The City of San Diego

PRIORITY DEVELOPMENT PROJECT (PDP) STORM WATER QUALITY MANAGEMENT PLAN (SWQMP) FOR

Riverwalk - Vesting Tentative Map No. 2213361
PTS No.: 581984
IO No.: TBD

ENGINEER OF WORK:

Wayne W. Chang, M S, PE 46548
Provide Wet Signature and Stamp Above Line

REGISTERED PROFESSIONAL ENGINEER
WAYNE W. CHANG
No. 46548
Exp. 6/30/21
CIVIL
STATE OF CALIFORNIA

PREPARED FOR:

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PREPARED BY:

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Civil Engineering•Hydrology•Hydraulics•Sedimentation

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DATE:
April 7, 2020

Approved by: City of San Diego   Date

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Project Name: Riverwalk

TABLE OF CONTENTS

- Acronyms
- Certification Page
- Submittal Record
- Project Vicinity Map
- FORM DS-560: Storm Water Applicability Checklist
- FORM I-1: Applicability of Permanent, Post-Construction Storm Water BMP Requirements
- FORM I-3B: Site Information Checklist for PDPs
- FORM I-4: Source Control BMP Checklist for All Development Projects
- FORM I-5: Site Design BMP Checklist for All Development Projects
- FORM I-6: Summary of PDP Structural BMPs
- FORM DS-563: Permanent BMP Construction, Self Certification Form
- Attachment 1: Backup for PDP Pollutant Control BMPs
  - Attachment 1a: DMA Exhibit
  - Attachment 1b: Tabular Summary of DMAs and Design Capture Volume Calculations
  - Attachment 1c: Harvest and Use Feasibility Screening (when applicable)
  - Attachment 1d: Categorization of Infiltration Feasibility Condition (when applicable)
  - Attachment 1e: Pollutant Control BMP Design Worksheets / Calculations
- Attachment 2: Backup for PDP Hydromodification Control Measures
  - Attachment 2a: Hydromodification Management Exhibit
  - Attachment 2b: Management of Critical Coarse Sediment Yield Areas
  - Attachment 2c: Geomorphic Assessment of Receiving Channels
  - Attachment 2d: Flow Control Facility Design
- Attachment 3: Structural BMP Maintenance Plan
  - Attachment 3a: Structural BMP Maintenance Thresholds and Actions
  - Attachment 3b: Draft Maintenance Agreement (when applicable)
- Attachment 4: Copy of Plan Sheets Showing Permanent Storm Water BMPs
- Attachment 5: Project's Drainage Report
- Attachment 6: Project's Geotechnical and Groundwater Investigation Report

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ACRONYMS

APN	Assessor's Parcel Number
ASBS	Area of Special Biological Significance
BMP	Best Management Practice
CEQA	California Environmental Quality Act
CGP	Construction General Permit
DCV	Design Capture Volume
DMA	Drainage Management Areas
ESA	Environmentally Sensitive Area
GLU	Geomorphic Landscape Unit
GW	Ground Water
HMP	Hydromodification Management Plan
HSG	Hydrologic Soil Group
HU	Harvest and Use
INF	Infiltration
LID	Low Impact Development
LUP	Linear Underground/Overhead Projects
MS4	Municipal Separate Storm Sewer System
N/A	Not Applicable
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PDP	Priority Development Project
PE	Professional Engineer
POC	Pollutant of Concern
SC	Source Control
SD	Site Design
SDRWQCB	San Diego Regional Water Quality Control Board
SIC	Standard Industrial Classification
SWPPP	Stormwater Pollutant Protection Plan
SWQMP	Storm Water Quality Management Plan
TMDL	Total Maximum Daily Load
WMAA	Watershed Management Area Analysis
WPCP	Water Pollution Control Program
WQIP	Water Quality Improvement Plan

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CERTIFICATION PAGE

Project Name: Riverwalk
Permit Application Number: PTS 581984

I hereby declare that I am the Engineer in Responsible Charge of design of storm water BMPs for this project, and that I have exercised responsible charge over the design of the project as defined in Section 6703 of the Business and Professions Code, and that the design is consistent with the requirements of the Storm Water Standards, which is based on the requirements of SDRWQCB Order No. R9-2013-0001 as amended by R9-2015-0001 and R9-2015-0100 (MS4 Permit).

I have read and understand that the City Engineer has adopted minimum requirements for managing urban runoff, including storm water, from land development activities, as described in the Storm Water Standards. I certify that this PDP SWQMP has been completed to the best of my ability and accurately reflects the project being proposed and the applicable source control and site design BMPs proposed to minimize the potentially negative impacts of this project's land development activities on water quality. I understand and acknowledge that the plan check review of this PDP SWQMP by the City Engineer is confined to a review and does not relieve me, as the Engineer in Responsible Charge of design of storm water BMPs for this project, of my responsibilities for project design.

Engineer of Work's Signature, PE Number & Expiration Date

Wayne W. Chang
Print Name

Chang Consultants
Company

April 7, 2020
Date

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Project Name: **Riverwalk**

SUBMITTAL RECORD

Use this Table to keep a record of submittals of this PDP SWQMP. Each time the PDP SWQMP is re-submitted, provide the date and status of the project. In last column indicate changes that have been made or indicate if response to plancheck comments is included. When applicable, insert response to plancheck comments.

Submittal Number	Date	Project Status	Changes
1	9/25/17	◉ Preliminary Design/Planning/CEQA ○ Final Design	Initial Submittal
2	2/6/18	◉ Preliminary Design/Planning/CEQA ○ Final Design	Second Submittal
3	11/7/18	◉ Preliminary Design/Planning/CEQA ○ Final Design	Third Submittal
4	4/17/19	◉ Preliminary Design/Planning/CEQA ○ Final Design	Fourth Submittal
5	12/06/20	x Preliminary Design/Planning/CEQA	Fifth Submittal
6	4/07/20	x Preliminary Design/Planning/CEQA	Sixth Submittal

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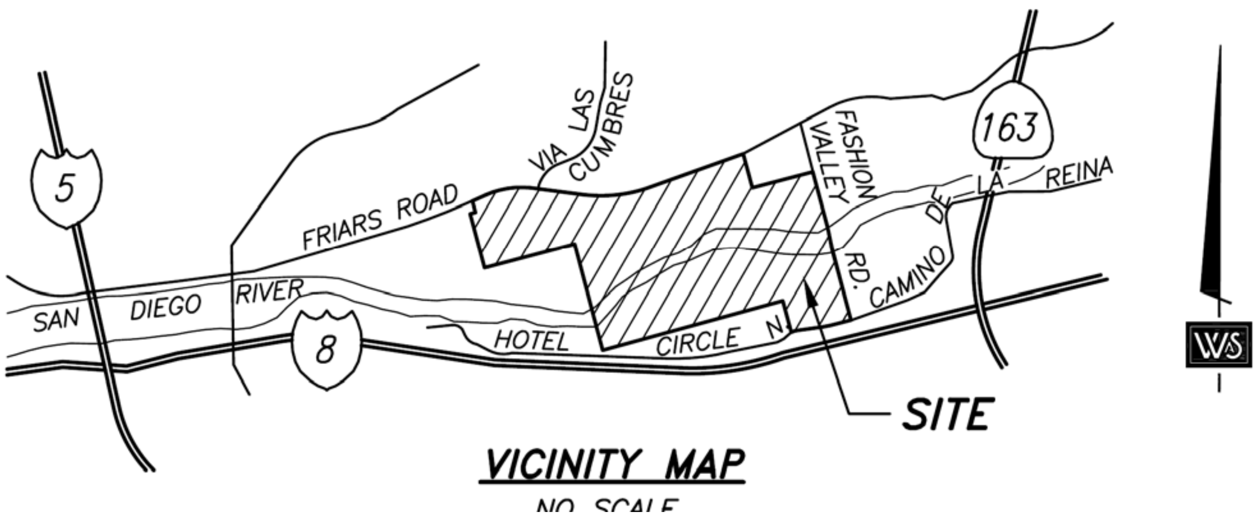
PROJECT VICINITY MAP

Project Name: Riverwalk
Permit Application Number: PTS 581984



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Project Name: Riverwalk

The City of San Diego	City of San Diego **Development Services** 1222 First Ave., MD-302 San Diego, CA 92101 (619) 446-5000	**Storm Water Requirements Applicability Checklist**	FORM **DS-560** February 2016

Project Address: 1150 Fashion Valley Road San Diego, CA 92108	Project Number *(for the City Use Only)*:

SECTION 1. Construction Storm Water BMP Requirements:

All construction sites are required to implement construction BMPs in accordance with the performance standards in the Storm Water Standards Manual. Some sites are additionally required to obtain coverage under the State Construction General Permit (CGP)[1], which is administrated by the State Water Resources Control Board.

For all projects complete PART A: If project is required to submit a SWPPP or WPCP, continue to PART B.

PART A: Determine Construction Phase Storm Water Requirements.

1. Is the project subject to California's statewide General NPDES permit for Storm Water Discharges Associated with construction activities, also known as the State Construction General Permit (CGP)? (Typically projects with land disturbance greater than or equal to 1 acre.)

   ◉ Yes; SWPPP required, skip questions 2-4 ○ No; next question

2. Does the project propose construction or demolition activity, including but not limited to, clearing, grading, grubbing, excavation, or any other activity that results in ground disturbance and contact with storm water runoff?

   ○ Yes; WPCP required, skip questions 3-4 ◉ No; next question

3. Does the project propose routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of the facility? (projects such as pipeline/utility replacement)

   ○ Yes; WPCP required, skip questions 4 ◉ No; next question

4. Does the project only include the following Permit types listed below?
   - Electrical Permit, Fire Alarm Permit, Fire Sprinkler Permit, Plumbing Permit, Sign Permit, Mechanical Permit, Spa Permit.
   - Individual Right of Way Permits that exclusively include one of the following activities and associated curb/ sidewalk repair: water services, sewer lateral, storm drain lateral, or dry utility service.
   - Right of Way Permits with a project footprint less than 150 linear feet that exclusively include only ONE of the following activities: curb ramp, sidewalk and driveway apron replacement, curb and gutter replacement, and retaining wall encroachments.

     ☐ Yes; no document required

Check one of the boxes to the right, and continue to PART B:

☒ If you checked "Yes" for question 1,
a SWPPP is REQUIRED. Continue to PART B

☐ If you checked "No" for question 1, and checked "Yes" for question 2 or 3,
a WPCP is REQUIRED. If the project processes less than 5,000 square feet of ground disturbance AND has less than a 5-foot elevation change over the entire project area, a Minor WPCP may be required instead. **Continue to PART B.**

☐ If you checked "No" for all question 1-3, and checked "Yes" for question 4
PART B **does not apply and no document is required. Continue to Section 2.**

More information on the City's construction BMP requirements as well as CGP requirements can be found at: www.sandiego.gov/stormwater/regulations/swguide/constructing.shtml

Project Name: Riverwalk

PART B: Determine Construction Site Priority.
This prioritization must be completed within this form, noted on the plans, and included in the SWPPP or WPCP. The city reserves the right to adjust the priority of projects both before and after construction. Construction projects are assigned an inspection frequency based on if the project has a "high threat to water quality." The City has aligned the local definition of "high threat to water quality" to the risk. Determination approach of the Stat e Construction General Permit (CGP). The CGP determines risk level based on project specific sediment risk and receiving water risk. Additional inspection is required for projects within the Areas of Special Biological Significance (ASBS) watershed. **NOTE:** The construction priority does **NOT** change construction BMP requirements that apply to projects; rather, it determines the frequency of inspections that will be conducted by city staff.

Complete PART B and continued to Section 2

1. ☐ **ASBS**
   a. Projects located in the ASBS watershed. A map of the ASBS watershed can he found here

2. ☒ **High Priority**
   a. Projects 1 acre or more determined to be Risk Level 2 or Risk Level 3 per the Construction General Permit and not located in the ASBS watershed.
   b. Projects 1 acre or more determined to be LUP Type 2 or LUP Type 3 per the Construction General Permit and not located in the ASBS watershed.

3. ☐ **Medium Priority**
   a. Projects 1 acre or more but not subject to an ASBS or high priority designation.
   b. Projects determined to be Risk Level 1 or LUP Type 1 per the Construction General Permit and not located in the ASBS watershed.

4. ☐ **Low Priority**
   a. Projects not subject to ASBS, high or medium priority designation.

SECTION 2. Permanent Storm Water BMP Requirements.

Additional information for determining the requirements is found in the Storm Water Standards Manual.

PART C: Determine if Not Subject to Permanent Storm Water Requirements.
Projects that are considered maintenance, or otherwise not categorized as "new development projects" or "redevelopment projects" according to the Storm Water Standards Manual are not subject to Permanent Storm Water BMPs.

If "yes" is checked for any number in Part C, proceed to Part F and check "Not Subject to Permanent Storm Water BMP Requirements".

If "no" is checked for all of the numbers in Part C continue to Part D.

1.	Does the project only include interior remodels and/or is the project entirely within an existing enclosed structure and does not have the potential to contact storm water?	○ Yes ◉ No
2.	Does the project only include the construction of overhead or underground utilities without creating new impervious surfaces?	○ Yes ◉ No
3.	Does the project fall under routine maintenance? Examples include, but are not limited to: roof or exterior structure surface replacement, resurfacing or reconfiguring surface parking lots or existing roadways without expanding the impervious footprint, and routine replacement of damaged pavement (grinding, overlay, and pothole repair).	○ Yes ◉ No

Project Name: Riverwalk

PART D: PDP Exempt Requirements.

PDP Exempt projects are required to implement site design and source control BMPs.

If "yes" was checked for any questions in Part D, continue to Part F and check the box labeled "PDP Exempt."
If "no" was checked for all questions in Part D, continue to Part E.

1. Does the project ONLY include new or retrofit sidewalks, bicycle lanes, or trails that:

   • Are designed and constructed to direct storm water runoff to adjacent vegetated areas, or other non-erodible permeable areas? Or;
   • Are designed and constructed to be hydraulically disconnected from paved streets and roads? Or;
   • Are designed and constructed with permeable pavements or surfaces in accordance with the Green Streets guidance in the City's Storm Water Standards manual?

   ☐ Yes; PDP exempt requirements apply ☒ No; next question

2. Does the project ONLY include retrofitting or redeveloping existing paved alleys, streets or roads designed and constructed in accordance with the Green Streets guidance in the City's Storm Water Standards Manual?

   ☐ Yes; PDP exempt requirements apply ☒ No; PDP not exempt. PDP requirements apply.

PART E: Determine if Project is a Priority Development Project (PDP). Projects that match one of the definitions below are subject to additional requirements including preparation of a Storm Water Quality Management Plan (SWQMP).

If "yes" is checked for any number in PART E, continue to PART F and check the box labeled "Priority Development Project".
If "no" is checked for every number in PART E, continue to PART F and check the box labeled "Standard Project".

1.	**New Development that creates 10,000 square feet or more of impervious surfaces collectively over the project site.** This includes commercial, industrial, residential, mixed-use, and public development projects on public or private land.	☐ Yes ☒ No
2.	**Redevelopment project that creates and/or replaces 5,000 square feet or more of impervious surfaces on an existing site of 10,000 square feet or more of impervious surfaces.** This includes commercial, industrial, residential, mixed-use, and public development projects on public or private land.	☒ Yes ☐ No
3.	**New development or redevelopment of a restaurant.** Facilities that sell prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC 5812), and where the land development creates and/or replace 5,000 square feet or more of impervious surface.	☒ Yes ☐ No
4.	**New development or redevelopment on a hillside.** The project creates and/or replaces 5,000 square feet or more of impervious surface (collectively over the project site) and where the development will grade on any natural slope that is twenty-five percent or greater.	☐ Yes ☒ No

Page 4 of 4 City of San Diego • Development Services Department • Storm Water Requirements Applicability Checklist	
5. **New development or redevelopment of a parking lot that creates and/or replaces 5,000 square feet or more of impervious surface (collectively over the project site).**	☒ Yes ☐ No
6. **New development or redevelopment of streets, roads, highways, freeways, and driveways.** The project creates and/or replaces 5,000 square feet or more of impervious surface (collectively over the project site).	☒ Yes ☐ No
7. **New development or redevelopment discharging directly to an Environmentally Sensitive Area.** The project creates and/or replaces 2,500 square feet of impervious surface (collectively over project site), and discharges directly to an Environmentally Sensitive Area (ESA). "Discharging- directly to" includes flow that is conveyed overland a distance of 200 feet or less from the project to the ESA, or conveyed in a pipe or open channel any distance as an isolated flow from the project to the ESA (i.e. not commingled with flows from adjacent lands).	☒ Yes ☐ No
8. **New development or redevelopment projects of a retail gasoline outlet that creates and/or replaces 5,000 square feet of impervious surface.** The development project meets the following criteria: (a) 5,000 square feet or more or (b) has a projected Average Daily Traffic of 100 or more vehicles per day.	☐ Yes ☒ No
9. **New development or redevelopment projects of an automotive repair shops that creates and/or replaces 5,000 square feet or more of impervious surfaces.** Development projects categorized in any one of Standard Industrial Classification (SIC) codes 5013, 5014, 5541, 7532-7534, or 7536-7539.	☐ Yes ☒ No
10. **Other Pollutant Generating Project.** The project is not covered in the categories above, results in the disturbance of one or more acres of land and is expected to generate pollutants post construction, such as fertilizers and pesticides. This does not include projects creating less than 5,000 sf of impervious surface and where added landscaping does not require regular use of pesticides and fertilizers, such as slope stabilization using native plants. Calculation of the square footage of impervious surface need not include linear pathways that are for infrequent vehicle use, such as emergency maintenance access or bicycle pedestrian use, if they are built with pervious surfaces of if they sheet flow to surrounding pervious surfaces.	☐ Yes ☒ No
PART F: Select the appropriate category based on the outcomes of PART C through PART E.	
1. The project is **NOT SUBJECT TO STORM WATER REQUIREMENTS.**	☐
2. The project is a **STANDARD PROJECT**. Site design and source control BMP requirements apply. See the Storm Water Standards Manual for guidance.	☐
3. The project is **PDP EXEMPT**. Site design and source control BMP requirements apply. See the Storm Water Standards Manual for guidance.	☐
4. The project is a **PRIORITY DEVELOPMENT PROJECT**. Site design, source control, and structural pollutant control BMP requirements apply. See the Storm Water Standards Manual for guidance on determining if project requires hydromodification management.	☒
Name of Owner or Agent *(Please Print)*: Pete Shearer	Title: Development Director
Signature: [signature]	Date: July 16, 2019

<table>
<tr><td colspan="2">Applicability of Permanent, Post-Construction Storm Water BMP Requirements
(Storm Water Intake Form for all Development Permit Applications)</td><td>**Form I-1**</td></tr>
<tr><td colspan="3">Project Identification</td></tr>
<tr><td colspan="3">Project Name: Riverwalk</td></tr>
<tr><td colspan="2">Permit Application Number: PTS 581984</td><td>Date: 4/7/20</td></tr>
<tr><td colspan="3">Determination of Requirements</td></tr>
<tr><td colspan="3">The purpose of this form is to identify permanent, post-construction requirements that apply to the project. This form serves as a short <u>summary</u> of applicable requirements, in some cases referencing separate forms that will serve as the backup for the determination of requirements.

Answer each step below, starting with Step 1 and progressing through each step until reaching "Stop".
Refer to Part 1 of Storm Water Standards sections and/or separate forms referenced in each step below.</td></tr>
<tr><td>Step</td><td>Answer</td><td>Progression</td></tr>
<tr><td rowspan="2">Step 1: Is the project a "development project"?
See Section 1.3 of the BMP Design Manual (Part 1 of Storm Water Standards) for guidance.</td><td>☒ Yes</td><td>Go to Step 2.</td></tr>
<tr><td>☐ No</td><td>Stop.
Permanent BMP requirements do not apply. No SWQMP will be required. Provide discussion below.</td></tr>
<tr><td colspan="3">Discussion / justification if the project is <u>not</u> a "development project" (e.g., the project includes <u>only</u> interior remodels within an existing building):</td></tr>
<tr><td rowspan="3">Step 2: Is the project a Standard Project, Priority Development Project (PDP), or exception to PDP definitions?
To answer this item, see Section 1.4 of the BMP Design Manual (Part 1 of Storm Water Standards) <u>in its entirety</u> for guidance, AND complete Storm Water Requirements Applicability Checklist.</td><td>☐ Standard Project</td><td>Stop.
Standard Project requirements apply.</td></tr>
<tr><td>☒ PDP</td><td>PDP requirements apply, including PDP SWQMP.
Go to Step 3.</td></tr>
<tr><td>☐ PDP Exempt</td><td>Stop.
Standard Project requirements apply. Provide discussion and list any additional requirements below.</td></tr>
<tr><td colspan="3">Discussion / justification, and additional requirements for exceptions to PDP definitions, if applicable:</td></tr>
</table>

Project Name: Riverwalk

Form I-1 Page 2		
Step	Answer	Progression
Step 3. Is the project subject to earlier PDP requirements due to a prior lawful approval? See Section 1.10 of the BMP Design Manual (Part 1 of Storm Water Standards) for guidance.	○ Yes	Consult the City Engineer to determine requirements. Provide discussion and identify requirements below. Go to Step 4.
	◉ No	BMP Design Manual PDP requirements apply. Go to Step 4.
Discussion / justification of prior lawful approval, and identify requirements (<u>not required if prior lawful approval does not apply</u>):		
Step 4. Do hydromodification control requirements apply? See Section 1.6 of the BMP Design Manual (Part 1 of Storm Water Standards) for guidance.	○ Yes	PDP structural BMPs required for pollutant control (Chapter 5) and hydromodification control (Chapter 6). Go to Step 5.
	◉ No	Stop. PDP structural BMPs required for pollutant control (Chapter 5) only. Provide brief discussion of exemption to hydromodification control below.
Discussion / justification if hydromodification control requirements do <u>not</u> apply: The project site is located within and immediately adjacent to the San Diego River. This segment of the San Diego River is hydromodification exempt per the October 1, 2015, "San Diego County Regional Watershed Management Area Analysis." The flowline at the storm drain discharge points serving the site will outlet into the main San Diego River channel, which is below FEMA's 10-year floodplain elevations. Therfore, the project will meet the hydromodification exemption criteria.		
Step 5. Does protection of critical coarse sediment yield areas apply? See Section 6.2 of the BMP Design Manual (Part 1 of Storm Water Standards) for guidance.	○ Yes	Management measures required for protection of critical coarse sediment yield areas (Chapter 6.2). Stop.
	◉ No	Management measures not required for protection of critical coarse sediment yield areas. Provide brief discussion below. Stop.
Discussion / justification if protection of critical coarse sediment yield areas does <u>not</u> apply: The site currently is fully developed, so there are no natural on-site coarse sediment yield areas. In addition, the site is not identified as containing critical coarse sediment yield areas on the San Diego County Regional WMAA.		

Project Name: Riverwalk

Site Information Checklist For PDPs	Form I-3B
Project Summary Information	
Project Name	Riverwalk
Project Address	1150 Fashion Valley Road, San Diego, CA 92108
Assessor's Parcel Number(s) (APN(s))	436-610-10, -29; 436-611-06, -29, -30; 436-650-14; 437-240-03, -26, -27, -28, -29;
Permit Application Number	PTS 581984
Project Watershed	Select One: ☐ San Dieguito River ☐ Penasquitos ☐ Mission Bay ☒ San Diego River ☐ San Diego Bay ☐ Tijuana River
Hydrologic subarea name with Numeric Identifier up to two decimal paces (9XX.XX)	Mission San Diego Hydrologic Subarea (907.11)
Project Area (total area of Assessor's Parcel(s) associated with the project or total area of the right-of-way)	Approx. 195 Acres ([SQFT] Square Feet)
Area to be disturbed by the project (Project Footprint)	94.15 (excluding park) Acres (--- Square Feet)
Project Proposed Impervious Area (subset of Project Footprint)	67.97 Acres (--- Square Feet)
Project Proposed Pervious Area (subset of Project Footprint)	26.18 Acres (--- Square Feet)
Note: Proposed Impervious Area + Proposed Pervious Area = Area to be Disturbed by the Project. This may be less than the Project Area.	
The proposed increase or decrease in impervious area in the proposed condition as compared to the pre-project condition.	>50% so 50% rule does not apply. %

Project Name: **Riverwalk**

Form I-3B Page 2 of 11
Description of Existing Site Condition and Drainage Patterns
Current Status of the Site (select all that apply): ☒ Existing development ☐ Previously graded but not built out ☐ Agricultural or other non-impervious use ☐ Vacant, undeveloped/natural Description / Additional Information: The site currently supports the Riverwalk Golf Club (27 holes with a clubhouse building and parking.
Existing Land Cover Includes (select all that apply): ☒ Vegetative Cover ☒ Non-Vegetated Pervious Areas ☒ Impervious Areas Description / Additional Information: Under existing conditions, the approximately 195-acre site is primarily pervious consisting of the golf course and associated landscaping. Non-vegetated pervious areas include sand traps and miscellaneous dirt areas. Impervious surfaces include parking lots, golf cart paths, sidewalks, hardscape, and a clubhouse.
Underlying Soil belongs to Hydrologic Soil Group (select all that apply): ☒ NRCS Type A ☒ NRCS Type B ☐ NRCS Type C ☒ NRCS Type D
Approximate Depth to Groundwater (GW): ○ GW Depth < 5 feet ◉ 5 feet < GW Depth < 10 feet ○ 10 feet < GW Depth < 20 feet ○ GW Depth > 20 feet
Existing Natural Hydrologic Features (select all that apply): ☒ Watercourses ☐ Seeps ☐ Springs ☒ Wetlands ☐ None Description / Additional Information: The San Diego River flows in a westerly direction through the site. The FEMA 100-year floodplain extends over the majority of the site south of the trolley line. Several wetland communities have been mapped at the site in the "General Survey Report, Biological Resources" by Michael Baker International, Inc. and Busby Biological Servics. The wetland communities including riparian forest, riparian scrub, freshwater marsh, and other wetlands.

Form I-3B Page 3 of 11
Description of Existing Site Topography and Drainage:
How is storm water runoff conveyed from the site? At a minimum, this description should answer: 1. Whether existing drainage conveyance is natural or urban; 2. If runoff from offsite is conveyed through the site? If yes, quantification of all offsite drainage areas, design flows, and locations where offsite flows enter the project site and summarize how such flows are conveyed through the site; 3. Provide details regarding existing project site drainage conveyance network, including storm drains, concrete channels, swales, detention facilities, storm water treatment facilities, and natural and constructed channels; 4. Identify all discharge locations from the existing project along with a summary of the conveyance system size and capacity for each of the discharge locations. Provide summary of the pre-project drainage areas and design flows to each of the existing runoff discharge locations.
Description / Additional Information:
The existing condition runoff north and south of the main river channel is described below. The main river channel flows westerly through the middle of the site. Under existing conditions, site runoff north of the river channel flows southerly in a series of landscape area drains and existing storm drain pipes as well as overland flow. An existing east-west trolley embankment splits the northerly portion. The area north of the trolley embankment discharges to the river via existing storm drain outfalls. The area south of the trolley embankment (but still north of the river), drains southerly via a combination of storm drains and, to a lesser degree, overland flow. The site receives a considerable amount of off-site run-on from Friars Road (northerly project boundary) and properties further to the north. The off-site flow is conveyed to the San Diego River via existing on-site storm drains. Site runoff south of the river drains northerly via a series of landscape area drains and existing storm drain and, to a lesser degree, as overland flow. Under existing and proposed conditions, a majority of the site runoff is discharged to the San Diego River via existing storm drain outfalls. Site runoff is discharged to the river at four location.

Form I-3B Page 4 of 11
Description of Proposed Site Development and Drainage Patterns
Project Description / Proposed Land Use and/or Activities: The Riverwalk project proposes an amendment to the existing Levi-Cushman Specific Plan to replace the 195-acre Riverwalk property with the Riverwalk Specific Plan and redevelop the existing golf course as a walkable, transit-centric, and modern live-work-play mixed-use neighborhood that features an expansive River Park along the San Diego River. The mix and quantity of land uses would change from what is approved in the existing Levi-Cushman Specific Plan to include 4,300 multi-family residential dwelling units; 152,000 square feet of commercial retail space; 1,000,000 square feet of office and non-retail commercial; approximately 95 acres of park, open space, and trails; adaptive reuse of the existing golf clubhouse into a community amenity; and a new Green Line Trolley stop within the development. Improvements to surrounding public infrastructure and roadways would be implemented as part of the Riverwalk project, including improvements to the Fashion Valley Road crossing of the San Diego River as a 10- to 15-year storm event crossing. Continued on Form I-3B Page 11 of 11.
List/describe proposed impervious features of the project (e.g., buildings, roadways, parking lots, courtyards, athletic courts, other impervious features): Proposed improvements include impervious surfaces typical of mixed residential and community development (including buildings, roadways, parking lots, walkways, courtyards, etc.).
List/describe proposed pervious features of the project (e.g., landscape areas): Pervious areas include decorative landscape, biofiltration basins, and a riverfront park.
Does the project include grading and changes to site topography? ◉ Yes ○ No Description / Additional Information: Fill will be required to raise finished floor elevations in order to comply with City and National Flood Insurance Program (NFIP) regulatory standards for development within FEMA mapped Special Flood Hazard Areas (SFHA). Lowering of areas in the floodplain will be used to avoid rises in water surface elevations.

Form I-3B Page 5 of 11

Does the project include changes to site drainage (e.g., installation of new storm water conveyance systems)?

- [x] Yes
- [ ] No

If yes, provide details regarding the proposed project site drainage conveyance network, including storm drains, concrete channels, swales, detention facilities, storm water treatment facilities, natural and constructed channels, and the method for conveying offsite flows through or around the proposed project site. Identify all discharge locations from the proposed project site along with a summary of the conveyance system size and capacity for each of the discharge locations. Provide a summary of pre and post-project drainage areas and design flows to each of the runoff discharge locations. Reference the drainage study for detailed calculations.

Description / Additional Information:

Under proposed conditions, off-site storm water will be conveyed to the San Diego River via storm drains consistent with existing conditions. The intent will be to avoid commingling off-site run-on within on-site runoff.

On-site runoff will be directed to on-site pollutant control BMPs (biofiltration basins and Bio Clean Environmental Services' Modular Wetland System (MWS) Linear units) prior to comingling with off-site flow. Storm drain outlets into the San Diego River are into the existing main river channel, so will be below the 10-year water surface elevations to qualify for a hydromodification exemption.

Form I-3B Page 6 of 11

Identify whether any of the following features, activities, and/or pollutant source areas will be present (select all that apply):

☒ On-site storm drain inlets
☒ Interior floor drains and elevator shaft sump pumps
☒ Interior parking garages
☒ Need for future indoor & structural pest control
☒ Landscape/Outdoor Pesticide Use
☒ Pools, spas, ponds, decorative fountains, and other water features
☒ Food service
☒ Refuse areas
☐ Industrial processes
☐ Outdoor storage of equipment or materials
☐ Vehicle and Equipment Cleaning
☐ Vehicle/Equipment Repair and Maintenance
☐ Fuel Dispensing Areas
☒ Loading Docks
☒ Fire Sprinkler Test Water
☒ Miscellaneous Drain or Wash Water
☒ Plazas, sidewalks, and parking lots
☐ Large Trash Generating Facilities
☐ Animal Facilities
☐ Plant Nurseries and Garden Centers
☐ Automotive-related Uses

Description / Additional Information:

The features, activities, and pollutant sources are those typically associated with mixed-use residential and community development.

Form I-3B Page 7 of 11
Identification and Narrative of Receiving Water
Narrative describing flow path from discharge location(s), through urban storm conveyance system, to receiving creeks, rivers, and lagoons and ultimate discharge location to Pacific Ocean (or bay, lagoon, lake or reservoir, as applicable) The project and tributary off-site flows will be conveyed to the San Diego River within the site by proposed (and existing, as applicable) storm drain systems.
Provide a summary of all beneficial uses of receiving waters downstream of the project discharge locations. The existing beneficial uses from the 2016 "Water Quality Control Plan for the San Diego Basin" (Mission San Diego Hydrologic Subarea 907.11) for inland surface waters include AGR, IND, REC1, REC2, BIOL, WARM, WILD, and RARE. The potential groundwater beneficial uses are AGR, IND, and PROC with a potential beneficial use of MUN. The San Diego River mouth has beneficial uses of REC1, REC2, COMM, EST, WILD, RARE, MAR, MIGR, SPWN, AND SHELL.
Identify all ASBS (areas of special biological significance) receiving waters downstream of the project discharge locations. N/A.
Provide distance from project outfall location to impaired or sensitive receiving waters. The project outfalls will be into the San Diego River, which flows within the site.
Sumarize information regarding the proximity of the permanent, post-construction storm water BMPs to the City's Multi-Habitat Planning Area and environmentally sensitive lands The project's environmental consultant, Alden Environmental, Inc., has defined the current MHPA within the site, which generally follows the main river channel.

Project Name: Riverwalk

Form I-3B Page 8 of 11		
Identification of Receiving Water Pollutants of Concern		
List any 303(d) impaired water bodies within the path of storm water from the project site to the Pacific Ocean (or bay, lagoon, lake or reservoir, as applicable), identify the pollutant(s)/stressor(s) causing impairment, and identify any TMDLs and/or Highest Priority Pollutants from the WQIP for the impaired water bodies:		
303(d) Impaired Water Body	Pollutant(s)/Stressor(s)	TMDLs/ WQIP Highest Priority Pollutant
San Diego River	Enterococcus, fecal coliform,	Per 2010 303(d), TMDL req'd,
	low dissolved oxygen,	but not completed
	manganese, nitrogen,	Per Jan. 2016 WQIP, Highest
	phosphorus, total dissolved	Priority Pollutant is bacteria.
	solids, and toxicity.	

Identification of Project Site Pollutants*			
*Identification of project site pollutants is only required if flow-thru treatment BMPs are implemented onsite in lieu of retention or biofiltration BMPs (note the project must also participate in an alternative compliance program unless prior lawful approval to meet earlier PDP requirements is demonstrated) Identify pollutants anticipated from the project site based on all proposed use(s) of the site (see BMP Design Manual (Part 1 of Storm Water Standards) Appendix B.6):			
Pollutant	Not Applicable to the Project Site	Anticipated from the Project Site	Also a Receiving Water Pollutant of Concern
Sediment	☐	☒	☐
Nutrients	☐	☒	☒
Heavy Metals	☐	☐	☒
Organic Compounds	☐	☒	☐
Trash & Debris	☐	☒	☐
Oxygen Demanding Substances	☐	☐	☒
Oil & Grease	☐	☒	☐
Bacteria & Viruses	☐	☐	☒
Pesticides	☐	☒	☐

Form I-3B Page 9 of 11
Hydromodification Management Requirements
Do hydromodification management requirements apply (see Section 1.6 of the BMP Design Manual)? ☐ Yes, hydromodification management flow control structural BMPs required. ☐ No, the project will discharge runoff directly to existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean. ☐ No, the project will discharge runoff directly to conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean. ☒ No, the project will discharge runoff directly to an area identified as appropriate for an exemption by the WMAA for the watershed in which the project resides. Description / Additional Information (to be provided if a 'No' answer has been selected above): The project runoff will be treated and conveyed to storm drain systems within the site. The storm drain systems will discharge directly into the San Diego River's main channel, which is exempt from hydromodification per the WMAA. The discharge flowlines will be lower than the FEMA 10-year floodplain elevations.
Critical Coarse Sediment Yield Areas* *This Section only required if hydromodification management requirements apply
Based on Section 6.2 and Appendix H does CCSYA exist on the project footprint or in the upstream area draining through the project footprint? ☐ Yes ☒ No, No critical coarse sediment yield areas to be protected based on WMAA maps Discussion / Additional Information: N/A. The project is hydromodification exempt.

Form I-3B Page 10 of 11
Flow Control for Post-Project Runoff* *This Section only required if hydromodification management requirements apply
List and describe point(s) of compliance (POCs) for flow control for hydromodification management (see Section 6.3.1). For each POC, provide a POC identification name or number correlating to the project's HMP Exhibit and a receiving channel identification name or number correlating to the project's HMP Exhibit. N/A. The project is hydromodification exempt.
Has a geomorphic assessment been performed for the receiving channel(s)? ☒ No, the low flow threshold is 0.1Q2 (default low flow threshold) ☐ Yes, the result is the low flow threshold is 0.1Q2 ☐ Yes, the result is the low flow threshold is 0.3Q2 ☐ Yes, the result is the low flow threshold is 0.5Q2 If a geomorphic assessment has been performed, provide title, date, and preparer: N/A.
Discussion / Additional Information: (optional) N/A.

Project Name: **Riverwalk**

Form I-3B Page 11 of 11
Other Site Requirements and Constraints
When applicable, list other site requirements or constraints that will influence storm water management design, such as zoning requirements including setbacks and open space, or local codes governing minimum street width, sidewalk construction, allowable pavement types, and drainage requirements. N/A.
Optional Additional Information or Continuation of Previous Sections As Needed
This space provided for additional information or continuation of information from previous sections as needed. Project description continued from Form I-3B Page 4 of 11: The project would also include a habitat restoration effort on-site to create and/or enhance 25.16 acres of native habitats along the San Diego River, within and adjacent to the MHPA, and setting aside area for establishing a future wetland habitat mitigation bank. The project would establish Irrevocable Offers of Dedication (IODs) for two Community Plan Circulation Element roadways envisioned in the Mission Valley Community Plan Update: future Riverwalk Street "J," which would cross the San Diego River in a north-south direction; and future Riverwalk Street "U," which would travel approximately east-west along the southern project site boundary and connect to future Street "J." Street "J" would be an elevated roadway crossing the river valley. Per the City's Planning Department, these roads are regional facilities with uncertain funding, design, and construction timing. While these improvements would not be constructed as part of the project, the project would grant the City IODs for the required rights-of-way to construct these roads in the future. .

