LEE'S SUMMIT
MISSOURI

DESIGN AND CONSTRUCTION MANUAL DESIGN MODIFICATION REQUEST

PROJECT NAME: Discovery Park Phase 1

PREMISE ADDRESS: NW Lee's Summit Rd & NE Douglas St.

PERMIT NUMBER:

OWNER'S NAME: Discovery Park Lee's Summit, LLC Brian Maenner

TO: The City Engineer

In accordance with the Lee's Summit Design and Construction Manual (DCM) Section 1002.A, I wish to apply for a modification to one or more specification (s). The following articulates my request for your review and action. (NOTE: Cite specific code sections and engineering justification and drawings.)

A waiver is being requested to remove 10.3 acres of stream buffer located within the project site (outlined in Section 5605 of KC-APWA Section 5600). The need to remove the existing creek channel, as shown on the attached exhibit, is driven by:

- The site layout provides maximum development programming, which includes a wet-bottom detention basin that is part of a development amenity space with a pond, parkland, and walking trail.
- A required entrance drive off of NE Douglas Road with minimum spacing allowed by the project traffic study to the adjacent intersection placing it in conflict with the existing creek channel.

The upstream end of the existing creek channel begins at the outlet point of an existing concrete box culvert under NE Douglas Street. This box culvert will be extended approximately 670 linear feet and discharge into the proposed wet-bottom detention basin.

The proposed development has been extensively coordinated with Unity Village, the owner/operator of Unity Lake #2, an existing lake that is located approximately ½ mile downstream of the proposed stream buffer impacts. As indicated in the attached letter from Unity Village, with the level of storm water quality treatment and peak runoff rate control being provided by the proposed improvements, this project has their full support.

As part of the due diligence performed for the development, the following reviews were completed:

- A jurisdictional determination was requested by the United States Army Corps of Engineers (USACE). The USACE provided a determination letter (attached with this request) that states the affected creek channel and attached wetlands are not jurisdictional water of the US.
- Review of existing FEMA floodplains was completed and no regulated floodplains exist within the affected creek channel as shown on the attached FEMA FIRM panel.

As a part of any development, the City of Lee's Summit requires that 40-hour extended dry detention of the water quality storm event be provided, or equivalent on-site water quality treatment be provided per the MARC BMP Manual. This is to promote the removal of pollutants and debris out of storm water prior to being discharged downstream of the development. The proposed development will provide an equivalent, or greater, level of service than 40-hr extended dry detention through a mix of 40-hr

extended dry detention of the water quality storm and individual best management practices (BMPs) constructed upstream of the proposed detention basin. BMPs will be constructed internally to the project pad sites, closer to the source point of the pollutant. Water quality analysis treatment measures and calculations will be provided in future micro stormwater studies as each phase of the project is finalized through the Final Development Plan process.

Furthermore, with the culvert discharging into the wet-bottom detention basin with approximately 680 feet of travel length through a permanent pool of water, suspended solids and floatables that are conveyed into the basin from upstream (offsite) areas, not required to be treated by this development, will have an opportunity to settle out or be collected and disposed of. Discharging the culvert extension directly into the permanent pool basin will also provide scour and erosion protection that is a common problem at pipe outlets into dry basins or creek channels. Permanent pool detention basins also promote wildlife and aquatic habitats where dry basins are typically mowed and maintained to prevent vegetation, often deemed as 'unsightly' by landowners, from growing.

To improve the aesthetics and quality of the proposed wet detention basin, landscape design guidelines are being established for the development. The proposed guidelines require a 15-ft buffer of native plantings in areas not encumbered by retaining walls around the perimeter of the pond, restricting the use of turf grass in that zone. The taller native plantings and grasses provide wildlife habitat and refuse while filtering physical and chemical pollutants. Native planted buffer zones in conjunction with the existing old growth tree preservation (when possible) will enhance wildlife habitat and connectivity.

In addition to the water quality treatment being provided for the development prior to discharging runoff into the creek, 5.2 acres of enhanced stream buffer is being proposed to be set aside downstream of the impacted creek channel to further offset any environmental/wildlife impact caused by removing stream buffer described.

With the support of Unity Village, due diligence performed on the project site, and increased level of water quality being provided to on- and off-site discharges with separate water quality treatment measures and a wet detention basin, we request this waiver be approved.

SUBMITTED BY:
NAME: Nicholas D. Heiser_____ ( ) OWNER (X) OWNER'S AGENT
ADDRESS: 1301 Burlington St. Suite 100_____ Tel.# 816-442-6056_____
CITY, STATE, ZIP_North Kansas City, MO 64116_____
Email: nheiser@olsson.com_____ SIGNATURE: _____

FORWARDING MANAGER: _____RECOMMENDATION ( ) APPROVAL ( ) DENIAL

SIGNATURE:_____ DATE:_____

GEORGE BINGER III, P.E. – CITY ENGINEER: ( ) APPROVED ( ) DENIED

SIGNATURE:_____ DATE:_____

COMMENTS_____

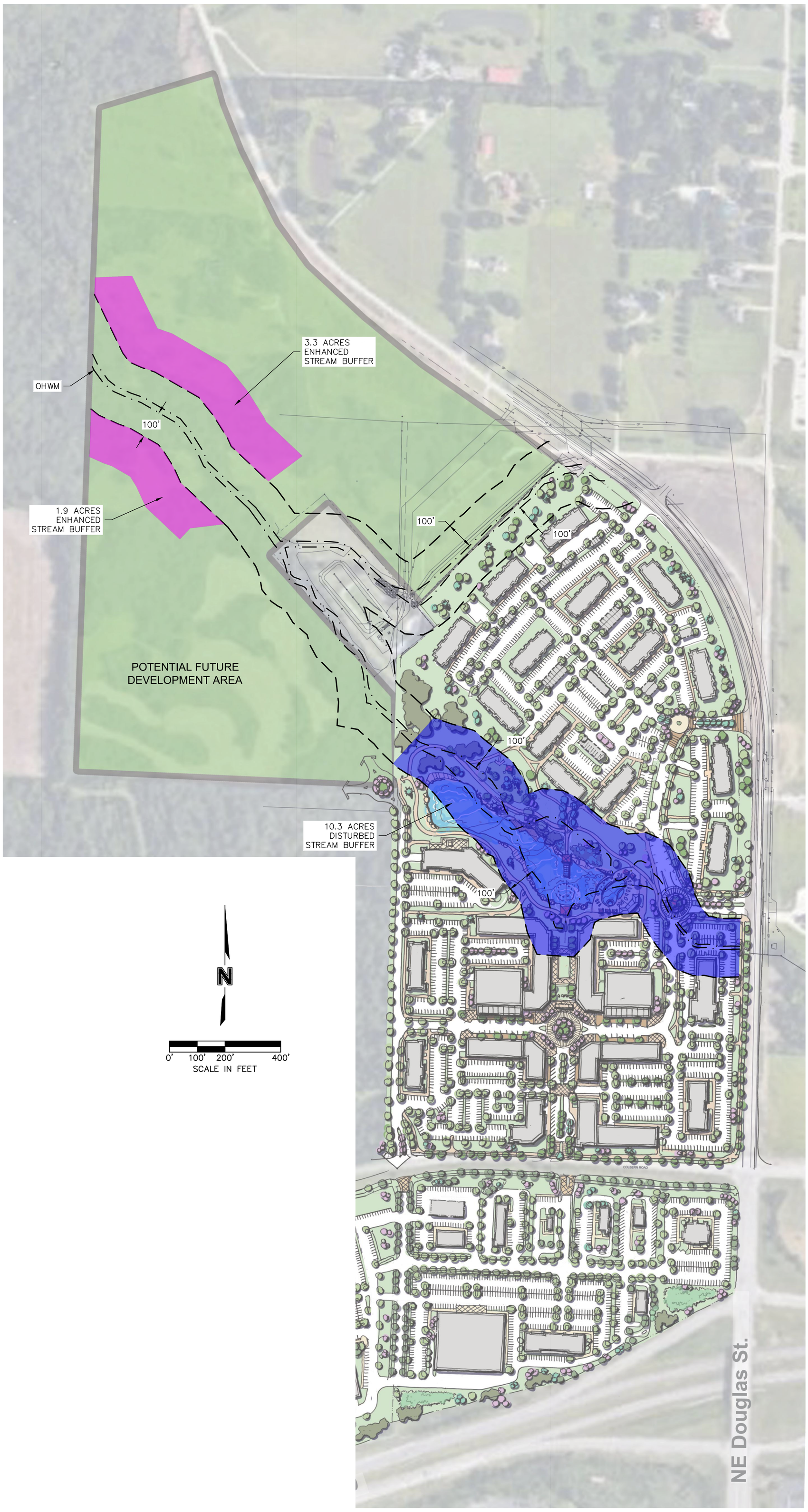
_____

_____

A COPY MUST BE ATTACHED TO THE APPROVED PLANS

Stream Buffer Impact Exhibit

DWG: F:\2021\04501-05000\021-04643-A\40-Design\Exhibits\EX-005 Stream Impact Exhibit\EX-005A_A2104643.dwg USER: cholmquist
DATE: Jan 09, 2023 11:34am XREFS: C_PBASE_A2104643 C_FBASE_A2104643 C_FROAD_A2104643 L_PBASE02_A2104643 C_XSURF_A2104643 C_XBASE_A2103436



SHEET
EX-005A

drawn by: CJH
checked by: JFE
approved by: CP
QA/QC by: JFE
project no.: A21-04643
drawing no.: EX-005A_A2104643
date: 2023.01.09

ZONE 1 STREAM BUFFER EXHIBIT

DISCOVERY PARK

LEE'S SUMMIT, MO | 2022

REV. NO.	DATE	REVISIONS DESCRIPTION	BY

REVISIONS

olsson

Olsson - Civil Engineering
Missouri Certificate of Authority #001592
1301 Burlington Street
North Kansas City, MO 64116 TEL 816.361.1177 www.olsson.com

Letter of Support

unity®
World Headquarters
at Unity Village

David Vest, CPA
Chief Financial Officer

January 17, 2023

Re: Discovery Park Zones 1 & 2 – Proposed Stormwater Best Management Practices (BMPs)

To whom it may concern,

We have reviewed the proposed stormwater management plan proposed for the Discovery Park Zones 1 & 2 development. Water quality treatment being provided by the proposed development appears to help mitigate any impacts to stormwater being conveyed by the existing creek channel and thus we are in support of the proposed development and removal of the existing creek channel.

We do not believe this will have any negative impacts to Unity Lake #1.

Sincerely,

David R. Vest, CPA
Mayor – Town of Unity Village

Chief Financial Officer – Unity School of Christianity

1901 NW Blue Parkway | Unity Village, MO 64065-0001 | Tel: 816-524-3550 | www.unity.org
Email: vestdr@unityonline.org | Tel: 816-347-5509

Landscape Design Guidelines

LANDSCAPE

Landscape Buffers

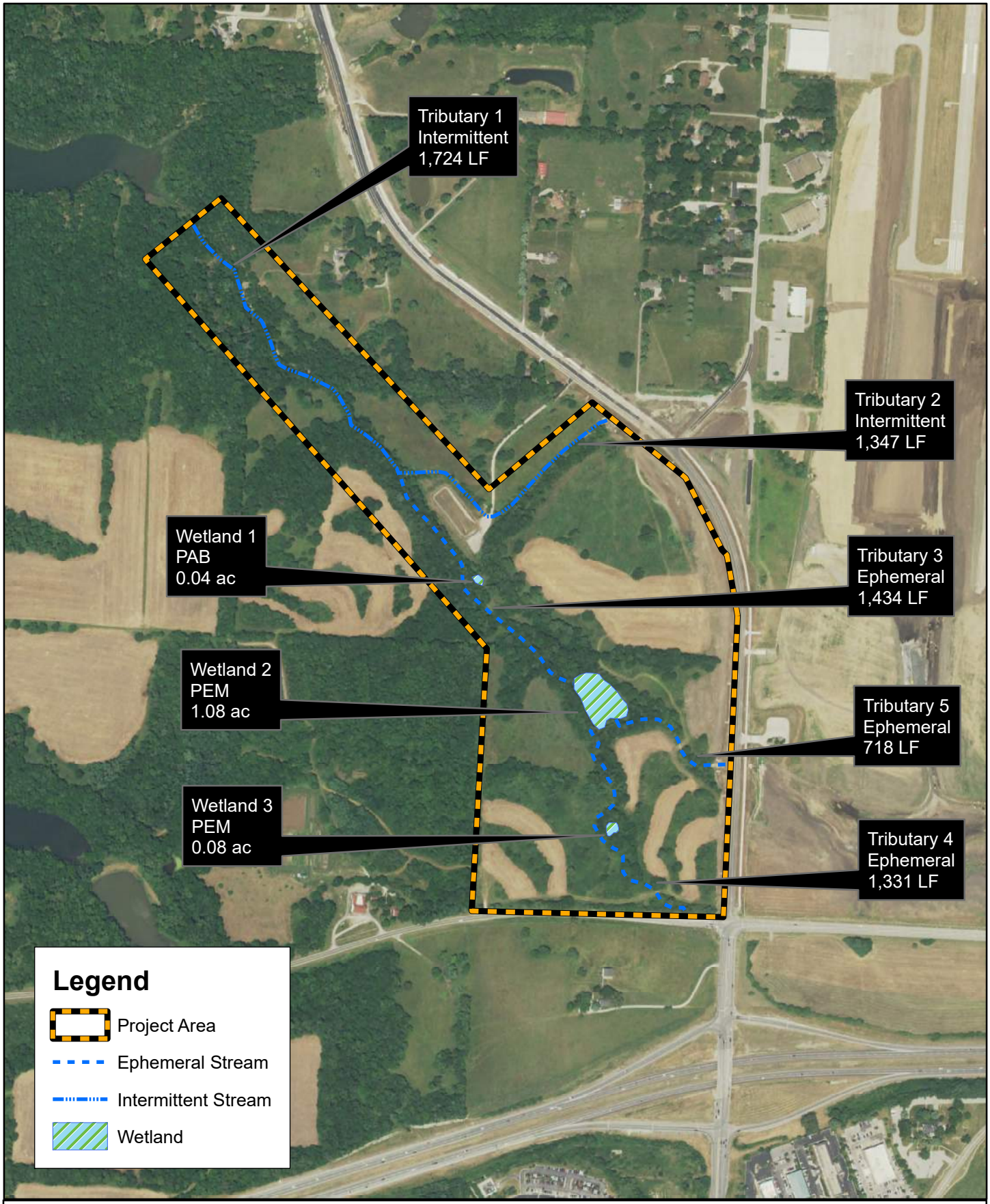
Vegetative buffers and riparian should be included to reduce noise pollution, enhance long term wildlife habitat connectivity, and improve storm water quality.

Dense vegetative buffering should be included in any portion of the development adjacent to I-470. This buffering should include a variety of native deciduous and evergreen trees as well as stands of native understory shrubs and grasses. These plantings will assist in minimizing noise pollution from the adjacent interstate. Buffer plantings along Colbern Rd. and Lee's Summit Rd. should include a combination of street tree plantings, native prairie stands with bermed landforms.

Native plantings/grasses that require minimal maintenance should be included along stream buffers and planned detention areas. Turf lawn areas should not be allowed within 15' of delineated detention area or ponds. These taller native plantings and grasses provide wildlife habitat and refuse while filtering physical and chemical pollutants. Native planted buffer zones in conjunction with the existing old growth tree preservation (when possible) will enhance wildlife habitat and connectivity.

Native buffer and riparian plantings should require temporary irrigation until established.

Jurisdictional Determination



Project Number: B19-0012	**Aquatic Resources Map** Aria Apartments NW Colbern Rd and NE Douglas St Lee's Summit, Missouri	DISCLAIMER : This Geographic Information System (GIS) and its components are designed as a source of reference for answering inquiries, for planning and for modeling. GIS is not intended, nor does it replace legal description information in the chain of title and other information contained in official government records such as the County Clerk and Recorders office or the courts. In addition, the representations of locations in this GIS cannot be substituted for actual legal surveys.	olsson 7301 West 133rd Street Suite 200 Overland Park, Kansas 66213 P: 913.381.1170 F: 913.381.1174	Figure **5**
Drawn By: CRW				
Revision Date: 8/12/2019				

F:\2019\0001-0500\019-0012\40-Design\GIS\MXD\NRPL\Ex5_AquResources_cw.mxd

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
635 FEDERAL BUILDING
601 E. 12TH STREET
KANSAS CITY, MISSOURI 64106-2824

September 16, 2020

Regulatory Branch
NWK-2020-765

Ms. Kyleen Kelly
Olsson Associates
7301 West 133rd Street, Suite 200
Overland Park, Kansas 66213

Dear Ms. Kelly:

This letter is in response to your request, submitted on behalf of Central States Construction, for a Jurisdictional Determination for the Aria Apartments residential development. The site is located in Section 19 & 30, Township 48 north, Range 31 west, Jackson County, Missouri. Your request has been assigned Regulatory File No. NWK-2020-765. Please reference this file number on any correspondence to us or to other interested parties concerning this matter.

This letter contains an approved jurisdictional determination for your project site. This jurisdictional determination is valid for a 5-year period from the date of this letter unless new information warrants revision of the determination before the expiration date. If you object to this determination, you may request an administrative appeal under Corps regulations at 33 CFR Part 331. Enclosed you will find a Notification of Administrative Appeal Options and Process and Request for Appeal (NAO-RFA) form. If you request to appeal this determination, you must submit a completed NAO-RFA form to the Northwestern Division Office at the following address:

Division Engineer
U.S. Army Corps of Engineers, Northwestern Division
ATTN: Melinda M. Larsen
Regulatory Appeals Review Officer
1201 NE Lloyd Blvd., Suite 400
Portland, OR 97232
Telephone: 503-808-3888

In order for an NAO-RFA to be accepted by the Corps, the Corps must determine that it is completed, that it meets the criteria for appeal under 33 CFR Part 331.5, and that it has been received by the Division Office within 60 days of the date of the NAO-RFA. Should you decide to submit an NAO-RFA form, it must be received at the above address by November 15, 2020. It is not necessary to submit an NAO-RFA form to the Division Office if you do not object to the determination in this letter.

