.859
R_H (ft) =	1.292

Q (cfs) =	328.00
V (Q/A) (ft/s) =	7.8

Top Width (free surface) =	32.48	ft
Hydraulic Depth, y_h =	1.31	ft
Fr =	1.20	
Shear Stress, τ =	1.39	lb/ft^2

Alternative No. 1



Appendix F – Windemere to Hidden Cove

Alternative No. 1

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Windemere To Hidden Cove Alternative 1: Grading and TRM					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$4,000.00	$4,000.00
2	Erosion Control	LS	1	$1,000.00	$1,000.00
3	Site Restoration	LS	1	$500.00	$500.00
4	Earthwork Excavation	CY	71	$5.00	$355.00
5	Earthwork Embankment	CY	5	$5.00	$25.00
6	Seeding and Fertilizing	SY	956	$3.00	$2,868.00
7	8" D50 16" Depth Riprap With Filer Fabric	SY	104	$150.00	$15,600.00
8	Turf Reinforced Matrix Channel Lining	SY	956	$13.00	$12,428.00
9	Spreading and Placing Top Soil (2")	CY	54	$55.00	$2,970.00

Subtotal	$39,746.00
Contingency(20%)	$7,949.20
Total Construction Cost	$47,695.20
Design Engineering	$5,000.00
Construction Administration	$1,000.00
Permitting	$1,630.00
Total Project Cost	$55,325.20

Proposed 10% Storm

Sideslope LT. =	7 :1
Sideslope RT. =	5 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	1.717103121
Channel Slope =	1.7300%

Area (ft^2) =	27.9932775
WP (ft) =	26.897
R_H (ft) =	1.041

Q (cfs) =	187.30
V (Q/A) (ft/s) =	6.7

Top Width (free surface) =	26.61 ft
Hydraulic Depth, y_h =	1.05 ft
Fr =	1.15
Shear Stress, τ =	1.12 lb/ft^2

Proposed 1% Storm

Sideslope LT. =	7 :1
Sideslope RT. =	5 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	2.20619065
Channel Slope =	1.7300%

Area (ft^2) =	42.44080702
WP (ft) =	32.850
R_H (ft) =	1.292

Q (cfs) =	328.00
V (Q/A) (ft/s) =	7.8

Top Width (free surface) =	32.47 ft
Hydraulic Depth, y_h =	1.31 ft
Fr =	1.20
Shear Stress, τ =	1.39 lb/ft^2

Alternative No. 2

Proposed 10% Storm

Sideslope LT. =	7 :1
Sideslope RT. =	5 :1
n =	0.03
Bottom Width (ft) =	6
Flow Depth (ft) =	1.717103121
Channel Slope =	1.7300%

Area (ft^2) =	27.9932775
WP (ft) =	26.897
R_H (ft) =	1.041

Q (cfs) =	187.30
V (Q/A) (ft/s) =	6.7

Top Width (free surface) =	26.61 ft
Hydraulic Depth, y_h =	1.05 ft
Fr =	1.15
Shear Stress, τ =	1.12 lb/ft^2

Engineer's Conceptual Construction Cost Estimate					
Raintree Lake Stormwater Study					
Windemere to Hidden Cove Alternative 2: Infiltration Trenches					
Raintree Lake Homeowners Association					
Item No.	Item Description	Unit	Estimated Quantity	Unit Price	Total
1	Mobilization	LS	1	$5,000.00	$5,000.00
2	Erosion Control	LS	1	$1,000.00	$1,000.00
3	Site Restoration	LS	1	$500.00	$500.00
4	Earthwork Excavation	CY	71	$5.00	$355.00
5	Earthwork Embankment	CY	5	$5.00	$25.00
6	8" D50 16" Depth Riprap With Filer Fabric	SY	49	$160.00	$7,840.00
7	Aggregate Clean Rock	CY	20	$70.00	$1,400.00
8	Amended Soil	CF	180	$6.00	$1,080.00
9	Geotextile Fabric	EA	1	$1,300.00	$1,300.00
10	Seeding and Fertilizing	SY	956	$3.00	$2,868.00
11	8" D50 16" Depth Riprap With Filer Fabric	SY	104	$150.00	$15,600.00
12	Turf Reinforced Matrix Channel Lining	SY	956	$13.00	$12,428.00
13	Spreading and Placing Top Soil (2")	CY	54	$55.00	$2,970.00

Subtotal	$52,366.00
Contingency(20%)	$10,473.20
Total Construction Cost	$62,839.20
Design Engineering and Survey	$5,000.00
Construction Administration	$1,000.00
Permitting	$1,630.00
Total Project Cost	$70,469.20