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Project Name: **Riverwalk**

Source Control BMP Checklist for All Development Projects	Form I-4		
Source Control BMPs			
All development projects must implement source control BMPs SC-1 through SC-6 where applicable and feasible. See Chapter 4 and Appendix E of the BMP Design Manual (Part 1 of the Storm Water Standards) for information to implement source control BMPs shown in this checklist. Answer each category below pursuant to the following. • "Yes" means the project will implement the source control BMP as described in Chapter 4 and/or Appendix E of the BMP Design Manual. Discussion / justification is not required. • "No" means the BMP is applicable to the project but it is not feasible to implement. Discussion / justification must be provided. • "N/A" means the BMP is not applicable at the project site because the project does not include the feature that is addressed by the BMP (e.g., the project has no outdoor materials storage areas). Discussion / justification may be provided.			
Source Control Requirement	**Applied?**		
SC-1 Prevention of Illicit Discharges into the MS4	☒ Yes	☐ No	☐ N/A
Discussion / justification if SC-1 not implemented: N/A			
SC-2 Storm Drain Stenciling or Signage	☒ Yes	☐ No	☐ N/A
Discussion / justification if SC-2 not implemented: N/A			
SC-3 Protect Outdoor Materials Storage Areas from Rainfall, Run-On, Runoff, and Wind Dispersal	☐ Yes	☐ No	☒ N/A
Discussion / justification if SC-3 not implemented: N/A			
SC-4 Protect Materials Stored in Outdoor Work Areas from Rainfall, Run-On, Runoff, and Wind Dispersal	☐ Yes	☐ No	☒ N/A
Discussion / justification if SC-4 not implemented: N/A			
SC-5 Protect Trash Storage Areas from Rainfall, Run-On, Runoff, and Wind Dispersal	☒ Yes	☐ No	☐ N/A
Discussion / justification if SC-5 not implemented: N/A			

Project Name: **Riverwalk**

Form I-4 Page 2 of 2	
Source Control Requirement	Applied?
SC-6 Additional BMPs Based on Potential Sources of Runoff Pollutants (must answer for each source listed below)	
On-site storm drain inlets	◉ Yes ○ No ○ N/A
Interior floor drains and elevator shaft sump pumps	◉ Yes ○ No ○ N/A
Interior parking garages	◉ Yes ○ No ○ N/A
Need for future indoor & structural pest control	◉ Yes ○ No ○ N/A
Landscape/Outdoor Pesticide Use	◉ Yes ○ No ○ N/A
Pools, spas, ponds, decorative fountains, and other water features	◉ Yes ○ No ○ N/A
Food service	◉ Yes ○ No ○ N/A
Refuse areas	◉ Yes ○ No ○ N/A
Industrial processes	○ Yes ○ No ◉ N/A
Outdoor storage of equipment or materials	○ Yes ○ No ◉ N/A
Vehicle/Equipment Repair and Maintenance	○ Yes ○ No ◉ N/A
Fuel Dispensing Areas	○ Yes ○ No ◉ N/A
Loading Docks	◉ Yes ○ No ○ N/A
Fire Sprinkler Test Water	◉ Yes ○ No ○ N/A
Miscellaneous Drain or Wash Water	◉ Yes ○ No ○ N/A
Plazas, sidewalks, and parking lots	◉ Yes ○ No ○ N/A
SC-6A: Large Trash Generating Facilities	○ Yes ○ No ◉ N/A
SC-6B: Animal Facilities	○ Yes ○ No ◉ N/A
SC-6C: Plant Nurseries and Garden Centers	○ Yes ○ No ◉ N/A
SC-6D: Automotive-related Uses	○ Yes ○ No ◉ N/A
Discussion / justification if SC-6 not implemented. Clearly identify which sources of runoff pollutants are discussed. Justification must be provided for <u>all</u> "No" answers shown above. N/A.	

Project Name: Riverwalk

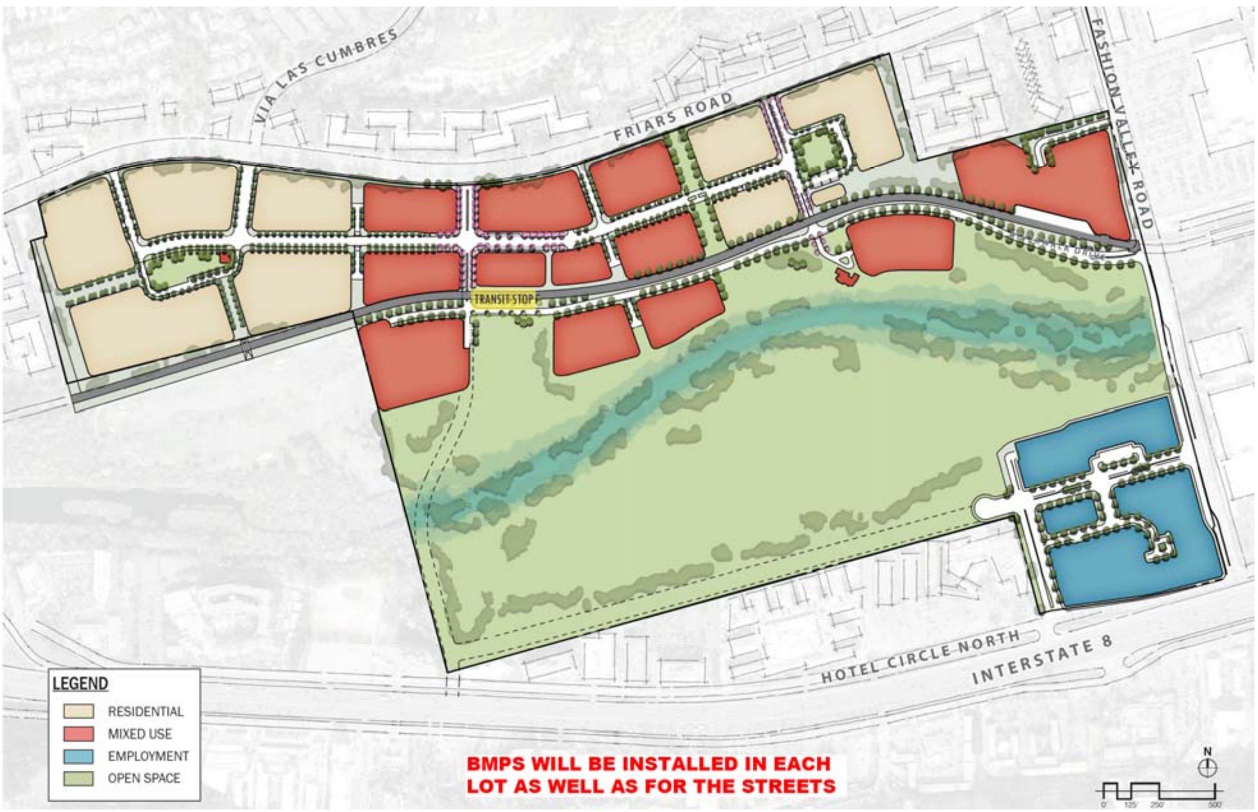
Site Design BMP Checklist for All Development Projects			Form I-5
Site Design BMPs			
All development projects must implement site design BMPs SD-1 through SD-8 where applicable and feasible. See Chapter 4 and Appendix E of the BMP Design Manual (Part 1 of Storm Water Standards) for information to implement site design BMPs shown in this checklist. Answer each category below pursuant to the following. • "Yes" means the project will implement the site design BMP as described in Chapter 4 and/or Appendix E of the BMP Design Manual. Discussion / justification is not required. • "No" means the BMP is applicable to the project but it is not feasible to implement. Discussion / justification must be provided. • "N/A" means the BMP is not applicable at the project site because the project does not include the feature that is addressed by the BMP (e.g., the project site has no existing natural areas to conserve). Discussion / justification may be provided. A site map with implemented site design BMPs must be included at the end of this checklist.			
Site Design Requirement	Applied?		
SD-1 Maintain Natural Draiange Pathways and Hydrologic Features	◉ Yes	☐ No	☐ N/A
Discussion / justification if SD-1 not implemented:			
1-1 Are existing natural drainage pathways and hydrologic features mapped on the site map?	◉ Yes	☐ No	☐ N/A
1-2 Are street trees implemented? If yes, are they shown on the site map?	◉ Yes	☐ No	☐ N/A
1-3 Implemented street trees meet the design criteria in SD-1 Fact Sheet (e.g. soil volume, maximum credit, etc.)?	◉ Yes	☐ No	☐ N/A
1-4 Is street tree credit volume calculated using Appendix B.2.2.1 and SD-1 Fact Sheet in Appendix E?	◉ Yes	☐ No	☐ N/A
SD-2 Have natural areas, soils and vegetation been conserved?	☐ Yes	☐ No	◉ N/A
Discussion / justification if SD-2 not implemented: The current project submittal is for a Vesting Tentative Map (VTM 2213361). All DMAs are being treated by biofiltration basins or Modular Wetland System Linear BMPs except DMA 78 near the southeast corner of the site. Per Walter Gefrom, street trees will be used to treat this area. Calculations are included in Attachment 1e.			

Project Name: Riverwalk

Form I-5 Page 2 of 4			
Site Design Requirement	Applied?		
SD-3 Minimize Impervious Area	◉ Yes	○ No	○ N/A
Discussion / justification if SD-3 not implemented:			
SD-4 Minimize Soil Compaction	◉ Yes	○ No	○ N/A
Discussion / justification if SD-4 not implemented:			
SD-5 Impervious Area Dispersion	◉ Yes	○ No	○ N/A
Discussion / justification if SD-5 not implemented: The current project submittal is for a Vesting Tentative Map (VTM 2213361). Dispersion areas are not included on the VTM-level plans, but could be utilized in the future as the design progresses. Dispersion requirements will be met for areas using compact biofiltration BMPs, e.g., Modular Wetland System Linear BMPs.			
5-1 Is the pervious area receiving runon from impervious area identified on the site map?	◉ Yes	○ No	
5-2 Does the pervious area satisfy the design criteria in SD-5 Fact Sheet in Appendix E (e.g. maximum slope, minimum length, etc.)	◉ Yes	○ No	
5-3 Is impervious area dispersion credit volume calculated using Appendix B.2.1.1 and SD-5 Fact Sheet in Appendix E?	◉ Yes	○ No	

Form I-5 Page 3 of 4				
Site Design Requirement		Applied?		
SD-6 Runoff Collection		**(selected) Yes**	No	N/A
Discussion / justification if SD-6 not implemented: The current project submittal is for a Vesting Tentative Map (VTM 2213361). Permeable pavement is not included on the VTM-level plans, but will likely be utilized in the future in some areas as the design progresses. Credit may or may not be taken for the permeable pavement.				
6a-1	Are green roofs implemented in accordance with design criteria in SD-6A Fact Sheet? If yes, are they shown on the site map?	Yes	No	**(selected) N/A**
6a-2	Is green roof credit volume calculated using Appendix B.2.1.2 and SD-6A Fact Sheet in Appendix E?	Yes	No	**(selected) N/A**
6b-1	Are permeable pavements implemented in accordance with design criteria in SD-6B Fact Sheet? If yes, are they shown on the site map?	**(selected) Yes**	No	N/A
6b-2	Is permeable pavement credit volume calculated using Appendix B.2.1.3 and SD-6B Fact Sheet in Appendix E?	Yes	No	**(selected) N/A**
SD-7 Landscaping with Native or Drought Tolerant Species		**(selected) Yes**	No	N/A
Discussion / justification if SD-7 not implemented:				
SD-8 Harvesting and Using Precipitation		Yes	**(selected) No**	N/A
Discussion / justification if SD-8 not implemented: Harvest and use is anticipated to be infeasible per Form I-7 from the City "Storm Water Standards, Part 1: BMP Design Manual - Appendices." The harvest and use assessment is included in Attachment 1c.				
8-1	Are rain barrels implemented in accordance with design criteria in SD-8 Fact Sheet? If yes, are they shown on the site map?	Yes	No	**(selected) N/A**
8-2	Is rain barrel credit volume calculated using Appendix B.2.2.2 and SD-8 Fact Sheet in Appendix E?	Yes	No	**(selected) N/A**

Form I-5 Page 4 of 4
Insert Site Map with all site design BMPs identified:



Project Name: **Riverwalk**

Summary of PDP Structural BMPs	Form I-6
PDP Structural BMPs	

All PDPs must implement structural BMPs for storm water pollutant control (see Chapter 5 of the BMP Design Manual, Part 1 of Storm Water Standards). Selection of PDP structural BMPs for storm water pollutant control must be based on the selection process described in Chapter 5. PDPs subject to hydromodification management requirements must also implement structural BMPs for flow control for hydromodification management (see Chapter 6 of the BMP Design Manual). Both storm water pollutant control and flow control for hydromodification management can be achieved within the same structural BMP(s).

PDP structural BMPs must be verified by the City at the completion of construction. This includes requiring the project owner or project owner's representative to certify construction of the structural BMPs (complete Form DS-563). PDP structural BMPs must be maintained into perpetuity (see Chapter 7 of the BMP Design Manual).

Use this form to provide narrative description of the general strategy for structural BMP implementation at the project site in the box below. Then complete the PDP structural BMP summary information sheet (page 3 of this form) for each structural BMP within the project (copy the BMP summary information page as many times as needed to provide summary information for each individual structural BMP).

Describe the general strategy for structural BMP implementation at the site. This information must describe how the steps for selecting and designing storm water pollutant control BMPs presented in Section 5.1 of the BMP Design Manual were followed, and the results (type of BMPs selected). For projects requiring hydromodification flow control BMPs, indicate whether pollutant control and flow control BMPs are integrated or separate.

The project must meet pollutant control requirements. The City of San Diego's October 1, 2018 "Storm Water Standards" outlines steps in selecting structural BMPs. Harvest and use is considered first. As discussed in SD-8 above and in Attachment 1c, harvest and use is not feasible for the project.

Infiltration is considered next. The project's geotechnical engineer, NMG Geotechnical, Inc., has determined that full infiltration is infeasible because the design infiltration rates are between 0.01 and 0.50 inches per hour, which is below the City's reliable full infiltration rates (see Attachment 6). Partial infiltration is also infeasible because the fill thickness and BMP groundwater separation will not meet City requirements. Furthermore, NMG has concerns with long-term seepage, drainage problems, and liquefaction associated with full or partial infiltration.

The next BMP in the hierarchy is biofiltration. The project currently proposes a series of biofiltration basins throughout the development area. These will serve as pollutant control BMPs for the mixed-use development lots and streets. Conceptual sizing of the biofiltration basins is provided in this SWQMP for the VTM submittal. In addition, TAPE-certified devices (e.g., Modular Wetland System Linear or equivalent) will be incorporated into the design along with the required dispersion area where biofiltration basins are not feasible.

There is a street area shown on the DMA Exhibit (DMA 78) where street trees will be used.

(Continue on page 2 as necessary.)

Form I-6 Page 2 of X
(Page reserved for continuation of description of general strategy for structural BMP implementation at the site)
(Continued from page 1)

Form I-6 Page 3 of X (Copy as many as needed)	
Structural BMP Summary Information	
Structural BMP ID No. Biofiltration Basin 1-61	
Construction Plan Sheet No. Vesting Tentative Map sheets 8, 9 and 10	
Type of structural BMP: ☐ Retention by harvest and use (HU-1) ☐ Retention by infiltration basin (INF-1) ☐ Retention by bioretention (INF-2) ☐ Retention by permeable pavement (INF-3) ☐ Partial retention by biofiltration with partial retention (PR-1) ☒ Biofiltration (BF-1) ☐ Flow-thru treatment control with prior lawful approval to meet earlier PDP requirements (provide (BMP type/description in discussion section below) ☐ Flow-thru treatment control included as pre-treatment/forebay for an onsite retention or biofiltration BMP (provide BMP type/description and indicate which onsite retention or biofiltration BMP it serves in discussion section below) ☐ Flow-thru treatment control with alternative compliance (provide BMP type/description in ☐ Detention pond or vault for hydromodification management ☐ Other (describe in discussion section below)	
Purpose: ☒ Pollutant control only ☐ Hydromodification control only ☐ Combined pollutant control and hydromodification control ☐ Pre-treatment/forebay for another structural BMP ☐ Other (describe in discussion section below)	
Who will certify construction of this BMP? Provide name and contact information for the party responsible to sign BMP verification form DS-563	TBD
Who will be the final owner of this BMP?	SD Riverwalk, LLC (developer), 4747 Executive Drive, Suite 410, San Diego, CA 92121, (858) 435-4000
Who will maintain this BMP into perpetuity?	SD Riverwalk, LLC
What is the funding mechanism for maintenance?	SD Riverwalk, LLC

Form I-6 Page 4 of X (Copy as many as needed)
Structural BMP ID No. Biofiltration Basins 1-61
Construction Plan Sheet No. Vesting Tentative Map sheets 8, 9, and 10
Discussion (as needed): Conceptual sizing of biofiltration basins has been performed for this VTM submittal. The required basin area for each lot has been determined based on conceptual impervious and pervious footprints. This was done to verify feasiblity of setting aside the required BMP area. As the design progresses to the final engineering stages, additional basins can be incorporated into each lot. The BMPs will be established based on the building (roof), grading, and landscaping design. Since this is a preliminary SWQMP, all of the proposed bioifiltration basins are combined in one Form I-6. During final engineering, a separate Form I-6 will be provided for each structural BMP.

Project Name: Riverwalk

Form I-6 Page 3 of X (Copy as many as needed)	
Structural BMP Summary Information	
Structural BMP ID No. Modular Wetland System Linear 62-77	
Construction Plan Sheet No. Vesting Tentative Map sheets 8, 9 and 10	
Type of structural BMP: ☐ Retention by harvest and use (HU-1) ☐ Retention by infiltration basin (INF-1) ☐ Retention by bioretention (INF-2) ☐ Retention by permeable pavement (INF-3) ☐ Partial retention by biofiltration with partial retention (PR-1) ☐ Biofiltration (BF-1) ☒ Flow-thru treatment control with prior lawful approval to meet earlier PDP requirements (provide (BMP type/description in discussion section below) ☐ Flow-thru treatment control included as pre-treatment/forebay for an onsite retention or biofiltration BMP (provide BMP type/description and indicate which onsite retention or biofiltration BMP it serves in discussion section below) ☐ Flow-thru treatment control with alternative compliance (provide BMP type/description in ☐ Detention pond or vault for hydromodification management ☐ Other (describe in discussion section below)	
Purpose: ☒ Pollutant control only ☐ Hydromodification control only ☐ Combined pollutant control and hydromodification control ☐ Pre-treatment/forebay for another structural BMP ☐ Other (describe in discussion section below)	
Who will certify construction of this BMP? Provide name and contact information for the party responsible to sign BMP verification form DS-563	TBD
Who will be the final owner of this BMP?	SD Riverwalk, LLC (developer), 4747 Executive Drive, Suite 410, San Diego, CA 92121, (858) 435-4000
Who will maintain this BMP into perpetuity?	SD Riverwalk, LLC
What is the funding mechanism for maintenance?	SD Riverwalk, LLC

Form I-6 Page 4 of X (Copy as many as needed)
Structural BMP ID No. Modular Wetland System Linear 62-77
Construction Plan Sheet No. Vesting Tentative Map sheets 8, 9, and 10
Discussion (as needed): Conceptual sizing of MWS Linear BMPs has been performed for this VTM submittal. The BMPs are proposed for street areas where biofiltration basins are not feasible. Since this is a preliminary SWQMP, all of the proposed MWS Linear BMPs are combined in one Form I-6. During final engineering, a separate Form I-6 will be provided for each structural BMP.

Project Name: Riverwalk

THE CITY OF SAN DIEGO	City of San Diego **Development Services** 1222 First Ave., MD-302 San Diego, CA 92101 (619) 446-5000	**Permenant BMP Construction** **Self Certification Form**	FORM DS-563 January 2016

Date Prepared: December 6, 2019	Project No.: PTS 581984
Project Applicant: SD Riverwalk, LLC	Phone: (858) 435-4000
Project Address: 4747 Executive Drive, Suite 410, San Diego, CA 92121	
Project Engineer: TBD	Phone: TBD

The purpose of this form is to verify that the site improvements for the project, identified above, have been constructed in conformance with the approved Storm Water Quality Management Plan (SWQMP) documents and drawings.

This form must be completed by the engineer and submitted prior to final inspection of the construction permit. Completion and submittal of this form is required for all new development and redevelopment projects in order to comply with the City's Storm Water ordinances and NDPES Permit Order No. R9-2013-0001 as amended by R9-2015-0001 and R9-2015-0100. Final inspection for occupancy and/or release of grading or public improvement bonds may be delayed if this form is not submitted and approved by the City of San Diego.

CERTIFICATION:
As the professional in responsible charge for the design of the above project, I certify that I have inspected all constructed Low Impact Development (LID) site design, source control and structural BMP's required per the approved SWQMP and Construction Permit No. Click here to enter text.; and that said BMP's have been constructed in compliance with the approved plans and all applicable specifications, permits, ordinances and Order No. R9-2013-0001 as amended by R9-2015-0001 and R9-2015-0100 of the San Diego Regional Water Quality Control Board.

I understand that this BMP certification statement does not constitute an operation and maintenance verification.

Signature: ________________________________

Date of Signature: _ TBD__

Printed Name: _TBD_

Title: _TBD_

Phone No. _TBD_

Engineer's Stamp

DS-563 (12-15)

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ATTACHMENT 1
BACKUP FOR PDP POLLUTANT CONTROL BMPS

This is the cover sheet for Attachment 1.

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Project Name: **Riverwalk**

Indicate which Items are Included:

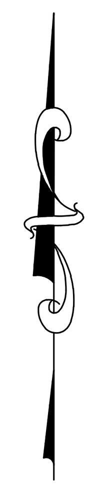
Attachment Sequence	Contents	Checklist
Attachment 1a	DMA Exhibit (Required) See DMA Exhibit Checklist.	☒ Included
Attachment 1b	Tabular Summary of DMAs Showing DMA ID matching DMA Exhibit, DMA Area, and DMA Type (Required)* *Provide table in this Attachment OR on DMA Exhibit in Attachment 1a	◉ Included on DMA Exhibit in Attachment 1a ○ Included as Attachment 1b, separate from DMA Exhibit
Attachment 1c	Form I-7, Harvest and Use Feasibility Screening Checklist (Required unless the entire project will use infiltration BMPs) Refer to Appendix B.3-1 of the BMP Design Manual to complete Form I-7.	◉ Included ○ Not included because the entire project will use infiltration BMPs
Attachment 1d	Form I-8, Categorization of Infiltration Feasibility Condition (Required unless the project will use harvest and use BMPs) Refer to Appendices C and D of the BMP Design Manual to complete Form I-8.	◉ Included ○ Not included because the entire project will use harvest and use BMPs
Attachment 1e	Pollutant Control BMP Design Worksheets / Calculations (Required) Refer to Appendices B and E of the BMP Design Manual for structural pollutant control BMP design guidelines and site design credit calculations	☒ Included

Project Name: Riverwalk

Use this checklist to ensure the required information has been included on the DMA Exhibit:

The DMA Exhibit must identify:

☒ Underlying hydrologic soil group
☒ Approximate depth to groundwater
☒ Existing natural hydrologic features (watercourses, seeps, springs, wetlands)
☒ Critical coarse sediment yield areas to be protected
☒ Existing topography and impervious areas
☒ Existing and proposed site drainage network and connections to drainage offsite
☒ Proposed grading
☒ Proposed impervious features
☒ Proposed design features and surface treatments used to minimize imperviousness
☒ Drainage management area (DMA) boundaries, DMA ID numbers, and DMA areas (square footage or acreage), and DMA type (i.e., drains to BMP, self-retaining, or self-mitigating)
☒ Potential pollutant source areas and corresponding required source controls (see Chapter 4, Appendix E.1, and Form I-3B)
☒ Structural BMPs (identify location, type of BMP, and size/detail)



GRAPHIC SCALE

200 0 100 200 400

1 INCH = 200 FEET

NOTES:

BIOFILTRATION BASINS WILL BE USED IN EACH LOT TO MEET POLLUTANT CONTROL REQUIREMENTS BASED ON THE LOT SIZE AND IMPERVIOUS/PERVIOUS AREAS. THE BASINS REPRESENTED HEREON ARE INTENDED TO DEMONSTRATE FEASIBILITY FOR THE TENTATIVE MAP. DURING FINAL ENGINEERING, MULTIPLE BIOFILTRATION BASINS CAN BE PROPOSED WITHIN EACH LOT BASED ON THE BUILDING (ROOF), GRADING, AND LANDSCAPING DESIGN. MODULAR WETLAND SYSTEM LINEAR BMPS AND STREETS PER SD-A FACT SHEET WILL BE USED FOR SOME OF THE STREET AREAS WHERE BIOFILTRATION IS NOT FEASIBLE.

THE UNDERLYING HYDROLOGIC SOIL GROUP IS PRIMARILY A. HYDROLOGIC SOIL GROUP D EXISTS ALONG THE MAIN RIVER CHANNEL AND ALONG FRIARS ROAD. THERE IS A SMALL SLIVER OF HYDROLOGIC SOIL GROUP B ALONG THE SOUTHWESTERLY PORTION OF THE SITE.

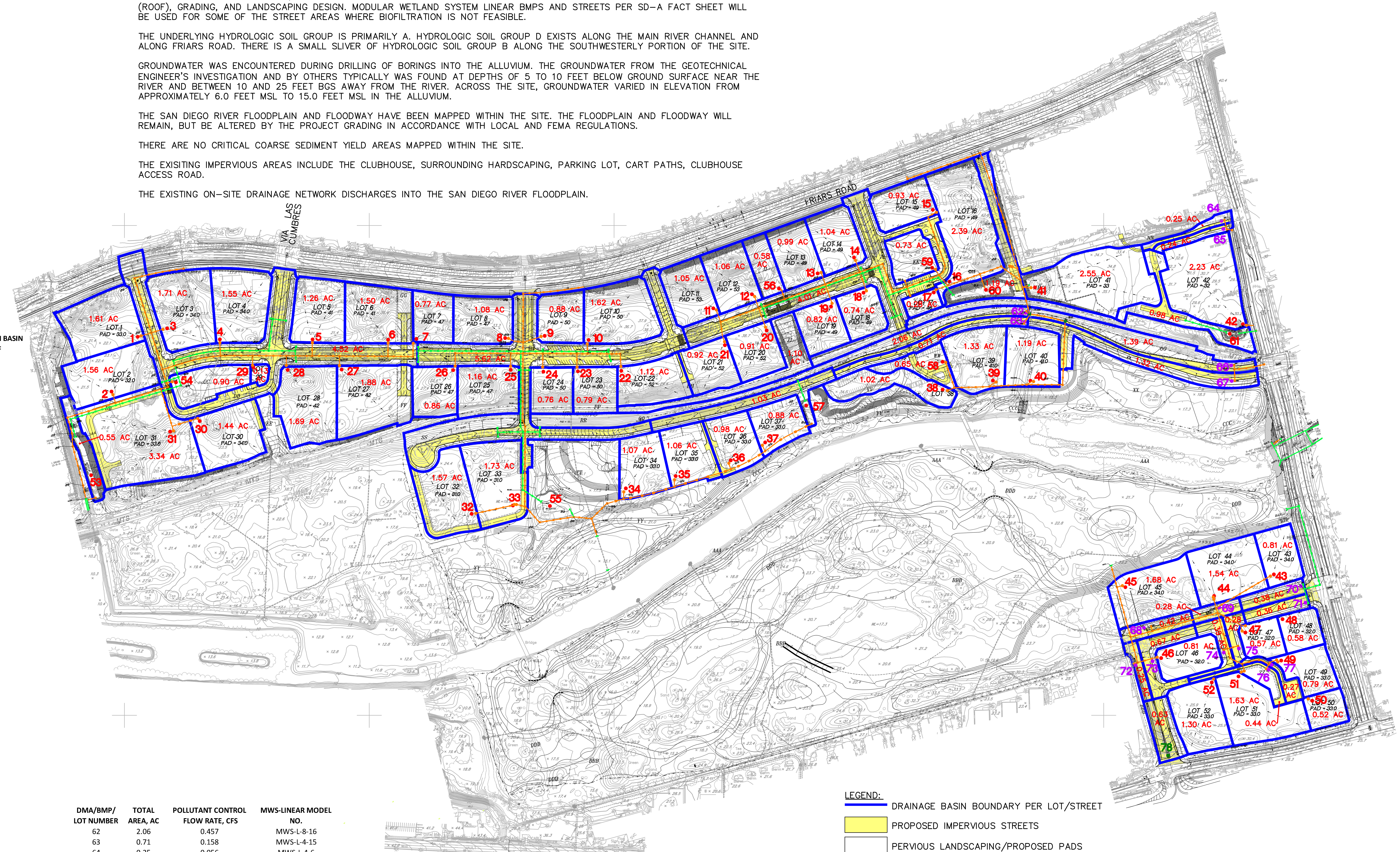
GROUNDWATER WAS ENCOUNTERED DURING DRILLING OF BORINGS INTO THE ALLUVIUM. THE GROUNDWATER FROM THE GEOTECHNICAL ENGINEER'S INVESTIGATION AND BY OTHERS TYPICALLY WAS FOUND AT DEPTHS OF 5 TO 10 FEET BELOW GROUND SURFACE NEAR THE RIVER AND BETWEEN 10 AND 25 FEET BGS AWAY FROM THE RIVER. ACROSS THE SITE, GROUNDWATER VARIED IN ELEVATION FROM APPROXIMATELY 6.0 FEET MSL TO 15.0 FEET MSL IN THE ALLUVIUM.

THE SAN DIEGO RIVER FLOODPLAIN AND FLOODWAY HAVE BEEN MAPPED WITHIN THE SITE. THE FLOODPLAIN AND FLOODWAY WILL REMAIN, BUT BE ALTERED BY THE PROJECT GRADING IN ACCORDANCE WITH LOCAL AND FEMA REGULATIONS.

THERE ARE NO CRITICAL COARSE SEDIMENT YIELD AREAS MAPPED WITHIN THE SITE.

THE EXISITING IMPERVIOUS AREAS INCLUDE THE CLUBHOUSE, SURROUNDING HARDSCAPING, PARKING LOT, CART PATHS, CLUBHOUSE ACCESS ROAD.

THE EXISTING ON-SITE DRAINAGE NETWORK DISCHARGES INTO THE SAN DIEGO RIVER FLOODPLAIN.



DMA/BMP/LOT NUMBER	PERVIOUS AREA, AC	IMPERVIOUS AREA, AC	TOTAL AREA, AC	BIOFILTRATION BASIN AREA, SF
1	0.48	1.13	1.61	1,388
2	0.47	1.09	1.56	1,347
3	0.51	1.20	1.71	1,475
4	0.46	1.08	1.55	1,333
5	0.38	0.88	1.26	1,087
6	0.45	1.05	1.50	1,290
7	0.23	0.54	0.77	665
8	0.32	0.75	1.08	928
9	0.27	0.62	0.88	762
10	0.49	1.13	1.62	1,395
11	0.31	0.73	1.05	905
12	0.32	0.74	1.06	917
13	0.30	0.69	0.99	855
14	0.31	0.73	1.04	901
15	0.28	0.65	0.93	806
16	0.72	1.67	2.39	2,060
17	0.08	0.20	0.28	240
18	0.22	0.52	0.74	635
19	0.25	0.57	0.82	707
20	0.27	0.64	0.91	787
21	0.28	0.64	0.92	793
22	0.34	0.79	1.12	969
23	0.24	0.55	0.79	679
24	0.23	0.53	0.76	651
25	0.35	0.82	1.16	1,004
26	0.26	0.60	0.86	738
27	0.56	1.32	1.88	1,622
28	0.51	1.18	1.69	1,455
29	0.04	0.09	0.13	113
30	0.43	1.00	1.44	1,238
31	1.00	2.34	3.34	2,882
32	0.47	1.10	1.57	1,355
33	0.52	1.21	1.73	1,494
34	0.32	0.75	1.07	922
35	0.32	0.74	1.06	915
36	0.29	0.68	0.98	841
37	0.26	0.61	0.88	757
38	0.31	0.71	1.02	881
39	0.40	0.93	1.33	1,148
40	0.36	0.84	1.19	1,030
41	0.77	1.79	2.55	2,200
42	0.67	1.56	2.23	1,923
43	0.16	0.64	0.81	779
44	0.31	1.24	1.54	1,494
45	0.34	1.34	1.68	1,622
46	0.16	0.65	0.81	782
47	0.11	0.46	0.57	556
48	0.12	0.47	0.58	564
49	0.16	0.63	0.79	764
50	0.10	0.41	0.52	499
51	0.33	1.30	1.63	1,577
52	0.26	1.04	1.30	1,258
53	1.01	4.06	5.07	4,908
54	0.72	0.18	0.90	306
55	1.12	4.49	5.62	5,431
56	0.46	0.12	0.58	197
57	0.21	0.83	1.03	1,000
58	0.19	0.45	0.65	557
59	0.58	0.15	0.73	247
60	1.56	3.64	5.20	4,482
61	0.29	0.68	0.98	841

BIOFILTRATION BASIN SIZING

DMA/BMP/ LOT NUMBER	TOTAL AREA, AC	POLLUTANT CONTROL FLOW RATE, CFS	MWS-LINEAR MODEL NO.
62	2.06	0.457	MWS-L-8-16
63	0.71	0.158	MWS-L-4-15
64	0.25	0.056	MWS-L-4-6
65	0.24	0.053	MWS-L-4-6
66	1.39	0.309	MWS-L-8-12
67	1.32	0.293	MWS-L-8-12
68	0.42	0.093	MWS-L-4-8
69	0.28	0.062	MWS-L-4-6
70	0.38	0.084	MWS-L-4-8
71	0.36	0.080	MWS-L-4-8
72	0.25	0.056	MWS-L-4-6
73	0.67	0.149	MWS-L-4-15
74	0.40	0.089	MWS-L-4-8
75	0.28	0.062	MWS-L-4-6
76	0.44	0.098	MWS-L-4-8
77	0.27	0.060	MWS-L-4-6

MODULAR WETLAND SIZING

LEGEND:

- DRAINAGE BASIN BOUNDARY PER LOT/STREET
- PROPOSED IMPERVIOUS STREETS
- PERVIOUS LANDSCAPING/PROPOSED PADS
- PROPOSED DRAINAGE SYSTEM FOR LOTS
- PROPOSED DRAINAGE SYSTEM FOR STREETS
- •2 PROPOSED BIOFILTRATION BASIN
- •2 PROPOSED MODULAR WETLAND SYSTEM LINEAR
- •2 PROPOSED STREET TREES

ATTACHMENT 1A AND 1B

GRAPHIC SCALE

200 0 100 200 400

1 INCH = 200 FEET

NOTE:
STORM RUNOFF FROM ALL DRAINAGE SUBAREAS DELINEATED HEREON ARE TREATED BY EITHER A BIOFILTRATION BASIN, MODULAR WETLANDS SYSTEM LINEAR, OR TREES (PER SD-A).

BIOFILTRATION BASINS ARE USED ON EACH PROPOSED DEVELOPMENT LOT AND ADJACENT AREA (LOT/DMAs 1 THROUGH 52, 54, 56, 58, 59, AND 61).

BIOFILTRATION BASINS ARE ALSO USED TO TREAT STREET AREAS (STREETS AND ADJACENT TRIBUTARY AREAS), WHERE FEASIBLE. THESE STREET AREAS ARE WITHIN DMAs 53, 55, 57, AND 60, AND ARE SHADED PER THE LEGEND ON THIS SHEET.

THE REMAINING STREET AREAS (DMAs 62 THROUGH 77), EXCEPT DMA 78, ARE TREATED BY A MODULAR WETLANDS SYSTEM LINEAR.

THE STREET AREA TRIBUTARY TO DMA 78 WILL INCORPORATE TREES PER SD-A AS A DCV OFFSET. THIS APPROACH WAS ACCEPTED BY CITY STAFF.