In the event that you disagree with an approved jurisdictional determination and you have **new information** not considered in the original determination, you may request reconsideration of that determination by the Corps District prior to initiating an appeal. To request this reconsideration based upon new information, you must submit the completed NAO-RFA form and the new information to the District Office so that it is received within 60 days of the date of the NAO-RFA. Send approved jurisdictional determination reconsideration requests to:

District Commander
U.S. Army Corps of Engineers, Kansas City District
ATTN: Mark D. Frazier
Chief, Regulatory Branch
601 East 12th Street, Suite 402
Kansas City, MO 64106-2824
Telephone: 816-389-3990 - FAX: 816-389-2032

The Corps of Engineers has jurisdiction over all waters of the United States. Discharges of dredged or fill material in waters of the United States, including wetlands, require prior authorization from the Corps under Section 404 of the Clean Water Act (33 USC 1344). The implementing regulation for this Act is found at 33 CFR 320-332.

We are interested in your thoughts and opinions concerning your experience with the Kansas City District, Corps of Engineers Regulatory Program. Please feel free to complete our Customer Service Survey form on our website at: http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey. You may also call and request a paper copy of the survey which you may complete and return to us by mail.

If you have any questions concerning this matter, please feel free to write or contact me at 816-389-3115 or by email at connor.n.bickford@usace.army.mil. Please reference Permit No. NWK-2020-765 in all comments and/or inquiries relating to this project. This letter is only being provided to you electronically at kkelly@olsson.com.

Sincerely,

Connor N. Bickford

Connor Bickford
Regulatory Specialist

Enclosures

cc (electronically w/o enclosures):

Environmental Protection Agency,
Watershed Planning and Implementation Branch
U.S. Fish and Wildlife Service, Columbia, Missouri
Missouri Department of Natural Resources,
Water Protection Program
State Historic Preservation Office
Missouri Department of Conservation

U.S. ARMY CORPS OF ENGINEERS
REGULATORY PROGRAM
APPROVED JURISDICTIONAL DETERMINATION FORM (INTERIM)
NAVIGABLE WATERS PROTECTION RULE

I. ADMINISTRATIVE INFORMATION

Completion Date of Approved Jurisdictional Determination (AJD): 9/15/2020
ORM Number: NWK-2020-765
Associated JDs: N/A
Review Area Location[1]: State/Territory: MO City: Lee's Summit County/Parish/Borough: Jackson County
Center Coordinates of Review Area: Latitude 38.950502 Longitude -94.380472

II. FINDINGS

A. Summary: Check all that apply. At least one box from the following list MUST be selected. Complete the corresponding sections/tables and summarize data sources.

- ☐ The review area is comprised entirely of dry land (i.e., there are no waters or water features, including wetlands, of any kind in the entire review area). Rationale: N/A
- ☐ There are "navigable waters of the United States" within Rivers and Harbors Act jurisdiction within the review area (complete table in Section II.B).
- ☒ There are "waters of the United States" within Clean Water Act jurisdiction within the review area (complete appropriate tables in Section II.C).
- ☒ There are waters or water features excluded from Clean Water Act jurisdiction within the review area (complete table in Section II.D).

B. Rivers and Harbors Act of 1899 Section 10 (§ 10)[2]

§ 10 Name	§ 10 Size		§ 10 Criteria	Rationale for § 10 Determination
N/A.	N/A.	N/A	N/A.	N/A.

C. Clean Water Act Section 404

Territorial Seas and Traditional Navigable Waters ((a)(1) waters):[3]				
(a)(1) Name	(a)(1) Size		(a)(1) Criteria	Rationale for (a)(1) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

Tributaries ((a)(2) waters):				
(a)(2) Name	(a)(2) Size		(a)(2) Criteria	Rationale for (a)(2) Determination
NWK-2020-765 Tributary 1	1,724	linear feet	(a)(2) Intermittent tributary contributes surface water flow directly or indirectly to an (a)(1) water in a typical year.	Tributary 1 is classified as an (a)(2) water per evidence gathered from the consultant's site visit 2019-8-6. From aerial photographs and NWI provided, Tributary 1 flows northwest and makes a downstream hydrologic connection with an (a)(3) water, Unity Lake 2. The water feature is naturally occurring and field data exhibits stream flow in absence of precipitation events, though defined as discrete and confined flow. Upstream, the tributary makes hydrologic connections with both a jurisdictional water feature (Tributary 2) and non-

[1] Map(s)/figure(s) are attached to the AJD provided to the requestor.
[2] If the navigable water is not subject to the ebb and flow of the tide or included on the District's list of Rivers and Harbors Act Section 10 navigable waters list, do NOT use this document to make the determination. The District must continue to follow the procedure outlined in 33 CFR part 329.14 to make a Rivers and Harbors Act Section 10 navigability determination.
[3] A stand-alone TNW determination is completed independently of a request for an AJD. A stand-alone TNW determination is conducted for a specific segment of river or stream or other type of waterbody, such as a lake, where upstream or downstream limits or lake borders are established. A stand-alone TNW determination should be completed following applicable guidance and should NOT be documented on the AJD Form.

Tributaries ((a)(2) waters):				
(a)(2) Name	(a)(2) Size		(a)(2) Criteria	Rationale for (a)(2) Determination
				jurisdictional feature (Tributary 3, ephemeral). Under new NWPR language, this hydrologic connection with a non-jurisdictional ephemeral feature does not sever jurisdiction for Tributary 1 due to downstream jurisdictional connection. Therefore, Tributary 1 is a jurisdictional (a)(2) water.
NWK-2020-765 Tributary 2	1,347	linear feet	(a)(2) Intermittent tributary contributes surface water flow directly or indirectly to an (a)(1) water in a typical year.	Tributary 2 is classified as an (a)(2) water per evidence gathered from the consultant's site visit 2019-8-6. The stream channel is described as wide and manipulated, having had a culvert constructed along the channel. Data collected shows stream flow occurring in Tributary 2 without aid of significant precipitation, though described as discrete and confined. As well, Tributary #2 makes a downstream hydrologic connection with Tributary 1, which further makes a connection to an (a)(3) water, Unity Lake 2. Based on this evidence, Tributary 2 is a jurisdictional (a)(2) water.

Lakes and ponds, and impoundments of jurisdictional waters ((a)(3) waters):				
(a)(3) Name	(a)(3) Size		(a)(3) Criteria	Rationale for (a)(3) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

Adjacent wetlands ((a)(4) waters):				
(a)(4) Name	(a)(4) Size		(a)(4) Criteria	Rationale for (a)(4) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

D. Excluded Waters or Features

Excluded waters ((b)(1) – (b)(12)):[4]				
Exclusion Name	Exclusion Size		Exclusion[5]	Rationale for Exclusion Determination
NWK-2020-765 Tributary 3	1,434	linear feet	(b)(3) Ephemeral feature, including an ephemeral stream, swale, gully, rill, or pool.	Tributary 3 is classified as a (b)(3) exclusion under new NWPR language per evidence from a 2019-8-6 site visit and delineation by the consultant. In this data, Tributary 3 had no flowing or standing water in the stream channel, thus meeting definitions of an ephemeral water feature. Therefore, Tributary 3 is a non-jurisdictional feature.
NWK-2020-765 Tributary 4	1,331	linear feet	(b)(3) Ephemeral feature, including an ephemeral	Tributary 4 is classified as a (b)(3) exclusion under new NWPR language per evidence from a 2019-8-6 site visit and delineation by the consultant. In this data, Tributary 4 had no

[4] Some excluded waters, such as (b)(2) and (b)(4), may not be specifically identified on the AJD form unless a requestor specifically asks a Corps district to do so. Corps districts may, in case-by-case instances, choose to identify some or all of these waters within the review area.
[5] Because of the broad nature of the (b)(1) exclusion and in an effort to collect data on specific types of waters that would be covered by the (b)(1) exclusion, four sub-categories of (b)(1) exclusions were administratively created for the purposes of the AJD Form. These four sub-categories are not new exclusions, but are simply administrative distinctions and remain (b)(1) exclusions as defined by the NWPR.

Excluded waters ((b)(1) – (b)(12)):[4]				
Exclusion Name	Exclusion Size		Exclusion[5]	Rationale for Exclusion Determination
			stream, swale, gully, rill, or pool.	flowing or standing water in the stream channel, thus meeting definitions of an ephemeral water feature. Therefore, Tributary 4 is a non-jurisdictional feature.
NWK-2020-765 Tributary 5	718	linear feet	(b)(3) Ephemeral feature, including an ephemeral stream, swale, gully, rill, or pool.	Tributary 5 is classified as a (b)(3) exclusion under new NWPR language per evidence from a 2019-8-6 site visit and delineation by the consultant. In this data, Tributary 5 had no flowing or standing water in the stream channel, thus meeting definitions of an ephemeral water feature. Therefore, Tributary 5 is a non-jurisdictional feature.
NWK-2020-765 Wetland 1	0.04	acre(s)	(b)(1) Non-adjacent wetland.	Wetland 1 is a small, palustrine aquatic bed wetland located in the middle of the project site. It is a stand-alone wetland that makes no hydrologic connection with a jurisdictional feature, with its nearest nexus being adjacency to a non-jurisdictional ephemeral feature. Therefore, Wetland 1 is a non-jurisdictional feature under a (b)(1) exclusion.
NWK-2020-765 Wetland 2	1.08	acre(s)	(b)(1) Non-adjacent wetland.	Wetland 2 is a palustrine emergent wetland classified as (b)(1) exclusion per evidence gathered from a 2019-8-6 delineation and site visit by the consultant. Wetland 2 is located upstream of Tributary 3 and downstream of Tributaries 4 and 5, with Tributaries 4 and 5 draining into Wetland 2 and then draining to Tributary 3. These hydrologic connections are only with non-jurisdictional ephemeral features. Therefore, Wetland 2 is a non-jurisdictional feature under a (b)(1) exclusion.
NWK-2020-765 Wetland 3	0.08	acre(s)	(b)(1) Non-adjacent wetland.	Wetland 3 is a palustrine emergent wetland located in the southern region of the project site. It is a stand-alone wetland that makes no hydrologic connection with a jurisdictional feature, with its nearest nexus being adjacency to a non-jurisdictional ephemeral feature. Therefore, Wetland 3 is a non-jurisdictional feature under a (b)(1) exclusion.

III. SUPPORTING INFORMATION

A. Select/enter all resources that were used to aid in this determination and attach data/maps to this document and/or references/citations in the administrative record, as appropriate.

☒ Information submitted by, or on behalf of, the applicant/consultant: Stream & wetland delineation report furnished by Olsson Associates, 2020-09-09

This information is sufficient for purposes of this AJD.

Rationale: N/A

- ☐ Data sheets prepared by the Corps: N/A
- ☐ Photographs: Select. N/A
- ☐ Corps site visit(s) conducted on: N/A
- ☐ Previous Jurisdictional Determinations (AJDs or PJDs): N/A
- ☒ Antecedent Precipitation Tool: *provide detailed discussion in Section III.B*.
- ☐ USDA NRCS Soil Survey: N/A
- ☒ USFWS NWI maps: NWI map sourced through USACE Regulatory Viewer, 2020-09-15
- ☐ USGS topographic maps: N/A

Other data sources used to aid in this determination:

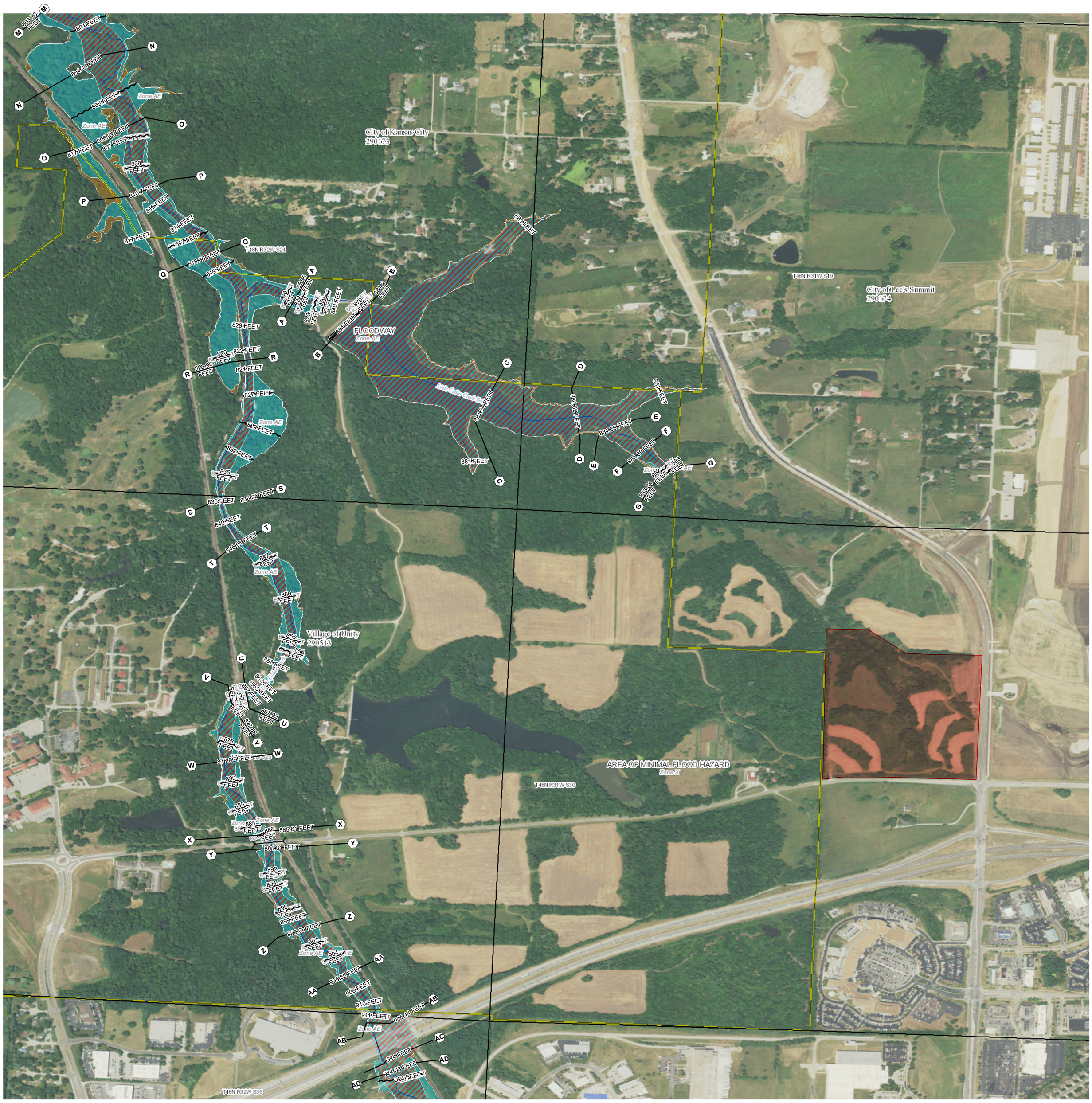
Data Source (select)	Name and/or date and other relevant information
USGS Sources	N/A.
USDA Sources	N/A.
NOAA Sources	N/A.
USACE Sources	N/A.
State/Local/Tribal Sources	N/A.
Other Sources	N/A.

B. Typical year assessment(s): The APT data generated for site and date show higher precipitation rates over the last 30 days from 2019-08-06 compared to the normal 30 year range. This data supports the site experiencing wetter than normal conditions of precipitation. There were small precipitation events a couple days before the date of the site visit and delineation, but this appears to be neglibile and have little effect on the findings of the site.

C. Additional comments to support AJD: N/A

FEMA Flood Map

94°24'22.95"W 38°58'14.11"N



USGS The National Map: Orthoimagery. Data refreshed April 2020

94°22'29.6"W 38°56'8.44"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS

- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES

- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **8/26/2020 8:37 AM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: NAVD88
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 500 feet 1:6,000

0 250 500 1,000 1,500 2,000 Feet

0 50 100 200 300 400 Meters

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

JACKSON COUNTY, MISSOURI AND INCORPORATED AREAS

PANEL 409 OF 605

Panel Contains:

COMMUNITY	NUMBER	PANEL
CITY OF KANSAS CITY	290173	0409
VILLAGE OF UNITY	290513	0409
CITY OF LEE'S SUMMIT	290174	0409

MAP NUMBER
29095C0409G
EFFECTIVE DATE
January 20, 2017

Stormwater Management Study Excerpt

DISCOVERY PARK MACRO STORMWATER REPORT

Prepared for:

Discovery Park Lee's Summit, LLC
Columbia, Missouri

January 2023

Revised March 2023

Olsson Project No. A21-04643

olsson

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

This Stormwater Drainage Study has been prepared to evaluate the stormwater hydrology of multiple developments (current and future) that are being proposed within the watershed. Once fully developed, the area treated by improvements proposed within this study will include:

- Aria Apartments: a 22.50-ac apartment development (Zoned RP-4)
- Discovery Park Phase 1: a 39.42-ac commercial development (Zoned CP-2, currently being rezoned to PMIX)
- Discovery Park Phase 2: a 19.82-ac commercial development (Zoned PMIX)
- Discovery Park Future: a 116.26-ac planned mixed use development (Zoned PMIX)
- A future Multi-Family Residential development of approximately 14.96-ac along the west side of NW Lee's Summit Road (Zoned RP-4)

The site is located at the northwest corner of NE Douglas Street and NE Colbern Road, in the NE ¼ of Section 30 & SE ¼ of Section 19, Township 48 North, Range 31 West, entirely within the City of Lee's Summit, Jackson County, Missouri.

Stormwater runoff from the project site is tributary to Unity Lake Number One and Unity Lake Number Two. Unity Lake Number One is approximately 1,000 feet downstream of the Discovery Park Future study area. Unity Lake Number Two is approximately 2,500 feet downstream of the Discovery Park Phase 1 and Aria study areas.