LEGEND:

- DRAINAGE BASIN BOUNDARY PER LOT/STREET
- PERVIOUS LANDSCAPING/PROPOSED PADS
- PROPOSED DRAINAGE SYSTEM FOR LOTS
- PROPOSED DRAINAGE SYSTEM FOR STREETS
- •2 PROPOSED BIOFILTRATION BASIN
- •2 PROPOSED MODULAR WETLAND SYSTEM LINEAR
- •2 PROPOSED STREET TREES
- PROPOSED STREET AREAS TRIBUTARY TO BIOFILTRATION BASIN 53
- PROPOSED STREET AREAS TRIBUTARY TO BIOFILTRATION BASIN 55
- PROPOSED STREET AREAS TRIBUTARY TO BIOFILTRATION BASIN 57
- PROPOSED STREET AREAS TRIBUTARY TO BIOFILTRATION BASIN 60

ATTACHMENT 1A AND 1B

Attachment 1c

<table>
<tr><th colspan="2">Harvest and Use Feasibility Checklist</th><th>Form I-7</th></tr>
<tr><td colspan="3">1. Is there a demand for harvested water (check all that apply) at the project site that is reliably present during the wet season?
☐ Toilet and urinal flushing
☐ Landscape irrigation
☐ Other:______________</td></tr>
<tr><td colspan="3">2. If there is a demand; estimate the anticipated average wet season demand over a period of 36 hours. Guidance for planning level demand calculations for toilet/urinal flushing and landscape irrigation is provided in Section B.3.2.
[Provide a summary of calculations here]
The overall project DCV is on attached Worksheet B.2-1 and is 125,435 cubic feet or 938,319 gallons, and 0.25DCV is 234,580 gallons. Items 3a to 3c below indicate that the 36 hour demand is compared to DCV to assess harvest and use feasibility. The demand from attached Table B.3-1 is 9.3 gallons per resident per day (24 hours) and 7 gallons per employee per day, or 14 and 10.5 gallons per 36 hours, respectively. In order for the residential demand to exceed 0.25DCV, the site must have 16,756 residents (234,580/14=16,756). Similarly, in order for the employee demand to exceed 0.25DCV, the site must have 22,341 employees (234,580/10.5=22,341). Since the project will be mixed-use, there will be some combination of residents and employees. The total amount will not exceed the 0.25DCV values, so harvest and use will be infeasible.</td></tr>
<tr><td colspan="3">3. Calculate the DCV using worksheet B-2.1.
DCV = 125,435 (cubic feet) See attached for DCV analysis.</td></tr>
<tr><td>3a. Is the 36 hour demand greater than or equal to the DCV?
☐ Yes / ☒ No ⇨
⇩</td><td>3b. Is the 36 hour demand greater than 0.25DCV but less than the full DCV?
☐ Yes / ☒ No ⇨
⇩</td><td>3c. Is the 36 hour demand less than 0.25DCV?
☒ Yes
⇩</td></tr>
<tr><td>Harvest and use appears to be feasible. Conduct more detailed evaluation and sizing calculations to confirm that DCV can be used at an adequate rate to meet drawdown criteria.</td><td>Harvest and use may be feasible. Conduct more detailed evaluation and sizing calculations to determine feasibility. Harvest and use may only be able to be used for a portion of the site, or (optionally) the storage may need to be upsized to meet long term capture targets while draining in longer than 36 hours.</td><td>Harvest and use is considered to be infeasible.</td></tr>
<tr><td colspan="3">Is harvest and use feasible based on further evaluation?
☐ Yes, refer to Appendix E to select and size harvest and use BMPs.
☐ No, select alternate BMPs.</td></tr>
</table>

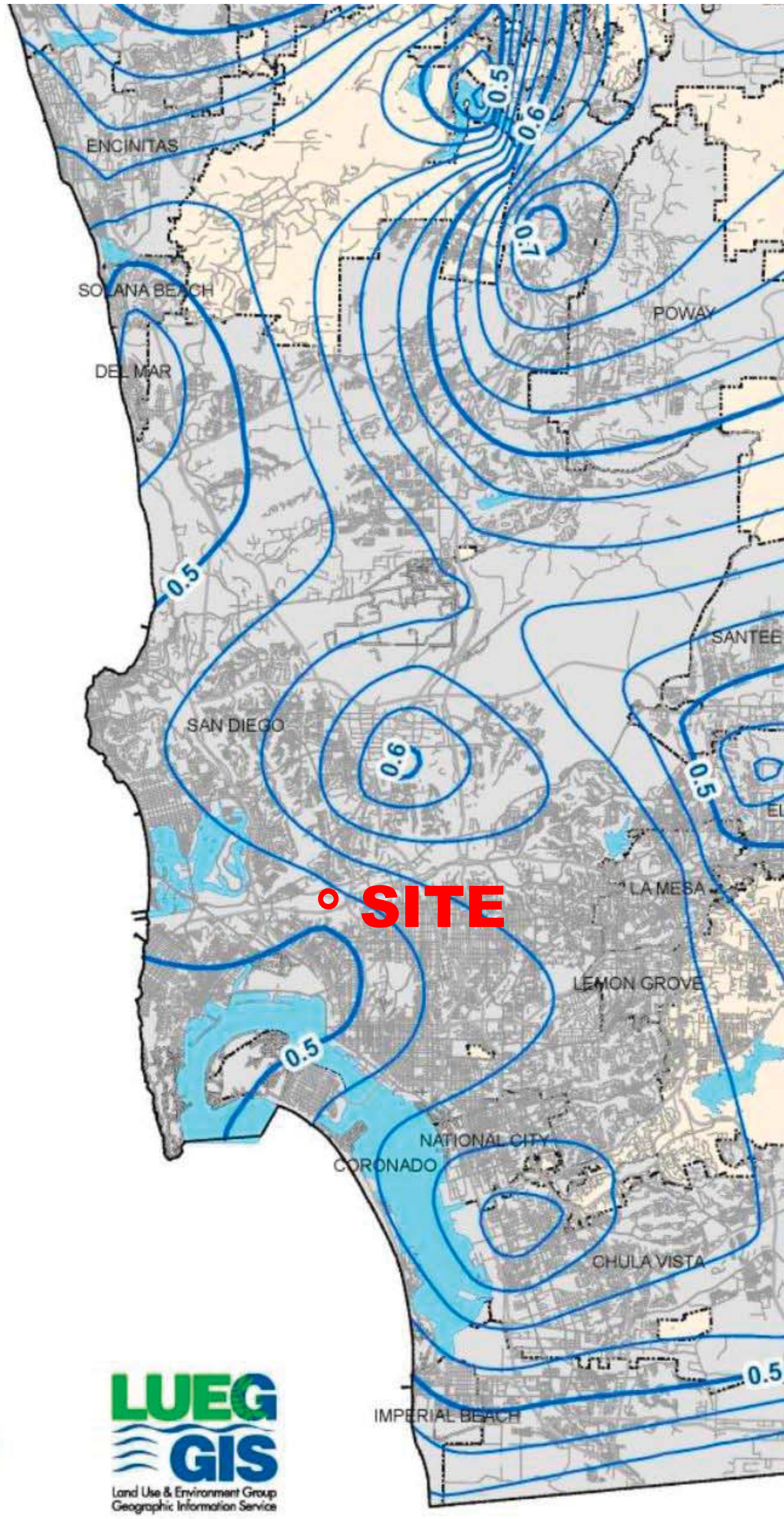
Furthermore, per discussions with city staff, toilet and urinal flushing harvest and use is not allowed by the plumbing code.

Worksheet B.2-1 DCV

Design Capture Volume		Worksheet B.2-1		
1	85th percentile 24-hr storm depth from Figure B.1-1	d=	0.52	inches
2	Area tributary to BMP (s)	A=	99.67	acres
3	Area weighted runoff factor (estimate using Appendix B.1.1 and B.2.1)	C=	0.67	unitless
4	Trees Credit Volume	TCV=	0	cubic-feet
5	Rain barrels Credit Volume	RCV=	0	cubic-feet
6	Calculate DCV = (3630 x C x d x A) – TCV - RCV	DCV=	125,435	cubic-feet

See attached for 85th percentile, 24-hour precipitation depth.

San Diego County
85 th Percentile Isopluvials



Legend

85th PERCENTILE ISOPLUVIAL

INCORPORATED CITY

NOTE:
The 85th percentile is a 24 hour rainfall total. It represetns a value such that 85% of the observed 24 hour rainfall totals will be less than that value.

N

0 1 2 4 6 8 Miles

05/14/2015
P:\Flood Control\NOAA_ATLAS_14\PCT85_REVISITED_2015\
\PCT85_DISPLAY.mxd

EXCERPT FROM FIGURE B.1-1
(24-HOUR, 85TH PERCENTILE
PRECIPITATION = 0.51")

Table B.3-1: Toilet and Urinal Water Usage per Resident or Employee

Land Use Type	Toilet User Unit of Normalization	Per Capita Use per Day		Visitor Factor[4]	Water Efficiency Factor	Total Use per Resident or Employee
		Toilet Flushing[1,2]	Urinals[3]			
Residential	Resident	18.5	NA	NA	0.5	9.3
Office	Employee (non-visitor)	9.0	2.27	1.1	0.5	7 (avg)
Retail	Employee (non-visitor)	9.0	2.11	1.4	0.5	
Schools	Employee (non-student)	6.7	3.5	6.4	0.5	33
Various Industrial Uses (excludes process water)	Employee (non-visitor)	9.0	2	1	0.5	5.5

[1]Based on American Waterworks Association Research Foundation, 1999. Residential End Uses of Water. Denver, CO: AWWARF

[2]Based on use of 3.45 gallons per flush and average number of per employee flushes per subsector, Table D-1 for MWD (Pacific Institute, 2003)

[3]Based on use of 1.6 gallons per flush, Table D-4 and average number of per employee flushes per subsector, Appendix D (Pacific Institute, 2003)

[4]Multiplied by the demand for toilet and urinal flushing for the project to account for visitors. Based on proportion of annual use allocated to visitors and others (includes students for schools; about 5 students per employee) for each subsector in Table D-1 and D-4 (Pacific Institute, 2003)

[5]Accounts for requirements to use ultra-low flush toilets in new development projects; assumed that requirements will reduce toilet and urinal flushing demand by half on average compared to literature estimates. Ultra low flush toilets are required in all new construction in California as of January 1, 1992. Ultra low flush toilets must use no more than 1.6 gallons per flush and Ultra low flush urinals must use no more than 1 gallon per flush. Note: If zero flush urinals are being used, adjust accordingly.

B.3.2.2 General Requirements for Irrigation Demand Calculations

The following guidelines should be followed for computing harvested water demand from landscape irrigation:

- If reclaimed water is planned for use for landscape irrigation, then the demand for harvested storm water should be reduced by the amount of reclaimed water that is available during the wet season.
- Irrigation rates should be based on the irrigation demand exerted by the types of landscaping that are proposed for the project, with consideration for water conservation requirements.
- Irrigation rates should be estimated to reflect the average wet season rates (defined as November through April) accounting for the effect of storm events in offsetting harvested water demand. In the absence of a detailed demand study, it should be assumed that irrigation demand is not present during days with greater than 0.1 inches of rain and the subsequent 3-day period. This irrigation shutdown period is consistent with standard practice in land application of wastewater and is applicable to storm water to prevent irrigation from resulting in dry weather runoff. Based on a statistical analysis of San Diego County rainfall patterns, approximately 30 percent of wet season days would not have a demand for irrigation.

Table B.3-3: Planning Level Irrigation Demand by Plant Factor and Landscape Type

General Landscape Type	36-Hour Planning Level Irrigation Demand (gallons per irrigated acre per 36 hour period)
Hydrozone – Low Plant Water Use	390
Hydrozone – Moderate Plant Water Use	1,470
Hydrozone – High Plant Water Use	2,640
Special Landscape Area	2,640

B.3.2.3 Calculating Other Harvested Water Demands

Calculations of other harvested water demands should be based on the knowledge of land uses, industrial processes, and other factors that are project-specific. Demand should be calculated based on the following guidelines:

- Demand calculations should represent actual demand that is anticipated during the wet season (November through April).
- Sources of demand should only be included if they are reliably and consistently present during the wet season.
- Where demands are substantial but irregular, a more detailed analysis should be conducted based on a statistical analysis of anticipated demand and precipitation patterns.

B.1.1 Runoff Factor

Estimate the area weighted runoff factor for the tributary area to the BMP using runoff factor (from Table B.1-1) and area of each surface type in the tributary area and the following equation.

Equation B.1-2: Estimating Runoff Factor for Area

$$C = \frac{\sum C_x A_x}{\sum A_x}$$

where:

C_x = Runoff factor for area X

A_x = Tributary area X (acres)

These runoff factors apply to areas receiving direct rainfall only. For conditions in which runoff is routed onto a surface from an adjacent surface, see Section B.2 for determining composite runoff factors for these areas.

Table B.1-1: Runoff factors for surfaces draining to BMPs – Pollutant Control BMPs

Surface	Runoff Factor
Roofs[1]	0.90
Concrete or Asphalt[1]	0.90
Unit Pavers (grouted)[1]	0.90
Decomposed Granite	0.30
Cobbles or Crushed Aggregate	0.30
Amended, Mulched Soils or Landscape[2]	0.10
Compacted Soil (e.g., unpaved parking)	0.30
Natural (A Soil)	0.10
Natural (B Soil)	0.14
Natural (C Soil)	0.23
Natural (D Soil)	0.30

[1]Surface is considered impervious and could benefit from use of Site Design BMPs and adjustment of the runoff factor per Section B.2.1.

[2]Surface shall be designed in accordance with SD-4 (Amended soils) fact sheet in Appendix E

Attachment 1d

C.1.1 Infiltration Feasibility Condition Letter

The geotechnical engineer shall provide an **Infiltration Feasibility Condition Letter** in the SWQMP to demonstrate that the DMA is in a no infiltration condition. The letter shall be stamped/signed by a licensed geotechnical engineer who prepared the letter.

The letter shall be submitted during the discretionary phase for private projects and during the initial project submittal to the Public Works Department for public projects. The letter shall at a minimum document:

- The phase of the project in which the geotechnical engineer first analyzed the site for infiltration feasibility.
- Results of previous geotechnical analyses conducted in the project area, if any.
- The development status of the site prior to the project application (i.e., new development with raw ungraded land, or redevelopment with existing graded conditions).
- The history of design discussions for the project footprint, resulting in the final design determination.
- Full/partial infiltration BMP standard setbacks to underground utilities, structures, retaining walls, fill slopes, and natural slopes applicable to the DMA that prevent full/partial infiltration.
- The physical impairments (i.e., fire road egress, public safety considerations, etc.) that prevent full/partial infiltration.
- The consideration of site design alternatives to achieve partial/full infiltration within the DMA.
- The extent site design BMPs requirements were included in the overall design.
- Conclusion or recommendation from the geotechnical engineer regarding the DMA's infiltration condition.
- An Exhibit for all applicable DMAs that clearly labels:
  - Proposed development areas and development type.
  - All applicable features and setbacks that prevent partial or full infiltration, including underground utilities, structures, retaining walls, fill slopes, natural slopes, and existing fill materials greater than 5 feet.
  - Potential locations for structural BMPs.
  - Areas where full/partial infiltration BMPs cannot be proposed.

Completion of **Worksheet C.4-1(Form I-8A) and/or Worksheet C.4-2 (Form I-8B)** is not required in instances where the applicant submits an infiltration feasibility condition letter that meets the requirements in this section.

Worksheets not required. See Attachment 6 for infiltration feasibility report.

ATTACHMENT 1e

POLLUTANT CONTROL BMP DESIGN

Pollutant control BMPs were selected to treat the project's pollutants of concern identified on Form I-3B. Based on the infiltration results in Attachment 6, full and partial infiltration is not feasible, so biofiltration basins and Bio Clean Environmental Services, Inc.'s Modular Wetland System (MWS) Linear units will primarily be used (see the Attachment 1a/b exhibit – Drainage Management Area Plan) because these have a high pollutant removal efficiency for the project's pollutants of concern.

Biofiltration Basins
Biofiltration basins are shallow, vegetated basins underlain by an engineered soil media, gravel, underdrain, and impervious liner. The biofiltration basins shall contain overflow catch basins set above the basin floor to convey the flow rates in excess of the water quality flows.

Conceptual sizing of biofiltration basins has been performed for this VTM submittal and is described below. The required basin area for each lot and street areas has been estimated based on the conceptual impervious and pervious footprints, which will be refined in the future. This was done to verify feasibility of setting aside the required BMP area in each lot. In addition, biofiltration basins will treat the street area runoff, where feasible (see Attachment 1a and 1b). The required bioretention footprint calculated for each lot is included on Attachment 1a/b. As the design progresses to the final engineering stages, additional basins can be incorporated into each lot to accommodate the site layouts. The on-lot BMPs will be established based on the building (roof), grading, and landscaping design.

The analyses of each basin was performed as follows. The design capture volume (DCV) to each biofiltration basin with was determined first (see attached). The design capture volume is the 24-hour, 85th percentile storm volume at the site, which is determined by multiplying the 24-hour, 85^{th} percentile precipitation by the average runoff factor and tributary area. The 24-hour, 85th percentile precipitation is 0.52 inches (see Attachment 1c). The average runoff factor was determined from estimated pervious and impervious areas based on conceptual land use. The average runoff factor is the total impervious area (i.e., roof areas) multiplied by a runoff factor of 0.9 plus the pervious area (i.e., biofiltration area serving the roof area) multiplied by a runoff factor of 0.1 divided by the total area, i.e., C = [(impervious area × 0.9) + pervious area × 0.1)] ÷ total area.

After the DCV is determined, each biofiltration basin is sized using Worksheet B.5-1. The worksheet is attached followed by corresponding spreadsheet output for each biofiltration basin.

Modular Wetland System Linear
There are proposed street areas where biofiltration basins are not readily feasible. Consequently, MWS Linear units will treat the runoff from these areas. MWS Linear are TAPE-certified and recently approved by the City of San Diego on other projects. Furthermore, infiltration and partial infiltration are not feasible according to the geotechnical consultant. MWS Linear have been selected in this entitlement-level SWQMP to demonstrate feasibility of using compact biofiltration

BMPs at the site. Equivalent acceptable compact biofiltration BMPs can be selected during final engineering. MWS Linear uses flow-based sizing. The *BMP Design Manual*, outlines the flow-based sizing procedure. The rational method is used to determine the treatment control flow rate and has the following form:

$Q_{BMP} = CIA$ where, Q_{BMP} = flow-based design flow rate, cfs
C = composite runoff factor for the drainage management areas
I = rainfall intensity = 0.2 inches per hour
A = area tributary to the BMP, acres

Table 1 summarizes the rational method results for each MWS Linear and preliminary sizing. The Q_{BMP} value is multiplied by 1.5 to compute the design flow rate. The attached MWS Linear sizing table from the Bio Clean brochure shows that each DMA can be treated by a single unit.

DMA	C	Intensity, in/hr	Area, acres	Q_{BMP}, cfs	Q_{DESIGN}[1], cfs	MWS-Linear Model
62	0.74	0.2	2.06	0.305	0.457	MWS-L-8-16
63	0.74	0.2	0.71	0.105	0.158	MWS-L-4-15
64	0.74	0.2	0.25	0.037	0.056	MWS-L-4-6
65	0.74	0.2	0.24	0.036	0.053	MWS-L-4-6
66	0.74	0.2	1.39	0.206	0.309	MWS-L-8-12
67	0.74	0.2	1.32	0.195	0.293	MWS-L-8-12
68	0.74	0.2	0.42	0.062	0.093	MWS-L-4-8
69	0.74	0.2	0.28	0.041	0.062	MWS-L-4-6
70	0.74	0.2	0.38	0.056	0.084	MWS-L-4-8
71	0.74	0.2	0.36	0.053	0.080	MWS-L-4-8
72	0.74	0.2	0.25	0.037	0.056	MWS-L-4-6
73	0.74	0.2	0.67	0.099	0.149	MWS-L-4-15
74	0.74	0.2	0.40	0.059	0.089	MWS-L-4-8
75	0.74	0.2	0.28	0.041	0.062	MWS-L-4-6
76	0.74	0.2	0.44	0.065	0.098	MWS-L-4-8
77	0.74	0.2	0.27	0.040	0.060	MWS-L-4-6

[1]Q_{DESIGN} is 1.5 times Q_{BMP}. Q_{DESIGN} is used for the flow-based sizing.

Table 1. Rational Method Results

<u>*Street Trees*</u>

One area along the southwest development footprint contains a proposed street that cannot be readily treated by biofiltration basins or MWS Linear (see DMA 78). The street will satisfy water quality requirements by using trees to offset the design capture volume. This has been discussed with Walter Gefrom to verify applicability. DMA 78 covers 27,261 square feet and contains a street with parkways on the east and west sides that will be planted with trees. Table B.2-2 from the attached *Storm Water Standards* provides tree credit volume for contributing areas (see attached for calculations). As an example, trees can be planted along the parkways so that the contributing area to each tree is less than 5,333 square feet. In this case, the tree credit volume from Table B.2-2 is 200 cubic feet. The DMA 78 design capture volume based on 80 percent impervious is 874 cubic feet, so five trees will offset the design capture volume. The demonstrates feasibility of street trees to offset the design capture volume in DMA 78. During final engineering, the amount, size, and location of trees in DMA 78 can be adjusted in conjunction with the landscape architect.

The current submittal is for entitlements. Some of the boxes are not relevant for the VTM, but have been checked to indicate they will be addressed during final engineering.

Biofiltration Criteria Checklist

The applicant must provide documentation of compliance with each criterion in this checklist as part of the project submittal. The right column of this checklist identifies the submittal information that is recommended to document compliance with each criterion. Biofiltration BMPs that substantially meet all aspects of Fact Sheets PR-1 or BF-1 should still use this checklist; however additional documentation (beyond what is already required for project submittal) should not be required.

1	**Biofiltration BMPs shall be allowed to be used only as described in the BMP selection process based on a documented feasibility analysis.** Intent: This manual defines a specific prioritization of pollutant treatment BMPs, where BMPs that retain water (retained includes evapotranspired, infiltrated, and/or harvested and used) must be used before considering BMPs that have a biofiltered discharge to the MS4 or surface waters. Use of a biofiltration BMP in a manner in conflict with this prioritization (i.e., without a feasibility analysis justifying its use) is not permitted, regardless of the adequacy of the sizing and design of the system.	
☒	The project applicant has demonstrated that it is not technically feasible to retain the full DCV onsite.	Document feasibility analysis and findings in the PDP SWQMP. Applicant must include harvest and use feasibility and infiltration feasibility in the PDP SWQMP
2	**Biofiltration BMPs must be sized using acceptable sizing methods.** Intent: The MS4 Permit and this manual defines specific sizing methods that must be used to size biofiltration BMPs. Sizing of biofiltration BMPs is a fundamental factor in the amount of storm water that can be treated and also influences volume and pollutant retention processes.	
☒	The project applicant has demonstrated that biofiltration BMPs are sized to meet one of the biofiltration sizing options available (Appendix B.5).	Submit sizing worksheets (Appendix B.5) or other equivalent documentation (such as results derived from continuous simulation calculations of treatment volume, retention, etc.) with the PDP SWQMP.
3	**Biofiltration BMPs must be sited and designed to achieve maximum feasible infiltration and evapotranspiration.** Intent: Various decisions about BMP placement and design influence how much water is retained via infiltration and evapotranspiration. The MS4 Permit requires that biofiltration BMPs achieve maximum feasible retention (evapotranspiration and infiltration) of storm water volume.	
☒	The biofiltration BMP is sited to allow for maximum infiltration of runoff volume based on the feasibility factors considered in site planning efforts. It is also designed to maximize evapotranspiration through the use of amended media and plants.	Document site planning and feasibility analyses in PDP SWQMP per Section 5.4.
☒	The biofiltration BMP meets the volume retention performance standard specified in Table B.5-1 in Appendix B.5.	Included documentation in the PDP SWQMP using worksheets in Appendix B.5 that show that the volume retention performance standard is met. Note, retention depth profiles that are too shallow or too deep may not be acceptable.

☒	An impermeable liner or other hydraulic restriction layer on the bottom of the BMP is only used when needed to avoid geotechnical and/or subsurface contamination issues in locations identified as "No Infiltration Condition."	If using an impermeable liner or hydraulic restriction layer, provide documentation of feasibility findings per Appendix C that recommend the use of this feature.
4	**Biofiltration BMPs must be designed with a hydraulic loading rate to maximize pollutant retention, preserve pollutant control processes, and minimize potential for pollutant washout.** Intent: Various decisions about biofiltration BMP design influence the degree to which pollutants are retained. The MS4 Permit requires that biofiltration BMPs achieve maximum feasible retention of storm water pollutants.	
☒	Media selected for the biofiltration BMP meets minimum quality and material specifications per Appendix F.3 or County LID Manual, including the maximum allowable design filtration rate and minimum thickness of media. OR Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in Appendix F.3 or County LID Manual, field scale testing data are provided to demonstrate that proposed media meets the pollutant treatment performance criteria in Section F.1 below.	Provide documentation that media meets the specifications in Appendix F.3 or County LID Manual. Provide documentation of performance information as described in Section F.1.
☒	To the extent practicable, filtration rates are outlet controlled (e.g., via an underdrain and orifice/weir) instead of controlled by the infiltration rate of the media.	Include outlet control in designs or provide documentation of why outlet control is not practicable.
☒	Surface ponding is limited to 24 hours from the end of storm event flow to preserve plant health and promote healthy soil structure.	Include calculations to demonstrate that drawdown rate is adequate. Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the City Engineer if certified by a landscape architect or agronomist.
☐	If nutrients are a pollutant of concern, design of the biofiltration BMP follows nutrient-sensitive design criteria. N/A.	Follow specifications for nutrient sensitive design in Fact Sheet BF-2. Or provide alternative documentation that nutrient treatment is addressed and potential for nutrient release is minimized.
☒	Media gradation calculations demonstrate that migration of media between layers will be prevented and permeability will be preserved.	Follow specification for choking layer in Fact Sheet PR-1 or BF-1. Or include calculations to demonstrate that choking layer is appropriately specified.

5	**Biofiltration BMPs must be designed to promote appropriate biological activity to support and maintain treatment processes.** Intent: Biological processes are an important element of biofiltration performance and longevity.	
☒	Plants have been selected to be tolerant of project climate, design ponding depths and the treatment media composition.	Provide documentation justifying plant selection. Refer to the plant list in Appendix E.26.
☒	Plants have been selected to minimize irrigation requirements.	Provide documentation describing irrigation requirements for establishment and long term operation.
☒	Plant location and growth will not impede expected long-term media filtration rates and will enhance long term infiltration rates to the extent possible.	Provide documentation justifying plant selection. Refer to the plant list in Appendix E.26.
6	**Biofiltration BMPs must be designed with a hydraulic loading rate to prevent erosion, scour, and channeling within the BMP.** Intent: Erosion, scour, and/or channeling can disrupt treatment processes and reduce biofiltration effectiveness.	
☒	Scour protection has been provided for both sheet flow and pipe inflows to the BMP, where needed.	Provide documentation of scour protection as described in Fact Sheets PR-1 or BF-1 or approved equivalent.
☒	Where scour protection has not been provided, flows into and within the BMP are kept to non-erosive velocities.	Provide documentation of design checks for erosive velocities as described in Fact Sheets PR-1 or BF-1 or approved equivalent.
☒	For proprietary BMPs, the BMP is used in a manner consistent with manufacturer guidelines and conditions of its third-party certification[21] (i.e., maximum tributary area, maximum inflow velocities, etc., as applicable).	Provide copy of manufacturer recommendations and conditions of third-party certification.

[21]Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the New Jersey Corporation for Advanced Technology programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification

7	**Biofiltration BMP must include operations and maintenance design features and planning considerations for continued effectiveness of pollutant and flow control functions.** Intent: Biofiltration BMPs require regular maintenance in order provide ongoing function as intended. Additionally, it is not possible to foresee and avoid potential issues as part of design; therefore, plans must be in place to correct issues if they arise.	
☒	The biofiltration BMP O&M plan describes specific inspection activities, regular/periodic maintenance activities and specific corrective actions relating to scour, erosion, channeling, media clogging, vegetation health, and inflow and outflow structures.	Include O&M plan with project submittal as described in Chapter 7.
☒	Adequate site area and features have been provided for BMP inspection and maintenance access.	Illustrate maintenance access routes, setbacks, maintenance features as needed on project water quality plans.
☒	For proprietary biofiltration BMPs, the BMP maintenance plan is consistent with manufacturer guidelines and conditions of its third-party certification (i.e., maintenance activities, frequencies).	Provide copy of manufacturer recommendations and conditions of third-party certification.

Worksheet B.2-1: DCV

Design Capture Volume		Worksheet B.2-1		
1	85th percentile 24-hr storm depth from Figure B.1-1	d=		inches
2	Area tributary to BMP (s)	A=		acres
3	Area weighted runoff factor (estimate using Appendix B.1.1 and B.2.1)	C=		unitless
4	Trees Credit Volume Note: In the SWQMP list the number of trees, size of each tree, amount of soil volume installed for each tree, contributing area to each tree and the inlet opening dimension for each tree.	TCV=		cubic-feet
5	Rain barrels Credit Volume Note: In the SWQMP list the number of rain barrels, size of each rain barrel and the use of the captured storm water runoff.	RCV=		cubic-feet
6	Calculate DCV = (3630 x C x d x A) – TCV - RCV	DCV=		cubic-feet

See attached sheets and DMA Plan for DCV at each biofiltration basin based on this worksheet.

Worksheet B.5-1: Sizing Method for Pollutant Removal Criteria

See attached sheets and DMA Exhibit for sizing of each biofiltration basin using this worksheet.

Sizing Method for Pollutant Removal Criteria		Worksheet B.5-1	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85[th] percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
BMP Parameters			
5	Surface ponding [6 inch minimum, 12 inch maximum]		inches
6	Media thickness [18 inches minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		inches
7	Aggregate storage (also add ASTM No 8 stone) above underdrain invert (12 inches typical) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
8	Aggregate storage below underdrain invert (3 inches minimum) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
9	Freely drained pore storage of the media	0.2	in/in
10	Porosity of aggregate storage	0.4	in/in
11	Media filtration rate to be used for sizing (maximum filtration rate of 5 in/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate (includes infiltration into the soil and flow rate through the outlet structure) which will be less than 5 in/hr.)		in/hr.
Baseline Calculations			
12	Allowable routing time for sizing	6	hours
13	Depth filtered during storm [Line 11 x Line 12]		inches
14	Depth of Detention Storage [Line 5 + (Line 6 x Line 9) + (Line 7 x Line 10) + (Line 8 x Line 10)]		inches
15	Total Depth Treated [Line 13 + Line 14]		inches
Option 1 – Biofilter 1.5 times the DCV			
16	Required biofiltered volume [1.5 x Line 4]		cu. ft.
17	Required Footprint [Line 16/ Line 15] x 12		sq. ft.
Option 2 - Store 0.75 of remaining DCV in pores and ponding			
18	Required Storage (surface + pores) Volume [0.75 x Line 4]		cu. ft.
19	Required Footprint [Line 18/ Line 14] x 12		sq. ft.
Footprint of the BMP			
20	BMP Footprint Sizing Factor (Default 0.03 or an alternative minimum footprint sizing factor from Line 11 in Worksheet B.5-4)		
21	Minimum BMP Footprint [Line 1 x Line 2 x Line 20]		sq. ft.
22	Footprint of the BMP = Maximum (Minimum (Line 17, Line 19), Line 21)		sq. ft.
23	Provided BMP Footprint		sq. ft.
24	Is Line 23 ≥ Line 22? If Yes, then footprint criterion is met. If No, increase the footprint of the BMP.	☐ Yes	☐ No

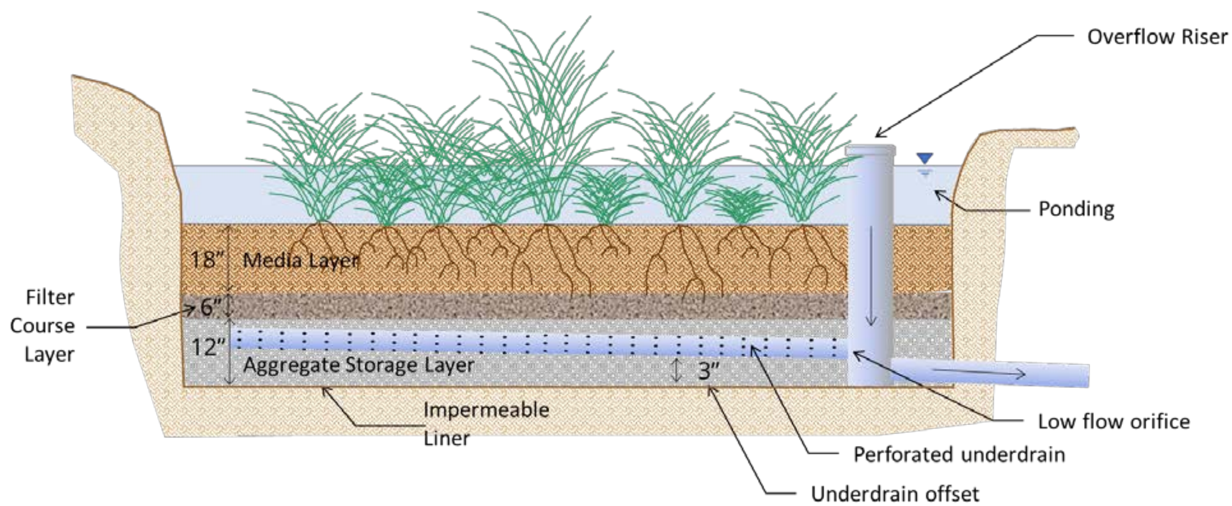
Since there are 61 basins, a spreadsheet was used, which has been accepted on other projects.

G.2.4 Sizing Factors for Biofiltration

Table G.2-5 presents sizing factors for calculating the required surface area (A) for a biofiltration BMP (formerly known as flow-through planter and/or biofiltration BMP with impermeable liner). The BMPs consist of four layers:

- **Ponding layer**: 12-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- **Growing medium**: 18-inches of soil [bioretention soil media]
- **Filter Course**: 6-inches
- **Storage layer**: 12-inches of gravel at 40 percent porosity. The underdrain offset shall be 3-inches.
- **Overflow structure:** San Diego Regional Standard Drawing Type I Catch Basin (D-29). For the purposes of hydromodification flow control other type of overflow structures are allowed.

This BMP includes an impermeable liner to prevent infiltration into underlying soils.



Biofiltration BMP Example Illustration

How to use the sizing factors for flow control BMP Sizing:

Obtain sizing factors from Table G.2-5 based on the project's lower flow threshold fraction of Q_2, hydrologic soil group, post-project slope, and rain gauge (rainfall basin). Multiply the area tributary to the structural BMP (A, square feet) by the area weighted runoff factor (C, unitless) (see Table G.2-1) by the sizing factors to determine the required surface area (A, square feet). Select a low flow orifice for the underdrain that will discharge the lower flow threshold flow at the overflow riser elevation. The civil engineer shall provide the necessary surface area of the BMP and the underdrain and orifice detail on the plans.

E.18 BF-1 Biofiltration

Location: 43rd Street and Logan Avenue, San Diego, California

MS4 Permit Category
Biofiltration
Manual Category
Biofiltration
Applicable Performance Standard
Pollutant Control Flow Control
Primary Benefits
Treatment Volume Reduction (Incidental) Peak Flow Attenuation (Optional)

Description

Biofiltration (Bioretention with underdrain) facilities are vegetated surface water systems that filter water through vegetation, and soil or engineered media prior to discharge via underdrain or overflow to the downstream conveyance system. Bioretention with underdrain facilities are commonly incorporated into the site within parking lot landscaping, along roadsides, and in open spaces. Because these types of facilities have limited or no infiltration, they are typically designed to provide enough hydraulic head to move flows through the underdrain connection to the storm drain system. Treatment is achieved through filtration, sedimentation, sorption, biochemical processes and plant uptake.

Typical bioretention with underdrain components include:

- Inflow distribution mechanisms (e.g, perimeter flow spreader or filter strips)
- Energy dissipation mechanism for concentrated inflows (e.g., splash blocks or riprap)
- Shallow surface ponding for captured flows
- Side slope and basin bottom vegetation selected based on expected climate and ponding depth
- Non-floating mulch layer
- Media layer (planting mix or engineered media) capable of supporting vegetation growth
- Filter course layer (aka choking layer) consisting of aggregate to prevent the migration of fines into uncompacted native soils or the aggregate storage layer
- Aggregate storage layer with underdrain(s)
- Impermeable liner or uncompacted native soils at the bottom of the facility
- Overflow structure

Design Adaptations for Project Goals

Biofiltration Treatment BMP for storm water pollutant control. The system is lined or un-lined to provide incidental infiltration, and an underdrain is provided at the bottom to carry away filtered runoff. This configuration is considered to provide biofiltration treatment via flow through the media layer. Storage provided above the underdrain within surface ponding, media, and aggregate storage is considered included in the biofiltration treatment volume. Saturated storage within the aggregate storage layer can be added to this design by raising the underdrain above the bottom of the aggregate storage layer or via an internal weir structure designed to maintain a specific water level elevation.

Integrated storm water flow control and pollutant control configuration. The system can be designed to provide flow rate and duration control by primarily providing increased surface ponding and/or having a deeper aggregate storage layer above the underdrain. This will allow for significant detention storage, which can be controlled via inclusion of an outlet structure at the downstream end of the underdrain.

Recommended Siting Criteria

	Siting Criteria	Intent/Rationale
□	Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
□	An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration or lateral flows should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.
□	Contributing tributary area shall be ≤ 5 acres (≤ 1 acre preferred).	Bigger BMPs require additional design features for proper performance. Contributing tributary area greater than 5 acres may be allowed at the discretion of the City Engineer if the following conditions are met: 1) incorporate design features (e.g. flow spreaders) to minimizing short circuiting of flows in the BMP and 2) incorporate additional design features requested by the City Engineer for proper performance of the regional BMP.
□	Finish grade of the facility is ≤ 2%.	Flatter surfaces reduce erosion and channelization within the facility.