This report, intended to serve as the project Macro Stormwater Drainage Study for Aria, Discovery Park Phase 1, and a portion of the Discovery Park Phase 2 Development, has been prepared to evaluate the Existing Conditions stormwater hydrology to establish Allowable Release Rates and to review impacts the proposed development has on the existing hydrology. The Existing Conditions stormwater hydrology will be analyzed for the Discovery Park Future areas to establish Allowable Release Rates similar to the Macro-study area, however, no proposed detention will be analyzed. A future Macro-study for that development area will be required with its Preliminary Development Plan submittal. Refer to Section 7 for hydrologic model input data and simulation results for Existing- and Proposed Conditions. Refer to Section 8 for maps and exhibits depicting the watersheds evaluated in the analyses.

Vicinity Map

1.1. FEMA Floodplain Classification

The FEMA FIRM Panel 29095C-0409G (eff. 20 January, 2017) depict the proposed development areas as “Zone X.” This is the FEMA flood insurance rate zone that “corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less

than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFE's or base flood depths are shown for this zone." Refer to the attached FEMA Floodplain Map (Exhibit 8-1.1) for depiction of the established floodplains relative to the project site.

The lower reaches of the modeled sub-watershed that is the subject of this report does include a "Zone AE" boundary along the Little Cedar Creek – Tributary No. 2 channel that forms the main branch of the Unity Lake Number 2 impoundment. No construction proposed for these three areas is proposed to affect the boundaries of the defined floodway for this channel.

1.2. Soil Classification

Soil Maps published in the Soil Survey for Jackson County, Missouri categorizes soils in this watershed as:

Table 1.2-1. Soil Classifications

HSG	Map Symbol	Type	Land-Form
C	10000	Arisburg Silt Loam	1% to 5% Slopes
D	10024	Greenton-Urban Land Complex	5% to 9% Slopes
C	10026	Higginsville Silt Loam	5% to 9% Slopes
C	10082	Arisburg-Urban Land Complex	1% to 5% Slopes
D	10113	Oska Silty Clay Loam	5% to 9% Slopes, E
C/D	10116	Sampsel Silty Clay Loam	2% to 5% Slopes
C/D	10117	Sampsel Silty Clay Loam	5% to 9% Slopes
C	10120	Sharpsburg Silt Loam	2% to 5% Slopes
D	10128	Sharpsburg-Urban Land Complex	2% to 5% Slopes
D	10129	Sharpsburg-Urban Land Complex	5% to 9% Slopes
C	10132	Sibley Silt Loam	2% to 5% Slopes
C	10136	Sibley-Urban Land Complex	2% to 5% Slopes
D	10143	Snead-Urban Land Complex	9% to 30% Slopes
C	10179	Udarents-Urban Land-Oska Complex	5% to 9% Slopes
C	10180	Udarents-Urban Land-Sampsel Complex	2% to 5% Slopes
C/D	30080	Greenton Silty Clay Loam	5% to 9% Slopes
C	30180	Polo Silt Loam	5% to 9% Slopes
C	36083	Kennebec Silt Loam	1% to 4% Slopes, OF
D	40107	Snead-Rock Outcrop Complex, Warm	5% to 14% Slopes
D	40108	Snead-Rock Outcrop Complex, Warm	14% to 30% Slopes
-	99001	Water	-
-	99012	Urban Land, Upland	5% to 9% Slopes

(HSG = Hydrologic Soil Group, E=Eroded, OF=Occasionally Flooded)

NRCS Runoff Curve Numbers (CN's) in this study have been assigned to tributary areas based upon these Hydrologic Soil Groups and associated existing and proposed land use. The majority of land within the modeled sub-watersheds is previously developed, and the CN's are assigned accordingly. Refer to the Soils Map in Section 8 for distribution of soil types throughout the sub-watersheds.

2. METHODOLOGY

The hydrologic analysis provided in this report utilizes methods prescribed by the City of Lee's Summit, Missouri and the Kansas City Metropolitan Chapter of the APWA "Standard Specifications and Design Criteria," Division V, Section 5600 (February 2011) provides the overall framework for stormwater hydrology. The following approved methods were used in this report to model Existing- and Proposed Conditions for stormwater runoff.

- Haestad Methods, Inc. "PondPack" V8*i* (08.11.01.56).
- NRCS TR-55 Unit Hydrograph Method
- 2-, 10-, and 100-year Return Frequency, 24-hr. Storm Precipitation Depths (TP-40)
- ARC-II Soil Moisture Conditions
- 24-Hour NRCS Type II Rainfall Distribution
- Runoff Curve Numbers per NRCS TR-55 (Tables 2-2a – 2-2c) and APWA Sec.5602.3
- NRCS TR-55 Methods for determination of Time of Concentration and Travel Time.

NOTE: Where detailed information pertaining to channel geometry is unavailable, "length & velocity" estimates for channel-flow Travel Time is utilized per Section 5602.7, Kansas City Metropolitan Chapter- APWA Standard Specifications and Design Criteria.
NOTE: PondPack models utilize "Time of Concentration" rather than "Lag Time" for computing subarea hydrology.

Input data for the Existing- and Proposed Conditions hydrology models and results of computations are included in Section 7. Refer to the attached Drainage Area Maps for Existing- and Proposed Conditions subarea locations, weighted Runoff Curve Numbers, and tributary acreage included in Section 8.

Stormwater runoff models were created for the 2-, 10-, and 100-year design storm events. The precipitation depths used in the analyses have been interpolated from the "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (TP-40; May 1961) isopluvial maps. The following table depicts the rainfall depths used in this analysis:

Table 2-1. Precipitation Depths

Return Period:	24-hour Precipitation Depth (in):
Water Quality Storm[1]	1.37
2-Year (50% Storm)	3.50
10-Year (10% Storm)	5.34
100-Year (1% Storm)	7.71

[1]The "Water Quality Storm" is defined in the MARC & APWA "Manual of Best Management Practices for Stormwater Quality" as a 24-hr 1.37" rainfall depth. This particular storm event is utilized for proposed water quality analysis.

Each of the PondPack models constructed for this analysis evaluates multiple rainfall events using these three defined design storms.

The overall hydrology defines 9 modeled sub-watersheds (sub-watersheds “A,” “B,” “C,” “D,” “E,” “F,” “G,” “H,” “I”), and 30 subareas, encompassing approximately 998 acres overall.

Several offsite subareas are included in the models prepared for this report that will remain unaltered as a result of the proposed development areas. Sub-watersheds “B” and “C” are both offsite regions, as are some portions of sub-watershed “A,” “D,” “E,” “F,” “G,” “H,” “I”.

- The Aria site lies within portions of Subareas A3, A4(E), and A5(E).
- The Discovery Park Phase 1 site is located within Subareas A4(E), A4(W), A5(E) and A5(W).
- The Discovery Park Phase 2 site is located within Subareas A6 and D2.
- The Discovery Park Future site is located within Subareas D2, E1, F2, G2, H1 and I1.
- The future Multi-Family Residential development is located within Subarea A1(E).

In accordance with the City-specified criterion and design provision established in the 2011 edition of APWA Section 5600, the proposed stormwater management plan shall “be consistent with the Comprehensive Control Strategy.” This requirement establishes the maximum Allowable Release Rates for the 2-year (0.50 cfs/ac), 10-year (2.0 cfs/ac), and 100-year (3.0 cfs/ac) design storms. In addition to the large storm hydrology design constraints, this strategy requires extended detention (≥ 40hr.) of the “Water Quality Storm” runoff volume.

Points of Interest

The hydrologic models prepared for this stormwater Drainage Study includes 30 Points of Interest in total. The 17 critical points of interest to be analyzed are briefly described as:

- **Point A1,** located at the southern inlet to the Unity Lake Number 2 impoundment, the downstream point of interest modeled in this report.
- **Point A2** is the confluence of Channels A and B, located north of an existing sanitary holding basin. All stormwater runoff generated by the Aria and Discovery Park projects is conveyed to this point.
- **Point A3** is a culvert in Channel B crossing an access drive for the existing sanitary holding basin.
- **Point A4** is a point within Channel A, upstream of Point A2, Portions of the Aria and Discovery Park projects contribute flow to this point of interest.
- **Point A5** is the downstream end of an existing pond with a breached embankment within Channel A.
- **Point A6** is the downstream end of an existing culvert under NW Colbern Road. A portion of Discovery Park Phase 2 will contribute flow to this point of interest.

- **Point A7** is the downstream end of an existing culvert within Channel A, located at station 25+65 of NE Douglas Street. All stormwater runoff contributed to this point is generated by offsite areas.
- **Point B1** is the downstream end of an existing culvert within Channel B, located at station 45+15 of NE Douglas Street. All stormwater runoff contributed to this point is generated by offsite areas.
- **Point D1** is located at an eastern inlet to the Unity Lake Number 1 impoundment, the downstream point of interest of sub-watershed D. Portions of Discovery Park Phase 1, Discovery Park Phase 2 and Discovery Park Future will contribute flow to this point of interest.
- **Point D2** is the downstream end of an existing culvert under NW Colbern Road. Portions of Discovery Park Phase 2 and Discovery Park Future will contribute flow to this point of interest. This point is where the majority of offsite stormwater, from areas south of Interstate 470, will drain through the future development area.
- **Point D4** is the downstream end of an existing culvert under I-470 highway. All stormwater runoff contributed to this point is generated by offsite areas. The culvert represents a choke point for all the offsite area draining to Discovery Park Future from South of I-470.
- **Point E1** is the downstream end of an existing culvert under NW Colbern Road. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point F1** is located at a southeastern inlet to the Unity Lake Number 1 impoundment, the downstream point of interest of sub-watershed F. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point F2** is the downstream end of an existing culvert under NW Colbern Road. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point G1** is located at a southwestern inlet to the Unity Lake Number 1 impoundment, the downstream point of interest of sub-watershed G. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point G2** is the downstream end of an existing culvert under NW Colbern Road. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point H1** is the downstream end of an existing culvert under N Main Street that discharges directly to Little Cedar Creek. A portion of Discovery Park Future will contribute flow to this point of interest.
- **Point I1** is the downstream end of an existing culvert under N Main Street. A small portion of Discovery Park Future will contribute flow to this point of interest.

Several additional points are utilized in the models to assist with the hydrologic analysis for offsite areas. The locations of these points are depicted in the attached Drainage Area Maps,

and the results of the analyses are included in tables provided in this narrative, and in the attached modeling output.

In order to provide a direct comparison between the Existing and Proposed Conditions hydrology models, efforts have been made to ensure that the points of interest are consistent between these analyses with the exception of Point A5 as discussed in Section 4 of this report. As noted, additional points to those previously described are included in the hydrologic models, these junctions are of secondary interest to this particular development. Refer to the attached Drainage Area Maps for graphical representation of the modeled subareas and points of interest; refer to Section 7 for schematic view of the PondPack watershed model and connectivity between subareas, channel reaches, and points of interest.

3. EXISTING CONDITIONS ANALYSIS

The purpose of this report is to provide the Macro Stormwater Drainage analysis to ensure that the proposed site development is compliant with City of Lee's Summit, Missouri requirements. This section of the report will provide the Existing Conditions analysis, representing the current site hydrology. The results of this analysis will be used to establish the "Allowable Release Rates" for the project and will be compared to those of Proposed Conditions in order to determine the hydrologic effects of the development upon the receiving stormwater conveyances and sub-watersheds.

Runoff Curve Numbers have been developed based upon the current land use obtained from survey data, aerial photographs, and site visits. Refer to Section 7 for Existing Conditions weighted NRCS Runoff Curve Number (CN) and Time of Concentration (T_C) calculations. Table 3-1 contains the hydrologic parameters used to characterize subareas the Existing Conditions PondPack model. A graphical representation of the areas is provided on exhibit EX-300 in Section 8.

Table 3-1(a). Existing Conditions Input Data

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):	NRCS Weighted CN:	T_C [1] (hr):
Subarea A1(e):	27.97				12.36	77	0.1736
Subarea A1(w):	43.14					76	0.2511
Subarea A2(e):	3.08					80	0.0875
Subarea A2(w):	23.41					73	0.2133
Subarea A3:	24.42	11.62				80	0.1284
Subarea A4(e):	9.85	5.99	3.35			81	0.1367
Subarea A4(w):	17.41		9.19			73	0.1656
Subarea A5(e):	15.16	4.88	8.00			80	0.1195
Subarea A5(w):	19.77		18.66			76	0.1578
Subarea A6:	13.45			9.21		80	0.1063
Subarea A7:	30.60					76	0.1596
Subarea A8:	21.56					81	0.1299
Subarea A9:	31.84					84	0.1420
Subarea A10:	12.23					94	0.1545
Subtotal:	*293.88*	*22.50*	*39.20*	*9.21*	*12.36*		
Subarea B1:	31.94					79	0.1385
Subarea B2:	48.54					78	0.1987
Subarea B3:	40.69					83	0.1447
Subarea B4-DET:	25.05					94	0.1155

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):	NRCS Weighted CN:	T_C [1] (hr):
Subarea B4-BYP:	7.42					94	0.0787
Subtotal:	*153.64*						
Subarea C1:	45.21					90	0.2860
Subarea C2:	57.13					81	0.3308
Subarea C3:	52.36					83	0.1199
Subtotal:	154.70						
Subarea D1:	36.91		0.22			77	0.1275
Subarea D2:	47.00			10.62	24.74	78	0.1755
Subarea D3:	16.84					88	0.1561
Subarea D4:	112.38					88	0.1792
Subarea D5:	53.24					89	0.2652
Subtotal:	*266.37*		*0.22*	*10.62*	*24.74*		
Subarea E1:	22.59				20.68	80	0.1062
Subarea E2:	6.56					73	0.1021
Subtotal:	*29.15*				*20.68*		
Subarea F1:	7.85					77	0.0938
Subarea F2:	12.76				12.06	81	0.1260
Subtotal:	*20.60*				*12.06*		
Subarea G1:	14.04					81	0.1055
Subarea G2:	7.93				7.11	85	0.1175
Subtotal:	*21.96*				*7.11*		
Subarea H1:	56.17				51.06	78	0.1348
Subtotal:	*56.17*				*51.06*		
Subarea I1:	1.40				0.61	86	0.1019
Subtotal:	*1.40*				*0.61*		
Total:	***997.89***	***22.50***	***39.42***	***19.83***	***128.62***		

[1] ***Note:*** *Per TR-55 documentation, minimum T_C is 0.10 hours; model is configured with default value of 0.10 hr. minimum Tc.*

Table 3-1(b). Existing Conditions Input Sub-Watershed Data

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):
Sub-W'Shed A Subtotal:	293.88	22.50	39.20	9.21	12.36
Sub-W'Shed B Subtotal:	153.64				
Sub-W'Shed C Subtotal:	154.70				
Sub-W'Shed D Subtotal:	266.37		0.22	10.62	24.74
Sub-W'Shed E Subtotal:	29.15				20.68
Sub-W'Shed F Subtotal:	20.60				12.06
Sub-W'Shed G Subtotal:	21.96				7.11
Sub-W'Shed H Subtotal:	56.17				51.06
Sub-W'Shed I Subtotal:	1.40				0.61
Modeled Total:	997.89	22.50	39.42	19.83	128.62

These tributary areas, Runoff Curve Numbers (CN), and Times of Concentration (T_C) for the corresponding subareas were used as input to the Existing Conditions PondPack model to evaluate the stormwater hydrology. The subareas representing Existing Conditions for the development and associated sub-watersheds are utilized in the PondPack model to compute the stormwater runoff for the three design storms. The resultant peak discharge rate (Q_P), peak time (T_P), and runoff volume (V_R) for the computed hydrographs of modeled subareas are included in Table 3-2.

Table 3-2. Hydrologic Information – Existing Conditions Summary (Subareas)

	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea A-1(e):	53.91	12.01	3.334	110.32	11.99	6.783	187.82	11.99	11.675
Subarea A-1(w):	70.15	12.05	4.908	146.86	12.05	10.132	252.55	12.05	17.597
Subarea A-2(e):	7.64	11.94	0.420	14.90	11.93	0.819	24.63	11.93	1.374
Subarea A-2(w):	34.59	12.03	2.301	76.77	12.03	4.975	136.28	12.03	8.884
Subarea A-3:	57.61	11.96	3.330	112.58	11.95	6.495	186.13	11.95	10.895
Subarea A-4(e):	23.97	11.96	1.402	45.97	11.96	2.698	75.15	11.96	4.488
Subarea A-4(w):	27.56	12.01	1.712	60.85	11.99	3.700	108.22	11.99	6.607
Subarea A-5(e):	36.40	11.95	2.067	70.90	11.95	4.031	116.98	11.95	6.762
Subarea A-5(w):	37.02	12.00	2.249	77.10	11.99	4.643	132.61	11.97	8.064
Subarea A-6:	37.98	11.93	2.083	70.54	11.93	3.904	113.19	11.93	6.389
Subarea A-7:	57.26	12.00	3.482	119.03	11.98	7.186	204.90	11.98	12.481
Subarea A-8:	53.05	11.96	3.070	101.89	11.95	5.907	166.82	11.95	9.826
Subarea A-9:	87.15	11.97	5.138	158.95	11.96	9.507	252.78	11.96	15.435
Subarea A-10:	45.61	11.97	2.890	72.57	11.97	4.733	106.86	11.97	7.128

	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea B-1:	70.94	11.97	4.168	140.29	11.96	8.242	234.20	11.95	13.944
Subarea B-2:	94.72	12.03	6.057	190.16	12.01	12.146	320.74	12.00	20.725
Subarea B-3:	106.50	11.97	6.302	197.62	11.96	11.812	317.37	11.96	19.332
Subarea B-4 (BYP):	30.29	11.93	1.753	48.22	11.92	2.871	71.04	11.92	4.324
Subarea B-4 (DET):	99.43	11.94	5.919	158.21	11.94	9.694	232.94	11.94	14.599
Subarea C-1:	124.83	12.05	9.223	209.38	12.05	15.842	317.10	12.05	24.565
Subarea C-2:	104.44	12.09	8.134	200.90	12.08	15.652	329.78	12.08	26.038
Subarea C-3:	142.61	11.95	8.110	264.83	11.94	15.199	425.51	11.94	24.875
Subarea D-1:	75.69	11.97	4.400	155.84	11.95	8.95	265.94	11.95	15.407
Subarea D-2:	99.28	12.00	6.134	195.91	12.00	12.128	326.27	11.98	20.518
Subarea D-3:	52.46	11.97	3.185	90.29	11.97	5.605	138.69	11.97	8.822
Subarea D-4:	338.74	11.99	21.246	582.43	11.99	37.391	894.20	11.99	58.857
Subarea D-5:	146.13	12.05	10.458	247.91	12.05	18.183	377.88	12.03	28.406
Subarea E-1:	55.42	11.94	3.080	107.96	11.94	6.008	178.18	11.93	10.078
Subarea E-2:	11.34	11.94	0.645	25.34	11.94	1.394	45.12	11.94	2.489
Subarea F-1:	16.88	11.94	0.935	34.70	11.93	1.903	59.21	11.93	3.275
Subarea F-2:	31.60	11.96	1.816	60.52	11.95	3.495	99.00	11.95	5.814
Subarea G-1:	36.14	11.94	1.999	69.23	11.93	3.846	113.41	11.93	6.398
Subarea G-2:	23.49	11.94	1.332	42.32	11.94	2.433	66.71	11.94	3.92
Subarea H-1:	119.73	11.97	7.009	240.97	11.96	14.056	406.72	11.95	23.984
Subarea I-1:	4.44	11.93	0.244	7.87	11.93	0.441	12.29	11.93	0.705

The PondPack models created for these analyses include 24 channel reaches modeled using the Muskingum Method. Various modeled points of interest are connected in the model by these channel reaches. The reach segments account for the time-lagging effect on the hydrograph peaks, including a relatively insignificant amount of peak flow rate attenuation as the flood wave travels downstream. Travel time for each reach is based upon the reach length and average bed-slope. The following table contains the input data for the channel reaches used in the Existing- and Proposed Conditions PondPack models.