Example Schematic Design – Plan and Section View

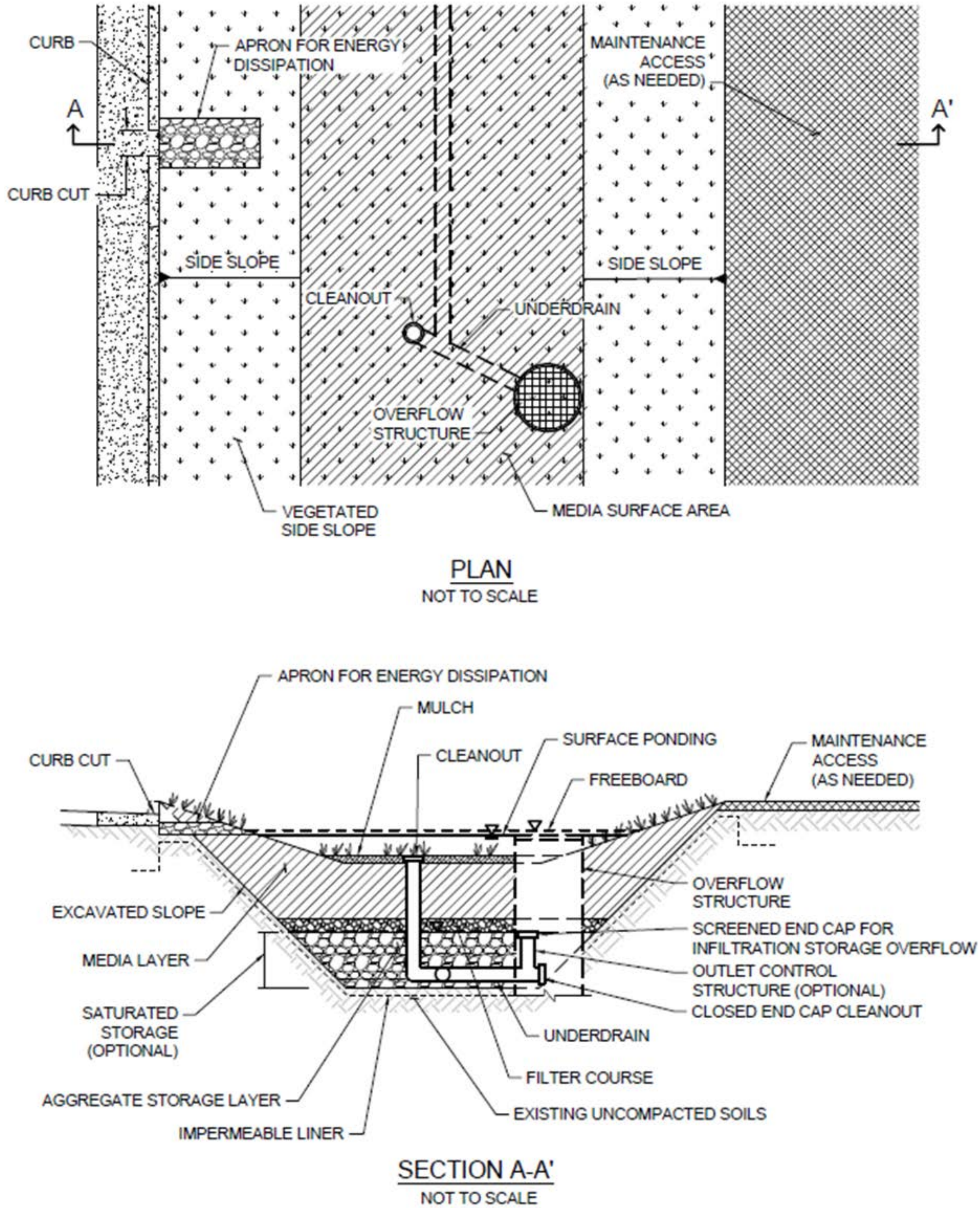


Figure E.18-1 : Typical Plan and Section View of a Biofiltration BMP

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Freeboard	≥ 2 inches	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
Surface Ponding	≥ 6 and ≤ 12 inches	The minimum ponding depth is required so that the runoff is uniformly spread throughout the basin (minimizes the likelihood of short circuiting). Deep surface ponding raises safety concerns. When the BMP is adjoining walkways the minimum surface ponding depth can be reduced to 4 inches. Surface ponding depth greater than 12 inches (for additional pollutant control or surface outlet structures or flow-control orifices) may be allowed at the discretion of the City Engineer if the following conditions are met: 1) surface ponding depth drawdown time is less than 24 hours; and 2) safety issues and fencing requirements are considered (typically ponding greater than 18" will require a fence) and 3) potential for elevated clogging risk is evaluated (Worksheet B.5.4).
Ponding Area Side Slopes	3H:1V or shallower	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
Mulch	≥ 3 inches	Mulch will suppress weeds and maintain moisture for plant growth.
Media Layer	≥ 18 inches	A deep media layer provides additional filtration and supports plants with deeper roots. Where the minimum depth of 18 inches is used, only shallow-rooted species shall be planted. A minimum 24-inch media layer shall typically be required to support vegetation, with a minimum 36-inch media layer depth required for trees.
Filter Course	6 inches	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4). This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.
Underdrain Diameter	≥ 8 inches	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
Cleanout Diameter	≥ 8 inches	Facilitates simpler cleaning, when needed. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

Design Criteria and Considerations

Bioretention with underdrain must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the City Engineer if it is determined to be appropriate:

	Design Criteria	Intent/Rationale
Surface Ponding		
□	Surface ponding is limited to a 24-hour drawdown time.	Surface ponding limited to 24 hour for plant health. Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the City Engineer if certified by a landscape architect or agronomist.
Vegetation		
□	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.26.	Plants suited to the climate and ponding depth are more likely to survive.
□	An irrigation system with a connection to water supply should be provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
Mulch		
□	A minimum of 3 inches of well-aged, shredded hardwood mulch that has been stockpiled or stored for at least 12 months is provided.	Mulch will suppress weeds and maintain moisture for plant growth. Aging mulch kills pathogens and weed seeds and allows the beneficial microbes to multiply.
Media Layer		
□	Media maintains a minimum filtration rate of 5 in/hr. over lifetime of facility. Additional Criteria for media hydraulic conductivity described in the bioretention soil media model specification (Appendix F.3)	A filtration rate of at least 5 inches per hour allows soil to drain between events. The initial rate should be higher than long term target rate to account for clogging over time. However an excessively high initial rate can have a negative impact on treatment performance, therefore an upper limit is needed.

	Design Criteria	Intent/Rationale
□	Media shall be a minimum 18 inches deep for filtration purposes, with a minimum 24-inch media layer depth typically required to support vegetation and a minimum 36-inch media layer depth required for trees. Media shall meet the following specifications. Model bioretention soil media specification provided in Appendix F.3 or County of San Diego Low Impact Development Handbook: Appendix G - Bioretention Soil Specification (June 2014, unless superseded by more recent edition). Alternatively, for proprietary designs and custom media mixes not meeting the media specifications, the media meets the pollutant treatment performance criteria in Section F.1.	A deep media layer provides additional filtration and supports plants with deeper roots. Standard specifications shall be followed. For non-standard or proprietary designs, compliance with Appendix F.1 ensures that adequate treatment performance will be provided.
□	Media surface area is 3% of contributing area times adjusted runoff factor or greater. Unless demonstrated that the BMP surface area can be smaller than 3%.	Greater surface area to tributary area ratios: a) maximizes volume retention as required by the MS4 Permit and b) decrease loading rates per square foot and therefore increase longevity. Adjusted runoff factor is to account for site design BMPs implemented upstream of the BMP (such as rain barrels, impervious area dispersion, etc.). Refer to Appendix B.2 guidance. Refer to Appendix B.5 for guidance to support use of smaller than 3% footprint..
□	Where receiving waters are impaired or have a TMDL for nutrients, the system is designed with nutrient sensitive media design (see fact sheet BF-2).	Potential for pollutant export is partly a function of media composition; media design must minimize potential for export of nutrients, particularly where receiving waters are impaired for nutrients.
Filter Course Layer		
□	A filter course is used to prevent migration of fines through layers of the facility. Filter fabric is not used.	Migration of media can cause clogging of the aggregate storage layer void spaces or subgrade and can result in poor water quality performance for turbidity and suspended solids. Filter fabric is more likely to clog.
□	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
□	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4).	This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.

	Design Criteria	Intent/Rationale
Aggregate Storage Layer		
☐	ASTM #57 open graded stone is used for the storage layer and a two layer filter course (detailed above) is used above this layer	This layer provides additional storage capacity. ASTM #8 stone provides an acceptable choking/bridging interface with the particles in ASTM #57 stone.
☐	The depth of aggregate provided (12-inch typical) and storage layer configuration is adequate for providing conveyance for underdrain flows to the outlet structure.	Proper storage layer configuration and underdrain placement will minimize facility drawdown time.
Inflow, Underdrain, and Outflow Structures		
☐	Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
☐	Inflow velocities are limited to 3 ft./s or less or use energy dissipation methods. (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
☐	Curb cut inlets are at least 18 inches wide, have a 4-6 inch reveal (drop) and an apron and energy dissipation as needed.	Inlets must not restrict flow and apron prevents blockage from vegetation as it grows in. Energy dissipation prevents erosion.
☐	Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve hydraulic performance by allowing perforations to remain unblocked.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
☐	Underdrains are made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
☐	An underdrain cleanout with a minimum 8-inch diameter and lockable cap is placed every 50 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.
☐	Overflow is safely conveyed to a downstream storm drain system or discharge point Size overflow structure to pass 100-year peak flow for on-line infiltration basins and water quality peak flow for off-line basins.	Planning for overflow lessens the risk of property damage due to flooding.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design bioretention with underdrain for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended media surface area tributary ratio.
2. Calculate the DCV per **Appendix B** based on expected site design runoff for tributary areas.
3. Use the sizing worksheet presented in **Appendix B.5** to size biofiltration BMPs.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding and/or aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in **Chapter 6** of the manual.

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended media surface area tributary ratio.
2. Iteratively determine the facility footprint area, surface ponding and/or aggregate storage layer depth required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If biofiltration with underdrain cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with significant storage volume such as an underground vault can be used to provide remaining controls.
4. After biofiltration with underdrain has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 1		**Biofiltration Basin 2**		**Biofiltration Basin 3**	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.61	Area, ac	1.56	Area, ac	1.71
C	0.66	C	0.66	C	0.66
DCV, cf	2,005	DCV, cf	1,946	DCV, cf	2,130
Pervious, sf	21,036	Pervious, sf	20,409	Pervious, sf	22,347
Impervious, sf	49,085	Impervious, sf	47,620	Impervious, sf	52,143
Total, sf	70,121	Total, sf	68,029	Total, sf	74,490

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 1		**Biofiltration Basin 2**		**Biofiltration Basin 3**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	70,121	1	68,029	1	74,490
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	2,005	4	1,946	4	2,130
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	3,008	16	2,918	16	3,196
17	2,314	17	2,245	17	2,458
18	1,504	18	1,459	18	1,598
19	1,157	19	1,122	19	1,229
20	0.03	20	0.03	20	0.03
21	1,388	21	1,347	21	1,475
22	1,388	22	1,347	22	1,475
23	1,388	23	1,347	23	1,475
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 4		Biofiltration Basin 5		Biofiltration Basin 6	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.55	Area, ac	1.26	Area, ac	1.50
C	0.66	C	0.66	C	0.66
DCV, cf	1,925	DCV, cf	1,570	DCV, cf	1,864

Pervious, sf	20,197	Pervious, sf	16,465	Pervious, sf	19,550
Impervious, sf	47,126	Impervious, sf	38,417	Impervious, sf	45,617
Total, sf	67,323	Total, sf	54,882	Total, sf	65,167

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 4		Biofiltration Basin 5		Biofiltration Basin 6	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	67,323	1	54,882	1	65,167
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,925	4	1,570	4	1,864
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	2,888	16	2,354	16	2,796
17	2,222	17	1,811	17	2,151
18	1,444	18	1,177	18	1,398
19	1,111	19	906	19	1,075
20	0.03	20	0.03	20	0.03
21	1,333	21	1,087	21	1,290
22	1,333	22	1,087	22	1,290
23	1,333	23	1,087	23	1,290
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 7		Biofiltration Basin 8		Biofiltration Basin 9	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.77	Area, ac	1.08	Area, ac	0.88
C	0.66	C	0.66	C	0.66
DCV, cf	960	DCV, cf	1,340	DCV, cf	1,101
Pervious, sf	10,073	Pervious, sf	14,057	Pervious, sf	11,550
Impervious, sf	23,503	Impervious, sf	32,799	Impervious, sf	26,951
Total, sf	33,575	Total, sf	46,855	Total, sf	38,501

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 7		Biofiltration Basin 8		Biofiltration Basin 9	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	33,575	1	46,855	1	38,501
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	960	4	1,340	4	1,101
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,440	16	2,010	16	1,652
17	1,108	17	1,546	17	1,271
18	720	18	1,005	18	826
19	554	19	773	19	635
20	0.03	20	0.03	20	0.03
21	665	21	928	21	762
22	665	22	928	22	762
23	665	23	928	23	762
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 10		Biofiltration Basin 11		Biofiltration Basin 12	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.62	Area, ac	1.05	Area, ac	1.06
C	0.66	C	0.66	C	0.66
DCV, cf	2,015	DCV, cf	1,307	DCV, cf	1,324
Pervious, sf	21,137	Pervious, sf	13,705	Pervious, sf	13,890
Impervious, sf	49,320	Impervious, sf	31,978	Impervious, sf	32,411
Total, sf	70,457	Total, sf	45,683	Total, sf	46,301

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 10		**Biofiltration Basin 11**		**Biofiltration Basin 12**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	70,457	1	45,683	1	46,301
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	2,015	4	1,307	4	1,324
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	3,023	16	1,960	16	1,986
17	2,325	17	1,508	17	1,528
18	1,511	18	980	18	993
19	1,163	19	754	19	764
20	0.03	20	0.03	20	0.03
21	1,395	21	905	21	917
22	1,395	22	905	22	917
23	1,395	23	905	23	917
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 13		Biofiltration Basin 14		Biofiltration Basin 15	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.99	Area, ac	1.04	Area, ac	0.93
C	0.66	C	0.66	C	0.66
DCV, cf	1,235	DCV, cf	1,301	DCV, cf	1,164
Pervious, sf	12,956	Pervious, sf	13,646	Pervious, sf	12,213
Impervious, sf	30,230	Impervious, sf	31,842	Impervious, sf	28,496
Total, sf	43,185	Total, sf	45,488	Total, sf	40,709

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 13		Biofiltration Basin 14		Biofiltration Basin 15	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	43,185	1	45,488	1	40,709
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,235	4	1,301	4	1,164
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,853	16	1,951	16	1,746
17	1,425	17	1,501	17	1,343
18	926	18	976	18	873
19	713	19	751	19	672
20	0.03	20	0.03	20	0.03
21	855	21	901	21	806
22	855	22	901	22	806
23	855	23	901	23	806
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 16		Biofiltration Basin 17		Biofiltration Basin 18	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	2.39	Area, ac	0.28	Area, ac	0.74
C	0.66	C	0.66	C	0.66
DCV, cf	2,976	DCV, cf	347	DCV, cf	918
Pervious, sf	31,217	Pervious, sf	3,642	Pervious, sf	9,626
Impervious, sf	72,841	Impervious, sf	8,497	Impervious, sf	22,461
Total, sf	104,058	Total, sf	12,139	Total, sf	32,087

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 16		Biofiltration Basin 17		Biofiltration Basin 18	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	104,058	1	12,139	1	32,087
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	2,976	4	347	4	918
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	4,464	16	521	16	1,377
17	3,434	17	401	17	1,059
18	2,232	18	260	18	688
19	1,717	19	200	19	529
20	0.03	20	0.03	20	0.03
21	2,060	21	240	21	635
22	2,060	22	240	22	635
23	2,060	23	240	23	635
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 19		Biofiltration Basin 20		Biofiltration Basin 21	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.82	Area, ac	0.91	Area, ac	0.92
C	0.66	C	0.66	C	0.66
DCV, cf	1,021	DCV, cf	1,137	DCV, cf	1,146
Pervious, sf	10,706	Pervious, sf	11,929	Pervious, sf	12,017
Impervious, sf	24,980	Impervious, sf	27,834	Impervious, sf	28,041
Total, sf	35,685	Total, sf	39,763	Total, sf	40,058

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 19		Biofiltration Basin 20		Biofiltration Basin 21	
Row No. on Worksheet	Value	Row No. on Worksheet	Value	Row No. on Worksheet	Value
1	35,685	1	39,763	1	40,058
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,021	4	1,137	4	1,146
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,531	16	1,706	16	1,718
17	1,178	17	1,312	17	1,322
18	765	18	853	18	859
19	589	19	656	19	661
20	0.03	20	0.03	20	0.03
21	707	21	787	21	793
22	707	22	787	22	793
23	707	23	787	23	793
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 22		Biofiltration Basin 23		Biofiltration Basin 24	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.12	Area, ac	0.79	Area, ac	0.76
C	0.66	C	0.66	C	0.66
DCV, cf	1,399	DCV, cf	980	DCV, cf	941

Pervious, sf	14,675	Pervious, sf	10,285	Pervious, sf	9,870
Impervious, sf	34,241	Impervious, sf	23,997	Impervious, sf	23,030
Total, sf	48,916	Total, sf	34,282	Total, sf	32,900

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 22		**Biofiltration Basin 23**		**Biofiltration Basin 24**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	48,916	1	34,282	1	32,900
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,399	4	980	4	941
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	2,098	16	1,471	16	1,411
17	1,614	17	1,131	17	1,086
18	1,049	18	735	18	706
19	807	19	566	19	543
20	0.03	20	0.03	20	0.03
21	969	21	679	21	651
22	969	22	679	22	651
23	969	23	679	23	651
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 25		**Biofiltration Basin 26**		**Biofiltration Basin 27**	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.16	Area, ac	0.86	Area, ac	1.88
C	0.66	C	0.66	C	0.66
DCV, cf	1,451	DCV, cf	1,066	DCV, cf	2,343
Pervious, sf	15,219	Pervious, sf	11,177	Pervious, sf	24,582
Impervious, sf	35,512	Impervious, sf	26,079	Impervious, sf	57,357
Total, sf	50,731	Total, sf	37,256	Total, sf	81,939

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 25		**Biofiltration Basin 26**		**Biofiltration Basin 27**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	50,731	1	37,256	1	81,939
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,451	4	1,066	4	2,343
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	2,176	16	1,598	16	3,515
17	1,674	17	1,229	17	2,704
18	1,088	18	799	18	1,758
19	837	19	615	19	1,352
20	0.03	20	0.03	20	0.03
21	1,004	21	738	21	1,622
22	1,004	22	738	22	1,622
23	1,004	23	738	23	1,622
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 28		Biofiltration Basin 29		Biofiltration Basin 30	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.69	Area, ac	0.13	Area, ac	1.44
C	0.66	C	0.66	C	0.66
DCV, cf	2,102	DCV, cf	163	DCV, cf	1,788
Pervious, sf	22,044	Pervious, sf	1,711	Pervious, sf	18,759
Impervious, sf	51,437	Impervious, sf	3,993	Impervious, sf	43,772
Total, sf	73,481	Total, sf	5,704	Total, sf	62,531

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 28		Biofiltration Basin 29		Biofiltration Basin 30	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	73,481	1	5,704	1	62,531
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	2,102	4	163	4	1,788
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	3,152	16	245	16	2,683
17	2,425	17	188	17	2,064
18	1,576	18	122	18	1,341
19	1,212	19	94	19	1,032
20	0.03	20	0.03	20	0.03
21	1,455	21	113	21	1,238
22	1,455	22	113	22	1,238
23	1,455	23	113	23	1,238
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

	Biofiltration Basin 31		Biofiltration Basin 32		Biofiltration Basin 33
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	3.34	Area, ac	1.57	Area, ac	1.73
C	0.66	C	0.66	C	0.66
DCV, cf	4,163	DCV, cf	1,957	DCV, cf	2,158
Pervious, sf	43,671	Pervious, sf	20,524	Pervious, sf	22,636
Impervious, sf	101,898	Impervious, sf	47,890	Impervious, sf	52,817
Total, sf	145,569	Total, sf	68,414	Total, sf	75,453

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 31		Biofiltration Basin 32		Biofiltration Basin 33	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	145,569	1	68,414	1	75,453
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	4,163	4	1,957	4	2,158
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	6,245	16	2,935	16	3,237
17	4,804	17	2,258	17	2,490
18	3,122	18	1,467	18	1,618
19	2,402	19	1,129	19	1,245
20	0.03	20	0.03	20	0.03
21	2,882	21	1,355	21	1,494
22	2,882	22	1,355	22	1,494
23	2,882	23	1,355	23	1,494
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 34		Biofiltration Basin 35		Biofiltration Basin 36	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.07	Area, ac	1.06	Area, ac	0.98
C	0.66	C	0.66	C	0.66
DCV, cf	1,332	DCV, cf	1,322	DCV, cf	1,215
Pervious, sf	13,976	Pervious, sf	13,867	Pervious, sf	12,750
Impervious, sf	32,612	Impervious, sf	32,356	Impervious, sf	29,749
Total, sf	46,588	Total, sf	46,223	Total, sf	42,499

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 34		Biofiltration Basin 35		Biofiltration Basin 36	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	46,588	1	46,223	1	42,499
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,332	4	1,322	4	1,215
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,999	16	1,983	16	1,823
17	1,537	17	1,525	17	1,402
18	999	18	991	18	912
19	769	19	763	19	701
20	0.03	20	0.03	20	0.03
21	922	21	915	21	841
22	922	22	915	22	841
23	922	23	915	23	841
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 37		Biofiltration Basin 38		Biofiltration Basin 39	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.88	Area, ac	1.02	Area, ac	1.33
C	0.66	C	0.66	C	0.66
DCV, cf	1,094	DCV, cf	1,272	DCV, cf	1,659
Pervious, sf	11,477	Pervious, sf	13,343	Pervious, sf	17,399
Impervious, sf	26,780	Impervious, sf	31,134	Impervious, sf	40,597
Total, sf	38,257	Total, sf	44,477	Total, sf	57,995

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 37		Biofiltration Basin 38		Biofiltration Basin 39	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	38,257	1	44,477	1	57,995
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,094	4	1,272	4	1,659
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,641	16	1,908	16	2,488
17	1,262	17	1,468	17	1,914
18	821	18	954	18	1,244
19	631	19	734	19	957
20	0.03	20	0.03	20	0.03
21	757	21	881	21	1,148
22	757	22	881	22	1,148
23	757	23	881	23	1,148
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 40		Biofiltration Basin 41		Biofiltration Basin 42	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.19	Area, ac	2.55	Area, ac	2.23
C	0.66	C	0.66	C	0.66
DCV, cf	1,487	DCV, cf	3,178	DCV, cf	2,778
Pervious, sf	15,602	Pervious, sf	33,333	Pervious, sf	29,137
Impervious, sf	36,406	Impervious, sf	77,776	Impervious, sf	67,985
Total, sf	52,008	Total, sf	111,109	Total, sf	97,122

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 40		Biofiltration Basin 41		Biofiltration Basin 42	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	52,008	1	111,109	1	97,122
2	0.66	2	0.66	2	0.66
3	0.52	3	0.52	3	0.52
4	1,487	4	3,178	4	2,778
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	2,231	16	4,767	16	4,167
17	1,716	17	3,667	17	3,205
18	1,116	18	2,383	18	2,083
19	858	19	1,833	19	1,603
20	0.03	20	0.03	20	0.03
21	1,030	21	2,200	21	1,923
22	1,030	22	2,200	22	1,923
23	1,030	23	2,200	23	1,923
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 43		Biofiltration Basin 44		Biofiltration Basin 45	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.81	Area, ac	1.54	Area, ac	1.68
C	0.74	C	0.74	C	0.74
DCV, cf	1,126	DCV, cf	2,157	DCV, cf	2,342
Pervious, sf	7,021	Pervious, sf	13,456	Pervious, sf	14,609
Impervious, sf	28,086	Impervious, sf	53,825	Impervious, sf	58,435
Total, sf	35,107	Total, sf	67,281	Total, sf	73,044

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 43		Biofiltration Basin 44		Biofiltration Basin 45	
Row No. on Worksheet	Value	Row No. on Worksheet	Value	Row No. on Worksheet	Value
1	35,107	1	67,281	1	73,044
2	0.74	2	0.74	2	0.74
3	0.52	3	0.52	3	0.52
4	1,126	4	2,157	4	2,342
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,689	16	3,236	16	3,513
17	1,299	17	2,489	17	2,703
18	844	18	1,618	18	1,757
19	649	19	1,245	19	1,351
20	0.03	20	0.03	20	0.03
21	779	21	1,494	21	1,622
22	779	22	1,494	22	1,622
23	779	23	1,494	23	1,622
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 46		**Biofiltration Basin 47**		**Biofiltration Basin 48**	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.81	Area, ac	0.57	Area, ac	0.58
C	0.74	C	0.74	C	0.74
DCV, cf	1,130	DCV, cf	803	DCV, cf	815

Pervious, sf	7,045	Pervious, sf	5,007	Pervious, sf	5,084
Impervious, sf	28,181	Impervious, sf	20,028	Impervious, sf	20,335
Total, sf	35,226	Total, sf	25,035	Total, sf	25,419

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 46		**Biofiltration Basin 47**		**Biofiltration Basin 48**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	35,226	1	25,035	1	25,419
2	0.74	2	0.74	2	0.74
3	0.52	3	0.52	3	0.52
4	1,130	4	803	4	815
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,694	16	1,204	16	1,223
17	1,303	17	926	17	941
18	847	18	602	18	611
19	652	19	463	19	470
20	0.03	20	0.03	20	0.03
21	782	21	556	21	564
22	782	22	556	22	564
23	782	23	556	23	564
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 49		Biofiltration Basin 50		Biofiltration Basin 51	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.79	Area, ac	0.52	Area, ac	1.63
C	0.74	C	0.74	C	0.74
DCV, cf	1,103	DCV, cf	721	DCV, cf	2,278
Pervious, sf	6,878	Pervious, sf	4,499	Pervious, sf	14,209
Impervious, sf	27,514	Impervious, sf	17,996	Impervious, sf	56,834
Total, sf	34,392	Total, sf	22,495	Total, sf	71,043

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 49		Biofiltration Basin 50		Biofiltration Basin 51	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	34,392	1	22,495	1	71,043
2	0.74	2	0.74	2	0.74
3	0.52	3	0.52	3	0.52
4	1,103	4	721	4	2,278
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,654	16	1,082	16	3,417
17	1,273	17	832	17	2,629
18	827	18	541	18	1,709
19	636	19	416	19	1,314
20	0.03	20	0.03	20	0.03
21	764	21	499	21	1,577
22	764	22	499	22	1,577
23	764	23	499	23	1,577
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 52		**Biofiltration Basin 53**		**Biofiltration Basin 54**	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	1.30	Area, ac	5.07	Area, ac	0.90
C	0.74	C	0.74	C	0.26
DCV, cf	1,817	DCV, cf	7,089	DCV, cf	441
Pervious, sf	11,331	Pervious, sf	44,212	Pervious, sf	31,342
Impervious, sf	45,323	Impervious, sf	176,848	Impervious, sf	7,836
Total, sf	56,654	Total, sf	221,060	Total, sf	39,178

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 52		**Biofiltration Basin 53**		**Biofiltration Basin 54**	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	56,654	1	221,060	1	39,178
2	0.74	2	0.74	2	0.26
3	0.52	3	0.52	3	0.52
4	1,817	4	7,089	4	441
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	2,725	16	10,633	16	662
17	2,096	17	8,179	17	509
18	1,363	18	5,316	18	331
19	1,048	19	4,090	19	255
20	0.03	20	0.03	20	0.03
21	1,258	21	4,908	21	306
22	1,258	22	4,908	22	306
23	1,258	23	4,908	23	306
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 55		Biofiltration Basin 56		Biofiltration Basin 57	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	5.62	Area, ac	0.58	Area, ac	1.03
C	0.74	C	0.26	C	0.74
DCV, cf	7,845	DCV, cf	285	DCV, cf	1,445

Pervious, sf	48,927	Pervious, sf	20,239	Pervious, sf	9,011
Impervious, sf	195,707	Impervious, sf	5,060	Impervious, sf	36,044
Total, sf	244,634	Total, sf	25,299	Total, sf	45,055

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 55		Biofiltration Basin 56		Biofiltration Basin 57	
Row No. on Worksheet	Value	Row No. on Worksheet	Value	Row No. on Worksheet	Value
1	244,634	1	25,299	1	45,055
2	0.74	2	0.26	2	0.74
3	0.52	3	0.52	3	0.52
4	7,845	4	285	4	1,445
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	11,767	16	428	16	2,167
17	9,051	17	329	17	1,667
18	5,883	18	214	18	1,084
19	4,526	19	164	19	834
20	0.03	20	0.03	20	0.03
21	5,431	21	197	21	1,000
22	5,431	22	197	22	1,000
23	5,431	23	197	23	1,000
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 58		Biofiltration Basin 59		Biofiltration Basin 60	
85th %, in	0.52	85th %, in	0.52	85th %, in	0.52
Area, ac	0.65	Area, ac	0.73	Area, ac	5.20
C	0.66	C	0.26	C	0.66
DCV, cf	804	DCV, cf	356	DCV, cf	6,474
Pervious, sf	8,438	Pervious, sf	25,301	Pervious, sf	67,913
Impervious, sf	19,688	Impervious, sf	6,325	Impervious, sf	158,463
Total, sf	28,126	Total, sf	31,626	Total, sf	226,375

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 58		Biofiltration Basin 59		Biofiltration Basin 60	
Row No. on Worksheet	**Value**	**Row No. on Worksheet**	**Value**	**Row No. on Worksheet**	**Value**
1	28,126	1	31,626	1	226,375
2	0.66	2	0.26	2	0.66
3	0.52	3	0.52	3	0.52
4	804	4	356	4	6,474
5	6	5	6	5	6
6	18	6	18	6	18
7	12	7	12	7	12
8	3	8	3	8	3
9	0.2	9	0.2	9	0.2
10	0.4	10	0.4	10	0.4
11	0	11	0	11	0
12	6	12	6	12	6
13	0	13	0	13	0
14	15.6	14	15.6	14	15.6
15	15.6	15	15.6	15	15.6
16	1,207	16	534	16	9,711
17	928	17	411	17	7,470
18	603	18	267	18	4,856
19	464	19	206	19	3,735
20	0.03	20	0.03	20	0.03
21	557	21	247	21	4,482
22	557	22	247	22	4,482
23	557	23	247	23	4,482
24	Yes	24	Yes	24	Yes

BIOFILTRATION BASIN SIZING FOR TREATMENT CONTROL

Design Capture Volume (Worksheet B.2-1. DCV, cf)

Biofiltration Basin 61

85th %, in	0.52
Area, ac	0.98
C	0.66
DCV, cf	1,215

Pervious, sf	12,747
Impervious, sf	29,743
Total, sf	42,490

Basin Sizing (Worksheet B.5-1)

Biofiltration Basin 61

Row No. on Worksheet	Value
1	42,490
2	0.66
3	0.52
4	1,215
5	6
6	18
7	12
8	3
9	0.2
10	0.4
11	0
12	6
13	0
14	15.6
15	15.6
16	1,823
17	1,402
18	911
19	701
20	0.03
21	841
22	841
23	841
24	Yes

TAPE Certification

April 2014

GENERAL USE LEVEL DESIGNATION FOR BASIC, ENHANCED, AND PHOSPHORUS TREATMENT

For the

MWS-Linear Modular Wetland

Ecology's Decision:

Based on Modular Wetland Systems, Inc. application submissions, including the Technical Evaluation Report, dated April 1, 2014, Ecology hereby issues the following use level designation:

1. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Basic treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.
2. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Phosphorus treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.
3. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Enhanced treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.

4. Ecology approves the MWS - Linear Modular Wetland Stormwater Treatment System units for Basic, Phosphorus, and Enhanced treatment at the hydraulic loading rate listed above. Designers shall calculate the water quality design flow rates using the following procedures:

   - Western Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
   - Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
   - Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

5. These use level designations have no expiration date but may be revoked or amended by Ecology, and are subject to the conditions specified below.

<u>Ecology's Conditions of Use:</u>

Applicants shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the MWS – Linear Modular Wetland Stormwater Treatment System units, in accordance with Modular Wetland Systems, Inc. applicable manuals and documents and the Ecology Decision.
2. Each site plan must undergo Modular Wetland Systems, Inc. review and approval before site installation. This ensures that site grading and slope are appropriate for use of a MWS – Linear Modular Wetland Stormwater Treatment System unit.
3. MWS – Linear Modular Wetland Stormwater Treatment System media shall conform to the specifications submitted to, and approved by, Ecology.
4. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.

   - Typically, Modular Wetland Systems, Inc. designs MWS - Linear Modular Wetland systems for a target prefilter media life of 6 to 12 months.
   - Indications of the need for maintenance include effluent flow decreasing to below the design flow rate or decrease in treatment below required levels.
   - Owners/operators must inspect MWS - Linear Modular Wetland systems for a minimum of twelve months from the start of post-construction operation to determine site-specific maintenance schedules and requirements. You must conduct inspections monthly during the wet season, and every other month during the dry season. (According to the SWMMWW, the wet season in western Washington is October 1 to April 30. According to SWMMEW, the wet season in eastern Washington is October 1 to June 30). After the

first year of operation, owners/operators must conduct inspections based on the findings during the first year of inspections.

- Conduct inspections by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flowrate and/or a decrease in pollutant removal ability.
- When inspections are performed, the following findings typically serve as maintenance triggers:
    - Standing water remains in the vault between rain events, or
    - Bypass occurs during storms smaller than the design storm.
    - If excessive floatables (trash and debris) are present (but no standing water or excessive sedimentation), perform a minor maintenance consisting of gross solids removal, not prefilter media replacement.
    - Additional data collection will be used to create a correlation between pretreatment chamber sediment depth and pre-filter clogging (see *Issues to be Addressed by the Company* section below)

6. Discharges from the MWS - Linear Modular Wetland Stormwater Treatment System units shall not cause or contribute to water quality standards violations in receiving waters.

Applicant:	Modular Wetland Systems, Inc.
Applicant's Address:	*PO. Box 869* *Oceanside, CA 92054*

Application Documents:

- *Original Application for Conditional Use Level Designation*, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., January 2011
- *Quality Assurance Project Plan*: Modular Wetland system – Linear Treatment System performance Monitoring Project, draft, January 2011.
- *Revised Application for Conditional Use Level Designation*, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., May 2011
- *Memorandum: Modular Wetland System-Linear GULD Application Supplementary Data, April 2014*
- *Technical Evaluation Report: Modular Wetland System Stormwater Treatment System Performance Monitoring, April 2014.*

Applicant's Use Level Request:

General use level designation as a Basic, Enhanced, and Phosphorus treatment device in accordance with Ecology's Guidance for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol – Ecology (TAPE) January 2011 Revision.

Applicant's Performance Claims:

- The MWS – Linear Modular wetland is capable of removing a minimum of 80-percent of TSS from stormwater with influent concentrations between 100 and 200 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 50-percent of Total Phosphorus from stormwater with influent concentrations between 0.1 and 0.5 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 30-percent of dissolved Copper from stormwater with influent concentrations between 0.005 and 0.020 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 60-percent of dissolved Zinc from stormwater with influent concentrations between 0.02 and 0.30 mg/l.

Ecology Recommendations:

- Modular Wetland Systems, Inc. has shown Ecology, through laboratory and field-testing, that the MWS - Linear Modular Wetland Stormwater Treatment System filter system is capable of attaining Ecology's Basic, Total phosphorus, and Enhanced treatment goals.

Findings of Fact:

<u>Laboratory Testing</u>

The MWS-Linear Modular wetland has the:

- Capability to remove 99 percent of total suspended solids (using Sil-Co-Sil 106) in a quarter-scale model with influent concentrations of 270 mg/L.
- Capability to remove 91 percent of total suspended solids (using Sil-Co-Sil 106) in laboratory conditions with influent concentrations of 84.6 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 93 percent of dissolved Copper in a quarter-scale model with influent concentrations of 0.757 mg/L.
- Capability to remove 79 percent of dissolved Copper in laboratory conditions with influent concentrations of 0.567 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 80.5-percent of dissolved Zinc in a quarter-scale model with influent concentrations of 0.95 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 78-percent of dissolved Zinc in laboratory conditions with influent concentrations of 0.75 mg/L at a flow rate of 3.0 gpm per square foot of media.

<u>Field Testing</u>

- Modular Wetland Systems, Inc. conducted monitoring of an MWS-Linear (Model # MWS-L-4-13) from April 2012 through May 2013, at a transportation maintenance facility in Portland, Oregon. The manufacturer collected flow-weighted composite samples of the system's influent and effluent during 28 separate storm events. The system treated approximately 75 percent of the runoff from 53.5 inches of rainfall during the monitoring period. The applicant sized the system at 1 gpm/sq ft. (wetland media) and 3gpm/sq ft. (prefilter).

- Influent TSS concentrations for qualifying sampled storm events ranged from 20 to 339 mg/L. Average TSS removal for influent concentrations greater than 100 mg/L (n=7) averaged 85 percent. For influent concentrations in the range of 20-100 mg/L (n=18), the upper 95 percent confidence interval about the mean effluent concentration was 12.8 mg/L.
- Total phosphorus removal for 17 events with influent TP concentrations in the range of 0.1 to 0.5 mg/L averaged 65 percent. A bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean total phosphorus reduction was 58 percent.
- The lower 95 percent confidence limit of the mean percent removal was 60.5 percent for dissolved zinc for influent concentrations in the range of 0.02 to 0.3 mg/L (n=11). The lower 95 percent confidence limit of the mean percent removal was 32.5 percent for dissolved copper for influent concentrations in the range of 0.005 to 0.02 mg/L (n=14) at flow rates up to 28 gpm (design flow rate 41 gpm). Laboratory test data augmented the data set, showing dissolved copper removal at the design flow rate of 41 gpm (93 percent reduction in influent dissolved copper of 0.757 mg/L).

Issues to be addressed by the Company:

1. Modular Wetland Systems, Inc. should collect maintenance and inspection data for the first year on all installations in the Northwest in order to assess standard maintenance requirements for various land uses in the region. Modular Wetland Systems, Inc. should use these data to establish required maintenance cycles.
2. Modular Wetland Systems, Inc. should collect pre-treatment chamber sediment depth data for the first year of operation for all installations in the Northwest. Modular Wetland Systems, Inc. will use these data to create a correlation between sediment depth and pre-filter clogging.