Table 3-3. Muskingum Channel Reach Routing Information

Reach I.D.	K (hr.):	X *(coeff.)*:	No. of Sub-reaches	K *(ea. sub-reach) (hr.):*
Route A2~A1:	0.0826	0.25	9	0.0092
Route A4~A2:	0.0288	0.25	3	0.0097
Route A5~A4:	0.0203	0.25	3	0.0067
Route A3~A2:	0.0192	0.25	2	0.0097
Route A6~A5:	0.0378	0.25	4	0.0094
Route A7~A5:	0.0412	0.25	5	0.0083
Route A8~A7:	0.0340	0.25	4	0.0086
Route A9~A7:	0.0390	0.25	4	0.0097
Route A10~A9:	0.0636	0.25	7	0.0092
Route B1~A3:	0.0331	0.25	4	0.0083
Route B2~B1:	0.0162	0.25	2	0.0081
Route B3~B2:	0.0824	0.25	9	0.0092
Route B4~B3:	0.0587	0.25	6	0.0097
Route C1~B1:	0.0210	0.25	3	0.0069
Route C2~C1:	0.0701	0.25	8	0.0089
Route C3~C2:	0.0148	0.25	2	0.0075
Route D2~D1:	0.0428	0.25	8	0.0053
Route D3~D2:	0.0758	0.25	6	0.0126
Route D4~D2:	0.0598	0.25	6	0.0100
Route D5~D4:	0.0475	0.25	5	0.0095
Route E1~D1:	0.0339	0.25	6	0.0056
Route E2~E1:	0.0336	0.25	3	0.0112
Route F2~F1:	0.0192	0.25	3	0.0064
Route G2~G1:	0.0244	0.25	3	0.0081

The preceding stormwater conveyances have been incorporated into both the Existing and Proposed Conditions PondPack models. The results of the Existing Conditions hydrologic routing are provided in Table 3.2-1, in Section 3.2, which provides the summary data for the points of interest defined in this Stormwater Drainage Study. Refer to the Existing Conditions Drainage Area Map for the location of the points of interest, modeled subareas, channels, and conveyances, in relation to proposed development area.

The defined subareas and stormwater conveyances, with associated hydrograph attenuation effects have been incorporated into the Existing (and Proposed) Conditions PondPack models. There are also several offsite storage areas included in the Existing- and Proposed Conditions models for the project site. The following section of this report provides the geometric configuration and hydrologic routing summary for existing locations. The results of the Existing Conditions hydrologic routing at the designated Points of Interest are provided in the Section 3.2.

3.1. Existing Stormwater Storage Areas & Detention Facilities

The following information is provided to define the geometry of the outfall structure and storage capacity for the existing modeled storage areas and stormwater detention basins included in the Existing Conditions hydrology models. The routing summary tables provided for each location contain the Existing Conditions hydrologic routing summary for each of the design storm events considered in this analysis.

Point A3 – Culverts at Pump Station Drive Culverts:

An access drive extends across the channel that runs along the northern edge of the Aria project site. This restricted-access drive leads to the pump station that is positioned at the confluence of two channels that define the upper regions of the modeled sub-watershed. The Existing- and Proposed Conditions geometry of the culverts positioned across the existing access drive to the pump station are defined as follows:

Primary Outlet Structure:

Dual 84" Diameter *(modeled equivalent circular: 72" x 96" CMPA Culvert);* Length ≈ 66.6 L.F. Flowline In / Out ≈ 900.81 / 900.43 (ft; NAVD)

Secondary Outlet Structure:

Roadway (Weir)-

Station (ft):	0	22	43.1	76.73	124.4	157.13	223.83	251	265.18	270.32	277.43
Elevation (ft):	912	910	908.52	907.24	907.44	908.16	908.35	908.6	909	910	912

Culvert flow at the threshold of overtopping/weir-flow is approximately 255 cfs.

The potential storage area upstream from this roadway crossing is defined in the following table based upon storage area for a given elevation. As depicted below, the potential storage area is somewhat modest, relative to the existing conditions flows that are contributed to this location.

Table 3.1-1(a). Existing Storage Volume – Pump Station Drive Storage Area

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
900.81	106	0	0.000
901	114	21	0.000
902	691	362	0.009
902.4	908	319	0.016
903	1,252	645	0.031
904	3,270	2,182	0.081
906	7,400	10,393	0.320
908	38,290	41,682	1.276
910	58,812	96,371	3.489
912	84,827	142,847	6.768

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

Utilizing these geometric parameters, the following table depicts the stormwater routing summary for this location.

Table 3.1-1(b). Existing Conditions Storage Area Routing – Point A3 – Pump Station Drive Culverts

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	102.98	12.15	101.73	12.18	9.704	904.61	0.134
2-Year:	632.94	12.13	628.64	12.15	52.997	908.50	1.747
10-Year:	1,109.82	12.13	1,107.67	12.15	97.952	909.07	2.341
100-Year:	1,597.03	12.16	1,595.56	12.17	159.297	909.50	2.849

The preceding routing summary indicates that the culverts are somewhat under-sized for most large-storm events, though the Water Quality Volume storm event is readily conveyed by this system.

Point A5 – Former Pond:

The Existing Conditions geometry of the outfall structure for the former pond site that is located just north of the Discovery Park Phase 1 property is based upon field survey and LIDAR topographic data. This former pond-site has an embankment breach, and therefore provides relatively minimal attenuation for larger precipitation events. The feature does, however affect the hydrograph timing somewhat, and is therefore included in these models. The pond is proposed to be removed with the Discovery Park Phase 1 development. The following information provides the outfall geometry and storage area for the Existing Conditions PondPack model:

Primary Outlet Structure- Weir Cut through Embankment:

Station (ft):	0	23.88	64.85	167.91	238.1	246.58	251.38	253.1	257.52	263.49	268.12	273.3	297.08	333.5
Elevation (ft):	940	938	936	934	932	930	929	929	930	932	934	936	938	940

The potential storage area upstream from this pond embankment is defined in the following table based upon a stage versus storage area for a given elevation.

Table 3.1-2(a). Existing Storage Volume – Boone Creek Embankment

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
929	20,212	0	0.000
930	34,209	26,905	0.618
932	75,878	107,357	3.082
934	98,561	173,945	7.075
936	130,004	227,841	12.306
938	171,091	300,156	19.197
940	226,998	396,774	28.305

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-2(b): Existing Conditions Storage Area Routing – Point A5 – Former Pond

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	47.52	12.08	22.44	12.24	3.428	930.22	0.800
2-Year:	315.36	12.05	242.32	12.15	20.98	932.48	3.940
10-Year:	552.78	12.05	489.66	12.12	39.91	933.43	5.828
100-Year:	847.10	12.05	799.19	12.10	66.087	934.15	7.413

Data provided in the preceding table indicates that, while larger storm events are not significantly affected by this feature, the more frequent events do exhibit some hydrograph attenuation at this location.

Point B1 – Lee's Summit Road RCB Culverts (Sta. 45+15):

Lee's Summit Road has a pair of RCB Culverts that convey stormwater across the roadway into the channel that runs along the northern edge of the Aria project site. This RCB includes stormwater flows generated by defined sub-watersheds "B" and "C." The following information provides the outfall geometry and storage area for this location in both Existing- and Proposed Conditions PondPack models:

Primary Outlet Structure:

Dual 10'-w x 7'-ht RCB Culvert; Length ≈ 174.4 L.F.
Flowline In / Out ≈ 916.22 / 911.54 (ft; NAVD)

Secondary Outlet Structure:

Roadway (Weir)-

Station (ft):	0	64.20	155.0	244.3	309.0
Elevation (ft):	930	929	928.68	929	930

Culvert flow at the threshold of overtopping/weir-flow is approximately 1,800 cfs.

Table 3.1-3(a). Existing Storage Volume – Pump Station Drive Storage Area

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
916.22	377	0	0
917	2,013	848	0.019
918	8,841	5,024	0.135
919	14,303	11,463	0.398
920	18,052	16,141	0.769
921	21,576	19,788	1.223
922	25,405	23,464	1.761
923	29,240	27,300	2.388
924	39,203	34,100	3.171
925	50,630	44,795	4.199
926	60,928	55,700	5.478
927	71,454	66,121	6.996
928	83,880	77,584	8.777
929	139,252	110,403	11.312
930	178,519	158,480	14.950

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-3(b). Existing Conditions Storage Area Routing – Point B1 – Lee's Summit Drive Culverts (Sta. 45+15)

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	101.70	12.11	100.64	12.12	9.245	917.82	0.101
2-Year:	634.00	12.07	615.14	12.11	49.667	921.57	1.519
10-Year:	1,121.63	12.07	1,076.61	12.11	91.457	923.99	3.164
100-Year:	1,726.54	12.06	1,551.65	12.14	148.401	926.77	6.626

Data provided in the preceding table indicates that each of the modeled events are effectively conveyed by the culverts, and sufficient freeboard appears to be available for the 100-year design storm.

Point A7 – NE Douglas Street RCB Culvert (Sta. 25+65):

NE Douglas Street has another RCB Culvert that conveys stormwater across the roadway into the channel that runs into the eastern edge of the Discovery Park project site. This culvert conveys stormwater into the project area from upper portions of the defined sub-watershed "A." The following information provides the outfall geometry and storage area for this location in both Existing- and Proposed Conditions PondPack models:

Primary Outlet Structure:

13'-w x 7'-ht RCB Culvert; Length ≈ 174.4 L.F.
Flowline In / Out ≈ 945.3 / 937.5 (ft; NAVD)

Secondary Outlet Structure:

Roadway (Weir)-

Station (ft):	0	46.5	118.2	206.1	276.8	345.4	392.4
Elevation (ft):	958	957	956	955.65	956	957	958

Culvert flow at the threshold of overtopping/weir-flow is approximately 1,213 cfs.

Table 3.1-4(a): Existing Storage Volume – Point A7 – Lee's Summit Road RCB Culvert (Sta. 25+65)

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
945.3	273	0	0.000
946	728	338	0.008
947	3,022	1,744	0.048
948	6,247	4,538	0.152
949	19,586	12,298	0.434
950	36,075	27,414	1.064
951	52,213	43,896	2.071
952	62,652	57,353	3.388
953	78,881	70,611	5.009
954	93,052	85,869	6.980
955	109,368	101,100	9.301
956	141,847	125,256	12.177
957	178,341	159,746	15.844
958	220,369	198,985	20.412

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-4(b): Existing Conditions Storage Area Routing – Point A7 – Lee's Summit Drive Culverts (Sta.25+65)

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	38.00	12.06	37.95	12.06	2.539	946.33	0.015
2-Year:	236.01	12.02	229.26	12.05	14.58	948.71	0.319
10-Year:	437.94	12.01	397.23	12.07	27.333	950.22	1.251
100-Year:	707.16	12.00	603.32	12.08	44.871	951.80	3.100

Data provided in the preceding table indicates that each of the modeled events is effectively conveyed by this existing culvert, and sufficient freeboard appears to be available for each design storm.

<u>Sub-Basin B4- Stormwater Detention Facility</u>:

The upper reaches of the sub-watershed "B" region includes a relatively large, impervious property that includes an onsite wet-basin stormwater detention facility. The following information provides the modeled outfall geometry and storage area for the Existing- and Proposed Conditions PondPack models:

Primary Outlet Structure:

Inlet Box: 4.2 S.F. Opening; Crest Elev. ≈ 992.0
36" Dia. RCP Discharge Culvert: Length = 280 L.F.
Flowline In / Out ≈ 981 / 976 (ft; NAVD)

Table 3.1-5(a): Existing Storage Volume – Proposed Sub-Basin B4 Detention Facility

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
992	75,323	0	0.000
994	88,777	163,916	3.763
996	101,439	190,076	8.127
998	114,890	216,190	13.090

Note: *The conic method is used to compute the incremental volume between pond contours. The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation*.

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-5(b). Existing Conditions Storage Area Routing – Sub-Basin B4 Detention Facility

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	30.27	11.95	8.05	12.15	1.713	992.37	0.642
2-Year:	99.43	11.94	22.46	12.16	5.919	993.25	2.284
10-Year:	158.21	11.94	28.68	12.19	9.694	994.04	3.850
100-Year:	232.94	11.94	34.97	12.24	14.599	995.03	5.948

The preceding routing summary indicates that the existing wet-basin detention facility provides significant attenuation for the modeled events.

Point C2 – Storage Area~Inlet C2:

The Existing- and Proposed Conditions models include a relatively significant storage unit in the defined sub-watershed "C" area. Geometric parameters for this storage area are based upon LIDAR topography and GIS base data. The following information provides the modeled outfall geometry and storage area for the Existing- and Proposed Conditions PondPack models:

Primary Outlet Structure:

Grate Inlet; Crest Elev. ≈ 956.85
Opening Area: 27.2 S.F.
66" Dia. RCP Discharge Culvert: Length = 177 L.F.
Flowline In / Out ≈ 945.7 / 945.1 (ft; NAVD)

Table 3.1-6(a). Existing Storage Volume – Storage Area C2

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
956.85	777	0	0
958	10,771	5,536	0.127
960	29,311	38,567	1.012
962	63,479	90,617	3.093
964	98,380	160,590	6.779
966	135,252	232,656	12.120
968	175,712	310,083	19.239
970	245,445	419,220	28.863
972	310,449	554,622	41.595

Note: *The conic method is used to compute the incremental volume between pond contours. The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.*

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-6(b). Existing Conditions Storage Area Routing – Storage Area C2

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	21.38	12.02	21.36	12.02	1.338	956.90	0.001
2-Year:	142.28	11.96	137.26	12.00	8.110	957.95	0.115
10-Year:	264.20	11.96	219.81	12.05	15.199	959.67	0.804
100-Year:	423.95	11.96	285.13	12.07	24.875	961.59	2.539

The preceding routing summary indicates that, while the more frequent events are minimally affected by this feature, the larger events do undergo some attenuation.

<u>Point D4 – I-470 Highway Culvert</u>:

I-470 Highway has an RCB Culvert that conveys stormwater across the highway into the Discovery Park Future project site. This culvert conveys stormwater into the project area from upper portions of the defined sub-watershed “D.” The following information provides the outfall geometry and storage area for this location in the Existing-Conditions PondPack model:

Primary Outlet Structure:

5’-w x 8’-ht RCB Culvert; Length ≈ 323 L.F.
Flowline In / Out ≈ 952.00 / 948.00 (ft; NAVD)

Table 3.1-4(a): Existing Storage Volume – Point D4 – I-470 Highway Culvert

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):
956	14,459	0	0
958	38,781	51,280	1.177
960	77,382	113,963	3.793
962	119,729	195,577	8.283
964	164,668	283,206	14.785
966	324,776	480,468	25.815

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

The following table depicts the stormwater routing summary for this location under each of the modeled precipitation events.

Table 3.1-4(b): Existing Conditions Storage Area Routing – Point D4 – I-470 Highway Culvert

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
WQv:	98.35	12.04	95.20	12.07	6.953	954.62	0.188
2-Year:	447.33	12.02	377.63	12.10	31.704	958.57	2.269
10-Year:	761.81	12.02	526.54	12.14	55.574	960.91	6.129
100-Year:	1157.85	12.02	638.44	12.19	87.262	963.49	13.467

Data provided in the preceding table indicates that each of the modeled events is effectively conveyed by this existing culvert, and sufficient freeboard below I-470 Highway appears to be available for each design storm.

The previously defined modeled stormwater conveyances and the associated hydrograph attenuation effects from the existing storage areas have been incorporated into both Existing- and Proposed Conditions PondPack models. Each of these storage areas is offsite from the proposed development areas contemplated by this Macro Stormwater Drainage Study. The results of the Existing Conditions hydrologic routing are provided in the following section. Additional minor storage and conveyance systems are included in the PondPack model to further expand and represent existing conditions for the watersheds. These systems are available within the model output provided in Section 8, for review.

3.2. Existing Conditions Hydrologic Modeling Results

The stormwater storage areas and resultant hydrograph attenuation effects are incorporated into the Existing Conditions PondPack models. The results of this hydrologic routing of the hydrographs generated by the modeled subareas through the sub-watersheds are provided in the following summary tables. This information is provided at the defined Points of Interest.