Technology Description:
Download at http://www.modularwetlands.com/

Contact Information:
Applicant: Greg Kent
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P.O. Box 869
Oceanside, CA 92054
gkent@biocleanenvironmental.net

Applicant website: http://www.modularwetlands.com/

Ecology web link: http://www.ecy.wa.gov/programs/wg/stormwater/newtech/index.html

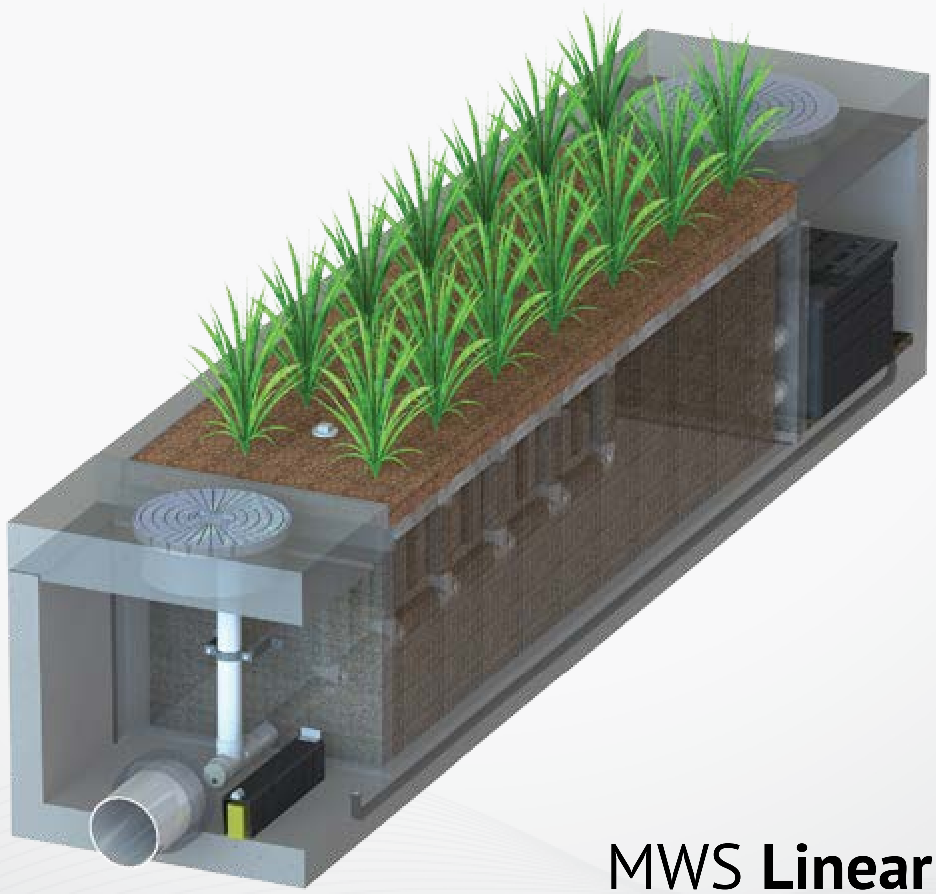
Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Revision History

Date	**Revision**
June 2011	Original use-level-designation document
September 2012	Revised dates for TER and expiration
January 2013	Modified Design Storm Description, added Revision Table, added maintenance discussion, modified format in accordance with Ecology standard
December 2013	Updated name of Applicant
April 2014	Approved GULD designation for Basic, Phosphorus, and Enhanced treatment

MODULAR WETLANDS™

*Advanced **Stormwater** Biofiltration*



MWS **Linear**

Contents

1 Introduction

2 Applications

3 Configurations

4 Advantages

5 Operation

6 Orientations | Bypass

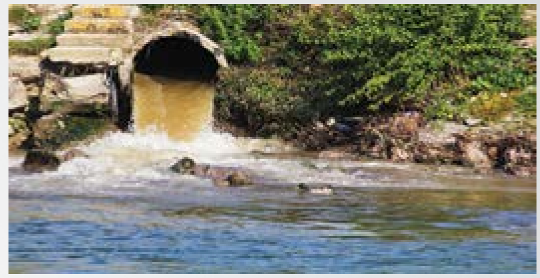
7 Performance | Approvals

8 Sizing

9 Installation | Maintenance | Plants

The Urban Impact

For hundreds of years natural wetlands surrounding our shores have played an integral role as nature's stormwater treatment system. But as our cities grow and develop, these natural wetlands have perished under countless roads, rooftops, and parking lots.



Plant A Wetland

Without natural wetlands our cities are deprived of water purification, flood control, and land stability. Modular Wetlands and the MWS Linear re-establish nature's presence and rejuvenate water ways in urban areas.

MWS **Linear**

The Modular Wetland System Linear represents a pioneering breakthrough in stormwater technology as the only biofiltration system to utilize patented horizontal flow, allowing for a smaller footprint and higher treatment capacity. While most biofilters use little or no pre-treatment, the MWS Linear incorporates an advanced pre-treatment chamber that includes separation and pre-filter cartridges. In this chamber sediment and hydrocarbons are removed from runoff before it enters the biofiltration chamber, in turn reducing maintenance costs and improving performance.

Applications

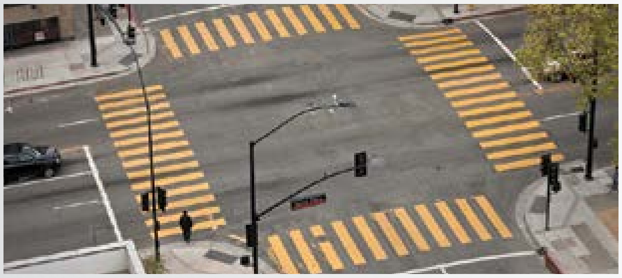
The MWS Linear has been successfully used on numerous new construction and retrofit projects. The system's superior versatility makes it beneficial for a wide range of stormwater and waste water applications - treating rooftops, streetscapes, parking lots, and industrial sites.

Industrial

Many states enforce strict regulations for discharges from industrial sites. The MWS Linear has helped various sites meet difficult EPA mandated effluent limits for dissolved metals and other pollutants.

Residential

Low to high density developments can benefit from the versatile design of the MWS Linear. The system can be used in both decentralized LID design and cost-effective end-of-the-line configurations.



Streets

Street applications can be challenging due to limited space. The MWS Linear is very adaptable, and offers the smallest footprint to work around the constraints of existing utilities on retrofit projects.

Parking Lots

Parking lots are designed to maximize space and the MWS Linear's 4 ft. standard planter width allows for easy integration into parking lot islands and other landscape medians.

Commercial

Compared to bioretention systems, the MWS Linear can treat far more area in less space - meeting treatment and volume control requirements.

Mixed Use

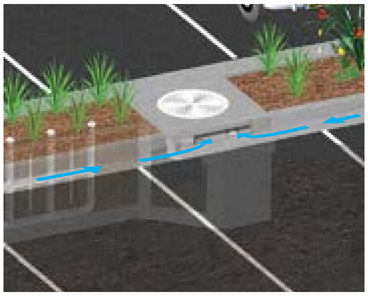
The MWS Linear can be installed as a raised planter to treat runoff from rooftops or patios, making it perfect for sustainable "live-work" spaces.

More applications are available on our website: www.ModularWetlands.com/Applications

- Agriculture
- Reuse
- Low Impact Development
- Waste Water

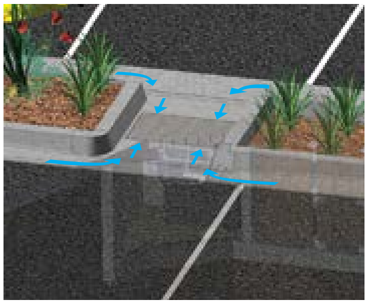
Configurations

The MWS Linear is the preferred biofiltration system of Civil Engineers across the country due to its versatile design. This highly versatile system has available "pipe-in" options on most models, along with built-in curb or grated inlets for simple integration into your stormdrain design.



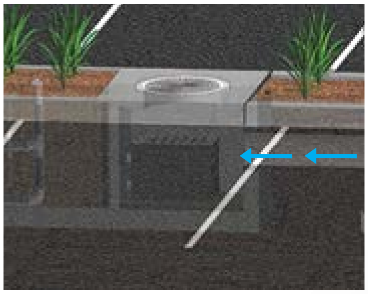
Curb Type

The *Curb Type* configuration accepts sheet flow through a curb opening and is commonly used along road ways and parking lots. It can be used in sump or flow by conditions. Length of curb opening varies based on model and size.



Grate Type

The *Grate Type* configuration offers the same features and benefits as the *Curb Type* but with a grated/drop inlet above the systems pre-treatment chamber. It has the added benefit of allowing for pedestrian access over the inlet. ADA compliant grates are available to assure easy and safe access. The *Grate Type* can also be used in scenarios where runoff needs to be intercepted on both sides of landscape islands.



Vault Type

The system's patented horizontal flow biofilter is able to accept inflow pipes directly into the pre-treatment chamber, meaning the MWS Linear can be used in end-of-the-line installations. This greatly improves feasibility over typical decentralized designs that are required with other biofiltration/bioretention systems. Another benefit of the "pipe in" design is the ability to install the system downstream of underground detention systems to meet water quality volume requirements.

Downspout Type

The *Downspout Type* is a variation of the *Vault Type* and is designed to accept a vertical downspout pipe from roof top and podium areas. Some models have the option of utilizing an internal bypass, simplifying the overall design. The system can be installed as a raised planter and the exterior can be stuccoed or covered with other finishes to match the look of adjacent buildings.

Advantages & Operation

The MWS Linear is the most efficient and versatile biofiltration system on the market, and the only system with horizontal flow which improves performance, reduces footprint, and minimizes maintenance. Figure-1 and Figure-2 illustrate the invaluable benefits of horizontal flow and the multiple treatment stages.

Featured Advantages

- Horizontal Flow Biofiltration
- Greater Filter Surface Area
- Pre-Treatment Chamber
- Patented Perimeter Void Area
- Flow Control
- No Depressed Planter Area

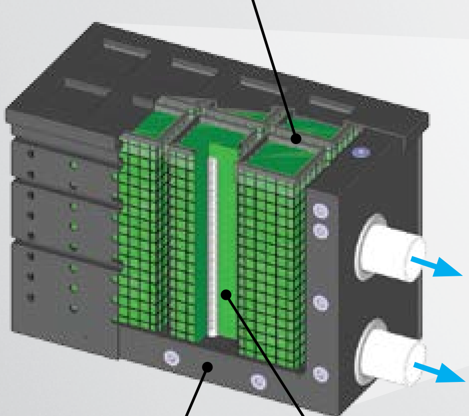
1 Pre-Treatment

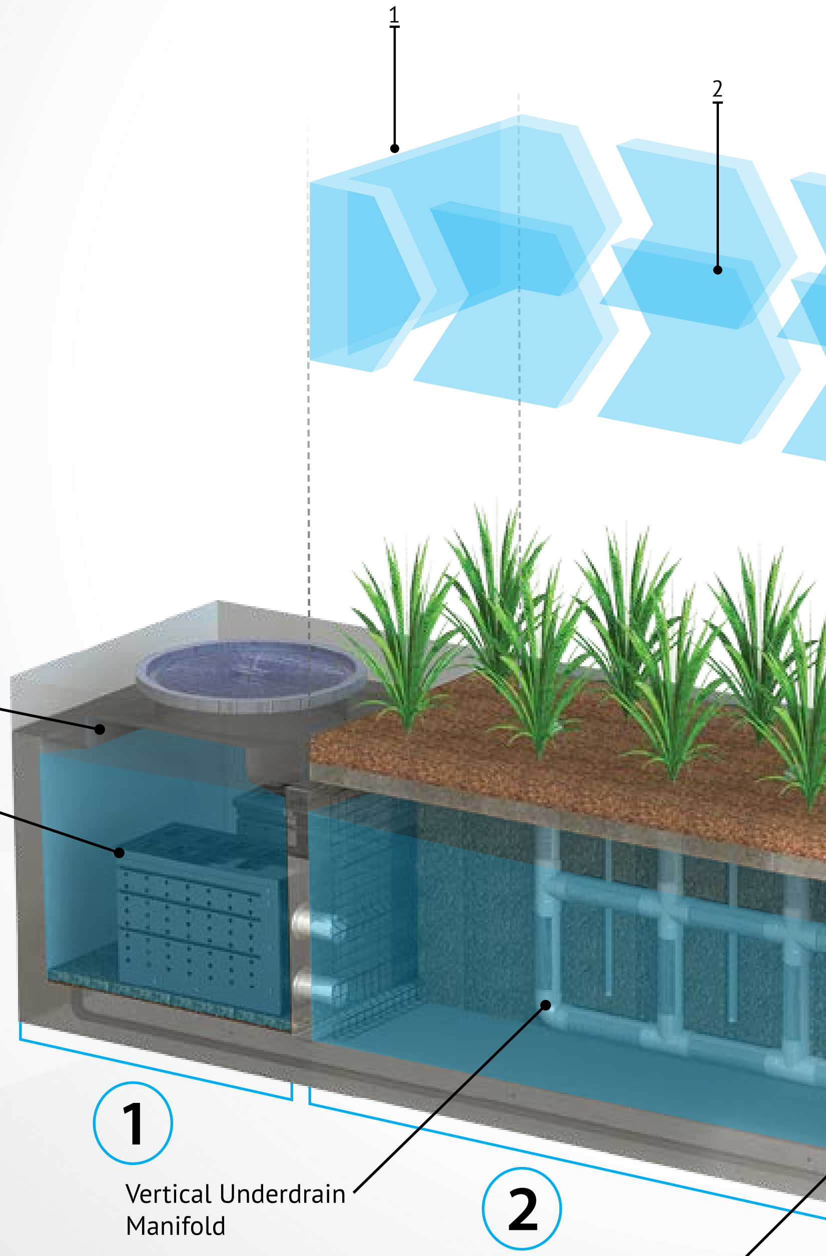
Separation

- Trash, sediment, and debris are separated before entering the pre-filter cartridges
- Designed for easy maintenance access

Pre-Filter Cartridges

- Over 25 ft^2 of surface area per cartridge
- Utilizes BioMediaGREEN filter material
- Removes over 80% of TSS & 90% of hydrocarbons
- Prevents pollutants that cause clogging from migrating to the biofiltration chamber





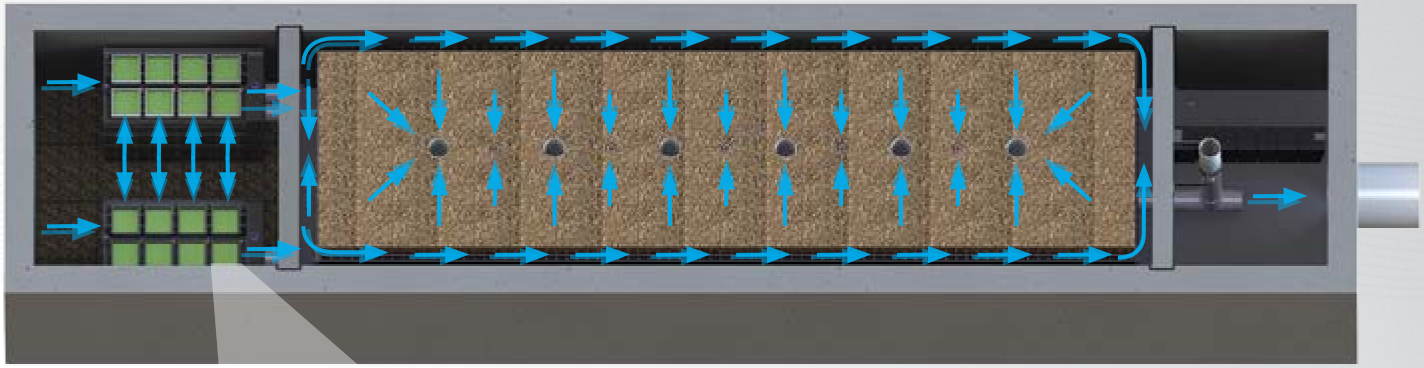
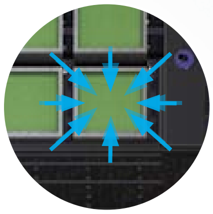
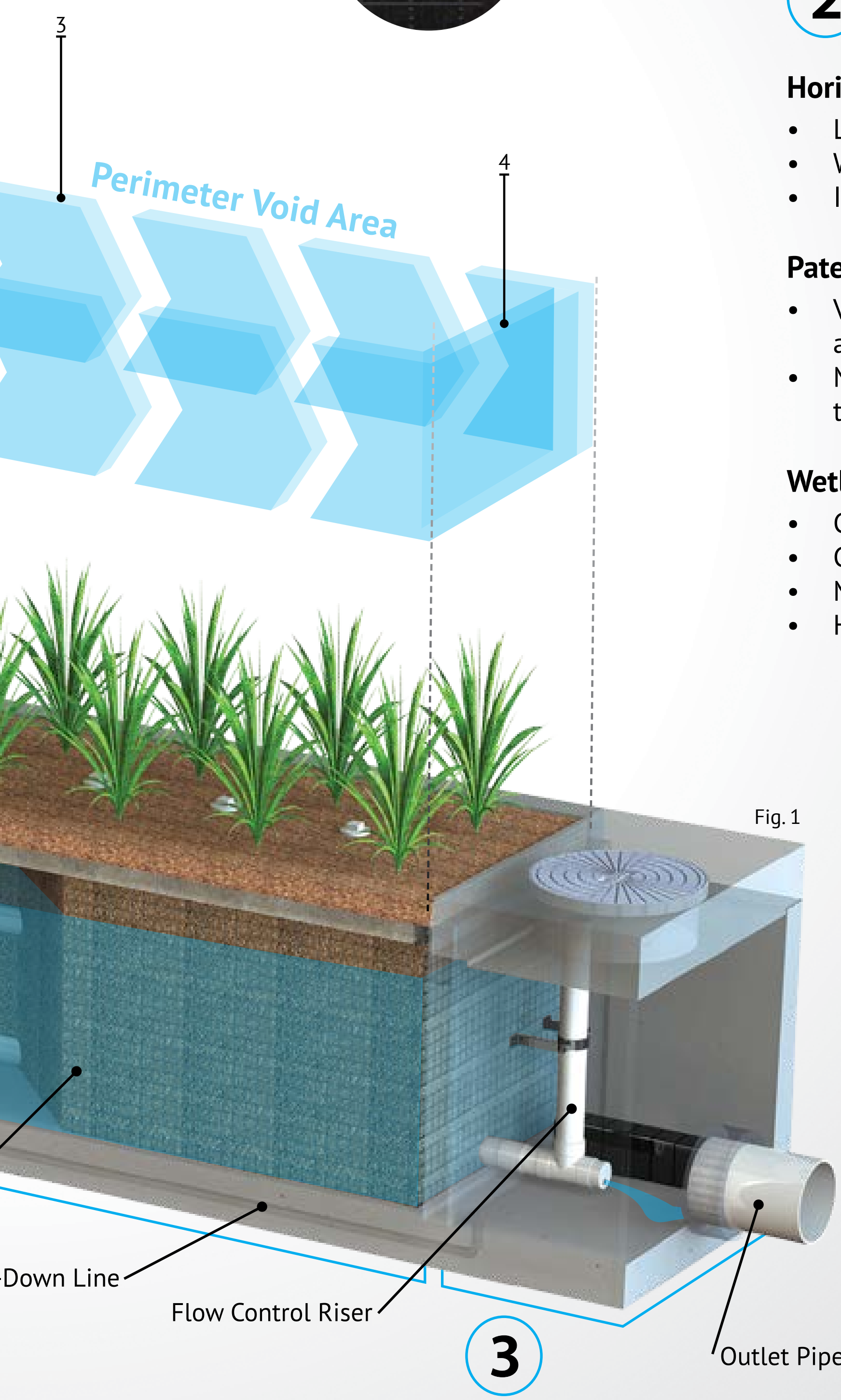


Fig. 2 - Top View



2x to 3x More Surface Area Than Traditional Downward Flow Bioretention Systems.



2 Biofiltration

Horizontal Flow

- Less clogging than downward flow biofilters
- Water flow is subsurface
- Improves biological filtration

Patented Perimeter Void Area

- Vertically extends void area between the walls and the WetlandMEDIA on all four sides.
- Maximizes surface area of the media for higher treatment capacity

WetlandMEDIA

- Contains no organics and removes phosphorus
- Greater surface area and 48% void space
- Maximum evapotranspiration
- High ion exchange capacity and light weight

3 Discharge

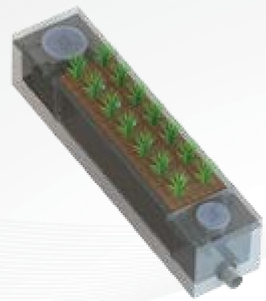
Flow Control

- Orifice plate controls flow of water through WetlandMEDIA to a level lower than the media's capacity.
- Extends the life of the media and improves performance

Drain-Down Filter

- The Drain-Down is an optional feature that completely drains the pre-treatment chamber
- Water that drains from the pre-treatment chamber between storm events will be treated

Orientations



Side-By-Side

The *Side-By-Side* orientation places the pre-treatment and discharge chamber adjacent to one another with the biofiltration chamber running parallel on either side. This minimizes the system length, providing a highly compact footprint. It has been proven useful in situations such as streets with directly adjacent sidewalks, as half of the system can be placed under that sidewalk. This orientation also offers internal bypass options as discussed below.

End-To-End

The *End-To-End* orientation places the pre-treatment and discharge chambers on opposite ends of the biofiltration chamber therefore minimizing the width of the system to 5 ft (outside dimension). This orientation is perfect for linear projects and street retrofits where existing utilities and sidewalks limit the amount of space available for installation. One limitation of this orientation is bypass must be external.

Bypass

Internal Bypass Weir (Side-by-Side Only)

The *Side-By-Side* orientation places the pre-treatment and discharge chambers adjacent to one another allowing for integration of internal bypass. The wall between these chambers can act as a bypass weir when flows exceed the system's treatment capacity, thus allowing bypass from the pre-treatment chamber directly to the discharge chamber.

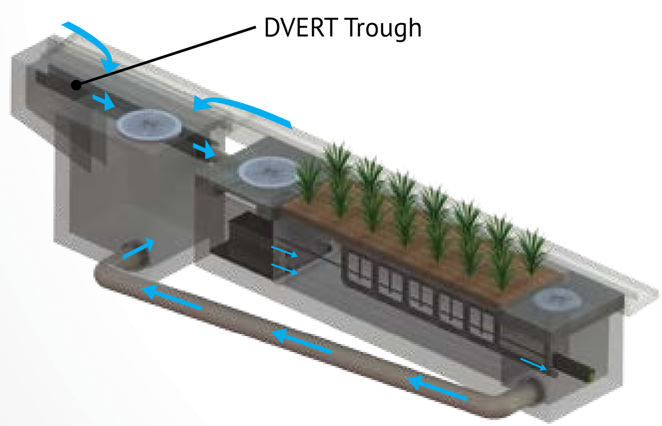
External Diversion Weir Structure

This traditional offline diversion method can be used with the MWS Linear in scenarios where runoff is being piped to the system. These simple and effective structures are generally configured with two outflow pipes. The first is a smaller pipe on the upstream side of the diversion weir - to divert low flows over to the MWS Linear for treatment. The second is the main pipe that receives water once the system has exceeded treatment capacity and water flows over the weir.

Flow By Design

This method is one in which the system is placed just upstream of a standard curb or grate inlet to intercept the first flush. Higher flows simply pass by the MWS Linear and into the standard inlet downstream.

DVERT Low Flow Diversion



This simple yet innovative diversion trough can be installed in existing or new curb and grate inlets to divert the first flush to the MWS Linear via pipe. It works similar to a rain gutter and is installed just below the opening into the inlet. It captures the low flows and channels them over to a connecting pipe exiting out the wall of the inlet and leading to the MWS Linear. The DVERT is perfect for retrofit and green street applications that allows the MWS Linear to be installed anywhere space is available.

Performance

The MWS Linear continues to outperform other treatment methods with superior pollutant removal for TSS, heavy metals, nutrients, hydrocarbons and bacteria. Since 2007 the MWS Linear has been field tested on numerous sites across the country. With it's advanced pre-treatment chamber and innovative horizontal flow biofilter, the system is able to effectively remove pollutants through a combination of physical, chemical, and biological filtration processes. With the same biological processes found in natural wetlands, the MWS Linear harnesses natures ability to process, transform, and remove even the most harmful pollutants.

Approvals

The MWS Linear has successfully met years of challenging technical reviews and testing from some of the most prestigious and demanding agencies in the nation, and perhaps the world.

State of Washington TAPE GULD Basic Enhanced/Metals Phosphorus

Washington State TAPE Approved

The MWS Linear is approved for General Use Level Designation (GULD) for Basic, Enhanced, and Phosphorus treatment at 1 gpm/ft^2 loading rate. The highest performing BMP on the market for all main pollutant categories.

TSS	Total Phosphorus	Ortho Phosphorus	Nitrogen	Dissolved Zinc	Dissolved Copper	Total Zinc	Total Copper	Motor Oil
85%	64%	67%	45%	66%	38%	69%	50%	95%

VA

DEQ Assignment

The Virginia Department of Environmental Quality assigned the MWS Linear, the highest phosphorus removal rating for manufactured treatment devices to meet the new Virginia Stormwater Management Program (VSMP) Technical Criteria.

MD

Maryland Department Of The Environment Approved

Granted ESD (Environmental Site Design) status for new construction, redevelopment and retrofitting when designed in accordance with the Design Manual.

MA

MASTEP Evaluation

The University of Massachusetts at Amherst – Water Resources Research Center, issued a technical evaluation report noting removal rates up to 84% TSS, 70% Total Phosphorus, 68.5% Total Zinc, and more.

RI

Rhode Island DEM Approved

Approved as an authorized BMP and noted to achieve the following minimum removal efficiencies: 85% TSS, 60% Pathogens, 30% Total Phosphorus, and 30% Total Nitrogen.

Flow Based Sizing

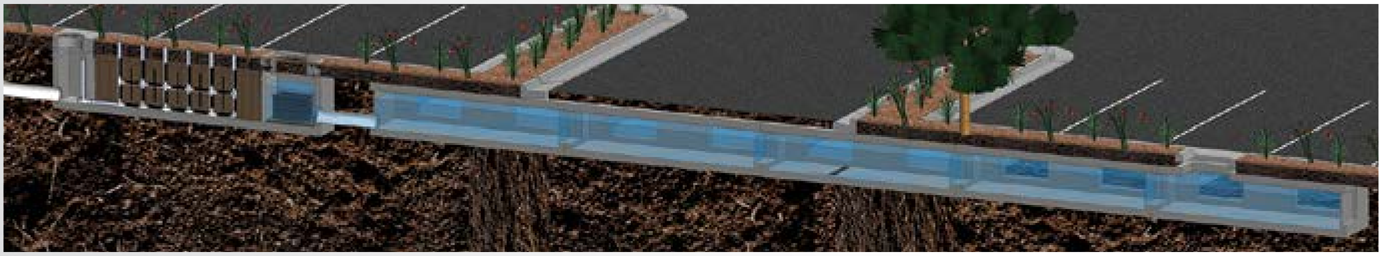
The MWS Linear can be used in stand alone applications to meet treatment flow requirements. Since the MWS Linear is the only biofiltration system that can accept inflow pipes several feet below the surface it can be used not only in decentralized design applications but also as a large central end-of-the-line application for maximum feasibility.

Treatment Flow Sizing Table

Model #	Dimensions	WetlandMedia Surface Area	Treatment Flow Rate (cfs)
MWS-L-4-4	4' x 4'	23 ft^2	0.052
MWS-L-4-6	4' x 6'	32 ft^2	0.073
MWS-L-4-8	4' x 8'	50 ft^2	0.115
MWS-L-4-13	4' x 13'	63 ft^2	0.144
MWS-L-4-15	4' x 15'	76 ft^2	0.175
MWS-L-4-17	4' x 17'	90 ft^2	0.206
MWS-L-4-19	4' x 19'	103 ft^2	0.237
MWS-L-4-21	4' x 21'	117 ft^2	0.268
MWS-L-8-8	8' x 8'	100 ft^2	0.230
MWS-L-8-12	8' x 12'	151 ft^2	0.346
MWS-L-8-16	8' x 16'	201 ft^2	0.462

Volume Based Sizing

Many states require treatment of a water quality volume and do not offer the option of flow based design. The MWS Linear and its unique horizontal flow makes it the only biofilter that can be used in volume based design installed downstream of ponds, detention basins, and underground storage systems.



Treatment Volume Sizing Table

Model #	Treatment Capacity (cu. ft.) @ 24-Hour Drain Down	Treatment Capacity (cu. ft.) @ 48-Hour Drain Down
MWS-L-4-4	1140	2280
MWS-L-4-6	1600	3200
MWS-L-4-8	2518	5036
MWS-L-4-13	3131	6261
MWS-L-4-15	3811	7623
MWS-L-4-17	4492	8984
MWS-L-4-19	5172	10345
MWS-L-4-21	5853	11706
MWS-L-8-8	5036	10072
MWS-L-8-12	7554	15109
MWS-L-8-16	10073	20145

Installation

The MWS Linear is simple, easy to install, and has a space efficient design that offers lower excavation and installation costs compared to traditional tree-box type systems. The structure of the system resembles pre-cast catch basin or utility vaults and is installed in a similar fashion.

The system is delivered fully assembled for quick installation. Generally, the structure can be unloaded and set in place in 15 minutes. Our experienced team of field technicians are available to supervise installations and provide technical support.

Maintenance

Reduce your maintenance costs, man hours, and materials with the MWS Linear. Unlike other biofiltration systems that provide no pre-treatment, the MWS Linear is a self-contained treatment train which incorporates simple and effective pre-treatment.

Maintenance requirements for the biofilter itself are almost completely eliminated, as the pre-treatment chamber removes and isolates trash, sediments, and hydrocarbons. What's left is the simple maintenance of an easily accessible pre-treatment chamber that can be cleaned by hand or with a standard vac truck. Only periodic replacement of low-cost media in the pre-filter cartridges is required for long term operation and there is absolutely no need to replace expensive biofiltration media.

Plant Selection

Abundant plants, trees, and grasses bring value and an aesthetic benefit to any urban setting, but those in the MWS Linear do even more - they increase pollutant removal. What's not seen, but very important, is that below grade the stormwater runoff/flow is being subjected to nature's secret weapon: a dynamic physical, chemical, and biological process working to break down and remove non-point source pollutants. The flow rate is controlled in the MWS Linear, giving the plants more "contact time" so that pollutants are more successfully decomposed, volatilized and incorporated into the biomass of The MWS Linear's micro/macro flora and fauna.

A wide range of plants are suitable for use in the MWS Linear, but selections vary by location and climate. View suitable plants by selecting the list relative to your project location's hardy zone.

Please visit **www.ModularWetlands.com/Plants** for more information and various plant lists.

Permeable Pavement can also be designed as a structural BMP to treat run on from adjacent areas. Refer to INF-3 factsheet in **Appendix E** and **Appendix B.4** for additional guidance.

B.2.2 Adjustment to DCV

When the following site design BMPs are implemented the anticipated volume reduction from these BMPs shall be deducted from the DCV to estimate the volume for which the downstream structural BMP should be sized for:

- SD-A: Trees
- SD-E Rain barrels

B.2.2.1 Trees

Applicants are allowed to take credit for installing new trees using Table B.2-2 or Equation B.2-1 as applicable, when trees are implemented in accordance with SD-A fact sheet and meet the following criteria:

- Total tree credit volume is less than or equal to 0.25 DCV of the project footprint and
- Single tree credit volume is less than or equal to 400 ft^3.

Credit for trees that do not meet the above criteria shall be based on the criteria for sizing the tree as a storm water pollutant control BMP in SD-A fact sheet. These credit calculations are based on an assumption that each tree and associated trench or box is considered a single BMP, with calculations based on the media storage volume and contributing area.

Table B.2-2 was developed assuming that the entire tributary area is impervious (use Equation B.2-1 if there are different types of surfaces in the contributing area) and an 85th percentile 24-hour rainfall depth of 0.5 inches. The procedure for estimating the tree credit volume using Table B.2-2:

- Delineate the tributary area to the tree and use this tributary area to determine the tree credit volume using Table B.2-2. Use linear interpolation if the tributary area is in between the areas listed in Table B.2-2. When the contributing area is greater than 10,667 ft^2 this simplified method is not allowed.
- Using the amount of soil volume installed to determine the credit using Table B.2-2. Use linear interpolation if the soil volume is in between the values listed in Table B.2-2. When the soil volume is greater than 1,333 ft^3 this simplified method is not allowed.
- Use the smaller tree credit volume of the two estimates.

Street Tree Data for DMA 78

Table B.2-2: Allowable Reduction in DCV

Tree Credit Volume (ft^3/tree)[1]	Contributing Area (ft^2)	Soil Volume (ft^3)
10	267	33
50	1,333	167
100	2,667	333
150	4,000	500
200	5,333	667
300	8,000	1,000
400	10,667	1,333

Note: [1]If an underdrain is installed only 1/3rd of the tree credit volume shown in Table B.2-2 is allowed.

Applicant can also estimate the tree credit volume using Equation B.2-1.

Equation B.2-1: Tree Credit Volume

$$\boldsymbol{TCV = Minimum(SV \times 0.3,\ 3,630 \times d \times C \times A)}$$; With no underdrains installed

$$\boldsymbol{TCV = Minimum(SV \times 0.1,\ 3,630 \times d \times C \times A)}$$; When an underdrain is installed

where:

TCV	=	Tree credit volume (ft^3); maximum of 400 ft^3 for one tree and not more than 0.25*DCV from the project footprint for all trees proposed as site design BMPs
SV	=	Soil volume installed with the tree (ft^3)
d	=	85th percentile 24-hr storm depth (inches) from Figure B.1-1
C	=	Area weighted runoff factor (calculate using Appendix B.1.1 and B.2.1)
A	=	Area tributary to the tree (acres)

B.2.2.2 Rain Barrels

Rain barrels are containers that can capture rooftop runoff and store it for future use. Credit can be taken for the full rain barrel volume when each barrel volume is smaller than 100 gallons, implemented per SD-E fact sheet and meet the following criteria:

- Total rain barrel volume is less than 0.25 DCV **and**
- Landscape areas are greater than 30 percent of the project footprint.

Credit for harvest and use systems that do not meet the above criteria must be based on the criteria in **Appendix B.3** and HU-1 fact sheet in **Appendix E**.

Worksheet B.2-1: DCV

Design Capture Volume		Worksheet B.2-1		
1	85th percentile 24-hr storm depth from Figure B.1-1	d=	0.52	inches
2	Area tributary to BMP (s)	A=	0.63	acres
3	Area weighted runoff factor (estimate using Appendix B.1.1 and B.2.1)	C=	0.74	unitless
4	Trees Credit Volume Note: In the SWQMP list the number of trees, size of each tree, amount of soil volume installed for each tree, contributing area to each tree and the inlet opening dimension for each tree.	TCV=	5x200= 1,000	cubic-feet
5	Rain barrels Credit Volume Note: In the SWQMP list the number of rain barrels, size of each rain barrel and the use of the captured storm water runoff.	RCV=	0	cubic-feet
6	Calculate DCV = (3630 x C x d x A) – TCV - RCV	DCV=	0	cubic-feet

DCV is approximately 880 cf, so there is enough tree credit volume to reduce DCV to zero.

E.6 SD-A Tree

Source: County of San Diego LID Manual

MS4 Permit Category
Site Design

Manual Category
Site Design

Applicable Performance Standard
Site Design

Primary Benefits
Volume Reduction

Description

Trees planted to intercept rainfall and runoff can be used as storm water management measure that provide additional benefits beyond those typically associated with trees, (i.e. energy conservation, air quality improvement, and aesthetic enhancement). Typical storm water management benefits associated with trees include:

- **Interception of rainfall** – tree surfaces (roots, foliage, bark, and branches) intercept, evaporate, store, or convey precipitation to the soil before it reaches surrounding impervious surfaces
- **Reduced erosion** – trees protect denuded area by intercepting or reducing the velocity of rain drops as they fall through the tree canopy
- **Increased infiltration** – soil conditions created by roots and fallen leaves promote infiltration
- **Treatment of storm water** – trees provide treatment through uptake of nutrients and other storm water pollutants (phytoremediation) and support of other biological processes that break down pollutants

Typical tree system components include:

- Trees of the appropriate species for site conditions and constraints
- Available growing space based on tree species, soil type, water availability, surrounding land uses, and project goals
- Staking and planting requirements (see Standard Drawing: SDL-101)

- Optional suspended pavement design to provide structural support for adjacent pavement without requiring compaction of underlying layers
- As needed root barrier devices; a root barrier is a device installed in the ground, between a tree and the sidewalk, intended to guide roots down and away from the sidewalk in order to prevent sidewalk damage.
- Optional tree grates; maximize available space for pedestrian circulation and protect tree roots from compaction.
- Optional shallow surface depression for ponding of excess runoff
- Optional planter box drain

Design Adaptations for Project Goals

Storm water volume credits are only allowed for new trees implemented within the project footprint.

Site design BMP to provide incidental treatment. Trees primarily functions as site design BMPs for incidental treatment. Benefits from trees as a site design BMP are accounted by adjustment factors presented in **Appendix B.2.2**. Trees as a site design BMP are only credited up to 0.25 times the DCV from the project footprint (with a maximum single tree credit volume of 400 ft^3).

Storm water pollutant control BMP to provide treatment. Applicants are allowed to design trees as a pollutant control BMP and obtain credit greater than 0.25 times the DCV from the project footprint (or a credit greater than 400 ft^3 from a single tree). For this option to be approved by the City Engineer, applicant is required to do infiltration feasibility screening (Worksheet C.4-1/Form I-8) and provide calculations supporting the amount of credit claimed from implementing trees within the project footprint. The City Engineer has the discretion to request additional analysis before approving credits greater than 0.25 times the DCV from the project footprint (or a credit greater than 400 ft^3 from a single tree).

Design Criteria and Considerations

Trees must meet the following design criteria and considerations and the requirements of Standard Drawing SDL-101 where applicable. Deviations from the below criteria may be approved at the discretion of the City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	Tree species is appropriately chosen for the development (private or public). For public rights-of-ways, local planning guidelines and zoning provisions for the permissible species and placement of trees are consulted.	Proper tree placement and species selection minimizes problems such as pavement damage by surface roots and poor growth.

<table>
<tr><th></th><th>Siting and Design</th><th>Intent/Rationale</th></tr>
<tr><td>☐</td><td>Location of trees planted along public streets follows local requirements and guidelines. Vehicle and pedestrian line of sight are considered in tree selection and placement.
Unless exemption is granted by the City Engineer the following minimum tree separation distance (from the tree trunk) is followed
<table>
<tr><th>Improvement</th><th>Minimum distance to Tree</th></tr>
<tr><td>Traffic Signal, Stop sign</td><td>20 feet</td></tr>
<tr><td>Underground Utility lines (except sewer)</td><td>5 feet</td></tr>
<tr><td>Sewer Lines</td><td>10 feet</td></tr>
<tr><td>Above ground utility structures (Transformers, Hydrants, Utility poles, etc.)</td><td>10 feet</td></tr>
<tr><td>Driveways</td><td>10 feet</td></tr>
<tr><td>Intersections (intersecting curb lines of two streets)</td><td>25 feet</td></tr>
</table></td><td>Roadway safety for both vehicular and pedestrian traffic is a key consideration for placement along public streets.</td></tr>
<tr><td>☐</td><td>Underground utilities and overhead wires are considered in the design and avoided or circumvented. Underground utilities are routed around or through the planter in suspended pavement applications. All underground utilities are protected from water and root penetration.</td><td>Tree growth can damage utilities and overhead wires resulting in service interruptions. Protecting utilities routed through the planter prevents damage and service interruptions.</td></tr>
<tr><td>☐</td><td>Suspended pavement design was developed where appropriate to minimize soil compaction and improve infiltration and filtration capabilities.
Suspended pavement was constructed with an approved structural cell.</td><td>Suspended pavement designs provide structural support without compaction of the underlying layers, thereby promoting tree growth.
Recommended structural cells include poured in place concrete columns, Silva Cells manufactured by Deeproot Green Infrastructures and Stratacell and Stratavault systems manufactured by Citygreen Systems.</td></tr>
<tr><td>☐</td><td>A minimum soil volume of 2 cubic feet per square foot of canopy projection area is provided for each tree. Canopy projection area is the ground area beneath the tree, measured at the mature tree drip line.

Applicant uses soil amendments (SD-F), as necessary. Soil amendments result in healthier plant growth, reduced irrigation demands, and reduced need for fertilization and maintenance</td><td>The minimum soil volume is required to support a healthy tree.

A lower amount of soil volume may be allowed if certified by a landscape architect or agronomist that the installed soil volume will be adequate for health tree growth. The retention credit from the tree must be directly proportional to the soil volume installed for the tree.</td></tr>
</table>

	Siting and Design	Intent/Rationale
☐	DCV from the tributary area draining to the tree is equal to or greater than the tree credit volume	The minimum tributary area ensures that the tree receives enough runoff to fully utilize the infiltration and evapotranspiration potential provided. In cases where the minimum tributary area is not provided, the tree credit volume must be reduced proportionately to the actual tributary area.
☐	Inlet opening to the tree that is at least 18 inches wide. A minimum 2 inch drop in grade from the inlet to the finish grade of the tree. Grated inlets are allowed for pedestrian circulation. Grates need to be ADA compliant and have sufficient slip resistance.	Design requirement to ensure that the runoff from the tributary area is not bypassed. Different inlet openings and drops in grade may be allowed at the discretion of the City Engineer if calculations are shown that the diversion flow rate (**Appendix B.1.2**) from the tributary area can be conveyed to the tree. In cases where the inlet capacity is limiting the amount of runoff draining to the tree, the tree credit volume must be reduced proportionately.

Conceptual Design and Sizing Approach for Site Design and Storm Water Pollutant Control

- Determine the areas where trees can be used in the site design to achieve incidental treatment. Trees reduce runoff volumes from the site. Refer to **Appendix B.2.2**. Document the proposed tree locations in the SWQMP.
- When trees are proposed as a storm water pollutant control BMP, applicant must complete feasibility analysis in **Appendix C and D** and submit detailed calculations for the DCV treated by trees. Document the proposed tree locations, feasibility analysis and sizing calculations in the SWQMP. The following calculations should be performed and the smallest of the three should be used as the volume treated by trees:
    - Delineate the DMA (tributary area) to the tree and calculate the associated DCV.
    - Calculate the required diversion flow rate using **Appendix B.1.2** and size the inlet required to convey this flow rate to the tree. If the proposed inlet cannot convey the diversion flow rate for the entire tributary area, then the DCV that enters the tree should be proportionally reduced.
        - For example, 0.5 acre drains to the tree and the associated DCV is 820 ft^3. The required diversion flow rate is 0.10 ft^3/s, but only an inlet that can divert 0.05 ft^3/s could be installed.
        - Then the effective DCV draining to the tree = 820 ft^3 * (0.05/0.10) = 420 ft^3
    - Estimate the amount of storm water treated by the tree by summing the following:
        - Evapotranspiration credit of 0.1 * amount of soil volume installed; and
        - Infiltration credit calculated using sizing procedures in **Appendix B.4**.

ATTACHMENT 2
BACKUP FOR PDP HYDROMODIFICATION CONTROL MEASURES

This is the cover sheet for Attachment 2.

☒ Mark this box if this attachment is empty because the project is exempt from PDP hydromodification management requirements.

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Project Name: **Riverwalk**

Indicate which Items are Included:

Attachment Sequence	Contents	Checklist
Attachment 2a	Hydromodification Management Exhibit (Required)	☐ Included See Hydromodification Management Exhibit Checklist.
Attachment 2b	Management of Critical Coarse Sediment Yield Areas (WMAA Exhibit is required, additional analyses are optional) See Section 6.2 of the BMP Design Manual.	☐ Exhibit showing project drainage boundaries marked on WMAA Critical Coarse Sediment Yield Area Map (Required) Optional analyses for Critical Coarse Sediment Yield Area Determination ☐ 6.2.1 Verification of Geomorphic Landscape Units Onsite ☐ 6.2.2 Downstream Systems Sensitivity to Coarse Sediment ☐ 6.2.3 Optional Additional Analysis of Potential Critical Coarse Sediment Yield Areas Onsite
Attachment 2c	Geomorphic Assessment of Receiving Channels (Optional) See Section 6.3.4 of the BMP Design Manual.	○ Not Performed ○ Included ◉ Submitted as separate stand-alone document
Attachment 2d	Flow Control Facility Design and Structural BMP Drawdown Calculations (Required) Overflow Design Summary for each structural BMP See Chapter 6 and Appendix G of the BMP Design Manual	○ Included ◉ Submitted as separate stand-alone document
Attachment 2e	Vector Control Plan (Required when structural BMPs will not drain in 96 hours)	○ Included ◉ Not required because BMPs will drain in less than 96 hours

ATTACHMENT 3
STRUCTURAL BMP MAINTENANCE INFORMATION

This is the cover sheet for Attachment 3.

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Project Name: Riverwalk

Indicate which Items are Included:

Attachment Sequence	Contents	Checklist
Attachment 3a	Structural BMP Maintenance Thresholds and Actions (Required)	☒ Included See Structural BMP Maintenance Information Checklist.
Attachment 3b	Maintenance Agreement (Form DS-3247) (when applicable)	○ Included ◉ Not Applicable

Project Name: Riverwalk

Use this checklist to ensure the required information has been included in the Structural BMP Maintenance Information Attachment:

<u>Preliminary Design / Planning / CEQA level submittal:</u>

- Attachment 3a must identify:

  ☒ Typical maintenance indicators and actions for proposed structural BMP(s) based on Section 7.7 of the BMP Design Manual

- Attachment 3b is not required for preliminary design / planning / CEQA level submittal.

<u>Final Design level submittal:</u>

Attachment 3a must identify:

☐ Specific maintenance indicators and actions for proposed structural BMP(s). This shall be based on Section 7.7 of the BMP Design Manual and enhanced to reflect actual proposed components of the structural BMP(s)
☐ How to access the structural BMP(s) to inspect and perform maintenance
☐ Features that are provided to facilitate inspection (e.g., observation ports, cleanouts, silt posts, or other features that allow the inspector to view necessary components of the structural BMP and compare to maintenance thresholds)
☐ Manufacturer and part number for proprietary parts of structural BMP(s) when applicable
☐ Maintenance thresholds specific to the structural BMP(s), with a location-specific frame of reference (e.g., level of accumulated materials that triggers removal of the materials, to be identified based on viewing marks on silt posts or measured with a survey rod with respect to a fixed benchmark within the BMP)
☐ When applicable, frequency of bioretention soil media replacement
☐ Recommended equipment to perform maintenance
☐ When applicable, necessary special training or certification requirements for inspection and maintenance personnel such as confined space entry or hazardous waste management

Attachment 3b: For private entity operation and maintenance, Attachment 3b must include a Storm Water Management and Discharge Control Maintenance Agreement (Form DS-3247). The following information must be included in the exhibits attached to the maintenance agreement:

☐ Vicinity map
☐ Site design BMPs for which DCV reduction is claimed for meeting the pollutant control obligations.
☐ BMP and HMP location and dimensions
☐ BMP and HMP specifications/cross section/model
☐ Maintenance recommendations and frequency
☐ LID features such as (permeable paver and LS location, dim, SF).

ATTACHMENT 3a
STRUCTURAL BMP MAINTENANCE

The project proposes biofiltration basins and MWS-Linear units for its structural pollutant control BMPs. Biofiltration basins are shallow, vegetated basins underlain by an engineered soil media, gravel, underdrain, and impervious liner. Healthy plant and biological activity in the root zone maintain and renew the macro-pore space in the soil and maximize plant uptake of pollutants and runoff. This keeps the BMP from becoming clogged and allows more of the soil column to function as both a sponge (retaining water) and a highly effective and self-maintaining biofilter.

The landscape maintenance staff shall inspect each basin during routine weekly landscaping maintenance visits. Access will be from adjacent walkways, landscape areas, or paved areas. The vegetation shall be replanted, trimmed, pruned, removed, as needed, to maintain proper coverage and growth. The irrigation system shall be maintained, as needed. The drainage overflow from the basins shall be inspected monthly and after large storm events. Debris, sediment, and other obstructions shall be removed immediately from each basin, its outlet, and the interconnecting pipes. The infiltration rate shall be reviewed during storm events and the underlying soil/gravel shall be replaced as needed to maintain the required drawdown time.

The MWS-Linear units shall be maintained per the manufacturer’s requirements.

The street trees shall be routinely maintained by landscape maintenance staff. This includes ensuring proper irrigation, pruning, and trimming. Trees shall be replaced, if needed.

ATTACHMENT 4
COPY OF PLAN SHEETS SHOWING PERMANENT STORM WATER BMPS

This is the cover sheet for Attachment 4.

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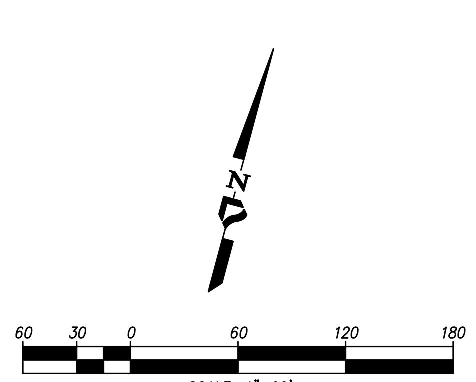
SEE SHEET 11



PROVISIONAL HYDROSEED MIX: (EXCLUDES LOTS AAA, CCC AND DDD-SEE NOTE BELOW)

SPECIES	PURE LIVE SEED LBS/AC
BROMUS CARINATUS 'CUCAMONGA"	20.0
TRIFOLIUM TRIDENTATUM	4.0
VULPIA MICROSTACHYS	8.0
PROMATRIX EFM	3,000
HYDROPOST PREMIUM COMPOST	1,000
TOTAL PURE LIVE SEED	4,032

SLURRY COMPONENTS:	
FLEXTERRA HP-FGM	3,000 LBS/ACRE
BIOSOL FORTE 7-2-1 FERTILIZER	600 LBS/ACRE
AM 120 MYCORRHIZAL INOCULUM	60 LBS/ACRE

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NOTES:

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B. EDGE TO EDGE SEPARATION OF LESS THAN 10' BETWEEN SEWER AND STORM DRAIN PER PROJECT WIDE DESIGN DEVIATION.

C. PRIVATE DRIVEWAY ENTRANCES FROM PUBLIC STREET ARE TO BE DESIGNED WITH ENHANCED PAVEMENT AND/OR CROSSWALK INCLUDING SIGNAGE TO THE SATISFACTION OF CITY ENGINEER.

NOTE: ALL STORM DRAIN SERVING THE PROJECT DISCHARGE INTO THE MAIN SAN DIEGO RIVER CHANNEL. THEREFORE, THE DISCHARGE LOCATION ARE WITHIN THE 10-YEAR FLOOD PLAIN.

NOTE:
NO OBSTRUCTION INCLUDING SOLID WALLS IN THE VISIBILITY AREA SHALL EXCEED 3 FEET IN HEIGHT. PLANT MATERIAL, OTHER THAN TREES, WITHIN THE PUBLIC RIGHT-OF-WAY THAT IS LOCATED WITHIN VISIBILITY AREAS NOT EXCEED 24 INCHES IN HEIGHT, MEASURED FROM THE TOP OF THE ADJACENT CURB.

VESTING TENTATIVE MAP FOR RIVERWALK

PROJECT DESIGN CONSULTANTS
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DESIGN BY: SC/JD DRAWN BY: KO/RF CHECKED BY: DR

Prepared By:
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Sheet 8 of 20

PTS # 581984

1856-6271 CCS83 COORDINATES
216-1711 LAMBERT COORDINATES

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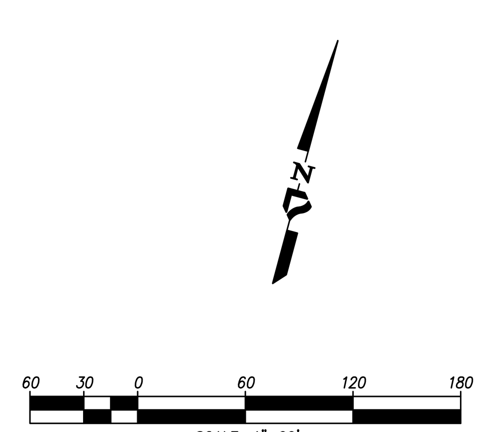

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TRIFOLIUM TRIDENTATUM	4.0
VULPIA MICROSTACHYS	8.0
PROMATRIX EFM	3,000
HYDROPOST PREMIUM COMPOST	1,000
TOTAL PURE LIVE SEED	4,032
SLURRY COMPONENTS:	
FLEXTERRA HP–FGM	3,000 LBS/ACRE
BIOSOL FORTE 7–2–1 FERTILIZER	600 LBS/ACRE
AM 120 MYCORRHIZAL INOCULUM	60 LBS/ACRE

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Sheet 9 of 20

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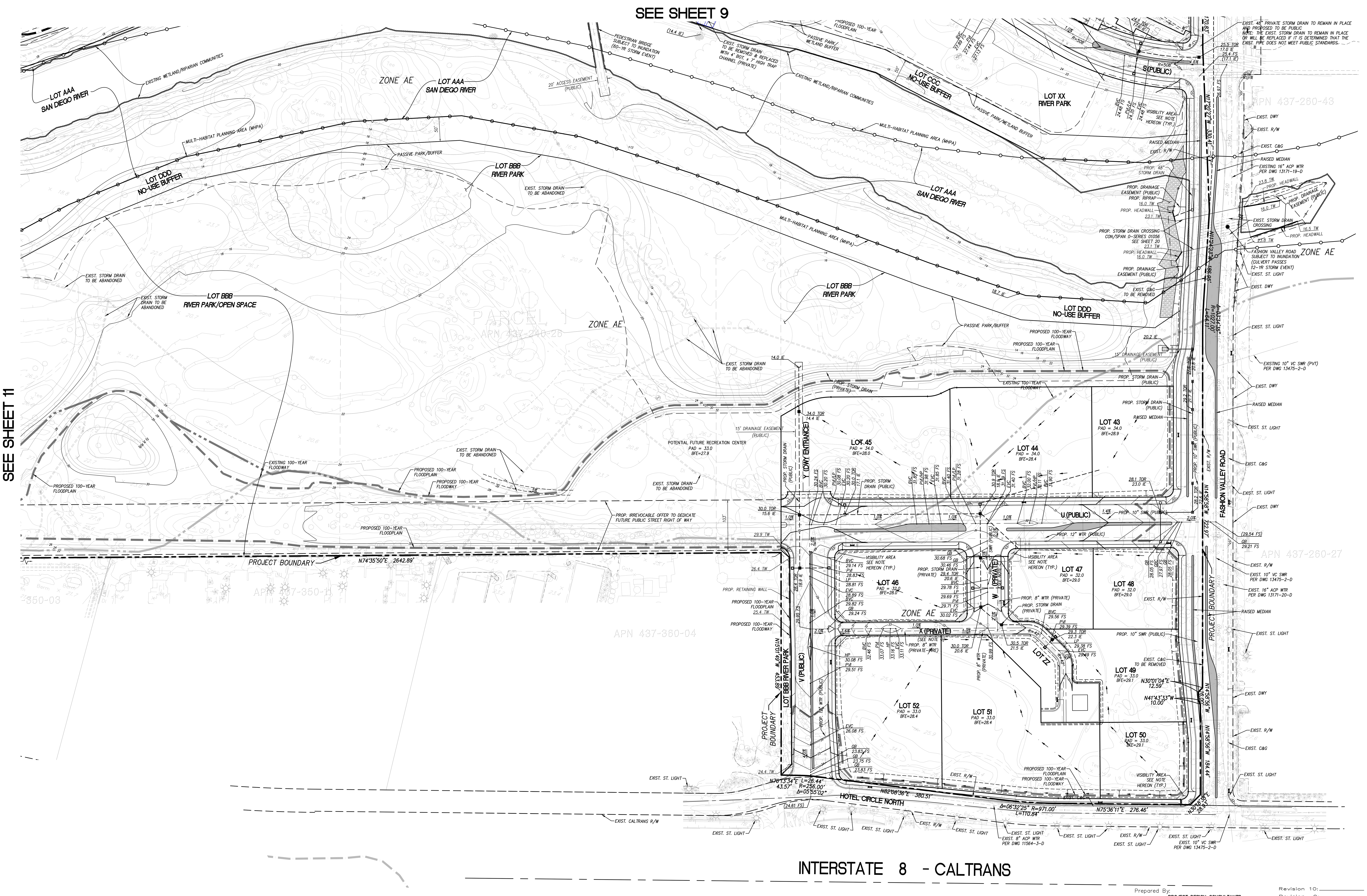

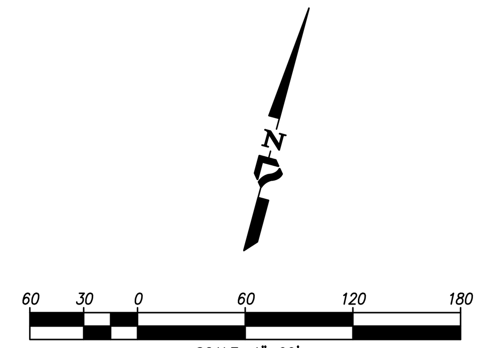

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Sheet 10 of 20

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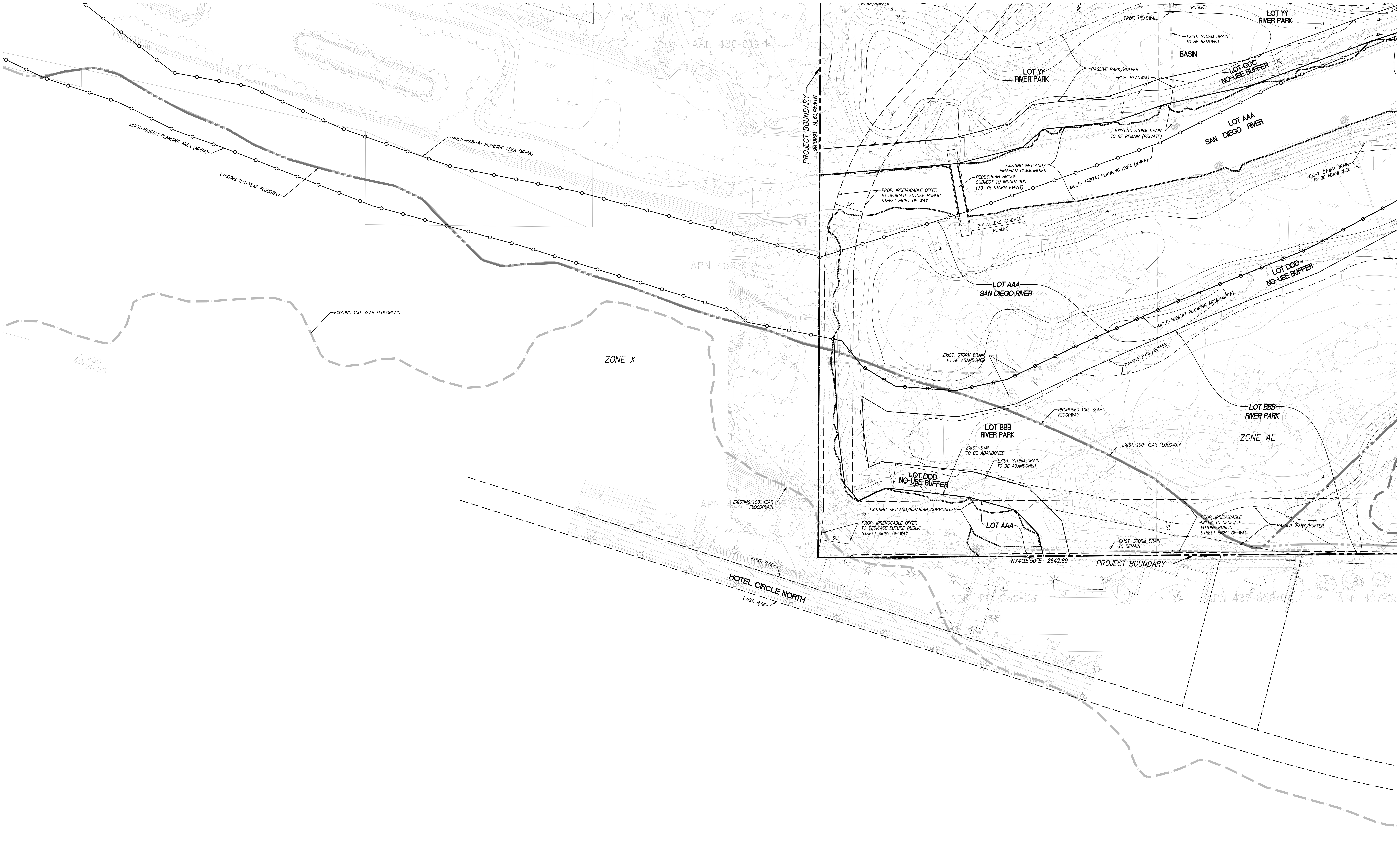

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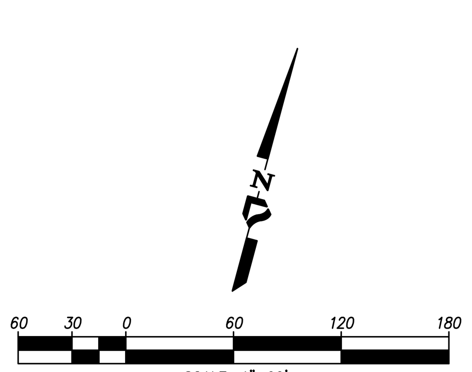

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PTS # 581984

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ATTACHMENT 5
DRAINAGE REPORT

Attach project's drainage report. Refer to Drainage Design Manual to determine the reporting requirements.

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PRELIMINARY DRAINAGE REPORT
FOR
RIVERWALK - VESTING
TENTATIVE MAP NO. 2213361
(PTS NO. 581984)

April 7, 2020

REGISTERED PROFESSIONAL ENGINEER
WAYNE W. CHANG
No. 46548
Exp. 6/30/21
CIVIL
STATE OF CALIFORNIA

Wayne W. Chang, MS, PE 46548

Chang Consultants
Civil Engineering ◦ Hydrology ◦ Hydraulics ◦ Sedimentation

P.O. Box 9496
Rancho Santa Fe, CA 92067
(858) 692-0760

-TABLE OF CONTENTS -

Introduction..1

Hydrologic Results..2

Hydraulic Results..4

Conclusion 5

APPENDIX

A. Rational Method Data and Results

B. HEC-RAS Results

MAP POCKET

William A. Steen and Associates Hydrology Work Maps

Proposed Condition Rational Method and HEC-RAS Work Map

INTRODUCTION

The Riverwalk project (see the Vicinity Map) proposes an amendment to the existing Levi-Cushman Specific Plan to replace the 195-acre Riverwalk property with the Riverwalk Specific Plan and redevelop the existing golf course as a walkable, transit-centric, and modern live-work-play mixed-use neighborhood that features an expansive River Park along the San Diego River. The mix and quantity of land uses would change from what is approved in the existing Levi-Cushman Specific Plan to include 4,300 multi-family residential dwelling units; 152,000 square feet of commercial retail space; 1,000,000 square feet of office and non-retail commercial; approximately 95 acres of park, open space, and trails; adaptive reuse of the existing golf clubhouse into a community amenity; and a new Green Line Trolley stop within the development. Improvements to surrounding public infrastructure and roadways would be implemented as part of the Riverwalk project, including improvements to the Fashion Valley Road crossing of the San Diego River as a 10- to 15-year storm event crossing. The project would also include a habitat restoration effort on-site to create and/or enhance 25.16 acres of native habitats along the San Diego River, within and adjacent to the MHPA, and setting aside area for establishing a future wetland habitat mitigation bank.

The project would establish Irrevocable Offers of Dedication (IODs) for two Community Plan Circulation Element roadways envisioned in the Mission Valley Community Plan Update: future Riverwalk Street "J," which would cross the San Diego River in a north-south direction; and future Riverwalk Street "U," which would travel approximately east-west along the southern project site boundary and connect to future Street "J." Street "J" would be an elevated roadway crossing the river valley. Per the City's Planning Department, these roads are regional facilities with uncertain funding, design, and construction timing. While these improvements would not be constructed as part of the project, the project would grant the City IODs for the required rights-of-way to construct these roads in the future.

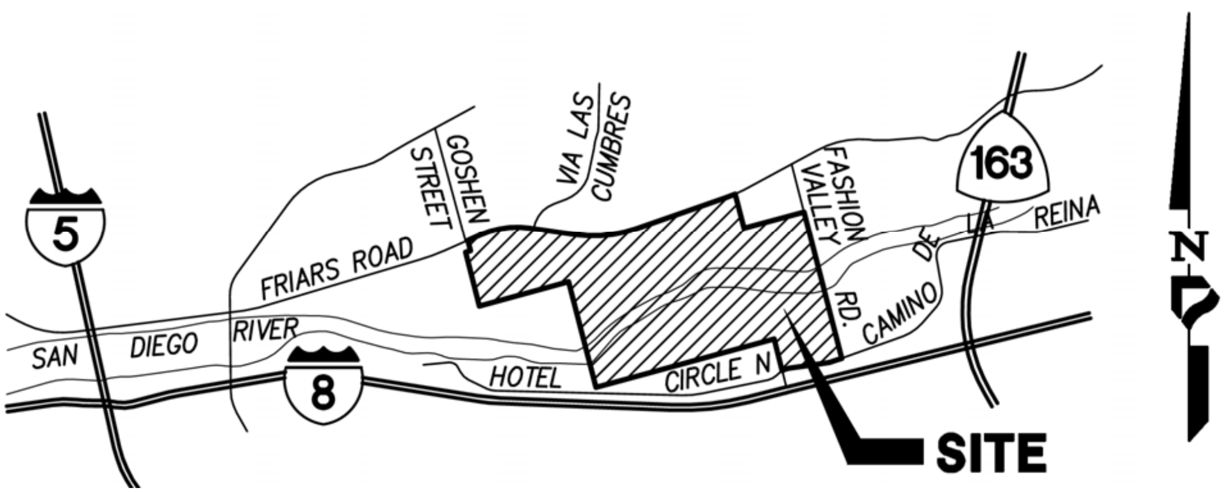

Figure 1. Vicinity Map

Surrounding uses include commercial retail (Fashion Valley Mall) and hotel (Town & Country Resort) east of Fashion Valley Road. Single- and multi-family residential and commercial office developments are located on the north side of Friars Road within the Linda Vista Community

Plan area. The properties west of the site include residential development in the form of condominium complexes and the Mission Valley YMCA. A mix of office, residential, hotel, and Interstate 8 (I-8) are located south of the project site.

Under existing conditions, a large portion of the site is within the San Diego River floodplain and floodway, which is mapped on FEMA's May 16, 2012, Flood Insurance Rate Map No. 06073C1618G (see Figure 2 after this report text). The floodplain and floodway flow in a westerly direction and are primarily south of the trolley. An off-site natural hillside area to north conveys flows to the site via storm drain facilities along Friars Road. The on- and off-site runoff are ultimately conveyed to the San Diego River.

The proposed project will include drainage facilities and water quality best management practices. The facilities will convey the off-site runoff through the site to the river. The off-site runoff will not commingle with the on-site runoff until the on-site runoff is treated. A dual storm drain system will be constructed on-site. One system will primarily convey storm runoff from the development pads, while the other will primarily convey street and adjacent runoff. The project runoff will be treated by biofiltration basins or compact biofiltration BMPs (e.g., Modular Wetland System Linear or equivalent) before discharging towards the river.

The project will impact jurisdictional Waters of the State and Waters of the US, which will require permitting from the US Army Corps of Engineers (Corps), California Dept. of Fish and Wildlife (CDFW), and Regional Water Quality Control Board (RWQCB). The impacts would result from filling of a small drainage in the northeast portion of the site, as well as at the location where improvements to Fashion Valley Road would occur. These impacts are considered unavoidable and have been minimized to the extent practicable. Unavoidable impacts include those necessary to allow reasonable use of a parcel entirely constrained by wetlands, roads where the only access to the developable portion of a site results in impacts to wetlands, and essential public facilities (essential roads like Fashion Valley Road, sewer, water lines, etc.) where no feasible alternative exists. Based on initial communication with the regulatory agencies, it is anticipated that a Federal Clean Water Act Section 404 Nationwide Permit will be required by the Corps, a Section 401 Water Quality Certification by the RWQCB, and a Streambed Alteration Agreement by the CDFW. The actual permitting requirements will be determined through consultation with the regulatory agencies

This preliminary drainage report has been prepared in support of the Vesting Tentative Map by Project Design Consultants. This report provides hydrologic and hydraulic analyses in order to determine preliminary flow rates, analyze the adjacent San Diego River, and demonstrate feasibility as well as compliance with drainage regulations.

HYDROLOGIC RESULTS

The overall proposed condition study area covers just over 306 acres, so the City of San Diego's 2017 *Drainage Design Manual's* rational method procedure was the basis for the proposed condition hydrologic analyses. The CivilDesign Rational Method Hydrology Program is based on the City criteria and was used for the 100-year analyses. Since the project discharges to the

San Diego River, City staff has indicated that detention analyses are not required. As a result, this report only contains proposed condition analyses. The rational method input parameters are summarized below, and the supporting data is included in Appendix A:

- Intensity-Duration-Frequency: The City's 100-year Intensity-Duration-Frequency curve from the *Drainage Design Manual* was used.

- Drainage area: The proposed condition drainage basins were delineated from the Vesting Tentative Map grading and storm drain layout. The drainage basin boundaries and grading are shown on the Rational Method and HEC-RAS Work Map in the map pocket. The tributary off-site area north of Friars Road was previously analyzed by William A. Steen and Associates. Their analyses are included in Appendix A and were used for the off-site data, which was entered as user-specified input. The off-site analyses shall be confirmed during final engineering. The site was divided into five major basins, 100 to 500, which reflect the five primary discharge areas.

- Hydrologic soil groups: The soil group within the site is entirely 'D' according to City criteria.

- Runoff coefficients: Under proposed conditions, the northerly project area will primarily support multi-family residential development, so the so the multi-unit land use was assumed (C=0.70). The southeasterly area will primarily support office uses, so the commercial land use was assumed (C=0.85).

- Flow lengths and elevations: The flow lengths and elevations were obtained from the topographic mapping and grading plan.

The overall 100-year rational method results are included in Appendix A and summarized in Table 1. The results indicate that the flow rates are of a magnitude that can be conveyed by standard drainage facilities. For proposed conditions, the overall flow rates from each of the five major basins was also confluenced. The confluencing will adjust for differences in time of concentration from the five locations.

Major Drainage Basin	Tributary Area, ac	100-Year Flow Rate, cfs
100	121.01	208
200	48.81	70
300	116.14	166
400	6.42	12
500	14.60	43
All	306.98	499

Table 1. Rational Method Summary

HYDRAULIC RESULTS

The project proposes a portion of the mixed-use development and a park site within portions of the floodplain and floodway. A park concept has been developed and the grading is included on the map pocket. The City of San Diego and FEMA's floodplain and floodway regulations apply for floodplain and floodway encroachments. The City' *Municipal Code* outlines the local regulations. The *Municipal Code* generally reflects the FEMA regulations provided in the *Code of Federal Regulations*, although the City can adopt more stringent criteria where they deem necessary. Relevant regulations are as follows:

- *Municipal Code* Section 143.0146(a)(7) states that floodway encroachments including fill, new construction, modifications, and other development are prohibited unless a registered engineer certifies that the encroachments will not increase the base flood (100-year water surface) levels.

- *Municipal Code* Section 143.0146(c)(6) requires new construction or substantial improvement of any structure to have the lower floor elevated at least 2 feet above the base flood elevation, i.e., 2 feet of freeboard over the 100-year water surface elevations.

The project will offset water surface impacts from the floodplain and floodway encroachments by increasing conveyance within the proposed park, i.e., the park area will be widened and/or lowered to provide the offset. Existing and proposed hydraulic analyses were performed using HEC-RAS to estimate the associated water surface elevations. The intent is to show that a concept is feasible that will not increase the 100-year water surface elevations. The existing condition HEC-RAS cross-sections were created from the project's topographic mapping supplemented with SANGIS mapping, while the proposed condition cross-sections were based on the tentative map grading. The cross-section locations, proposed 100-year floodplain, and proposed regulatory floodway are included on the Rational Method and HEC-RAS Work Map in the map pocket.

The additional HEC-RAS parameters are as follows. The FEMA 100-year flow rate of 36,000 cfs was used. The channel roughness was based on current conditions estimated from a site visit and aerial photography as well as potential proposed conditions. The project proposes to increase conveyance at Fashion Valley Road. The current crossing contains six 60-inch reinforced concrete pipes. The current vesting tentative map proposes to replace these with an arch culvert with a 56-foot span (CON/SPAN O-Series 01056 culvert), which will increase capacity.

The HEC-RAS results are included in Appendix B and summarized in Table 2. Comparison of the existing and proposed condition results shows that the grading will not increase the 100-year water surface elevations, so a no-rise condition is feasible. In addition, the water surface elevations upstream of Fashion Valley Road are lowered due to the proposed arch culvert. Since the San Diego River is under subcritical flow, changes at a given location will only impact upstream water surface elevations, not downstream. As a result, the off-site water surface elevations downstream of the project will not be altered or impacted by the project. On the other hand, Table 2 shows that the upstream water surface elevations will be benefited (lowered) by the project since the project causes a decrease just upstream of Fashion Valley Road. Ultimately, the upstream water surface elevations resulting from the project will match existing conditions. Above this, the project will not alter the off-site water surface elevations.

The current site contains two golf cart/pedestrian crossings (cross-section 24797 and 26944). As mentioned above, the Fashion Valley Road crossing (cross-section 28300) is also being improved with an arch culvert. Additional hydraulic analyses were performed to estimate the capacity of these three crossings. The results are included in Appendix B. They show that westerly golf course bridge can convey about 10,000 cfs under proposed conditions before water reaches the low end of the bridge or just over the 30-year event. The easterly golf course bridge can convey about 20,000 cfs under proposed conditions before water reaches the low end of the bridge or about the 60-year event. The proposed Fashion Valley Road culvert can convey about 4,000 cfs before overtopping the road or about the 12-year event.

CONCLUSION

This preliminary drainage report shows that the project flows are of a magnitude that can be conveyed by typical drainage facilities. Since the project outlets into the San Diego River detention is not required. The timing of flow increases at the site will occur before peak flow in the river. A portion of the golf course within the floodplain and floodway will be redeveloped with the multi-use project and contain a park. Since the project will encroach within the floodway, a no-rise will be met (i.e., no increase in the 100-year water surface elevations downstream of the site, within the site, nor upstream of the site). Hydraulic analyses demonstrate feasibility of developing a park concept that will achieve a no-rise. In addition, improvements to the Fashion Valley Road culverts will increase flow conveyance at the crossing. Finally, the work map delineates the updated 100-year floodplain and floodway. The proposed insurable structures will not be within the revised floodway. The revised floodway will be along the park site, which is allowed. Where the proposed 100-year floodplain and floodway lines are coincident, only the floodplain is delineated. A Conditional Letter of Map Revision and Letter of Map Revision will be prepared and processed through the city of San Diego and FEMA in order to modify the floodplain and floodway.