Refer to the Existing Conditions Drainage Area Map for the location of the points in relation to the proposed development areas, modeled subareas, channels, and conveyances.

Table 3.2-1. Hydrologic Information – Existing Conditions Summary (Junctions)

	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	948.96	12.25	88.053	1,784.23	12.22	166.969	2,754.84	12.19	276.008
Point A2:	909.05	12.17	79.810	1,691.73	12.15	150.055	2,566.59	12.13	246.736
Point A3:	628.64	12.15	52.997	1,107.67	12.15	97.952	1,595.56	12.17	159.297
Point A4:	260.92	12.15	24.092	539.49	12.11	46.309	906.56	12.09	77.182
Point A5:	242.32	12.15	20.979	489.66	12.12	39.911	799.19	12.10	66.087
Point A6:	37.98	11.93	2.083	70.54	11.93	3.904	113.19	11.93	6.389
Point A7:	229.26	12.05	14.580	397.23	12.07	27.333	603.32	12.08	44.871
Point A8:	53.05	11.96	3.070	101.89	11.95	5.907	166.82	11.95	9.826
Point A9:	128.79	12.00	8.028	223.48	11.99	14.240	346.07	11.99	22.563
Point A10:	45.61	11.97	2.890	72.57	11.97	4.733	106.86	11.97	7.128
Point B1:	615.14	12.11	49.667	1,076.61	12.11	91.457	1,551.65	12.14	148.401
Point B2:	242.31	12.05	20.032	446.43	12.04	36.522	715.56	12.03	58.980
Point B3:	153.04	11.99	13.975	266.04	11.98	24.377	411.65	11.97	38.255
Point B4:	48.10	11.94	7.673	71.04	11.93	12.565	98.80	11.93	18.924
Point C1:	350.42	12.09	25.466	604.01	12.10	46.692	890.10	12.10	75.478
Point C2:	232.89	12.04	16.244	417.32	12.07	30.851	614.91	12.08	50.912
Point C3:	142.61	11.95	8.110	264.83	11.94	15.199	425.51	11.94	24.875
Point D1:	560.43	12.08	49.147	941.67	12.07	89.659	1,351.30	12.05	144.576
Point D2:	485.06	12.10	41.022	752.83	12.06	73.431	1,052.38	12.06	117.417
Point D3:	52.46	11.97	3.185	90.29	11.97	5.605	138.69	11.97	8.822
Point D4:	377.63	12.10	31.704	526.54	12.14	55.574	638.44	12.19	87.262
Point D5:	142.73	12.07	10.458	239.98	12.08	18.183	357.61	12.09	28.406
Point E1:	65.98	11.95	3.725	106.88	11.99	7.278	143.00	11.98	11.753
Point E2:	11.34	11.94	0.645	25.34	11.94	1.394	45.12	11.94	2.489
Point F1:	47.57	11.97	2.752	74.89	11.96	5.398	106.16	11.94	9.090
Point F2:	31.56	11.96	1.816	45.26	12.06	3.495	65.86	12.07	5.814
Point G1:	58.32	11.95	3.331	102.21	11.94	6.279	163.43	11.97	10.317
Point G2:	23.29	11.96	1.332	36.98	12.02	2.433	62.01	11.99	3.920
Point H1:	119.54	11.97	7.009	240.90	11.96	14.056	406.43	11.96	23.984
Point I1	4.44	11.93	0.244	7.87	11.93	0.441	12.29	11.93	0.705

The information obtained in this Existing Conditions analysis is utilized to establish the "Allowable Release Rates" (ARR) for the project areas based upon percentages of onsite and offsite area draining to the points of interest. A summary of the computation of these ARR's is provided in the following section.

3.3. Allowable Release Rate Calculations

The purpose of this Stormwater Drainage Study for the proposed development is to ensure compliance with the current specifications and design criteria in effect for the City of Lee's Summit, Missouri. The Proposed Conditions and Macro hydrologic analyses are provided in Section 4. Results of that analysis will be compared to the Section 3, Existing Conditions results. The variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by development of the project site. The Actual- versus Allowable Release Rates for the fully developed, Proposed Conditions will be evaluated in Section 4 for the Macro-Study analysis in order to demonstrate compliance with the design objectives for this project.

The following tables are provided to compute the "Allowable Release Rate" (ARR) for the three design storm events in order to demonstrate compliance with the stated design objectives. The Proposed Conditions Macro- Models utilize five defined points of discharge that receive stormwater runoff from the project site. The proposed Stormwater Management Plan for the proposed development areas will evaluate the ARR's at each of these modeled outlet locations.

Allowable Release Rate Calculations:

This section of the Stormwater Drainage Study for the proposed development is provided to establish the project Allowable Release Rates. The ARR is based upon the "Comprehensive Control" strategy provided in the Section 5600 of the APWA "Standard Specifications and Design Criteria" (Feb, 2011). This strategy provides the maximum ARR for the 2-, 10-, and 100-Year Design Storms at 0.50, 2.0, and 3.0 cfs-per-acre, respectively. Additional requirements include Extended Detention of the "Water Quality" design storm (defined as a 1.37" precipitation event).

The following table is provided in order to establish the project ARR for the Discovery Park Macro Stormwater Drainage analysis. The ARR for each of the three modeled events is based upon the sum of the "Allowable Bypass" for offsite flows and the onsite "Allowable Release Rate." In order to prevent skewing the results, the ARR is based upon the Existing Conditions model. This ensures that the allowable bypass flows are not increased by onsite development, and that any diversions of tributary regions that takes place upon development is not incorporated into the allowable rates.

Information presented in the following table depicts the cumulative onsite and offsite areas for each of the Points, and the Existing Conditions peak discharge rates at these locations. From that information, the ARR is established in the second column from the right. The right-hand column depicts the relative difference in peak discharge rate that the proposed stormwater management plan would meet to achieve compliance with these targeted ARR's.

The Macro Study section of this report will provide a comparison of these Allowable Release Rates to the computed peak discharge rates at these Points of Interest to demonstrate compliance with the stated design objectives.

Table 3.3-1. Existing Conditions Allowable Release Rate Calculations

Location:	Return Event (Yr):	Existing Conditions Peak Flow Rate (cfs):	Total Area (ac):	Onsite ------ *(Offsite)* Area (ac):	Onsite ------ *(Offsite)* Area (%):	Allowable Bypass Flows (cfs):	Allowable Onsite Discharge Rate: (cfs):	Prop. Cond. ARR (cfs):	Difference in Flow Rate: (cfs):
Point A1			604.82	85.87	14%				
	2-Year:	948.96		------	------	814.24	42.93	857.17	-91.79
	10-Year:	1,784.23		*(518.96)*	*(86%)*	1530.93	171.73	1702.66	-81.57
	100-Year:	2,754.84				2363.74	257.60	2621.34	-133.50
Point A2			531.11	70.91	13%				
	2-Year:	909.05		------	------	787.68	35.46	823.14	-85.91
	10-Year:	1,691.73		*(460.20)*	*(87%)*	1465.86	141.82	1607.68	-84.05
	100-Year:	2,566.59				2223.92	212.73	2436.65	-129.94
Point A3			332.76	11.62	3%				
	2-Year:	628.64		------	------	606.69	5.81	612.50	-16.14
	10-Year:	1,107.67		*(321.14)*	*(97%)*	1068.99	23.24	1092.23	-15.44
	100-Year:	1,595.56				1539.85	34.86	1574.71	-20.85
Point A4			171.86	59.29	34%				
	2-Year:	260.92		------	------	170.90	29.65	200.55	-60.37
	10-Year:	539.49		*(112.57)*	*(66%)*	353.37	118.58	471.95	-67.54
	100-Year:	906.56				593.80	177.87	771.67	-134.89
Point A5			144.60	40.76	28%				
	2-Year:	242.32		------	------	174.02	20.38	194.40	-47.92
	10-Year:	489.66		*(103.85)*	*(72%)*	351.65	81.51	433.16	-56.50
	100-Year:	799.19				573.94	122.27	696.21	-102.98
Point A6			13.45	9.21	68%				
	2-Year:	37.98		------	------	11.97	4.61	16.57	-21.41
	10-Year:	70.54		*(4.24)*	*(32%)*	22.23	18.42	40.65	-29.89
	100-Year:	113.19				35.67	27.63	63.30	-49.89
Point A7			96.23	0.00	0%				
	2-Year:	229.26		------	------	229.26	0.00	229.26	0.00

Location:	Return Event (Yr):	Existing Conditions Peak Flow Rate (cfs):	Total Area (ac):	Onsite - - - - - - (Offsite) Area (ac):	Onsite - - - - - - (Offsite) Area (%):	Allowable Bypass Flows (cfs):	Allowable Onsite Discharge Rate: (cfs):	Prop. Cond. ARR (cfs):	Difference in Flow Rate: (cfs):
	10-Year:	397.23		*(96.23)*	*(100%)*	397.23	0.00	397.23	0.00
	100-Year:	603.32				603.32	0.00	603.32	0.00
Point B1			308.34	0.00	0%				
	2-Year:	615.14		- - - - - -	- - - - - -	615.14	0.00	615.14	0.00
	10-Year:	1,076.61		*(308.34)*	*(100%)*	1076.61	0.00	1076.61	0.00
	100-Year:	1,551.65				1551.65	0.00	1551.65	0.00
Point D1			295.52	56.26	19%				
	2-Year:	560.43		- - - - - -	- - - - - -	453.75	28.13	481.87	-78.56
	10-Year:	941.67		*(239.26)*	*(81%)*	762.41	112.51	874.92	-66.75
	100-Year:	1351.30				1094.07	168.77	1262.83	-88.47
Point D2			229.46	35.36	15%				
	2-Year:	485.06		- - - - - -	- - - - - -	410.31	17.68	427.99	-57.07
	10-Year:	752.83		*(194.10)*	*(85%)*	636.82	70.72	707.54	-45.29
	100-Year:	1052.38				890.21	106.08	996.29	-56.09
Point E1			29.15	20.68	71%				
	2-Year:	65.98		- - - - - -	- - - - - -	19.17	10.34	29.51	-36.47
	10-Year:	106.88		*(8.47)*	*(29%)*	31.06	41.36	72.41	-34.47
	100-Year:	143.00				41.55	62.03	103.59	-39.41
Point F1			20.60	12.06	59%				
	2-Year:	47.57		- - - - - -	- - - - - -	19.72	6.03	25.75	-21.82
	10-Year:	74.89		*(8.54)*	*(41%)*	31.05	24.12	55.17	-19.72
	100-Year:	106.16				44.02	36.18	80.20	-25.96
Point F2			12.76	12.06	95%				
	2-Year:	31.56		- - - - - -	- - - - - -	1.72	6.03	7.75	-23.81
	10-Year:	45.26		*(0.70)*	*(5%)*	2.47	24.12	26.59	-18.67
	100-Year:	65.86				3.59	36.18	39.78	-26.08
Point G1			21.96	7.11	32%				
	2-Year:	58.32		- - - - - -	- - - - - -	39.43	3.56	42.99	-15.33
	10-Year:	102.21		*(14.85)*	*(68%)*	69.10	14.23	83.33	-18.88
	100-Year:	163.43				110.49	21.34	131.84	-31.59
Point G2			7.93	7.11	90%				
	2-Year:	23.29		- - - - - -	- - - - - -	2.39	3.56	5.94	-17.35
	10-Year:	36.98		*(0.82)*	*(10%)*	3.79	14.23	18.02	-18.96
	100-Year:	62.01				6.35	21.34	27.70	-34.31
Point H1			56.17	51.06	91%				
	2-Year:	119.54		- - - - - -	- - - - - -	10.88	25.53	36.41	-83.13
	10-Year:	240.90		*(5.11)*	*(9%)*	21.93	102.12	124.05	-116.85

Location:	Return Event (Yr):	Existing Conditions Peak Flow Rate (cfs):	Total Area (ac):	Onsite - - - - - - *(Offsite)* Area (ac):	Onsite - - - - - - *(Offsite)* Area (%):	Allowable Bypass Flows (cfs):	Allowable Onsite Discharge Rate: (cfs):	Prop. Cond. ARR (cfs):	Difference in Flow Rate: (cfs):
	100-Year:	406.43				37.00	153.18	190.18	-216.25
Point I1			1.40	0.61	44%				
	2-Year:	4.44		- - - - - -	- - - - - -	2.49	0.31	2.80	-1.64
	10-Year:	7.87		*(0.78)*	*(56%)*	4.42	1.23	5.64	-2.23
	100-Year:	12.29				6.90	1.84	8.74	-3.55

The greatest required relative reduction in peak discharge rate occurs at the Point A2 location. This is the anticipated location for the greatest required impact, as that point is located at the confluence of the two channels that convey stormwater runoff from the three subareas (Sub's A3, A4(E), & A5(E)) that include portions of the proposed Discovery Park development site.

When the northern Multi-Family Residential, Aria, Discovery Park Phase 2 and Discovery Park Future areas are to be developed it will need to be ensured that these allowable release rates are met. Detention basins will need to be provided to attenuate the peak flows generated from development, as needed. Those detention basins will be discussed in the future Macro-Studies to be prepared when each area is developed. Subareas D through I were analyzed to provide allowable release rates only for future development. These subareas will not be included in the proposed Macro analysis in this report.

4. MACRO ANALYSIS

This section of the Stormwater Drainage Study for the proposed development is provided to evaluate the Proposed Conditions hydrology for the project. As in the Existing Conditions analysis, the overall modeled stormwater drainage area for the Macro Study encompasses approximately 602 acres, including 74 acres within the proposed development site. Due to a diversion of approximately 0.20 acres from adjacent tributary areas, the overall drainage area is slightly increased to approximately 602.42 acres in the Macro Study. The following sub-section will provide the Proposed Conditions analysis for the Macro- analysis. As previously stated, this section will analyze and review the final macro conditions for subareas A, B, and C which includes the Aria, Discovery Park Phase 1, Discovery Park Phase 2, and the Multi-Family Residential developments. Subareas D through I are part of future Discovery Park developments, which will be further reviewed and analyzed with future Macro stormwater studies as those layouts and designs are further refined and Preliminary Development Plans are submitted for city review and approval.

The purpose of this report is to provide the Macro Stormwater Drainage analysis to ensure that the proposed site development is compliant with City of Lee's Summit requirements. This section of the report will provide the Proposed Conditions analysis, representing the fully developed hydrology for the site. The results of this analysis will be compared to those of Existing Conditions in order to determine the hydrologic effects of the development upon the receiving stormwater conveyances and sub-watersheds. Compliance with the project ARR's will also be evaluated through comparison of the Actual- versus Allowable Release Rates at the five defined Points of Interest.

4.1. Macro Stormwater Model: Proposed Conditions Analysis

This section of the Stormwater Drainage Study for the Discovery Park Phase 1 commercial development is provided to evaluate the Macro-Study Proposed Conditions hydrology for the project. The proposed development totals 74.06-acres including 39.42-acres of commercial development (office buildings, hotels, restaurants, multifamily residential buildings, associated drives, parking, utilities) and mass grading of the Aria and Discovery Park Phase 2 sites totaling 34.64-acres. As previously discussed, the existing pond located at point A5 is being removed with the proposed development, however all other existing flow-attenuating structures and features will remain unchanged.

Proposed Conditions Runoff Curve Numbers have been developed based upon the current Development Plan for this commercial project. Refer to Section 7 for Macro-Study Proposed Conditions weighted NRCS Runoff Curve Number (CN) and Time of Concentration (T_C) calculations.

The tributary areas, Runoff Curve Numbers (CN), and Times of Concentration (T_C) for the corresponding subareas that are provided in Table 4.1-1 are used as input into the Proposed Conditions PondPack model to evaluate the stormwater hydrology. Subareas included in the Proposed Conditions for the Discovery Park property are utilized in the PondPack model to compute the stormwater runoff for the three design storms. The resultant peak discharge rate (Q_P), peak time (T_P), and runoff volume (V_R) for the computed hydrographs of modeled subareas are included in Table 4.1-2(a). Areas that are unchanged from the Existing Conditions analysis are presented as *grey print* in the following tables.

Table 4.1-1(a). Macro-Study Proposed Conditions Input Data

	Total Area (ac):	**Aria Onsite Area (ac):**	**Discovery Park Phase 1 Onsite Area (ac):**	**Discovery Park Phase 2 Onsite Area (ac):**	**Macro-Study Onsite Area (ac):**	**NRCS Weighted CN:**	**T_C [1] (hr):**
Subarea A1(e):	*27.97*				*12.36*	*77*	*0.1736*
Subarea A1(w):	*43.14*					*76*	*0.2511*
Subarea A2(e):	*3.08*					*80*	*0.0875*
Subarea A2(w):	*23.41*					*73*	*0.2133*
Subarea A3:	24.06	11.07			11.07	82	0.0714
Subarea A4(e):	1.48	0.14	0.84		0.98	88	0.0184
Subarea A4(w):	8.75		0.59		0.59	72	0.1095
Subarea A5(e):	19.12	11.29	6.92		18.20	86	0.0769
Subarea A5(w):	33.42		31.08		31.08	95	0.0647
Subarea A6:	13.42			9.88	9.88	83	0.0842
Subarea A7:	*30.60*					*76*	*0.1596*
Subarea A8:	*21.56*					*81*	*0.1299*
Subarea A9:	*31.84*					*84*	*0.1420*
Subarea A10:	*12.23*					*94*	*0.1545*
Subtotal:	*294.08*	*22.50*	*39.42*	*9.88*	*84.15*		
Subarea B1:	*31.94*					*79*	*0.1385*
Subarea B2:	*48.54*					*78*	*0.1987*
Subarea B3:	*40.69*					*83*	*0.1447*
Subarea B4-DET:	*25.05*					*94*	*0.1155*
Subarea B4-BYP:	*7.42*					*94*	*0.0787*
Subtotal:	*153.64*						
Subarea C1:	*45.21*					*90*	*0.2860*
Subarea C2:	*57.13*					*81*	*0.3308*
Subarea C3:	*52.36*					*83*	*0.1199*
Subtotal:	154.70						
Total:	**602.42**	**22.50**	**39.42**	**9.88**			

[1] ***Note:*** *Per TR-55 documentation, minimum T_C is 0.10 hours; model is configured with default value of 0.10 hr. minimum Tc.*

Table 4.1-1(b). Macro-Study Proposed Conditions Input Sub-Watershed Data

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):
Sub-W'Shed A Subtotal:	294.08	22.50	39.42	9.88	84.15
Sub-W'Shed B Subtotal:	*153.64*				
Sub-W'Shed C Subtotal:	*154.70*				
Modeled Total:	602.42	22.50	39.42	*9.88*	84.15

These tributary areas, Runoff Curve Numbers (CN), and Times of Concentration (T_C) for the corresponding subareas were used as input to the Proposed Conditions PondPack model to evaluate the stormwater hydrology for this Macro-Study. The subareas representing Existing-(offsite) and Proposed Conditions (onsite) for the Discovery Park site are utilized in the PondPack model to compute the stormwater runoff for the three design storms. The resultant peak discharge rate (Q_P), peak time (T_P), and runoff volume (V_R) for the computed hydrographs of modeled subareas are included in Table 4.1-2.