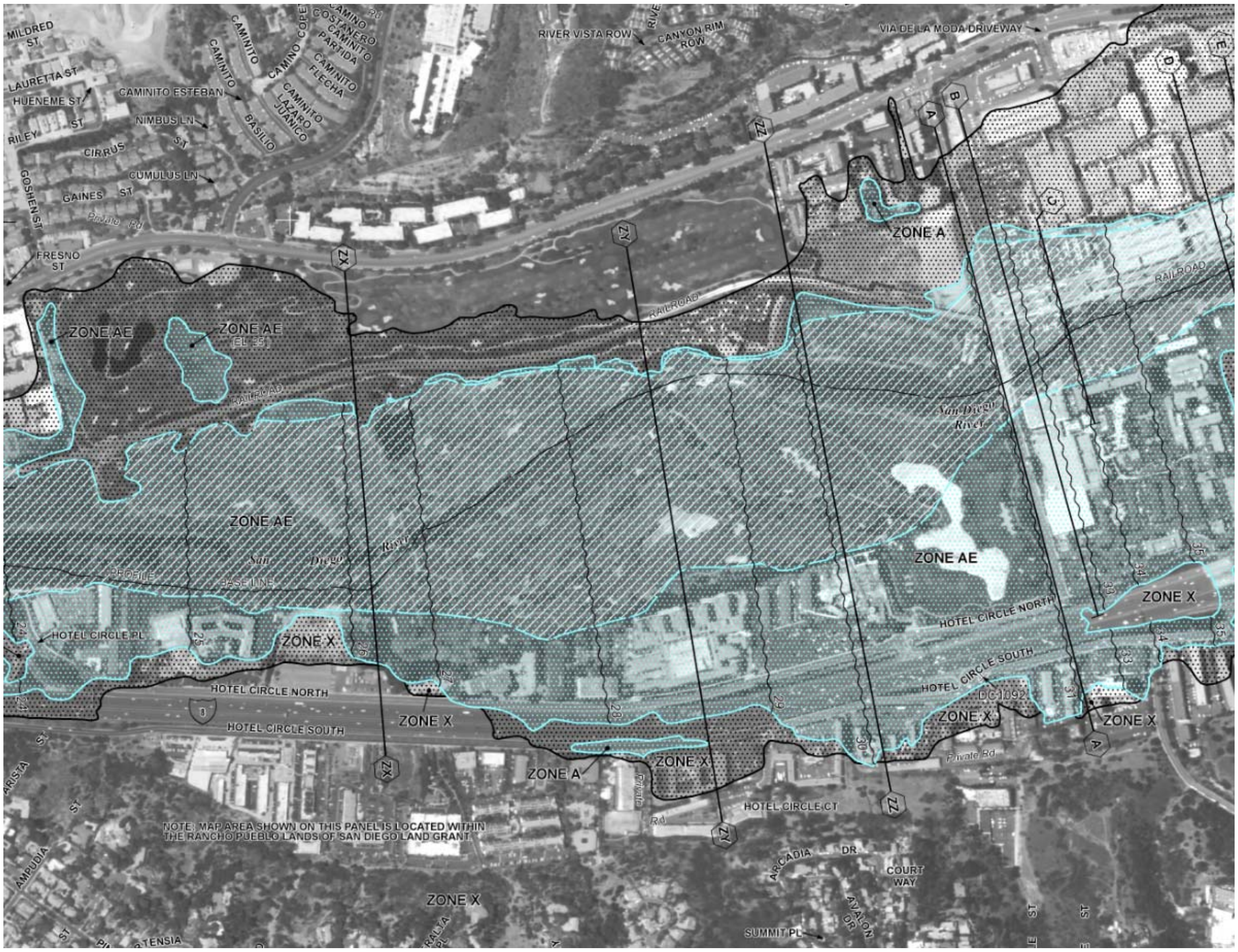

Figure 2. FEMA 100-Year Floodplain and Floodway

River Station	Exist. 100-Year Water Surface Elevations, feet	Prop. Concept 100-Year Water Surface Elevations, feet	Prop. – Exist., feet
28331	30.79	30.46	-0.33
28300	Fashion Valley Road		
28269	29.64	29.18	-0.46
28244	29.74	29.31	-0.43
28164	28.77	28.65	-0.12
28064	28.80	28.44	-0.36
27929	28.75	28.25	-0.50
27759	28.63	27.97	-0.66
27589	28.51	27.98	-0.53
27429	28.33	27.96	-0.37
27259	28.25	27.89	-0.36
27069	28.02	27.60	-0.42
26951	27.96	27.36	-0.60
26944	Easterly Golf Course Bridge		
26937	27.95	27.33	-0.62
26799	27.70	27.16	-0.54
26614	27.50	26.94	-0.56
26379	27.06	26.56	-0.50
26174	26.92	26.34	-0.58
25914	26.78	26.26	-0.52
25654	26.47	26.20	-0.27
25354	26.37	26.14	-0.23
25181	26.27	26.09	-0.18
25001	26.14	26.01	-0.13
24804	26.06	25.97	-0.09
24797	Westerly Golf Course Bridge		
24790	26.03	25.96	-0.07
24581	25.75	25.73	-0.02
24401	25.31	25.28	-0.03
24226	24.98	24.98	0.00
24019	24.62	24.62	0.00
23800	24.21	24.21	0.00
23796	24.13	24.13	0.00
23650	24.17	24.17	0.00
23636	24.05	24.05	0.00
23470	23.78	23.78	0.00
23461	23.76	23.76	0.00
23220	23.60	23.60	0.00
23210	23.17	23.17	0.00
23200	23.00	23.00	0.00
23171	22.60	22.60	0.00
22880	22.36	22.36	0.00
22870	22.53	22.53	0.00
22860	22.08	22.08	0.00
22850	22.15	22.15	0.00

Table 2. Comparison of 100-Year Water Surface Elevations

APPENDIX A

RATIONAL METHOD
DATA AND RESULTS

HYDROLOGY AND HYDRAULIC CALCULATIONS

FOR

STARDUST GOLF COURSE

W.O. NO. 950613

DWG. NO. 28076-D

C.U.P. 94-0563

REV. 10-20-97 ADD SHEETS 9a THRU 9e, DELETE SHEET 10

REV. 10-6-97 ADD SHEETS 10a AND 10b, REVISE SHEETS 10 AND 12

REV. 9-16-97 ADD SHEETS 12a THRU 12e

SCALE:	PROJ. ENGR. WILLIAM A. STEEN			WILLIAM A. STEEN & ASSOCIATES CONSULTING CIVIL ENGINEERS LAND SURVEYING & PLANNING
DATE 7-11-97	RCE: 18136			
SHEET 1 OF 21	JOB NO. 6600	DR. BY K.A.M.	CK. BY: Z.L.S.	8580 LA MESA BLVD., SUITE 102, LA MESA, CALIFORNIA 91941 ■ (619) 460-9000 ■ FAX (619) 460-9005 ■

THESE CALCULATIONS WERE PREPARED TO ADDRESS THE OFFSITE DRAINAGE THAT ENTERS THE GOLF COURSE FROM THE DRAINAGE BASINS NORTH OF FRIARS ROAD, CROSSES THE NORTHERLY PORTION OF THE GOLF COURSE, AND IS TRANSMITTED UNDER THE MTDB MISSION VALLEY WEST LRT EXTENSION THROUGH THE PROPOSED STORM DRAIN CULVERTS. THE PROPOSED STORM DRAIN CULVERTS WERE SIZED TO ACCOMODATE THIS OFFSITE DRAINAGE PLUS THE DRAINAGE FROM A COMMERCIALLY DEVELOPED SITE, IN THE EVENT THAT THE NORTHERLY PORTION OF THE GOLF COURSE IS SO DEVELOPED IN THE FUTURE.

THE MAJORITY OF THE GOLF COURSE IS INNUNDATED BY THE SAN DIEGO RIVER DURING MAJOR STORM EVENTS. THEREFORE, NO CALCULATIONS WERE PREPARED FOR THE OTHER PRIVATE STORM DRAINS AS THEIR PRIMARY FUNCTION IS TO FACILITATE THE DRAINAGE OF THE GOLF COURSE AFTER THESE MAJOR STORM EVENTS AND TO ELIMINATE PONDING DURING SMALL LOCAL STORM EVENTS.

WS WILLIAM A. STEEN & ASSOCIATES
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WEST BASIN:

DESTINATION: PROPOSED STORM DRAIN CULVERT NEAR HOLE 3V TEES AND EXISTING 24" RCP CULVERT NEAR HOLE 2V TURNING POINT NUMBER 1

BASIN W-1:

DESTINATION: EXISTING 24" RCP CULVERT IN FRIARS ROAD THEN PROPOSED STORM DRAIN CULVERT NEAR HOLE 3V TEES

$A_T = 18.6$ AC, $C_T = 0.55$ (USE FOR LARGE UNDEVELOPED AREAS)

URBAN OVERLAND FLOW:

$L = 440'$, $S = (247-245)/440 = 0.5\%$

USE: $C = 0.85$

$T_c \cong 1.8(1.1-C)D^{1/2}/S^{1/3} = 11.9$ MIN

$I_{100} = 3.2$ IN/HR

$A = 0.9$ AC

$Q_{100} = CI_{100}A = 2.4$ CFS

CHANNEL FLOW:

$L = 220'$, $S = (245-188)/220 = 25.9\%$

ASSUME: TRAPEZOIDAL SECTION, 5' BOTTOM WIDTH, 4:1 SIDE SLOPES, $n = 0.040$

$b^{8/3} = 73.10$, $S^{1/2} = 0.5089$, $K' = Qn/b^{8/3}S^{1/2} = 0.00258$

$D/b = 0.0215$, $D = 0.11'$

$A = bD + 2D^2 = 0.57$ SF

$V = Q/A = 4.2$ FPS

$T_c = 11.9 + 220/4.2(60) = 12.8$ MIN

$I_{100} = 3.1$ IN/HR

$A = 0.2$ AC

USE: $C = 0.45$

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BASIN W-1 (CONT.):

$Q_{100} = 3.1(2.4)/3.2 + 0.3 = 2.6$ CFS

GUTTER FLOW:

$L = 1405'$, $S = (188-37)/1405 = 10.7\%$

ASSUME: $Q_{AV} = 10$ CFS

$V = 7.8$ FPS

$T_c = 12.8 + 1405/7.8(60) = 15.8$ MIN

$I_{100} = 2.8$ IN/HR

$A = 17.5$ AC

$Q_{100} = 2.8(2.6)/3.1 + 27.0 = 29.3$ CFS

PIPE FLOW (SEE DWG. 13095-D AND 17923-D):

$L = 936'$, $S = 0.46\%$

24" RCP, $n = 0.013$

$d^{8/3} = 6.350$, $S^{1/2} = 0.0678$, $K' = Qn/d^{8/3}S^{1/2} = 0.885$

$K'_{max} = 0.498 < K' = 0.885$ ∴ $Q_{100} = 29.3$ CFS IS GREATER THAN THE CAPACITY OF A 24" RCP CULVERT WITHOUT ENTRANCE HEAD

AVAILABLE HEAD = 3.5' ±, $HW/D = 2.75$

$Q_{MAX} = 36$ CFS $> Q_{100} = 29.3$ CFS ∴ OK

$A = \pi D^2/4 = 3.14$ SF

$V = Q/A = 9.3$ FPS

$T_c = 15.8 + 936/9.3(60) = 17.5$ MIN

$I_{100} = 2.7$ IN/HR

$Q_{100} = 2.7(29.3)/2.8 = 28.3$ CFS

PIPE FLOW (PROPOSED):

$L = 75'$, $S = (17-13.7)/75 = 4.4\%$

ASSUME: 24" RCP CULVERT, $n = 0.013$

$d^{8/3} = 6.350$, $S^{1/2} = 0.2098$, $K' = 0.276$

$D/d = 0.5563$, $D = 1.11'$

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BASIN W-1 (CONT.):

$V = 15.8$ FPS

$T_c = 17.5 + 75/15.8(60) = 17.6$ MIN

$I_{100} = 2.7$ IN/HR

$Q_{100} = 2.7(28.3)/2.7 = 28.3$ CFS

BASIN W-2:

DESTINATION: EXISTING 12" ACP CULVERT ALONG COURTYARD CONDOMINIUM EASTERLY PROPERTY LINE THEN PROPOSED STORM DRAIN CULVERT NEAR HOLE 3V TEES

$A_T = 0.6$ AC, $C_T = 0.70$

URBAN OVERLAND FLOW:

$L = 435'$, $S = (29-24)/435 = 1.1\%$

$T_c = 14.5$ MIN

$I_{100} = 2.95$ IN/HR

$Q_{100} = 1.2$ CFS

PIPE FLOW (SEE DWG. 17923-D):

$L = 348'$, $S = 1.04\%$

12" ACP, $n = 0.013$

$d^{8/3} = 1.000$, $S^{1/2} = 0.1020$, $K' = 0.1529$

$D/d = 0.3955$, $D = 0.40'$

$V = 4.2$ FPS

$T_c = 14.5 + 348/4.2(60) = 15.9$ MIN

$I_{100} = 2.8$ IN/HR

$Q_{100} = 2.8(1.2)/2.95 = 1.1$ CFS

PIPE FLOW (PROPOSED):

$L = 65'$, $S = (17-13.7)/65 = 5.1\%$

ASSUME: 12" PVC CULVERT, $n = 0.013$

$d^{8/3} = 1.000$, $S^{1/2} = 0.2258$, $K' = 0.0633$

BASIN W-2 (CONT.):

$D/d = 0.2498$, $D = 0.25'$

$V = 7.2$ FPS

$T_c = 15.9 + 65/7.2(60) = 16.1$ MIN

$I_{100} = 2.8$ IN/HR

$Q_{100} = 2.8(1.1)/2.8 = 1.1$ CFS

BASIN W-3:

DESTINATION: EXISTING 42" RCP CULVERT IN FRIARS ROAD THEN PROPOSED STORM DRAIN CULVERT NEAR HOLE 3V TEES

$A_T = 77.4$ AC, $C_T = 0.55$ (USE FOR LARGE UNDEVELOPED AREAS)

URBAN OVERLAND FLOW:

$L = 215'$, $S = (271-265)/215 = 2.8\%$

USE: $C = 0.85$

$T_c = 4.7$ MIN ∴ USE $T_c = 5$ MIN

$I_{100} = 4.4$ IN/HR

$A = 0.8$ AC

$Q_{100} = 3.0$ CFS

GUTTER FLOW:

$L = 1600'$, $S = (265-114)/1600 = 9.4\%$

ASSUME: $Q_{AV} = 10$ CFS

$V = 7.3$ FPS

$T_c = 5 + 1600/7.3(60) = 8.7$ MIN

$I_{100} = 3.65$ IN/HR

$A = 9.5$ AC

$Q_{100} = 3.65(3.0)/4.4 + 19.1 = 21.6$ CFS

PIPE FLOW (SEE DWG. 14044-D):

$L = 195'$, $S = (114-77)/195 = 19.0\%$

18" RCP, $n = 0.013$

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BASIN W-3 (CONT.):

$d^{8/3} = 2.948$, $S^{1/2} = 0.4359$, $K' = 0.2185$

$D/d = 0.4832$, $D = 0.72'$

$V = 25.5$ FPS

$T_c = 8.7 + 195/25.5(60) = 8.8$ MIN

$I_{100} = 3.6$ IN/HR

$A = 0.1$ AC

USE: $C = 0.45$

$Q_{100} = 3.6(21.6)/3.65 + 0.2 = 21.5$ CFS

BROW DITCH FLOW:

$L = 90'$, $S = (77-65)/90 = 13.3\%$

ASSUME: CIRCULAR SECTION, 2' TOP WIDTH, $n = 0.018$

$d^{8/3} = 6.350$, $S^{1/2} = 0.3647$, $K' = 0.1671$

$D/d = 0.4152$, $D = 0.83'$

$V = 17.4$ FPS

$T_c = 8.8 + 90/17.4(60) = 8.9$ MIN

$I_{100} = 3.6$ IN/HR

$A = 0.1$ AC

USE: $C = 0.45$

$Q_{100} = 3.6(21.5)/3.6 + 0.2 = 21.7$ CFS

PIPE FLOW (SEE DWG. 14003-D AND 13095-D):

$L = 1195'$, $S = (65-35)/1195 = 2.5\%$

USE: 24" RCP, $n = 0.013$

$d^{8/3} = 6.350$, $S^{1/2} = 0.1581$, $K' = 0.281$

$D/d = 0.5625$, $D = 1.13'$

$V = 11.9$ FPS

$T_c = 8.9 + 1195/11.9(60) = 10.6$ MIN

$I_{100} = 3.35$ IN/HR

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BASIN W-3 (CONT.):

A = 66.9 AC

Q_{100} = 3.35(21.7)/3.6 + 123.3 = 143.5 CFS

PIPE FLOW (FUTURE WITH COMMERCIALLY DEVELOPED SITE):

L = 1350', S = (30 - 13.7)/1350 = 1.2%

ASSUME: 48" RCP CULVERT, n = 0.013

$d^{8/3}$ = 40.317, $S^{1/2}$ = 0.1095, K' = 0.423

D/d = 0.7514, D = 3.01'

V = 14.2 FPS

T_c = 10.6 + 1350/14.2(60) = 12.2 MIN

I_{100} = 3.2 IN/HR

Q_{100} = 3.2(143.5)/3.35 = 137.1 CFS

BASIN W-4:

DESTINATION: PROPOSED STORM DRAIN CULVERT NEAR HOLE 3V TEES AND EXISTING 24" RCP CULVERT NEAR HOLE 2V TURNING POINT NUMBER 1

ASSUME: - NORTHERLY PORTION OF THE GOLF COURSE IS DIVIDED INTO THREE BASINS BASED UPON PROPORTIONING THE FRIARS ROAD FRONTAGE INTO APPROXIMATELY EQUAL THIRDS.
- BASIN WILL BE DEVELOPED AS A COMMERCIAL SITE.
- LONGEST TIME OF CONCENTRATION WILL BE FROM AN OFFSITE DRAINAGE BASIN.
- EXISTING 24" RCP CULVERT AT 0.746% PER MTDB MISSION VALLEY WEST LTR EXTENSION PLANS IS INEFFICIENT AND WILL BE USED FOR NUISANCE FLOW ONLY AND THEREFORE, IGNORED FOR THESE CALCULATIONS.

A_T = 25.3 AC, C_T = 0.85

MIDDLE BASIN:

DESTINATION: PROPOSED STORM DRAIN CULVERT APPROXIMATELY 310' SOUTHEASTERLY OF HOLE IV GREEN

BASIN M-1:

DESTINATION: EXISTING 24" RCP CULVERT IN FRIARS ROAD THEN PROPOSED STORM DRAIN CULVERT APPROXIMATELY 310' SOUTHEASTERLY OF HOLE IV GREEN

$A_T = 26.6$ AC, $C_T = 0.55$ (USE FOR LARGE UNDEVELOPED AREAS)

URBAN OVERLAND FLOW:

$L = 410'$, $S = (279 - 274)/410 = 1.2\%$

$T_c = 18.9$ MIN

$I_{100} = 2.5$ IN/HR

$A = 1.5$ AC

$Q_{100} = 2.1$ CFS

CHANNEL FLOW:

$L = 1200'$, $S = (274 - 80)/1200 = 16.2\%$

ASSUME: TRAPEZOIDAL SECTION, 5' BOTTOM WIDTH, 2:1 SIDE SLOPES, $n = 0.04$, $Q_{AV} = 10$ CFS

$b^{8/3} = 73.10$, $S^{1/2} = 0.4025$, $K' = 0.01359$

$D/b = 0.0586$, $D = 0.29'$

$A = 1.62$ SF

$V = 6.2$ FPS

$T_c = 18.9 + 1200/6.2(60) = 22.1$ MIN

$I_{100} = 2.35$ IN/HR

$A = 16.2$ AC

$Q_{100} = 2.35(2.1)/2.5 + 20.9 = 22.9$ CFS

PIPE FLOW (SEE DWG. 14003-D AND 13095-D):

$L = 945'$, $S = (80 - 50)/945 = 3.2\%$

SCALE:	PROJ. ENGR.	WILLIAM A. STEEN & ASSOCIATES — CONSULTING CIVIL ENGINEERS, LAND SURVEYING & PLANNING
DATE 7-11-97	RCE:	
SHEET 13 OF 21	JOB NO. 6600 — DR. BY K.O.M. — CK. BY: Z.C.S.	8580 LA MESA BLVD., SUITE 102, LA MESA, CALIFORNIA 92041 ■ (619) 460-9000 ■ FAX (619) 460-9005 ■

BASIN M-1 (CONT.):

USE: 24" RCP, $n=0.013$

$d^{8/3}=6.350$, $S^{1/2}=0.1789$, $K'=0.262$

$D/d=0.5388$, $D=1.08'$

$V=13.3$ FPS

$T_c=22.1+945/13.3(60)=23.3$ min

$I_{100}=2.3$ IN/HR

$A=8.9$ AC

$Q_{100}=2.3(22.9)/2.35+11.3=33.7$ CFS

PIPE FLOW (FUTURE WITH COMMERCIALLY DEVELOPED SITE):

$L=445'$, $S=(50-23.3)/445=6.0\%$

ASSUME: 36" RCP CULVERT, $n=0.013$

$d^{8/3}=18.721$, $S^{1/2}=0.2449$, $K'=0.0956$

$D/d=0.3083$, $D=0.92'$

$V=18.2$ FPS

$T_c=23.3+445/18.2(60)=23.7$ min

$I_{100}=2.3$ IN/HR

$Q_{100}=2.3(33.7)/2.3=33.7$ CFS

BASIN M-2:

DESTINATION: PROPOSED STORM DRAIN CULVERT APPROXIMATELY 310' SOUTHEASTERLY OF HOLE IV GREEN

ASSUME:
- NORTHERLY PORTION OF THE GOLF COURSE IS DIVIDED INTO THREE BASINS BASED UPON PROPORTIONING THE FRIARS ROAD FRONTAGE INTO APPROXIMATELY EQUAL THIRDS.
- BASIN WILL BE DEVELOPED AS A COMMERCIAL SITE.
- LONGEST TIME OF CONCENTRATION WILL BE FROM THE OFFSITE DRAINAGE BASIN.

$A_T=20.5$ AC, $C_T=0.85$

EAST BASIN:

DESTINATION: PROPOSED STORM DRAIN CULVERT NEAR HOLE 9V TEES

BASIN E-1:

DESTINATION: EXISTING 36" RCP CULVERT IN FRIARS ROAD THEN PROPOSED STORM DRAIN CULVERT NEAR HOLE 9V TEES

$A_T = 89.0$ AC, $C_T = 0.55$

URBAN OVERLAND FLOW:

$L = 120'$, $S = 1\%$

$T_c = 10.8$ MIN

$I_{100} = 3.35$ IN/HR

$A = 0.1$ AC

$Q_{100} = 0.2$ CFS

GUTTER FLOW:

$L = 2575'$, $S = (327 - 215)/2575 = 4.3\%$

ASSUME: $Q_{AV} = 10$ CFS

$V = 5.4$ FPS

$T_c = 10.8 + 2575/5.4(60) = 18.7$ MIN

$I_{100} = 2.6$ IN/HR

$A = 14.5$ AC

$Q_{100} = 2.6(0.2)/3.35 + 20.7 = 20.9$ CFS

PIPE FLOW (SEE DWG. 15418-D, 24523-D, 14408-D, AND 13095-D):

$L = 1690'$, $S = (215 - 55)/1690 = 9.5\%$

USE: 30" RCP, $n = 0.013$, $Q_{AV} = 60$ CFS

$d^{8/3} = 11.513$, $S^{1/2} = 0.3082$, $K' = 0.2198$

$D/d = 0.4849$, $D = 1.21'$

$V = 25.4$ FPS

$T_c = 18.7 + 1690/25.4(60) = 19.8$ MIN

$I_{100} = 2.5$ IN/HR

SCALE:	PROJ. ENGR.		WILLIAM A. STEEN & ASSOCIATES CONSULTING CIVIL ENGINEERS LAND SURVEYING & PLANNING
DATE 7-11-97	RCE:		
SHEET 18 OF 21	JOB NO. 6600	DR. BY K.A.M. CK. BY: Z.L.S.	8580 LA MESA BLVD., SUITE 102, LA MESA, CALIFORNIA 92041 ■ (619) 460-9000 ■ FAX (619) 460-9005 ■

BASIN E-1 (CONT.):

$A = 74.4\ AC$

$Q_{100} = 2.5(20.9)/2.6 + 102.3 = 122.4\ CFS$

PIPE FLOW (FUTURE WITH COMMERCIALLY DEVELOPED SITE):

$L = 775'$, $S = (50 - 26.5)/775 = 3.0\%$

ASSUME: 42" RCP CULVERT, $n = 0.013$

$d^{8/3} = 28.239$, $S^{1/2} = 0.1732$, $K' = 0.325$

$D/d = 0.6175$, $D = 2.16'$

$V = 19.6\ FPS$

$T_c = 19.8 + 775/19.6(60) = 20.5\ MIN$

$I_{100} = 2.45\ IN/HR$

$Q_{100} = 2.45(122.4)/2.5 = 120.0\ CFS$

BASIN E-2:

DESTINATION: PROPOSED STORM DRAIN CULVERT NEAR HOLE 9V TEES

ASSUME:
- NORTHERLY PORTION OF GOLF COURSE IS DIVIDED INTO THREE BASINS BASED UPON PROPORTIONING THE FRIARS ROAD FRONTAGE INTO APPROXIMATELY EQUAL THIRDS.
- BASIN WILL BE DEVELOPED AS A COMMERCIAL SITE.
- LONGEST TIME OF CONCENTRATION WILL BE FROM THE OFFSITE DRAINAGE BASIN.

$A_T = 14.9\ AC$, $C_T = 0.85$

BASIN E-1:

$T_c = 20.5\ MIN$, $I_{100} = 2.45\ IN/HR$, $Q_{100} = 120.0\ CFS$

$Q_{100} = Q_{E-1} + Q_{E-2}$

$= 120.0 + 0.85(2.45)(14.9)$

$Q_{100} = 151.0\ CFS$

SCALE:	PROJ. ENGR.			WILLIAM A. STEEN & ASSOCIATES CONSULTING CIVIL ENGINEERS LAND SURVEYING & PLANNING
DATE 7-11-97	RCE:			
SHEET 19 OF 21	JOB NO. 6600	DR. BY K.O.M.	CK. BY: Z.L.S.	8580 LA MESA BLVD., SUITE 102, LA MESA, CALIFORNIA 92041 (619) 460-9000 ■ FAX (619) 460-9005

Table A-1. Runoff Coefficients for Rational Method

Land Use	Runoff Coefficient (C) Soil Type [1]
Residential:	
Single Family	0.55
Multi-Units	0.70
Mobile Homes	0.65
Rural (lots greater than ½ acre)	0.45
Commercial [2]	
80% Impervious	0.85
Industrial [2]	
90% Impervious	0.95

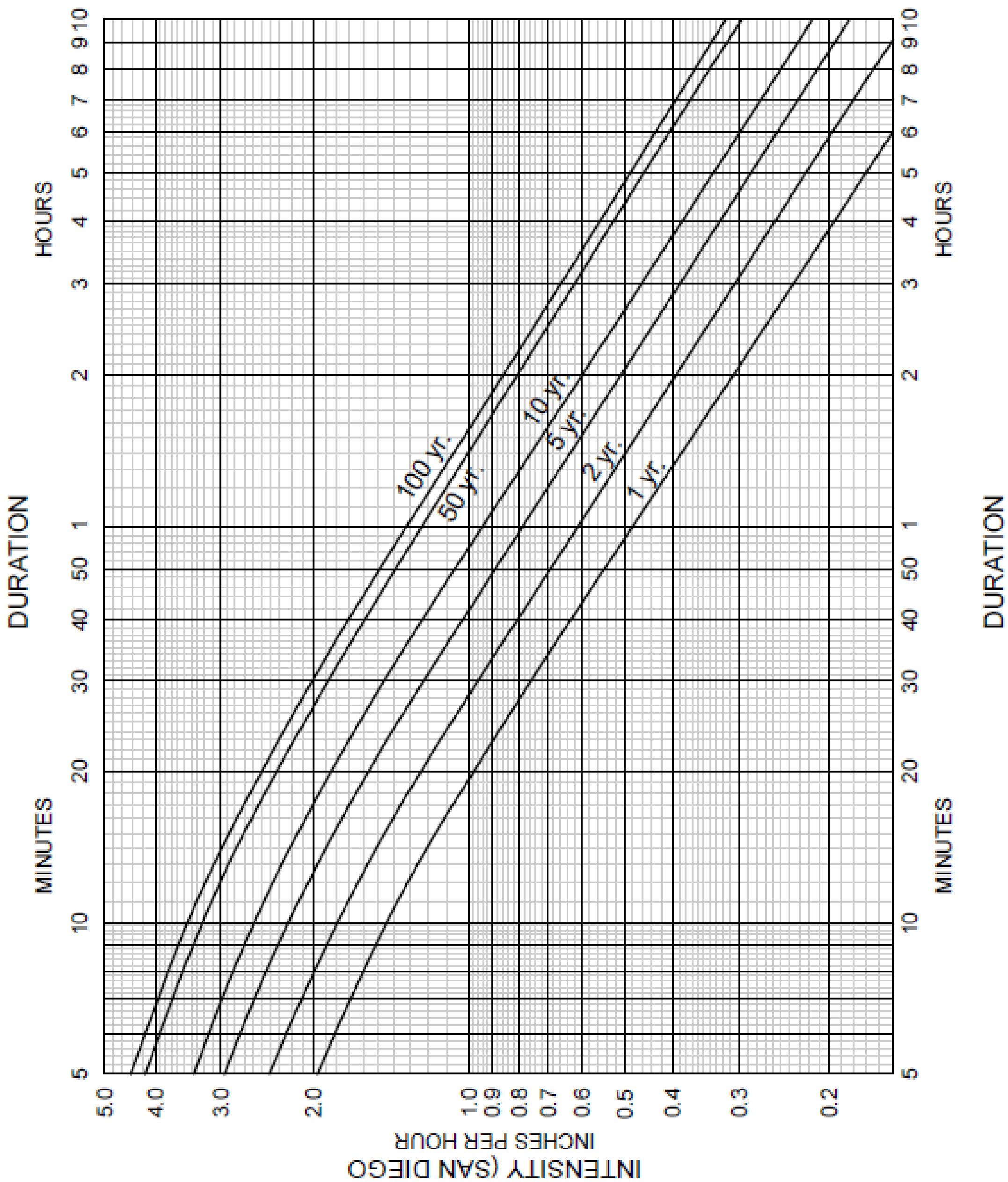
Note:
(1) Type D soil to be used for all areas.
(2) Where actual conditions deviate significantly from the tabulated imperviousness values of 80% or 90%, the values given for coefficient C, may be revised by multiplying 80% or 90% by the ratio of actual imperviousness to the tabulated imperviousness. However, in case shall the final coefficient be less than 0.50. For example: Consider commercial property on D soil.

Actual imperviousness			=	50%
Tabulated imperviousness			=	80%
Revised C	=	(50/80) x 0.85	=	0.53

The values in Table A–1 are typical for urban areas. However, if the basin contains rural or agricultural land use, parks, golf courses, or other types of nonurban land use that are expected to be permanent, the appropriate value should be selected based upon the soil and cover and approved by the City.

A.1.3. Rainfall Intensity

The rainfall intensity (I) is the rainfall in inches per hour (in/hr.) for a duration equal to the T_C for a selected storm frequency. Once a particular storm frequency has been selected for design and a T_C calculated for the drainage area, the rainfall intensity can be determined from the Intensity-Duration-Frequency Design Chart (Figure A-1).



ELEV.	FACTOR
0-1500	1.00
1500-3000	1.25
3000-4000	1.42
4000-5000	1.60
5000-6000	1.7
DESERT	1.25

TO OBTAIN CORRECT INTENSITY, MULTIPLY INTENSITY ON CHART BY FACTOR FOR DESIGN ELEVATION.

RAINFALL

INTENSITY - DURATION - FREQUENCY CURVES

FOR

COUNTY OF SAN DIEGO

Figure A-1. Intensity-Duration-Frequency Design Chart

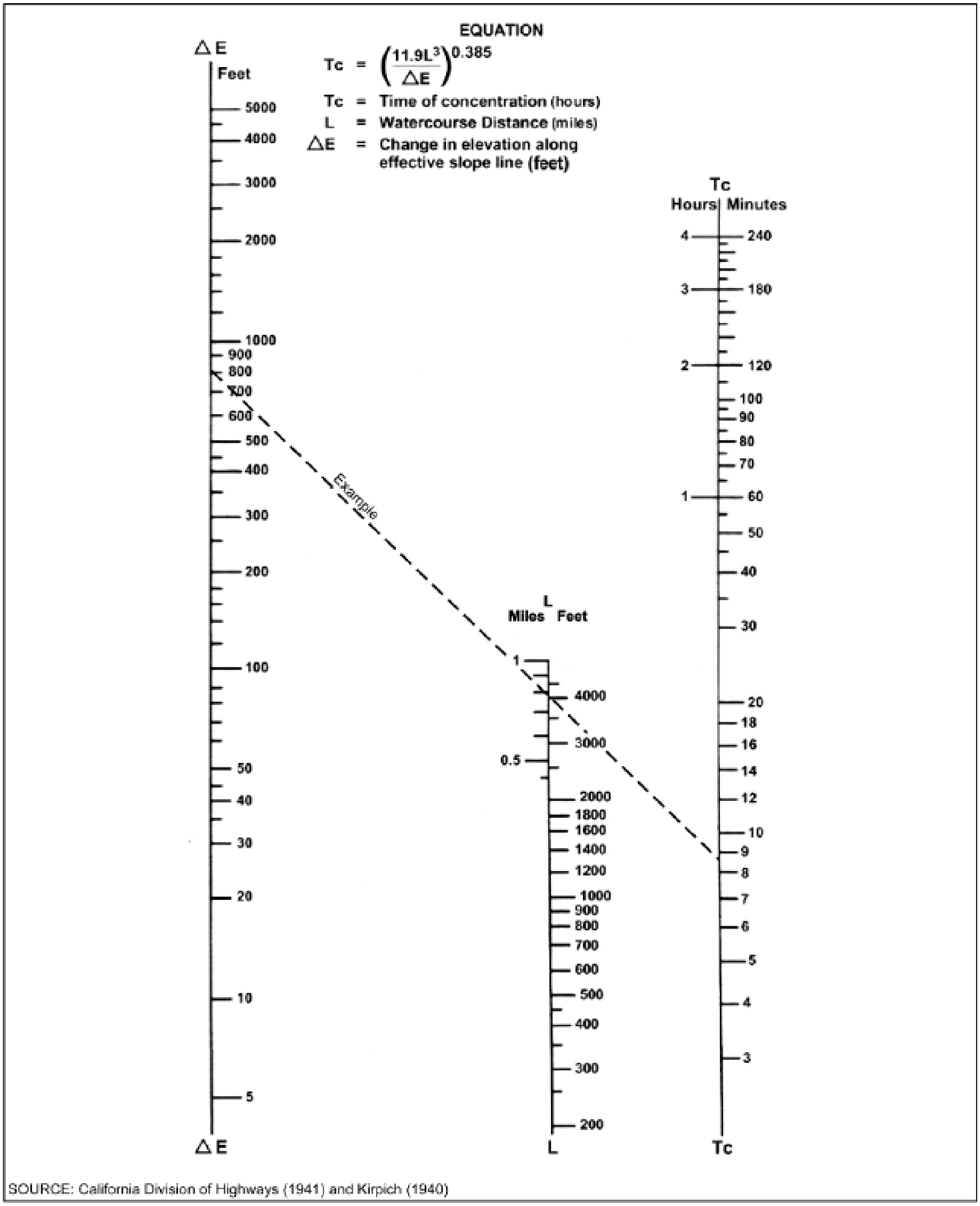
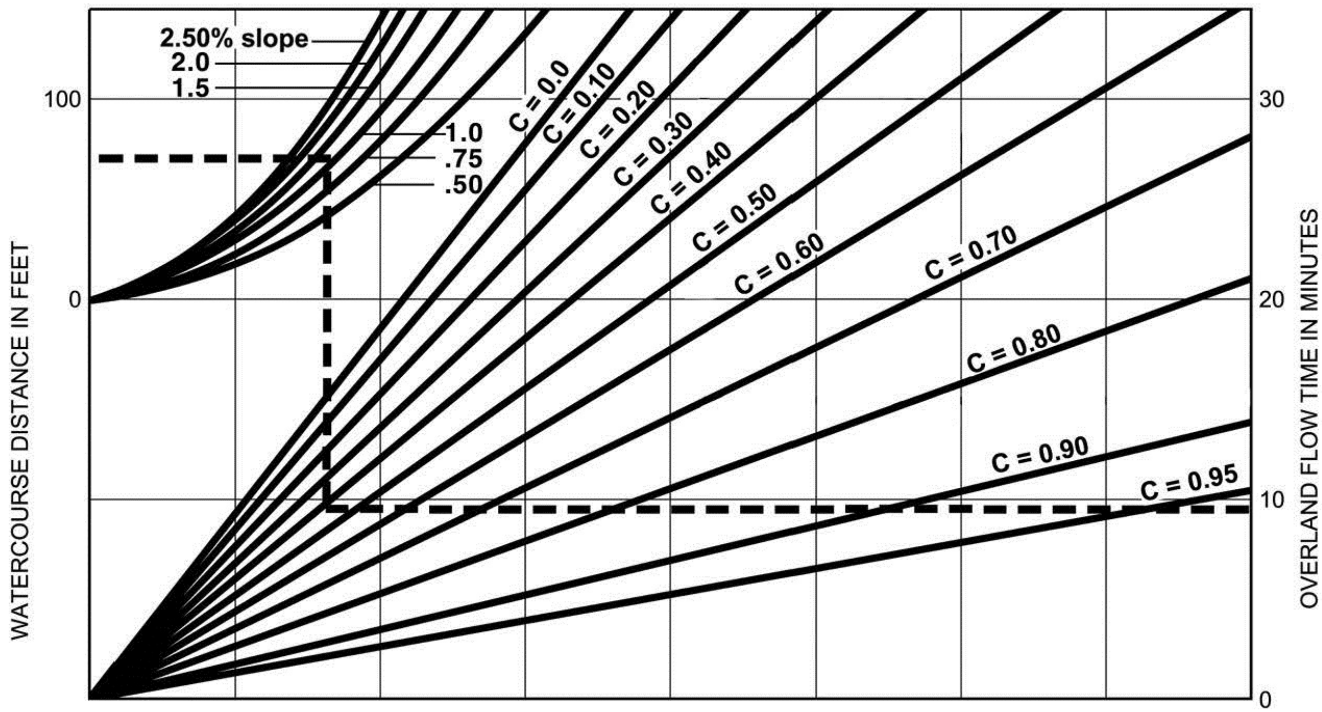


Figure A-2. Nomograph for Determination of T_c for Natural Watersheds

<u>**Note**</u>: Add ten minutes to the computed time of concentration from Figure A-2.