Table 4.1-2(a). Hydrologic Information – Macro-Study Proposed Conditions Summary (Subareas)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea A-1(e):	*53.91*	*12.01*	*3.334*	*110.32*	*11.99*	*6.783*	*187.82*	*11.99*	*11.675*
Subarea A-1(w):	*70.15*	*12.05*	*4.908*	*146.86*	*12.05*	*10.132*	*252.55*	*12.05*	*17.597*
Subarea A-2(e):	*7.64*	*11.94*	*0.420*	*14.90*	*11.93*	*0.819*	*24.63*	*11.93*	*1.374*
Subarea A-2(w):	*34.59*	*12.03*	*2.301*	*76.77*	*12.03*	*4.975*	*136.28*	*12.03*	*8.884*
Subarea A-3:	65.13	11.93	3.574	122.96	11.93	6.787	199.22	11.93	11.198
Subarea A-4(e):	5.05	11.93	0.279	8.68	11.93	0.491	13.33	11.93	0.773
Subarea A-4(w):	14.08	11.96	0.817	32.12	11.94	1.796	58.07	11.94	3.239
Subarea A-5(e):	60.82	11.93	3.344	107.76	11.93	6.033	168.25	11.93	9.642
Subarea A-5(w):	139.52	11.92	8.184	219.80	11.92	13.246	322.03	11.92	19.806
Subarea A-6:	37.88	11.93	2.077	70.35	11.93	3.893	112.88	11.93	6.372
Subarea A-7:	*57.26*	*12.00*	*3.482*	*119.03*	*11.98*	*7.186*	*204.90*	*11.98*	*12.481*
Subarea A-8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Subarea A-9:	*87.15*	*11.97*	*5.138*	*158.95*	*11.96*	*9.507*	*252.78*	*11.96*	*15.435*
Subarea A-10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Subarea B-1:	*70.94*	*11.97*	*4.168*	*140.29*	*11.96*	*8.242*	*234.20*	*11.95*	*13.944*
Subarea B-2:	*94.72*	*12.03*	*6.057*	*190.16*	*12.01*	*12.146*	*320.74*	*12.00*	*20.725*
Subarea B-3:	*106.50*	*11.97*	*6.302*	*197.62*	*11.96*	*11.812*	*317.37*	*11.96*	*19.332*
Subarea B-4 (BYP):	*30.29*	*11.93*	*1.753*	*48.22*	*11.92*	*2.871*	*71.04*	*11.92*	*4.324*

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea B-4 (DET):	*99.43*	*11.94*	*5.919*	*158.21*	*11.94*	*9.694*	*232.94*	*11.94*	*14.599*
Subarea C-1:	*124.83*	*12.05*	*9.223*	*209.38*	*12.05*	*15.842*	*317.10*	*12.05*	*24.565*
Subarea C-2:	*104.44*	*12.09*	*8.134*	*200.90*	*12.08*	*15.652*	*329.78*	*12.08*	*26.038*
Subarea C-3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

The hydrologic impact resulting from the Macro-Study Proposed Conditions results is partially revealed by the comparison of the preceding subarea data to those established in Section 3 (Existing Conditions) of this report. The hydrologic conditions for offsite subareas remain unchanged between Existing- and Proposed Conditions analyses. However, the onsite subareas do exhibit changes in impervious cover and diversion of tributary area under Proposed Conditions. The hydrologic impact to the overall sub-watershed of these modified areas will become apparent in the summary tables for the Points of Interest.

The variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by the proposed development project for given subareas. The following table depicts the difference in computed subarea hydrology between the Existing- and Proposed Conditions models.

Table 4.1-2(b). Hydrologic Information –
Macro-Study Proposed vs. Existing Conditions Summary (Subareas)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea A-1(e):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-1(w):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-2(e):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-2(w):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-3:	7.52	-0.03	0.244	10.38	-0.02	0.292	13.09	-0.02	0.303
Subarea A-4(e):	-18.92	-0.03	-1.123	-37.29	-0.03	-2.207	-61.82	-0.03	-3.715
Subarea A-4(w):	-13.48	-0.05	-0.895	-28.73	-0.05	-1.904	-50.15	-0.05	-3.368
Subarea A-5(e):	24.42	-0.02	1.277	36.86	-0.02	2.002	51.27	-0.02	2.88
Subarea A-5(w):	102.50	-0.08	5.935	142.70	-0.07	8.603	189.42	-0.05	11.742
Subarea A-6:	-0.10	n/c	-0.006	-0.19	n/c	-0.011	-0.31	n/c	-0.017
Subarea A-7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea B-4 (BYP):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-4 (DET):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

The previously defined stormwater detention basins, outfall structures, and resultant hydrograph attenuation effects have been incorporated into the Proposed Conditions PondPack model. The channel reaches defined in the Existing Conditions analysis are also included in this routing. Results of this Proposed Conditions hydrologic routing are provided in the following summary table. This information is provided at the same "Points of Interest" used in the Existing Conditions hydrologic analysis for this Stormwater Drainage Study. Refer to the Proposed Conditions Drainage Area Map for the location of the points of interest in relation to the development site, modeled subareas, channels and conveyances. As in the preceding tables, locations that are unchanged from the Existing Conditions analysis are presented as grey print in the following tables.

Table 4.1-3(a). Hydrologic Information–Macro-Study Proposed Conditions Summary (Junctions)
Un-Detained Hydrology (for Proposed Discovery Park Basin)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	1,036.29	12.19	91.367	1,891.07	12.16	171.623	2,890.34	12.14	281.712
Point A2:	979.74	12.11	83.974	1,759.80	12.09	155.560	2.641.51	12.08	253.290
Point A3:	625.11	12.16	52.191	1,100.39	12.15	97.194	1,586.54	12.08	158.549
Point A4:	414.66	12.03	29.282	697.74	12.03	52.792	1,047.68	12.03	84.703
Point A6:	37.88	11.94	2.077	70.35	11.93	3.893	112.88	11.93	6.372
Point A7:	*229.26*	*12.05*	*14.580*	*397.23*	*12.07*	*27.333*	*603.32*	*12.08*	*44.871*
Point A8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Point A9:	*128.79*	*12.00*	*8.028*	*223.48*	*11.99*	*14.240*	*346.07*	*11.99*	*22.563*
Point A10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Point B1:	*615.14*	*12.11*	*49.667*	*1,076.61*	*12.11*	*91.457*	*1,551.65*	*12.14*	*148.401*
Point B2:	*242.31*	*12.05*	*20.032*	*446.43*	*12.04*	*36.522*	*715.56*	*12.03*	*58.980*
Point B3:	*153.04*	*11.99*	*13.975*	*266.04*	*11.98*	*24.377*	*411.65*	*11.97*	*38.255*
Point B4:	*48.10*	*11.94*	*7.673*	*71.04*	*11.93*	*12.565*	*98.80*	*11.93*	*18.924*
Point C1:	*350.42*	*12.09*	*25.466*	*604.01*	*12.10*	*46.692*	*890.10*	*12.10*	*75.478*

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point C2:	*232.89*	*12.04*	*16.244*	*417.32*	*12.07*	*30.851*	*614.91*	*12.08*	*50.912*
Point C3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

As previously evaluated for the modeled Subareas, these Proposed Conditions results for the Points of Interest will be compared to those established in Section 3 (Existing Conditions) of this report. The points represent similar locations in both Existing- and Proposed Conditions analyses. Therefore, the variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by the proposed development. The following table depicts the difference between the Existing- and Proposed Conditions models.

Table 4.1-3(b). Hydrologic Information – Comparison of Results:
Macro- Proposed vs. Existing Conditions Summary (Junctions) Un-Detained Hydrology

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	84.85	-0.06	3.32	102.45	-0.06	4.660	130.62	-0.05	5.706
Point A2:	68.10	-0.06	4.173	62.88	-0.06	5.511	66.98	-0.04	6.556
Point A3:	-5.18	0.01	-0.821	-10.28	n/c	-0.777	-12.83	-0.09	-0.796
Point A4:	152.42	-0.13	5.214	156.66	-0.09	6.518	140.21	-0.06	7.572
Point A6:	0.88	-0.03	-0.813	0.78	n/c	0.011	1.10	n/c	0.018
Point A7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B4:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

Information presented in the preceding table exhibits a reduction in peak rates, relative to the existing conditions model. This is the result of reduced times of concentration that occur with Discovery Park development. Overall runoff volumes exhibit modest increase.

The following table is provided to examine the difference between the computed peak discharge rates and the established ARR's for the Discovery Park Macro-Study.

Table 4.1-4. Allowable Release Rate Evaluation – Proposed Conditions Macro Model – Without Detention

Location:	Event:	Computed Peak Discharge Rate (cfs):	ARR (cfs):	Difference (cfs):
Point A1	2-Year:	1,036.29	927.14	109.15
	10-Year:	1,891.07	1,766.79	124.28
	100-Year:	2,890.34	2,724.11	166.23
Point A2	2-Year:	979.74	884.27	95.57
	10-Year:	1,759.80	1,670.03	89.77
	100-Year:	2,641.51	2,532.96	108.55
Point A3	2-Year:	625.11	613.94	11.17
	10-Year:	1,100.39	1,094.99	5.40
	100-Year:	1,586.54	1,578.20	8.34
Point A4	2-Year:	414.66	251.18	163.48
	10-Year:	697.74	528.69	169.05
	100-Year:	1,047.68	882.87	164.81
Point A6	2-Year:	37.88	16.57	21.31
	10-Year:	70.35	40.65	29.70
	100-Year:	112.88	63.30	49.58

The sign-convention utilized for the information presented in the preceding table is based upon "Computed Rate minus ARR." Therefore, positive values indicate an exceedance of the Allowable Release Rate, whereas negative values would indicate a peak rate that is lower than the ARR, thereby meeting the targeted peak discharge rates. The difference in the rates depicted in this table are all in exceedance of the targeted rates, therefore stormwater detention is required for the project.

Proposed Discovery Park Stormwater Detention Facility:

Based upon the Proposed Conditions analysis, it is apparent that some form of stormwater detention will be required for this project. A wet detention basin will be constructed in the northwest corner of Discovery Park Phase 1 that will serve both Discovery Park and Aria. The basin is proposed to be constructed for detention only, without any water quality treatment in the basin. The areas A-4 and A-5 are proposed to discharge into the basin, with flows from area A-7 (East of Douglas Street), discharging into the basin through a proposed culvert directing flows into the basin.

Following is the Proposed Conditions geometry for the outlet structure:

Primary Outlet Structure:

Two (2) 5'(W) x 4' (H) RCB Culverts; Length ≈ 202 L.F.

Flowline In / Out ≈ 929.00 / 906.20(ft; NAVD)

Secondary Outlet Structure:

Emergency Spillway (Weir) 413' L x 1.0' H with 3:1 side slopes; Crest Elev. = 937.50

The proposed basin's storage area is provided in the following table. This proposed storage area is designed as the final configuration for the facility; it is intended to provide the necessary detention for the three separate development areas.

Table 4.1-5(a). Proposed Conditions Storage Volume – Discovery Park Stormwater Detention Facility

Elevation (ft; NAVD):	Storage Area (sq. ft.):	Incremental Volume (ft^3):	Cumulative Volume (ac-ft):	Cumulative Volume (Dry) (ac-ft):
920	89,372.00	0.00	0.00	0.00
921	94,134.00	91,742.70	2.11	0.00
922	98,954.00	96,533.97	4.32	0.00
923	103,829.00	101,381.73	6.65	0.00
924	108,761.00	106,285.46	9.09	0.00
925	113,750.00	111,246.18	11.64	0.00
926	118,795.00	116,263.38	14.31	0.00
927	123,897.00	121,337.06	17.10	0.00
928	129,055.00	126,467.23	20.00	0.00
929	134,270.00	131,653.89	23.02	0.00
930	140,150.00	137,199.50	26.17	3.15
931	145,315.00	142,724.71	29.45	6.43
932	150,465.00	147,882.53	32.84	9.83
933	155,331.00	152,891.55	36.35	13.34
934	160,582.00	157,949.23	39.98	16.96
935	166,505.00	163,534.56	43.73	20.72
936	170,375.00	168,436.30	47.60	24.58
937	189,499.00	179,852.25	51.73	28.71
938	209,384.00	199,358.84	56.31	33.29

Note: *The conic method is used to compute the incremental volume between pond contours.*
The sum of the computed incremental volumes provides the cumulative pond volume for a given elevation.

Utilizing these geometric parameters in the Proposed Conditions model, the following table depicts the stormwater routing summary for this location.

Table 4.1-5(b). Macro-Study Proposed Conditions Hydrologic Routing Summary– Discovery Park Stormwater Detention Facility

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
2-Year:	415.53	12.01	149.69	12.23	29.282	932.34	11.012
10-Year:	699.01	12.02	309.02	12.24	52.792	934.42	18.514
100-Year:	1,049.30	12.01	518.01	12.25	84.703	936.65	27.201

The preceding routing summary indicates that the detention aspect of this facility provides substantial attenuation of the all storm events.

The proposed stormwater detention facility is included in the PondPack modeling for the following table output. These Macro-Study Proposed Conditions results will be compared to the Existing Conditions in the following table. Areas that are unchanged from the Existing Conditions analysis are presented as *grey print* in the following tables.

Table 4.1-6(a). Hydrologic Information – Macro- Proposed Conditions Summary (Junctions) Including Proposed Discovery Park Detention Basin

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	822.31	12.25	91.367	1,511.28	12.24	171.623	2,280.25	12.24	281.712
Point A2:	782.43	12.18	83.974	1,425.45	12.17	155.560	2,141.89	12.19	253.290
Point A3:	625.11	12.16	52.191	1,100.39	12.15	97.194	1,586.54	12.17	158.549
Point A4:	149.63	12.25	29.282	308.87	12.26	52.792	517.84	12.27	84.703
Point A6:	37.88	11.93	2.077	70.35	11.93	3.893	112.88	11.93	6.372
Point A7:	*229.26*	*12.05*	*14.580*	*397.23*	*12.07*	*27.333*	*603.32*	*12.08*	*44.871*
Point A8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Point A9:	*128.79*	*12.00*	*8.028*	*223.48*	*11.99*	*14.240*	*346.07*	*11.99*	*22.563*
Point A10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Point B1:	*615.14*	*12.11*	*49.667*	*1,076.61*	*12.11*	*91.457*	*1,551.65*	*12.14*	*148.401*
Point B2:	*242.31*	*12.05*	*20.032*	*446.43*	*12.04*	*36.522*	*715.56*	*12.03*	*58.980*
Point B3:	*153.04*	*11.99*	*13.975*	*266.04*	*11.98*	*24.377*	*411.65*	*11.97*	*38.255*
Point B4:	*48.10*	*11.94*	*7.673*	*71.04*	*11.93*	*12.565*	*98.80*	*11.93*	*18.924*
Point C1:	*350.42*	*12.09*	*25.466*	*604.01*	*12.10*	*46.692*	*890.10*	*12.10*	*75.478*
Point C2:	*232.89*	*12.04*	*16.244*	*417.32*	*12.07*	*30.851*	*614.91*	*12.08*	*50.912*
Point C3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

The following table provides a comparison between the Macro-Study Proposed Conditions (with detention) and the Existing Conditions modeled results. As indicated by the grey font, the lowest six modeled points within the sub-watershed are the only locations that exhibit hydrologic impacts.

Table 4.1-6(b). Hydrologic Information – Comparison of Results:
Macro- Proposed vs. Existing Conditions Summary (Junctions) Detained Hydrology

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	-126.65	0.00	3.314	-272.95	0.02	4.654	-474.59	0.05	5.704
Point A2:	-126.62	0.00	4.164	-266.28	0.02	5.505	-424.70	0.06	6.554
Point A3:	-3.53	0.00	0.806	-7.28	0.00	0.758	-9.02	0.00	0.748
Point A4:	-111.29	0.08	5.190	-230.62	0.13	6.483	-388.72	0.16	7.521
Point A6:	0.10	-0.01	0.006	0.19	-0.01	0..011	0.31	-0.01	0.017
Point A7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B4:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

Information presented in the preceding table exhibits a reduction in peak rates, relative to the existing conditions model. Overall runoff volumes exhibit modest increase.

The following table is provided to examine the difference between the computed peak discharge rates and the established ARR's for the Discovery Park Macro-Study.

Table 4.1-7. Allowable Release Rate Evaluation – Proposed Conditions Macro Study (With Detention)

Location:	Event:	Computed Peak Discharge Rate (cfs):	ARR (cfs):	Difference (cfs):
Point A1	2-Year:	822.31	859.38	-37.07
	10-Year:	1511.28	1704.07	-192.79
	100-Year:	2280.25	2623.74	-343.49
Point A2	2-Year:	782.43	823.14	-40.71
	10-Year:	1425.45	1607.68	-182.23
	100-Year:	2141.89	2436.65	-294.76
Point A3	2-Year:	625.11	612.50	12.61
	10-Year:	1100.39	1092.23	8.16
	100-Year:	1586.54	1574.71	11.83
Point A4	2-Year:	149.63	200.55	-50.92
	10-Year:	308.87	471.95	-163.08
	100-Year:	518.04	771.67	-253.66
Point A6	2-Year:	37.88	16.57	21.31
	10-Year:	70.35	40.65	29.70
	100-Year:	112.88	63.30	49.58

Note: The sign-convention utilized for the information presented in the preceding table is based upon "Computed Rate minus ARR." Positive values indicate an exceedance of the ARR; negative values indicate that the peak rate is lower than the ARR.

The difference in the rates depicted in this table are generally in compliance with the targeted rates; the proposed stormwater management facility provides adequate attenuation for the primary Channel "A" tributary. The information provided in the preceding table does demonstrate that there are a few exceptions: Peak rates at Point A3 and A6. Point A3 is the terminal end of the Channel "B" tributary, immediately upstream from confluence at Point A2, while point A6 flows directly into the proposed basin.

Although the ARR is exceeded at the Point A3 location, the Proposed Conditions analysis does exhibit that areas further downstream are below ARR at all storm events. ARR is also exceeded at Point A6 during all storm events, however this point is located upstream of the proposed detention basin, and is routed through the basin for attenuation.

4.2. Macro Stormwater Model: Fully-Developed Conditions Analysis

This section of the Stormwater Drainage Study for the Discovery Park commercial development is provided to evaluate the Fully-Developed Proposed Conditions hydrology for the Unity Lake #2 tributary. Proposed conditions include the fully-developed condition of Aria, Discovery Park, and the Multi-Family Residential developments.

Fully-Developed Conditions Runoff Curve Numbers have been developed based upon the current Aria and Discovery Park Phase 1 Development Plans and for the future Multi-Family Residential development and a portion of the Discovery Park Phase 2 development. Refer to Section 7 for Macro-Study Fully-Developed Conditions weighted NRCS Runoff Curve Number (CN) and Time of Concentration (T_C) calculations. These values, summarized in Table 4.2-1(a) are used as input into the Fully-Developed Conditions PondPack model to evaluate the Macro-Study Fully Developed Conditions stormwater runoff for the three design storms. The resultant peak discharge rate (Q_P), peak time (T_P), and runoff volume (V_R) for the computed hydrographs of modeled subareas are included in Tale 4.2-2(a). Areas that are unchanged from the Existing Conditions analysis are presented as *grey print* in the following tables.

Table 4.2-1(a). Macro-Study Fully-Developed Conditions Input Data

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):	NRCS Weighted CN:	T_C [1] (hr):
Subarea A1(e):	30.57				*14.96*	85	0.1401
Subarea A1(w):	*43.14*					*76*	*0.2511*
Subarea A2(e):	*3.08*					*80*	*0.0875*
Subarea A2(w):	*23.41*					*73*	*0.2133*
Subarea A3:	24.06	11.07			11.07	87	0.0717
Subarea A4(e):	1.48	0.14	0.84		0.98	89	0.0184
Subarea A4(w):	8.75		0.59		0.59	72	0.1095
Subarea A5(e):	19.12	11.29	6.92		18.20	92	0.0615
Subarea A5(w):	33.42		31.08		31.08	95	0.0647
Subarea A6:	13.42			9.88	9.88	94	0.0842
Subarea A7:	*30.60*					*76*	*0.1596*
Subarea A8:	*21.56*					*81*	*0.1299*
Subarea A9:	*31.84*					*84*	*0.1420*
Subarea A10:	*12.23*					*94*	*0.1545*
Subtotal:	*296.68*	*22.50*	*39.42*	*9.88*	*86.76*		
Subarea B1:	*31.94*					*79*	*0.1385*
Subarea B2:	*48.54*					*78*	*0.1987*

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):	NRCS Weighted CN:	T_C [1] (hr):
Subarea B3:	*40.69*					*83*	*0.1447*
Subarea B4-DET:	*25.05*					*94*	*0.1155*
Subarea B4-BYP:	*7.42*					*94*	*0.0787*
Subtotal:	*153.64*						
Subarea C1:	*45.21*					*90*	*0.2860*
Subarea C2:	*57.13*					*81*	*0.3308*
Subarea C3:	*52.36*					*83*	*0.1199*
Subtotal:	154.70						
Modeled Total:	605.02	22.50	39.42	9.88	86.76		

[1] ***Note:*** *Per TR-55 documentation, minimum T_C is 0.10 hours; model is configured with default value of 0.10 hr. minimum Tc.*

Table 4.2-1(b). Macro-Study Fully-Developed Conditions Input Sub-Watershed Data

	Total Area (ac):	Aria Onsite Area (ac):	Discovery Park Phase 1 Onsite Area (ac):	Discovery Park Phase 2 Onsite Area (ac):	Macro-Study Onsite Area (ac):
Sub-W'Shed A Subtotal:	296.68	22.50	39.42	9.88	86.76
Sub-W'Shed B Subtotal:	*153.64*				
Sub-W'Shed C Subtotal:	*154.70*				
Modeled Total:	605.02	22.50	39.42	*9.88*	86.76

As noted, these tributary areas, Runoff Curve Numbers (CN), and Times of Concentration (T_C) for the corresponding subareas were used as input to the Proposed Conditions PondPack model to evaluate the stormwater hydrology for the Fully-Developed section of this report. The subareas representing Existing- (offsite) and Proposed Conditions (onsite) for the development sites are utilized in the PondPack model to compute the stormwater runoff for the three design storms. The resultant peak discharge rate (Q_P), peak time (T_P), and runoff volume (V_R) for the computed hydrographs of modeled subareas are included in Table 4.2-2(a).

Table 4.2-2(a). Hydrologic Information – Macro- Fully-Developed Conditions Summary (Subareas)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea A-1(e):	87.32	11.96	5.137	157.07	11.96	9.384	247.45	11.96	15.116
Subarea A-1(w):	*70.15*	*12.05*	*4.908*	*146.86*	*12.05*	*10.132*	*252.55*	*12.05*	*17.597*
Subarea A-2(e):	*7.64*	*11.94*	*0.420*	*14.90*	*11.93*	*0.819*	*24.63*	*11.93*	*1.374*
Subarea A-2(w):	*34.59*	*12.03*	*2.301*	*76.77*	*12.03*	*4.975*	*136.28*	*12.03*	*8.884*
Subarea A-3:	79.39	11.93	4.376	138.56	11.93	7.797	214.51	11.93	12.366
Subarea A-4(e):	5.22	11.93	0.290	8.85	11.93	0.504	13.49	11.92	0.788
Subarea A-4(w):	14.08	11.96	0.817	32.12	11.94	1.796	58.07	11.94	3.239
Subarea A-5(e):	74.12	11.93	4.202	120.76	11.93	7.047	180.16	11.92	10.767
Subarea A-5(w):	139.52	11.92	8.184	219.79	11.92	13.245	322.02	11.92	19.806
Subarea A-6:	54.75	11.93	3.169	87.16	11.92	5.190	128.41	11.92	7.817
Subarea A-7:	*57.26*	*12.00*	*3.482*	*119.03*	*11.98*	*7.186*	*204.90*	*11.98*	*12.481*
Subarea A-8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Subarea A-9:	*87.15*	*11.97*	*5.138*	*158.95*	*11.96*	*9.507*	*252.78*	*11.96*	*15.435*
Subarea A-10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Subarea B-1:	*70.94*	*11.97*	*4.168*	*140.29*	*11.96*	*8.242*	*234.20*	*11.95*	*13.944*
Subarea B-2:	*94.72*	*12.03*	*6.057*	*190.16*	*12.01*	*12.146*	*320.74*	*12.00*	*20.725*
Subarea B-3:	*106.50*	*11.97*	*6.302*	*197.62*	*11.96*	*11.812*	*317.37*	*11.96*	*19.332*
Subarea B-4 (BYP):	*30.29*	*11.93*	*1.753*	*48.22*	*11.92*	*2.871*	*71.04*	*11.92*	*4.324*
Subarea B-4 (DET):	*99.43*	*11.94*	*5.919*	*158.21*	*11.94*	*9.694*	*232.94*	*11.94*	*14.599*
Subarea C-1:	*124.83*	*12.05*	*9.223*	*209.38*	*12.05*	*15.842*	*317.10*	*12.05*	*24.565*
Subarea C-2:	*104.44*	*12.09*	*8.134*	*200.90*	*12.08*	*15.652*	*329.78*	*12.08*	*26.038*
Subarea C-3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

As in the previous section, the hydrologic impact resulting from the Fully-Developed Conditions results is partially revealed by the comparison of the preceding subarea data to those established in Section 3 (Existing Conditions) of this report. The hydrologic conditions for offsite subareas remain unchanged between Existing- and Proposed Conditions analyses. Onsite subareas do exhibit changes in impervious cover and diversion of tributary area under Fully-Developed Conditions. The hydrologic impact to the overall sub-watershed of these modified areas will become apparent in the summary tables for the Points of Interest.

The variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by the proposed development project for given subareas. The following table depicts the difference in computed subarea hydrology between the Existing- and Fully-Developed Conditions models.

Table 4.2-2(b). Hydrologic Information – Macro- Fully-Developed Conditions Summary (Subareas)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Subarea A-1(e):	33.41	-0.05	1.803	46.75	-0.03	2.601	59.63	-0.03	3.441
Subarea A-1(w):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-2(e):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-2(w):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-3:	21.78	-0.03	1.046	25.98	-0.02	1.302	28.38	-0.02	1.471
Subarea A-4(e):	-18.75	-0.03	-1.112	-37.12	-0.03	-2.194	-61.66	-0.04	-3.7
Subarea A-4(w):	-13.48	-0.05	-0.895	-28.73	-0.05	-1.904	-50.15	-0.05	-3.368
Subarea A-5(e):	37.72	-0.02	2.135	49.86	-0.02	3.016	63.18	-0.03	4.005
Subarea A-5(w):	102.50	-0.08	5.935	142.69	-0.07	8.602	189.41	-0.05	11.742
Subarea A-6:	16.77	n/c	1.086	16.62	-0.01	1.286	15.22	-0.01	1.428
Subarea A-7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea A-10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-4 (BYP):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea B-4 (DET):	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Subarea C-3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

The previously defined stormwater detention basins, outfall structures and resultant hydrograph attenuation effects have been incorporated into the Fully-Developed Conditions PondPack model. The channel reaches defined in the Existing Conditions analysis are also included in this routing. Results of this Fully-Developed Conditions hydrologic routing are provided in the following summary table. This information is provided at the same "Points of Interest" used in the Existing Conditions hydrologic analysis for this Stormwater Drainage Study. Refer to the Macro- Fully-Developed Drainage Area Map for the location of the points of interest in relation to the development sites, modeled subareas, channels and conveyances. As in the preceding tables, locations that are unchanged from the Existing Conditions analysis are presented as *grey print* in the following tables.

Table 4.2-3(a). Hydrologic Information – Macro- Fully-Developed Conditions Summary (Junctions)
Un-Detained Hydrology (for Proposed Discovery Park Basin)

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	1,074.58	12.17	95.932	1,932.54	12.16	177.559	2,939.19	12.14	288.906
Point A2:	1,005.57	12.10	86.736	1,784.23	12.09	158.893	2,665.36	12.08	257.043
Point A3:	627.78	12.15	52.992	1,103.02	12.15	98.204	1,588.55	12.17	159.717
Point A4:	436.65	12.03	31.243	718.69	12.03	55.115	1,066.26	12.03	87.287
Point A6:	54.75	11.93	3.169	87.16	11.92	5.190	128.41	11.92	7.817
Point A7:	*229.26*	*12.05*	*14.580*	*397.23*	*12.07*	*27.333*	*603.32*	*12.08*	*44.871*
Point A8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Point A9:	*128.79*	*12.00*	*8.028*	*223.48*	*11.99*	*14.240*	*346.07*	*11.99*	*22.563*
Point A10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Point B1:	*615.14*	*12.11*	*49.667*	*1,076.61*	*12.11*	*91.457*	*1,551.65*	*12.14*	*148.401*
Point B2:	*242.31*	*12.05*	*20.032*	*446.43*	*12.04*	*36.522*	*715.56*	*12.03*	*58.980*
Point B3:	*153.04*	*11.99*	*13.975*	*266.04*	*11.98*	*24.377*	*411.65*	*11.97*	*38.255*
Point B4:	*48.10*	*11.94*	*7.673*	*71.04*	*11.93*	*12.565*	*98.80*	*11.93*	*18.924*
Point C1:	*350.42*	*12.09*	*25.466*	*604.01*	*12.10*	*46.692*	*890.10*	*12.10*	*75.478*
Point C2:	*232.89*	*12.04*	*16.244*	*417.32*	*12.07*	*30.851*	*614.91*	*12.08*	*50.912*
Point C3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

As previously evaluated for the modeled Subareas, these Fully-Developed Proposed Conditions results for the Points of Interest will be compared to those established in Section 3 (Existing Conditions) of this report. The points represent similar locations in both Existing- and Proposed Conditions analyses. Therefore, the variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by the proposed development. The following table depicts the difference between the Existing- and Fully-Developed Conditions models without provisions for onsite stormwater detention.

Table 4.2-3(b). Hydrologic Information – Comparison of Results:
Macro- Fully-Developed vs. Existing Conditions Summary (Junctions) Un-Detained Hydrology

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	123.14	-0.08	7.888	143.92	-0.06	10.596	179.47	-0.05	12.900
Point A2:	93.93	-0.07	6.935	87.31	-0.06	8.844	90.83	-0.05	10.309
Point A3:	-2.51	n/c	-0.02	-7.65	n/c	0.223	-10.82	n/c	0.372
Point A4:	174.41	-0.12	7.175	177.61	-0.09	8.841	158.79	-0.06	10.156
Point A6:	17.21	-0.01	1.086	17.59	-0.01	1.286	21.55	-0.01	1.427
Point A7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B4:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

Information presented in the preceding table exhibits an increase in peak rates at most Points of Interest, relative to the existing conditions model. This is the result of the substantial increased imperviousness for the onsite areas.

Additional analysis is required to determine whether the performance of the proposed development is able to establish compliance with the proposed stormwater management objectives. The following table is provided to examine the difference between the computed peak discharge rates and the established ARR's for the Discovery Park Macro-Study.

Table 4.2-4. Allowable Release Rate Evaluation –
Macro- Fully-Developed Conditions Summary Model – Without Detention

Location:	Event:	Computed Peak Discharge Rate (cfs):	ARR (cfs):	Difference (cfs):
Point A1	2-Year:	1,074.58	881.71	192.87
	10-Year:	1,932.54	1,725.98	206.56
	100-Year:	2,939.19	2,657.53	281.66
Point A2	2-Year:	1,005.57	848.13	157.44
	10-Year:	1,784.23	1,634.53	149.70
	100-Year:	2,665.36	2,478.07	187.29
Point A3	2-Year:	627.78	613.94	13.84
	10-Year:	1,103.02	1,094.99	8.03
	100-Year:	1,588.55	1,578.20	10.35

Point A4	2-Year:	436.65	220.67	215.98
	10-Year:	718.69	494.51	224.18
	100-Year:	1,066.26	815.03	251.23
Point A6	2-Year:	54.75	16.57	38.18
	10-Year:	87.16	40.65	46.51
	100-Year:	128.41	63.30	65.11

The sign-convention utilized for the information presented in the preceding table is based upon "Computed Rate minus ARR." Therefore, positive values indicate an exceedance of the Allowable Release Rate, whereas negative values would indicate a peak rate that is lower than the ARR, thereby meeting the targeted peak discharge rates. The difference in the rates depicted in this table are all in exceedance of the targeted rates. Though the increased peak discharge rates at the defined Points of Interest are relatively moderate, these exceedances are of noticeably greater magnitude.

Proposed Discovery Park Stormwater Detention Facility:

The proposed stormwater management facility that is defined in the Macro Study section of this report is configured for the fully-developed geometry. Therefore, the basin geometry is not repeated in this section. Utilizing the effects of this basin, the following table depicts the stormwater routing summary for the Macro-Study Fully-Developed Conditions.

Table 4.2-5. Fully-Developed Conditions Hydrologic Routing Summary– Discovery Park Stormwater Detention Facility

	Peak Q In (cfs):	T_P In (hr.):	Peak Q Out (cfs):	T_P Out (hr.):	V_R (ac-ft):	Peak WSEL (ft; NAVD):	Max. Storage Volume (ac-ft):
2-Year:	447.89	12.01	163.97	12.21	31.243	932.55	11.748
10-Year:	738.58	12.01	325.43	12.22	55.115	934.61	19.231
100-Year:	1,095.79	12.01	535.06	12.23	87.287	936.81	27.902

The preceding routing summary indicates that, under Fully-Developed Conditions, this basin provides substantial attenuation of the modeled design storm events. Section 8 of this report includes hydrographs for this proposed stormwater management facility.

An emergency spillway is to be constructed on the northwest side of the basin at an elevation of 937.50. The spillway is designed to, should the primary outfall structure be clogged or completely fail, route the 100 year storm into the existing stream. The 100 year storm is calculated as a peak flow of 1,095.79 cfs. The spillway length is designed as 413 LF. In the 100 year storm, the water surface elevation in the weir is calculated as 938.08. The top of the basin is set at 938.25, giving the basin 1.07 LF of freeboard.

Results of this Fully-Developed Conditions hydrologic routing, including the proposed stormwater detention facility are provided in the following summary table. This information is provided at the same "Points of Interest" used in the Existing Conditions hydrologic analysis for this Stormwater Drainage Study. Refer to the Macro Fully-Developed Conditions Drainage Area Map for the location of the points of interest in relation to the development sites, modeled subareas, channels and conveyances. As in the preceding tables, locations that are unchanged from the Existing Conditions analysis are presented as *grey print* in the following tables.

Table 4.2-6(a). Hydrologic Information – Macro- Fully-Developed Conditions Summary (Junctions) Including Proposed Discovery Park Detention Basin

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	846.59	12.25	95.932	1,539.67	12.24	177.559	2,309.68	12.24	288.906
Point A2:	803.35	12.18	86.736	1,451.96	12.17	158.893	2,169.95	12.19	257.043
Point A3:	627.78	12.15	52.992	1,103.02	12.15	98.204	1,588.55	12.17	159.717
Point A4:	163.90	12.23	31.243	325.28	12.24	55.115	534.89	12.25	87.287
Point A6:	54.75	11.93	3.169	87.16	11.93	5.190	128.41	11.92	7.817
Point A7:	*229.26*	*12.05*	*14.580*	*397.23*	*12.07*	*27.333*	*603.32*	*12.08*	*44.871*
Point A8:	*53.05*	*11.96*	*3.070*	*101.89*	*11.95*	*5.907*	*166.82*	*11.95*	*9.826*
Point A9:	*128.79*	*12.00*	*8.028*	*223.48*	*11.99*	*14.240*	*346.07*	*11.99*	*22.563*
Point A10:	*45.61*	*11.97*	*2.890*	*72.57*	*11.97*	*4.733*	*106.86*	*11.97*	*7.128*
Point B1:	*615.14*	*12.11*	*49.667*	*1,076.61*	*12.11*	*91.457*	*1,551.65*	*12.14*	*148.401*
Point B2:	*242.31*	*12.05*	*20.032*	*446.43*	*12.04*	*36.522*	*715.56*	*12.03*	*58.980*
Point B3:	*153.04*	*11.99*	*13.975*	*266.04*	*11.98*	*24.377*	*411.65*	*11.97*	*38.255*
Point B4:	*48.10*	*11.94*	*7.673*	*71.04*	*11.93*	*12.565*	*98.80*	*11.93*	*18.924*
Point C1:	*350.42*	*12.09*	*25.466*	*604.01*	*12.10*	*46.692*	*890.10*	*12.10*	*75.478*
Point C2:	*232.89*	*12.04*	*16.244*	*417.32*	*12.07*	*30.851*	*614.91*	*12.08*	*50.912*
Point C3:	*142.61*	*11.95*	*8.110*	*264.83*	*11.94*	*15.199*	*425.51*	*11.94*	*24.875*

As with the previous section, these Fully-Developed Conditions results for the Points of Interest will be compared to those established in Section 3 (Existing Conditions) of this report. The points represent similar locations in both Existing- and Proposed Conditions analyses. Therefore, the variation in quantity and rate of stormwater discharge between these two models represents the hydrologic effect generated by the proposed development. The following table depicts the difference between the Existing- and Fully-Developed Conditions models, including the effects of the proposed onsite stormwater detention facility.

Table 4.2-6(b). Hydrologic Information – Comparison of Results:
Macro- Fully-Developed Conditions Summary (Junctions) Detained Hydrology

Location:	Q_{P-2} (cfs):	T_{P-2} (hr.):	V_{R-2} (ac-ft):	Q_{P-10} (cfs):	T_{P-10} (hr.):	V_{R-10} (ac-ft):	Q_{P-100} (cfs):	T_{P-100} (hr.):	V_{R-100} (ac-ft):
Point A1:	-102.37	0.00	7.882	-244.56	0.02	10.59	-445.16	0.05	12.898
Point A2:	-105.70	0.00	6.926	-239.77	0.02	8.838	-396.64	0.06	10.307
Point A3:	-0.86	0.00	0.005	-4.65	0.00	0.252	-7.01	0.00	0.420
Point A4:	97.02	0.08	7.151	-214.21	0.13	8.806	-371.50	0.16	10.105
Point A6:	16.77	-0.01	1.086	16.62	-0.01	.286	*15.22*	-0.01	1.428
Point A7:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A8:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A9:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point A10:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point B4:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C1:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C2:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*
Point C3:	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*	*n/c*

The sign-convention used in the preceding table is: Proposed Conditions minus Existing Conditions. Therefore, negative values indicate a reduction in computed value, whereas positive values reflect an increase. Those locations that do not exhibit any change in computed values are identified by "n/c."

Data presented in the preceding table depicts the significant reduction in peak rates relative to the Existing Conditions model along the Channel "A" tributary. There is no change from the Macro-Study Proposed Conditions at the Point A3 location. Although the peak discharge rates are reduced at the modeled Points of Interest, further analysis is required to establish compliance with the project's stormwater management objectives.

The following table is provided to examine the difference between the computed Fully-Developed Conditions peak discharge rates and the established ARR's for the overall development.

Table 4.2-7. Allowable Release Rate Evaluation – Fully-Developed Conditions Macro Study (W/Detention)

Location:	Event:	Computed Peak Discharge Rate (cfs):	ARR (cfs):	Difference (cfs):
Point A1	2-Year:	846.59	859.38	-12.79
	10-Year:	1539.67	1704.07	-164.40
	100-Year:	2309.68	2623.74	-314.06
Point A2	2-Year:	803.35	823.14	-19.79
	10-Year:	1451.96	1607.68	-155.72
	100-Year:	2169.95	2436.65	-266.70
Point A3	2-Year:	627.78	612.50	15.28
	10-Year:	1103.02	1092.23	10.79
	100-Year:	1588.55	1574.71	13.84
Point A4	2-Year:	163.90	200.55	-36.65
	10-Year:	325.28	471.95	-146.67
	100-Year:	534.89	771.67	-236.78
Point A6	2-Year:	54.75	16.57	38.18
	10-Year:	87.16	40.65	46.45
	100-Year:	128.41	63.30	65.11

Note: The sign-convention utilized for the information presented in the preceding table is based upon "Computed Rate minus ARR." Positive values indicate an exceedance of the ARR; negative values indicate that the peak rate is lower than the ARR.

The difference in the rates depicted in this table are generally in compliance with the targeted rates; the proposed stormwater management facility provides adequate attenuation for the primary Channel "A" tributary. The information provided in the preceding table does demonstrate that there are a few exceptions: Peak rates at Point A3 and A6. Point A3 is the terminal end of the Channel "B" tributary, immediately upstream from confluence at Point A2, while point A6 flows directly into the proposed basin.

Although the ARR is exceeded at the Point A3 location, the Proposed Conditions analysis does exhibit that areas further downstream are below ARR at all storm events. ARR is also exceeded at Point A6 during all storm events, however this point is located upstream of the proposed detention basin, and is routed through the basin for attenuation.

4.3. Proposed Stormwater Best Management Practices

This section of the study will address water quality treatment for the proposed development. While the City of Lee's Summit has not adopted the Mid America Regional Council and American Public Works Association "Manual of Best Management Practices for Stormwater Quality" (Oct. 2012), 40-hr extended detention of the water quality storm volume generated by the development is required.

The proposed wet detention basin provides sufficient storage and peak rate attenuation to meet all Allowable Release Rate requirements for the development, however it is not providing the required 40-hr extended detention of the water quality storm event. Alternative design for water quality treatment that provides an equal or greater Level of Service, as calculated by the MARC BMP Manual, is allowed in lieu of providing 40-hr extended detention. The Level of Service provided by 40-hr extended dry detention is 4.0. Micro stormwater studies required to be submitted with each Final Development Plan will need to demonstrate that the proposed development will provide water quality treatment that is equal to or greater than the Level of Service of 4.0 that is required for the land area proposed to be developed.

In accordance with the Lee's Summit Design and Construction Manual (DCM) Section 1002.A, a waiver is being requested to remove 10.3 acres of stream buffer located within the project site (outlined in Section 5605 of KC-APWA Section 5600). The need to remove the existing creek channel, as shown on the attached exhibit, is driven by:

- The site layout approved by the city TIF commission, which includes a wet-bottom detention basin that is part of a development amenity space with a pond, parkland, and walking trail.
- A required entrance drive off of NE Douglas Road with minimum spacing allowed by the project traffic study to the adjacent intersection placing it in conflict with the existing creek channel.
- A clubhouse with swimming pool between the proposed detention basin and entrance drive.

The upstream end of the existing creek channel begins at the outlet point of an existing concrete box culvert under NE Douglas Street. This box culvert will be extended approximately 670 linear feet and discharge into the proposed wet-bottom detention basin.

The proposed development has been extensively coordinated with Unity Village, the owner/operator of Unity Lake #2, an existing lake that is located approximately ½ mile downstream of the proposed stream buffer impacts. As indicated in the attached letter from Unity Village, with the level of storm water quality treatment and peak runoff rate control being provided by the proposed improvements, this project has their full support.

As part of the due diligence performed for the development, the following reviews were completed:

- A jurisdictional determination was requested by the United States Army Corps of Engineers (USACE). The USACE provided a determination letter (attached with this request) that states the affected creek channel and attached wetlands are not jurisdictional water of the US.
- Review of existing FEMA floodplains was completed and no regulated floodplains exist within the affected creek channel as shown on the attached FEMA FIRM panel.

As a part of any development, the City of Lee's Summit requires that 40-hour extended dry detention of the water quality storm event be provided for the project site or equivalent on-site water quality treatment per the APWA BMP Manual. This is to promote the removal of pollutants and debris out of storm water prior to being discharged downstream of the development site. Due to the existing culvert under NE Douglas Street being routed into the proposed wet-bottom detention basin, the water quality volume exceeds what the proposed detention basin could treat while still meeting required basin water surface elevation parameters outlined in KC-AWPA Section 5608.4. In lieu of 40-hr extended dry detention of the water quality storm, best management practices (BMPs) will be constructed upstream of the proposed detention basin, internal to the project site, closer to the source point of the pollutant. The BMPs will be required to provide an equivalent or greater level of service than 40-hr extended dry detention. Water quality analysis treatment measures will be provided in future micro stormwater studies as each phase of the project is finalized through the Final Development Plan process.

Furthermore, with the culvert discharging into the wet-bottom detention basin with approximately 680 feet of travel length through a permanent pool of water, suspended solids and floatables that are conveyed into the basin from upstream (offsite) areas, not required to be treated by this development, will have an opportunity to settle out or be collected and disposed of. Discharging the culvert extension directly into the permanent pool basin will also provide scour and erosion protection that is a common problem at pipe outlets into dry basins or creek channels. Permanent pool detention basins also promote wildlife and aquatic habitats where dry basins are typically mowed and maintained to prevent vegetation, often deemed as 'unsightly' by land owners, from growing.

To improve the aesthetics and quality of the proposed wet detention basin, landscape design guidelines are being established for the development. The proposed guidelines require a 15-ft buffer of native plantings around the perimeter of the pond, restricting the use of turf grass in that zone. The taller native plantings and grasses provide wildlife habitat and refuse while filtering physical and chemical pollutants. Native planted buffer zones in conjunction with the existing old growth tree preservation (when possible) will enhance wildlife habitat and connectivity.

In addition to the water quality treatment being provided for the development prior to discharging runoff into the creek, 5.2 acres of enhanced stream buffer is being proposed to be set aside downstream of the impacted creek channel to further offset any environmental/wildlife impact caused by removing stream buffer described.

5. SUMMARY

See Tables 5-1 and 5-2, below, for a summary comparison of Existing, Allowable, and Proposed peak flowrates during the Macro conditions.

Table 5-1. Macro- Proposed Peak Flowrate Comparison

Location:	Event:	Existing Flowrate (cfs):	ARR (cfs):	Proposed Flowrate (cfs):	Difference (Existing vs. Proposed) (cfs):	Difference (ARR vs. Proposed) (cfs):
Point A1	2-Year:	948.96	859.38	822.31	-126.65	-37.07
	10-Year:	1,748.23	1704.07	1511.28	-236.95	-192.79
	100-Year:	2,754.84	2623.74	2280.25	-474.59	-343.49
Point A2	2-Year:	909.05	823.14	782.43	-126.62	-40.71
	10-Year:	1,691.73	1607.68	1425.45	-266.28	-182.23
	100-Year:	2,566.59	2436.65	2141.89	-424.70	-294.76
Point A3	2-Year:	628.64	612.50	625.11	-3.53	12.61
	10-Year:	1,107.67	1092.23	1100.39	-7.28	8.16
	100-Year:	1,595.56	1574.71	1586.54	-9.02	11.83
Point A4	2-Year:	260.92	200.55	149.63	-111.29	-50.92
	10-Year:	539.49	471.95	308.87	-230.62	-163.08
	100-Year:	906.56	771.67	518.01	-388.72	-253.66
Point A6	2-Year:	37.98	16.57	37.88	-0.10	21.31
	10-Year:	70.54	40.65	70.35	-0.19	29.70
	100-Year:	113.19	63.30	112.88	-0.31	49.58

Note: The sign-convention utilized for the information presented in the preceding table is based upon "Proposed Rate minus Existing (or ARR)." Positive values indicate an exceedance of the Existing (or ARR); negative values indicate that the peak rate is lower than the Existing (or ARR).

Table 5-2. Macro-Fully Developed- Peak Flowrate Comparison

Location:	Event:	Existing Flowrate (cfs):	ARR (cfs):	Proposed Flowrate (cfs):	Difference (Existing vs. Proposed) (cfs):	Difference (ARR vs. Proposed) (cfs):
Point A1	2-Year:	948.96	857.17	846.59	-102.37	-12.79
	10-Year:	1,748.23	1702.66	1539.67	-208.56	-164.40
	100-Year:	2,754.84	2621.34	2309.68	-445.16	-314.06
Point A2	2-Year:	909.05	823.14	803.35	-105.70	-19.79
	10-Year:	1,691.73	1607.68	1451.96	-239.77	-155.72
	100-Year:	2,566.59	2436.65	2169.95	-396.64	-266.70
Point A3	2-Year:	628.64	612.5	627.78	-0.86	15.28
	10-Year:	1,107.67	1092.23	1103.02	-4.65	10.79
	100-Year:	1,595.56	1574.71	1588.55	-7.01	13.84
Point A4	2-Year:	260.92	200.55	163.90	-97.02	-36.65
	10-Year:	539.49	471.95	325.28	-214.21	-146.67
	100-Year:	906.56	771.67	534.89	-371.67	-236.78
Point A6	2-Year:	37.98	16.57	54.75	16.77	38.18
	10-Year:	70.54	40.65	87.16	16.62	46.45
	100-Year:	113.19	63.3	128.41	15.22	65.11

Note: The sign-convention utilized for the information presented in the preceding table is based upon "Proposed Rate minus Existing (or ARR)." Positive values indicate an exceedance of the Existing (or ARR); negative values indicate that the peak rate is lower than the Existing (or ARR).

Table 5-3. Macro ARR Comparison

Location:	Return Event (Yr):	Existing Conditions Flow Rate	ARR (cfs):
Point A7			
	2-Year:	229.26	229.26
	10-Year:	397.23	397.23
	100-Year:	603.32	603.32
Point B1			
	2-Year:	615.14	615.14
	10-Year:	1,076.61	1076.61
	100-Year:	1,551.65	1551.65
Point D1			
	2-Year:	560.43	481.87
	10-Year:	941.67	874.92
	100-Year:	1351.30	1262.83
Point D2			
	2-Year:	485.06	427.99
	10-Year:	752.83	707.54
	100-Year:	1052.38	996.29
Point E1			
	2-Year:	65.98	29.51
	10-Year:	106.88	72.41
	100-Year:	143.00	103.59
Point F1			
	2-Year:	47.57	25.75
	10-Year:	74.89	55.17
	100-Year:	106.16	80.20
Point F2			
	2-Year:	31.56	7.75
	10-Year:	45.26	26.59
	100-Year:	65.86	39.78
Point G1			
	2-Year:	58.32	42.99
	10-Year:	102.21	83.33
	100-Year:	163.43	131.84
Point G2			
	2-Year:	23.29	5.94
	10-Year:	36.98	18.02
	100-Year:	62.01	27.70

Location:	Return Event (Yr):	Existing Conditions Flow Rate	ARR (cfs):
Point H1			
	2-Year:	119.54	36.41
	10-Year:	240.90	124.05
	100-Year:	406.43	190.18
Point I1			
	2-Year:	4.44	2.80
	10-Year:	7.87	5.64
	100-Year:	12.29	8.74

The above table establishes ARR rates for locations unaffected in the Phase 1 Fully-Developed conditions. Future developments within the areas will by analyzed by their respective macro studies.

A design waiver is being requested to remove 10.3 acres of stream buffer located within the project site to allow for construction of a permanent pool detention basin, entrance drive off of NE Douglas Road, and clubhouse/pool amenity space for the development. Upstream water quality treatment is being provided to treat pollutants closer to the point source within the development, enhanced landscaping is required around the detention basin to promote wildlife and pollutant removal, and offsite discharges will be routed through the pond to allow for settlement and collection of suspended solids and floatable debris.

6. CONCLUSION

This study has been prepared to provide an analysis of the impacts that the fully-developed conditions of project site areas tributary to Unity Lake #2, and provide prescriptive release rate requirements for future development areas within the Discovery Park development. Once fully developed, the area treated by the proposed detention basin and water quality systems include:

- Aria Apartments: a 22.50-ac apartment development (Zoned RP-4)
- Discovery Park Phase 1: a 39.42-ac commercial development (Zoned CP-2)
- Discovery Park Phase 2: a 19.82-ac commercial development (currently zoned AG and to be rezoned at a future time)

As shown in the tables presented in the sections above, it has been determined that with the proposed development and detention basin, the peak runoff rates for the study area are reduced from the pre-developed conditions at all points analyzed. Comprehensive Control requirements are also met at the outfall point in the 2, 10 and 100 year storm events.

The existing basin located at Point A5 provides a slight attenuation of peak flows and delays in timing for offsite points A7, A8, A9 and A10. With construction of the new basin, the existing basin will be removed and flows from Point A7 will be rerouted into the proposed basin by extending the existing box culvert under Douglas Street. A design waiver is being requested to remove 10.3 acres of stream buffer while providing water quality treatment via upstream water quality systems to promote pollutant removal.

The results of this study demonstrate the overall general compliance with the City of Lee's Summit design criteria and a waiver is being submitted for approval of a deviation from the design criteria. We therefore request approval of this stormwater management report.