EXAMPLE:

Given: Watercourse Distance (D) = 70 Feet
Slope (s) = 1.3%
Runoff Coefficient (C) = 0.41
Overland Flow Time (T) = 9.5 Minutes

$$T = \frac{1.8\,(1.1-C)\sqrt{D}}{\sqrt[3]{s}}$$

SOURCE: Airport Drainage, Federal Aviation Administration, 1965

Figure A-4. Rational Formula – Overland Time of Flow Nomograph

<u>**Note**</u>: Use formula for watercourse distances in excess of 100 feet.

```
          San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2005 Version 6.4

Rational method hydrology  program based on
San Diego County Flood Control Division 1985 hydrology manual
     Rational Hydrology Study       Date: 04/03/20
------------------------------------------------------------------------
```
Riverwalk
Tentative Map
Proposed Conditions
100-Year Storm Event
```
------------------------------------------------------------------------
 *********   Hydrology Study Control Information **********

------------------------------------------------------------------------


Program License Serial Number 4028

------------------------------------------------------------------------
Rational hydrology study storm event year is   100.0
English (in-lb) input data Units used
English (in) rainfall data used

Standard intensity of Appendix I-B used for year and
Elevation 0 - 1500 feet
Factor (to multiply * intensity)  =  1.000
Only used if inside City of San Diego
San Diego hydrology manual 'C' values used
Runoff coefficients by rational method


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      100.000 to Point/Station      102.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  248.000(Ft.)
Highest elevation =   47.000(Ft.)
Lowest elevation =   44.500(Ft.)
Elevation difference =    2.500(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    11.31 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 248.000^.5)/( 1.008^(1/3)]=  11.31
Rainfall intensity (I) =      3.227(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
```

```
Subarea runoff =      1.739(CFS)
Total initial stream area =       0.770(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      102.000 to Point/Station      104.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    33.400(Ft.)
Downstream point/station elevation =    31.900(Ft.)
Pipe length  =   152.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.739(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     1.739(CFS)
Normal flow depth in pipe =    5.94(In.)
Flow top width inside pipe =   12.00(In.)
Critical Depth =    6.73(In.)
Pipe flow velocity =      4.49(Ft/s)
Travel time through pipe =    0.56 min.
Time of concentration (TC) =    11.87 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      106.000 to Point/Station      104.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    11.87 min.
Rainfall intensity =      3.170(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.329(CFS) for    1.500(Ac.)
Total runoff =      5.068(CFS)   Total area =       2.27(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      104.000 to Point/Station      108.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    31.900(Ft.)
Downstream point/station elevation =    29.900(Ft.)
Pipe length  =   198.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.068(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     5.068(CFS)
Normal flow depth in pipe =    9.97(In.)
Flow top width inside pipe =   14.16(In.)
Critical Depth =   10.96(In.)
Pipe flow velocity =      5.85(Ft/s)
```

```
Travel time through pipe =    0.56 min.
Time of concentration (TC) =    12.44 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      110.000 to Point/Station      108.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    12.44 min.
Rainfall intensity =      3.117(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      4.102(CFS) for    1.880(Ac.)
Total runoff =      9.170(CFS)   Total area =        4.15(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      108.000 to Point/Station      112.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    29.900(Ft.)
Downstream point/station elevation =    28.700(Ft.)
Pipe length  =   112.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     9.170(CFS)
Nearest computed pipe diameter  =    18.00(In.)
Calculated individual pipe flow  =     9.170(CFS)
Normal flow depth in pipe =   12.68(In.)
Flow top width inside pipe =   16.43(In.)
Critical Depth =   14.05(In.)
Pipe flow velocity =      6.90(Ft/s)
Travel time through pipe =    0.27 min.
Time of concentration (TC) =    12.71 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      114.000 to Point/Station      112.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    12.71 min.
Rainfall intensity =      3.092(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.727(CFS) for    1.260(Ac.)
Total runoff =     11.898(CFS)   Total area =        5.41(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      112.000 to Point/Station      116.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    28.700(Ft.)
Downstream point/station elevation =    27.200(Ft.)
Pipe length  =   106.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    11.898(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =    11.898(CFS)
Normal flow depth in pipe =   14.04(In.)
Flow top width inside pipe =   14.91(In.)
Critical Depth =   15.72(In.)
Pipe flow velocity =      8.05(Ft/s)
Travel time through pipe =    0.22 min.
Time of concentration (TC) =    12.93 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      118.000 to Point/Station      116.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    12.93 min.
Rainfall intensity =      3.073(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.635(CFS) for    1.690(Ac.)
Total runoff =     15.533(CFS)   Total area =       7.10(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      116.000 to Point/Station      120.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    27.200(Ft.)
Downstream point/station elevation =    25.800(Ft.)
Pipe length  =   138.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    15.533(CFS)
Nearest computed pipe diameter  =     21.00(In.)
Calculated individual pipe flow  =    15.533(CFS)
Normal flow depth in pipe =   16.73(In.)
Flow top width inside pipe =   16.90(In.)
Critical Depth =   17.47(In.)
Pipe flow velocity =      7.56(Ft/s)
Travel time through pipe =    0.30 min.
Time of concentration (TC) =    13.23 min.
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      122.000 to Point/Station      120.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    13.23 min.
Rainfall intensity =      3.046(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      0.277(CFS) for    0.130(Ac.)
Total runoff =     15.810(CFS)   Total area =       7.23(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      120.000 to Point/Station      124.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    25.800(Ft.)
Downstream point/station elevation =    24.400(Ft.)
Pipe length  =   131.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    15.810(CFS)
Nearest computed pipe diameter  =     21.00(In.)
Calculated individual pipe flow  =    15.810(CFS)
Normal flow depth in pipe =   16.59(In.)
Flow top width inside pipe =   17.10(In.)
Critical Depth =   17.60(In.)
Pipe flow velocity =      7.76(Ft/s)
Travel time through pipe =    0.28 min.
Time of concentration (TC) =    13.51 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      126.000 to Point/Station      124.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    13.51 min.
Rainfall intensity =      3.023(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.279(CFS) for    1.550(Ac.)
Total runoff =     19.090(CFS)   Total area =       8.78(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      124.000 to Point/Station      128.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.400(Ft.)
Downstream point/station elevation =    21.900(Ft.)
Pipe length  =   241.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    19.090(CFS)
Nearest computed pipe diameter  =     24.00(In.)
Calculated individual pipe flow  =    19.090(CFS)
Normal flow depth in pipe =   16.66(In.)
Flow top width inside pipe =   22.11(In.)
Critical Depth =   18.86(In.)
Pipe flow velocity =      8.20(Ft/s)
Travel time through pipe =    0.49 min.
Time of concentration (TC) =    14.00 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      124.000 to Point/Station      128.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      8.780(Ac.)
Runoff from this stream =     19.090(CFS)
Time of concentration =   14.00 min.
Rainfall intensity =     2.982(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      130.000 to Point/Station      130.000
**** USER DEFINED FLOW INFORMATION AT A POINT ****
______________________________________________________________________
User specified 'C' value of 0.550 given for subarea
Rainfall intensity (I) =      3.139(In/Hr) for a   100.0 year storm
User specified values are as follows:
TC =  12.20 min.  Rain intensity =       3.14(In/Hr)
Total area =       77.400(Ac.)  Total runoff =   137.100(CFS)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      130.000 to Point/Station      132.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    26.990(Ft.)
Downstream point/station elevation =    23.300(Ft.)
Pipe length  =   434.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   137.100(CFS)
Nearest computed pipe diameter  =     48.00(In.)
Calculated individual pipe flow  =   137.100(CFS)
Normal flow depth in pipe =   41.06(In.)
Flow top width inside pipe =   33.76(In.)
```

```
Critical Depth =   41.81(In.)
Pipe flow velocity =     11.98(Ft/s)
Travel time through pipe =    0.60 min.
Time of concentration (TC) =    12.80 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      134.000 to Point/Station      132.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    12.80 min.
Rainfall intensity =      3.084(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.475(CFS) for    1.610(Ac.)
Total runoff =    140.575(CFS)   Total area =       79.01(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      136.000 to Point/Station      132.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    12.80 min.
Rainfall intensity =      3.084(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.691(CFS) for    1.710(Ac.)
Total runoff =    144.267(CFS)   Total area =       80.72(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      132.000 to Point/Station      128.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    23.200(Ft.)
Downstream point/station elevation =    22.000(Ft.)
Pipe length  =   156.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   144.267(CFS)
Nearest computed pipe diameter  =     51.00(In.)
Calculated individual pipe flow  =   144.267(CFS)
Normal flow depth in pipe =   40.69(In.)
Flow top width inside pipe =   40.97(In.)
Critical Depth =   42.67(In.)
Pipe flow velocity =     11.90(Ft/s)
```

```
Travel time through pipe =    0.22 min.
Time of concentration (TC) =    13.02 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      132.000 to Point/Station      128.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     80.720(Ac.)
Runoff from this stream =    144.267(CFS)
Time of concentration =   13.02 min.
Rainfall intensity =     3.064(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                  (In/Hr)


1       19.090     14.00             2.982
2      144.267     13.02             3.064
Qmax(1) =
        1.000 *    1.000 *    19.090) +
        0.973 *    1.000 *   144.267) + =     159.491
Qmax(2) =
        1.000 *    0.930 *    19.090) +
        1.000 *    1.000 *   144.267) + =     162.020

Total of 2 streams to confluence:
Flow rates before confluence point:
      19.090     144.267
Maximum flow rates at confluence using above data:
      159.491      162.020
Area of streams before confluence:
        8.780       80.720
Results of confluence:
Total flow rate =    162.020(CFS)
Time of concentration =    13.022 min.
Effective stream area after confluence =     89.500(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      128.000 to Point/Station      138.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.900(Ft.)
Downstream point/station elevation =    21.500(Ft.)
Pipe length  =    50.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   162.020(CFS)
Nearest computed pipe diameter  =     54.00(In.)
Calculated individual pipe flow  =   162.020(CFS)
Normal flow depth in pipe =   40.88(In.)
```

```
Flow top width inside pipe =   46.32(In.)
Critical Depth =   44.63(In.)
Pipe flow velocity =     12.55(Ft/s)
Travel time through pipe =    0.07 min.
Time of concentration (TC) =    13.09 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      140.000 to Point/Station      138.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.09 min.
Rainfall intensity =      3.059(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.927(CFS) for    0.900(Ac.)
Total runoff =    163.947(CFS)   Total area =       90.40(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      138.000 to Point/Station      142.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.500(Ft.)
Downstream point/station elevation =    21.200(Ft.)
Pipe length  =    48.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   163.947(CFS)
Nearest computed pipe diameter  =     54.00(In.)
Calculated individual pipe flow  =   163.947(CFS)
Normal flow depth in pipe =   47.63(In.)
Flow top width inside pipe =   34.85(In.)
Critical Depth =   44.85(In.)
Pipe flow velocity =     11.05(Ft/s)
Travel time through pipe =    0.07 min.
Time of concentration (TC) =    13.16 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      144.000 to Point/Station      142.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.16 min.
Rainfall intensity =      3.052(In/Hr) for a   100.0 year storm
```

```
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.077(CFS) for    1.440(Ac.)
Total runoff =    167.024(CFS)   Total area =       91.84(Ac.)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Process from Point/Station      146.000 to Point/Station      142.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.16 min.
Rainfall intensity =      3.052(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      7.137(CFS) for    3.340(Ac.)
Total runoff =    174.161(CFS)   Total area =       95.18(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      142.000 to Point/Station      148.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.200(Ft.)
Downstream point/station elevation =    19.500(Ft.)
Pipe length  =   193.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   174.161(CFS)
Nearest computed pipe diameter  =     54.00(In.)
Calculated individual pipe flow  =   174.161(CFS)
Normal flow depth in pipe =   41.72(In.)
Flow top width inside pipe =   45.27(In.)
Critical Depth =   46.03(In.)
Pipe flow velocity =     13.20(Ft/s)
Travel time through pipe =    0.24 min.
Time of concentration (TC) =    13.40 min.


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Process from Point/Station      150.000 to Point/Station      148.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.40 min.
Rainfall intensity =      3.032(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.311(CFS) for    1.560(Ac.)
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Total runoff =    177.471(CFS)   Total area =       96.74(Ac.)


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Process from Point/Station      148.000 to Point/Station      152.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    19.400(Ft.)
Downstream point/station elevation =    14.100(Ft.)
Pipe length  =   566.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   177.471(CFS)
Nearest computed pipe diameter  =     54.00(In.)
Calculated individual pipe flow  =   177.471(CFS)
Normal flow depth in pipe =   41.34(In.)
Flow top width inside pipe =   45.75(In.)
Critical Depth =   46.36(In.)
Pipe flow velocity =     13.60(Ft/s)
Travel time through pipe =    0.69 min.
Time of concentration (TC) =    14.10 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      148.000 to Point/Station      152.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     96.740(Ac.)
Runoff from this stream =    177.471(CFS)
Time of concentration =   14.10 min.
Rainfall intensity =     2.975(In/Hr)


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Process from Point/Station      160.000 to Point/Station      162.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  517.000(Ft.)
Highest elevation =   44.000(Ft.)
Lowest elevation =   38.200(Ft.)
Elevation difference =    5.800(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    15.76 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 517.000^.5)/( 1.122^(1/3)]=  15.76
Rainfall intensity (I) =      2.850(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      2.115(CFS)
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Total initial stream area =        1.060(Ac.)


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Process from Point/Station      162.000 to Point/Station      164.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    31.500(Ft.)
Downstream point/station elevation =    30.700(Ft.)
Pipe length  =   108.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.115(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.115(CFS)
Normal flow depth in pipe =    7.32(In.)
Flow top width inside pipe =   11.70(In.)
Critical Depth =    7.45(In.)
Pipe flow velocity =      4.21(Ft/s)
Travel time through pipe =    0.43 min.
Time of concentration (TC) =    16.18 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      166.000 to Point/Station      164.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    16.18 min.
Rainfall intensity =      2.820(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.638(CFS) for    0.830(Ac.)
Total runoff =      3.753(CFS)   Total area =       1.89(Ac.)


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Process from Point/Station      164.000 to Point/Station      168.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    30.200(Ft.)
Downstream point/station elevation =    26.300(Ft.)
Pipe length  =   465.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     3.753(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     3.753(CFS)
Normal flow depth in pipe =    8.67(In.)
Flow top width inside pipe =   14.82(In.)
Critical Depth =    9.39(In.)
Pipe flow velocity =      5.10(Ft/s)
Travel time through pipe =    1.52 min.
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Time of concentration (TC) =    17.70 min.


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Process from Point/Station      170.000 to Point/Station      168.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    17.70 min.
Rainfall intensity =      2.719(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      5.006(CFS) for    2.630(Ac.)
Total runoff =      8.759(CFS)   Total area =       4.52(Ac.)


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Process from Point/Station      168.000 to Point/Station      172.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    26.200(Ft.)
Downstream point/station elevation =    17.800(Ft.)
Pipe length  =   581.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     8.759(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =     8.759(CFS)
Normal flow depth in pipe =   11.03(In.)
Flow top width inside pipe =   17.54(In.)
Critical Depth =   13.74(In.)
Pipe flow velocity =      7.72(Ft/s)
Travel time through pipe =    1.25 min.
Time of concentration (TC) =    18.96 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      172.000 to Point/Station      172.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[RURAL(greater than 0.5 Ac, 0.2 ha) area type]
Time of concentration =    18.96 min.
Rainfall intensity =      2.642(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.450
Subarea runoff =      0.654(CFS) for    0.550(Ac.)
Total runoff =      9.412(CFS)   Total area =       5.07(Ac.)
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Process from Point/Station      172.000 to Point/Station      152.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    15.100(Ft.)
Downstream point/station elevation =    14.100(Ft.)
Pipe length  =    43.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     9.412(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     9.412(CFS)
Normal flow depth in pipe =   11.74(In.)
Flow top width inside pipe =   12.37(In.)
Critical Depth =   14.02(In.)
Pipe flow velocity =      9.14(Ft/s)
Travel time through pipe =    0.08 min.
Time of concentration (TC) =    19.03 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      172.000 to Point/Station      152.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      5.070(Ac.)
Runoff from this stream =      9.412(CFS)
Time of concentration =   19.03 min.
Rainfall intensity =     2.637(In/Hr)


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Process from Point/Station      173.000 to Point/Station      152.000
**** USER DEFINED FLOW INFORMATION AT A POINT ****
______________________________________________________________________
User specified 'C' value of 0.550 given for subarea
Rainfall intensity (I) =      2.700(In/Hr) for a   100.0 year storm
User specified values are as follows:
TC =  18.00 min.  Rain intensity =       2.70(In/Hr)
Total area =       19.200(Ac.)  Total runoff =    29.400(CFS)


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Process from Point/Station      173.000 to Point/Station      152.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 3
Stream flow area =     19.200(Ac.)
Runoff from this stream =     29.400(CFS)
Time of concentration =   18.00 min.
Rainfall intensity =     2.700(In/Hr)
Summary of stream data:
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```
Stream   Flow rate      TC           Rainfall Intensity
 No.       (CFS)       (min)               (In/Hr)


1      177.471     14.10            2.975
2        9.412     19.03            2.637
3       29.400     18.00            2.700
Qmax(1) =
        1.000 *    1.000 *   177.471) +
        1.000 *    0.741 *     9.412) +
        1.000 *    0.783 *    29.400) + =     207.471
Qmax(2) =
        0.886 *    1.000 *   177.471) +
        1.000 *    1.000 *     9.412) +
        0.977 *    1.000 *    29.400) + =     195.442
Qmax(3) =
        0.908 *    1.000 *   177.471) +
        1.000 *    0.946 *     9.412) +
        1.000 *    1.000 *    29.400) + =     199.397

Total of 3 streams to confluence:
Flow rates before confluence point:
     177.471       9.412      29.400
Maximum flow rates at confluence using above data:
      207.471      195.442      199.397
Area of streams before confluence:
       96.740        5.070       19.200
Results of confluence:
Total flow rate =    207.471(CFS)
Time of concentration =    14.099 min.
Effective stream area after confluence =    121.010(Ac.)


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Process from Point/Station      152.000 to Point/Station      174.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    14.100(Ft.)
Downstream point/station elevation =    12.000(Ft.)
Pipe length  =   153.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   207.471(CFS)
Nearest computed pipe diameter  =     51.00(In.)
Calculated individual pipe flow  =   207.471(CFS)
Normal flow depth in pipe =   44.44(In.)
Flow top width inside pipe =   34.15(In.)
Critical Depth =   48.01(In.)
Pipe flow velocity =     15.80(Ft/s)
Travel time through pipe =    0.16 min.
Time of concentration (TC) =    14.26 min.


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Process from Point/Station      200.000 to Point/Station      202.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  320.000(Ft.)
Highest elevation =   52.000(Ft.)
Lowest elevation =   48.800(Ft.)
Elevation difference =    3.200(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    12.88 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 320.000^.5)/( 1.000^(1/3)]=  12.88
Rainfall intensity (I) =      3.077(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      2.412(CFS)
Total initial stream area =        1.120(Ac.)


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Process from Point/Station      202.000 to Point/Station      204.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    42.900(Ft.)
Downstream point/station elevation =    41.100(Ft.)
Pipe length  =   182.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.412(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.412(CFS)
Normal flow depth in pipe =    7.27(In.)
Flow top width inside pipe =   11.73(In.)
Critical Depth =    7.98(In.)
Pipe flow velocity =      4.85(Ft/s)
Travel time through pipe =    0.63 min.
Time of concentration (TC) =    13.50 min.


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Process from Point/Station      206.000 to Point/Station      204.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.50 min.
Rainfall intensity =      3.023(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
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Subarea runoff =      3.428(CFS) for    1.620(Ac.)
Total runoff =      5.841(CFS)   Total area =       2.74(Ac.)


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Process from Point/Station      204.000 to Point/Station      208.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    41.100(Ft.)
Downstream point/station elevation =    40.600(Ft.)
Pipe length  =    43.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.841(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     5.841(CFS)
Normal flow depth in pipe =   10.51(In.)
Flow top width inside pipe =   13.74(In.)
Critical Depth =   11.73(In.)
Pipe flow velocity =      6.36(Ft/s)
Travel time through pipe =    0.11 min.
Time of concentration (TC) =    13.62 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      210.000 to Point/Station      208.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.62 min.
Rainfall intensity =      3.014(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.667(CFS) for    0.790(Ac.)
Total runoff =      7.507(CFS)   Total area =       3.53(Ac.)


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Process from Point/Station      208.000 to Point/Station      212.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    40.600(Ft.)
Downstream point/station elevation =    38.700(Ft.)
Pipe length  =   139.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     7.507(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     7.507(CFS)
Normal flow depth in pipe =   12.21(In.)
Flow top width inside pipe =   11.67(In.)
Critical Depth =   13.08(In.)
Pipe flow velocity =      7.02(Ft/s)
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Travel time through pipe =    0.33 min.
Time of concentration (TC) =    13.95 min.


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Process from Point/Station      214.000 to Point/Station      212.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.95 min.
Rainfall intensity =      2.987(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.589(CFS) for    0.760(Ac.)
Total runoff =      9.096(CFS)   Total area =       4.29(Ac.)


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Process from Point/Station      212.000 to Point/Station      216.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    38.700(Ft.)
Downstream point/station elevation =    24.800(Ft.)
Pipe length  =    81.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     9.096(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     9.096(CFS)
Normal flow depth in pipe =    6.81(In.)
Flow top width inside pipe =   11.89(In.)
Critical depth could not be calculated.
Pipe flow velocity =     19.77(Ft/s)
Travel time through pipe =    0.07 min.
Time of concentration (TC) =    14.02 min.


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Process from Point/Station      212.000 to Point/Station      216.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      4.290(Ac.)
Runoff from this stream =      9.096(CFS)
Time of concentration =   14.02 min.
Rainfall intensity =     2.981(In/Hr)


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Process from Point/Station      218.000 to Point/Station      218.000
**** USER DEFINED FLOW INFORMATION AT A POINT ****
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User specified 'C' value of 0.550 given for subarea
Rainfall intensity (I) =      2.383(In/Hr) for a   100.0 year storm
User specified values are as follows:
TC =  23.70 min.  Rain intensity =       2.38(In/Hr)
Total area =       26.600(Ac.)  Total runoff =    33.700(CFS)


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Process from Point/Station      218.000 to Point/Station      220.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****

Upstream point/station elevation =    40.550(Ft.)
Downstream point/station elevation =    35.750(Ft.)
Pipe length  =   447.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    33.700(CFS)
Nearest computed pipe diameter  =     27.00(In.)
Calculated individual pipe flow  =    33.700(CFS)
Normal flow depth in pipe =   23.63(In.)
Flow top width inside pipe =   17.86(In.)
Critical Depth =   23.81(In.)
Pipe flow velocity =      9.14(Ft/s)
Travel time through pipe =    0.82 min.
Time of concentration (TC) =    24.52 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      222.000 to Point/Station      220.000
**** SUBAREA FLOW ADDITION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    24.52 min.
Rainfall intensity =      2.343(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.772(CFS) for    1.080(Ac.)
Total runoff =     35.472(CFS)   Total area =       27.68(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      224.000 to Point/Station      220.000
**** SUBAREA FLOW ADDITION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    24.52 min.
```

```
Rainfall intensity =      2.343(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.444(CFS) for    0.880(Ac.)
Total runoff =     36.915(CFS)   Total area =       28.56(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      220.000 to Point/Station      216.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    35.250(Ft.)
Downstream point/station elevation =    24.300(Ft.)
Pipe length  =    46.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    36.915(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =    36.915(CFS)
Normal flow depth in pipe =   11.31(In.)
Flow top width inside pipe =   17.40(In.)
Critical depth could not be calculated.
Pipe flow velocity =     31.57(Ft/s)
Travel time through pipe =    0.02 min.
Time of concentration (TC) =    24.54 min.


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Process from Point/Station      220.000 to Point/Station      216.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     28.560(Ac.)
Runoff from this stream =     36.915(CFS)
Time of concentration =   24.54 min.
Rainfall intensity =     2.342(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      226.000 to Point/Station      228.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  265.000(Ft.)
Highest elevation =   47.000(Ft.)
Lowest elevation =   44.350(Ft.)
Elevation difference =    2.650(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    11.72 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 265.000^.5)/( 1.000^(1/3)]=  11.72
```

```
Rainfall intensity (I) =      3.185(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.918(CFS)
Total initial stream area =       0.860(Ac.)


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Process from Point/Station      228.000 to Point/Station      230.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    39.000(Ft.)
Downstream point/station elevation =    36.300(Ft.)
Pipe length  =   274.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.918(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     1.918(CFS)
Normal flow depth in pipe =    6.29(In.)
Flow top width inside pipe =   11.99(In.)
Critical Depth =    7.08(In.)
Pipe flow velocity =      4.59(Ft/s)
Travel time through pipe =    0.99 min.
Time of concentration (TC) =    12.72 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      232.000 to Point/Station      230.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    12.72 min.
Rainfall intensity =      3.092(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.510(CFS) for    1.160(Ac.)
Total runoff =      4.428(CFS)   Total area =       2.02(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      230.000 to Point/Station      216.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    36.300(Ft.)
Downstream point/station elevation =    25.300(Ft.)
Pipe length  =    50.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     4.428(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     4.428(CFS)
Normal flow depth in pipe =    4.87(In.)
Flow top width inside pipe =    8.97(In.)
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```
Critical depth could not be calculated.
Pipe flow velocity =     18.14(Ft/s)
Travel time through pipe =    0.05 min.
Time of concentration (TC) =    12.76 min.


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Process from Point/Station      230.000 to Point/Station      216.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 3
Stream flow area =      2.020(Ac.)
Runoff from this stream =      4.428(CFS)
Time of concentration =   12.76 min.
Rainfall intensity =     3.088(In/Hr)
Summary of stream data:

Stream   Flow rate      TC             Rainfall Intensity
 No.       (CFS)       (min)                  (In/Hr)


1         9.096     14.02            2.981
2        36.915     24.54            2.342
3         4.428     12.76            3.088
Qmax(1) =
         1.000 *    1.000 *     9.096) +
         1.000 *    0.571 *    36.915) +
         0.966 *    1.000 *     4.428) + =      34.457
Qmax(2) =
         0.786 *    1.000 *     9.096) +
         1.000 *    1.000 *    36.915) +
         0.759 *    1.000 *     4.428) + =      47.421
Qmax(3) =
         1.000 *    0.910 *     9.096) +
         1.000 *    0.520 *    36.915) +
         1.000 *    1.000 *     4.428) + =      31.906

Total of 3 streams to confluence:
Flow rates before confluence point:
       9.096      36.915       4.428
Maximum flow rates at confluence using above data:
       34.457       47.421       31.906
Area of streams before confluence:
        4.290       28.560        2.020
Results of confluence:
Total flow rate =     47.421(CFS)
Time of concentration =    24.539 min.
Effective stream area after confluence =     34.870(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      216.000 to Point/Station      234.000
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```
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    23.800(Ft.)
Downstream point/station elevation =    13.500(Ft.)
Pipe length  =   622.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    47.421(CFS)
Nearest computed pipe diameter  =    30.00(In.)
Calculated individual pipe flow  =    47.421(CFS)
Normal flow depth in pipe =   22.22(In.)
Flow top width inside pipe =   26.30(In.)
Critical Depth =   27.16(In.)
Pipe flow velocity =     12.17(Ft/s)
Travel time through pipe =    0.85 min.
Time of concentration (TC) =    25.39 min.


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Process from Point/Station      216.000 to Point/Station      234.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     34.870(Ac.)
Runoff from this stream =     47.421(CFS)
Time of concentration =   25.39 min.
Rainfall intensity =     2.302(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      236.000 to Point/Station      238.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  306.000(Ft.)
Highest elevation =   34.000(Ft.)
Lowest elevation =   31.000(Ft.)
Elevation difference =    3.000(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    12.68 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 306.000^.5)/( 0.980^(1/3)]=  12.68
Rainfall intensity (I) =      3.095(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      3.401(CFS)
Total initial stream area =        1.570(Ac.)


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Process from Point/Station      238.000 to Point/Station      240.000
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**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    31.000(Ft.)
Downstream point/station elevation =    29.000(Ft.)
Pipe length  =   165.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     3.401(CFS)
Nearest computed pipe diameter  =    12.00(In.)
Calculated individual pipe flow  =     3.401(CFS)
Normal flow depth in pipe =    8.64(In.)
Flow top width inside pipe =   10.78(In.)
Critical Depth =    9.46(In.)
Pipe flow velocity =      5.62(Ft/s)
Travel time through pipe =    0.49 min.
Time of concentration (TC) =    13.17 min.


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Process from Point/Station      240.000 to Point/Station      240.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.17 min.
Rainfall intensity =      3.052(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.696(CFS) for    1.730(Ac.)
Total runoff =      7.097(CFS)   Total area =       3.30(Ac.)


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Process from Point/Station      240.000 to Point/Station      234.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.000(Ft.)
Downstream point/station elevation =    13.500(Ft.)
Pipe length  =    41.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     7.097(CFS)
Nearest computed pipe diameter  =     9.00(In.)
Calculated individual pipe flow  =     7.097(CFS)
Normal flow depth in pipe =    6.36(In.)
Flow top width inside pipe =    8.19(In.)
Critical depth could not be calculated.
Pipe flow velocity =     21.26(Ft/s)
Travel time through pipe =    0.03 min.
Time of concentration (TC) =    13.20 min.


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Process from Point/Station      240.000 to Point/Station      234.000
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**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      3.300(Ac.)
Runoff from this stream =      7.097(CFS)
Time of concentration =   13.20 min.
Rainfall intensity =     3.049(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1       47.421     25.39            2.302
2        7.097     13.20            3.049
Qmax(1) =
        1.000 *    1.000 *    47.421) +
        0.755 *    1.000 *     7.097) + =      52.778
Qmax(2) =
        1.000 *    0.520 *    47.421) +
        1.000 *    1.000 *     7.097) + =      31.748

Total of 2 streams to confluence:
Flow rates before confluence point:
      47.421       7.097
Maximum flow rates at confluence using above data:
       52.778       31.748
Area of streams before confluence:
       34.870        3.300
Results of confluence:
Total flow rate =     52.778(CFS)
Time of concentration =    25.391 min.
Effective stream area after confluence =     38.170(Ac.)


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Process from Point/Station      234.000 to Point/Station      242.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    13.500(Ft.)
Downstream point/station elevation =    11.000(Ft.)
Pipe length  =   248.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    52.778(CFS)
Nearest computed pipe diameter  =     33.00(In.)
Calculated individual pipe flow  =    52.778(CFS)
Normal flow depth in pipe =   26.86(In.)
Flow top width inside pipe =   25.69(In.)
Critical Depth =   28.54(In.)
Pipe flow velocity =     10.19(Ft/s)
Travel time through pipe =    0.41 min.
Time of concentration (TC) =    25.80 min.
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Process from Point/Station      234.000 to Point/Station      242.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     38.170(Ac.)
Runoff from this stream =     52.778(CFS)
Time of concentration =   25.80 min.
Rainfall intensity =     2.283(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      244.000 to Point/Station      246.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  617.000(Ft.)
Highest elevation =   53.500(Ft.)
Lowest elevation =   47.500(Ft.)
Elevation difference =    6.000(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    18.05 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 617.000^.5)/( 0.972^(1/3)]=  18.05
Rainfall intensity (I) =      2.697(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.699(CFS)
Total initial stream area =        0.900(Ac.)


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Process from Point/Station      246.000 to Point/Station      248.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    41.800(Ft.)
Downstream point/station elevation =    29.000(Ft.)
Pipe length  =    84.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.699(CFS)
Nearest computed pipe diameter  =      6.00(In.)
Calculated individual pipe flow  =     1.699(CFS)
Normal flow depth in pipe =    3.97(In.)
Flow top width inside pipe =    5.68(In.)
Critical depth could not be calculated.
Pipe flow velocity =     12.33(Ft/s)
Travel time through pipe =    0.11 min.
Time of concentration (TC) =    18.17 min.
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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      248.000 to Point/Station      250.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    18.17 min.
Rainfall intensity =      2.690(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      0.245(CFS) for    0.130(Ac.)
Total runoff =      1.944(CFS)   Total area =        1.03(Ac.)


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Process from Point/Station      250.000 to Point/Station      252.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.000(Ft.)
Downstream point/station elevation =    21.800(Ft.)
Pipe length  =   220.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.944(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     1.944(CFS)
Normal flow depth in pipe =    6.32(In.)
Flow top width inside pipe =   11.98(In.)
Critical Depth =    7.13(In.)
Pipe flow velocity =      4.64(Ft/s)
Travel time through pipe =    0.79 min.
Time of concentration (TC) =    18.96 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      254.000 to Point/Station      252.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    18.96 min.
Rainfall intensity =      2.642(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.627(CFS) for    0.880(Ac.)
Total runoff =      3.571(CFS)   Total area =        1.91(Ac.)


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Process from Point/Station      252.000 to Point/Station      256.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.700(Ft.)
Downstream point/station elevation =    20.100(Ft.)
Pipe length  =   158.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     3.571(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     3.571(CFS)
Normal flow depth in pipe =    9.80(In.)
Flow top width inside pipe =    9.29(In.)
Critical Depth =    9.68(In.)
Pipe flow velocity =      5.20(Ft/s)
Travel time through pipe =    0.51 min.
Time of concentration (TC) =    19.46 min.


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Process from Point/Station      258.000 to Point/Station      256.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    19.46 min.
Rainfall intensity =      2.612(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.792(CFS) for    0.980(Ac.)
Total runoff =      5.363(CFS)   Total area =       2.89(Ac.)


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Process from Point/Station      256.000 to Point/Station      260.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    20.000(Ft.)
Downstream point/station elevation =    17.600(Ft.)
Pipe length  =   241.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.363(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     5.363(CFS)
Normal flow depth in pipe =   10.45(In.)
Flow top width inside pipe =   13.79(In.)
Critical Depth =   11.26(In.)
Pipe flow velocity =      5.88(Ft/s)
Travel time through pipe =    0.68 min.
Time of concentration (TC) =    20.15 min.


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Process from Point/Station      262.000 to Point/Station      260.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    20.15 min.
Rainfall intensity =      2.572(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.909(CFS) for    1.060(Ac.)
Total runoff =      7.271(CFS)   Total area =       3.95(Ac.)


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Process from Point/Station      260.000 to Point/Station      264.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    17.500(Ft.)
Downstream point/station elevation =    15.400(Ft.)
Pipe length  =   214.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     7.271(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =     7.271(CFS)
Normal flow depth in pipe =   11.09(In.)
Flow top width inside pipe =   17.51(In.)
Critical Depth =   12.53(In.)
Pipe flow velocity =      6.37(Ft/s)
Travel time through pipe =    0.56 min.
Time of concentration (TC) =    20.71 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      266.000 to Point/Station      264.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    20.71 min.
Rainfall intensity =      2.541(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.903(CFS) for    1.070(Ac.)
Total runoff =      9.174(CFS)   Total area =       5.02(Ac.)


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Process from Point/Station      264.000 to Point/Station      242.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
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Upstream point/station elevation =    15.300(Ft.)
Downstream point/station elevation =    11.000(Ft.)
Pipe length  =   153.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     9.174(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     9.174(CFS)
Normal flow depth in pipe =   10.59(In.)
Flow top width inside pipe =   13.66(In.)
Critical Depth =   13.93(In.)
Pipe flow velocity =      9.90(Ft/s)
Travel time through pipe =    0.26 min.
Time of concentration (TC) =    20.96 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      264.000 to Point/Station      242.000
**** CONFLUENCE OF MINOR STREAMS ****

Along Main Stream number: 1 in normal stream number 2
Stream flow area =      5.020(Ac.)
Runoff from this stream =      9.174(CFS)
Time of concentration =   20.96 min.
Rainfall intensity =     2.526(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1       52.778     25.80            2.283
2        9.174     20.96            2.526
Qmax(1) =
        1.000 *    1.000 *    52.778) +
        0.904 *    1.000 *     9.174) + =      61.067
Qmax(2) =
        1.000 *    0.813 *    52.778) +
        1.000 *    1.000 *     9.174) + =      52.063

Total of 2 streams to confluence:
Flow rates before confluence point:
      52.778       9.174
Maximum flow rates at confluence using above data:
       61.067       52.063
Area of streams before confluence:
       38.170        5.020
Results of confluence:
Total flow rate =     61.067(CFS)
Time of concentration =    25.797 min.
Effective stream area after confluence =     43.190(Ac.)
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Process from Point/Station      242.000 to Point/Station      268.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    10.800(Ft.)
Downstream point/station elevation =    10.000(Ft.)
Pipe length  =   103.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    61.067(CFS)
Nearest computed pipe diameter  =     36.00(In.)
Calculated individual pipe flow  =    61.067(CFS)
Normal flow depth in pipe =   30.94(In.)
Flow top width inside pipe =   25.03(In.)
Critical Depth =   30.23(In.)
Pipe flow velocity =      9.45(Ft/s)
Travel time through pipe =    0.18 min.
Time of concentration (TC) =    25.98 min.


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Process from Point/Station      242.000 to Point/Station      268.000
**** CONFLUENCE OF MAIN STREAMS ****
______________________________________________________________________
The following data inside Main Stream is listed:
In Main Stream number: 1
Stream flow area =     43.190(Ac.)
Runoff from this stream =     61.067(CFS)
Time of concentration =   25.98 min.
Rainfall intensity =     2.274(In/Hr)
Program is now starting with Main Stream No. 2


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Process from Point/Station      270.000 to Point/Station      272.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Initial subarea flow distance  =  546.000(Ft.)
Highest elevation =   65.500(Ft.)
Lowest elevation =   50.000(Ft.)
Elevation difference =   15.500(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    11.88 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 546.000^.5)/( 2.839^(1/3)]=  11.88
Rainfall intensity (I) =      3.170(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      2.396(CFS)
Total initial stream area =       1.080(Ac.)
```

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Process from Point/Station      272.000 to Point/Station      274.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
_______________________________________________________________________
Upstream point/station elevation =    35.500(Ft.)
Downstream point/station elevation =    32.300(Ft.)
Pipe length  =   268.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.396(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.396(CFS)
Normal flow depth in pipe =    6.81(In.)
Flow top width inside pipe =   11.89(In.)
Critical Depth =    7.96(In.)
Pipe flow velocity =      5.21(Ft/s)
Travel time through pipe =    0.86 min.
Time of concentration (TC) =    12.74 min.


+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      276.000 to Point/Station      274.000
**** SUBAREA FLOW ADDITION ****
_______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    12.74 min.
Rainfall intensity =      3.090(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.341(CFS) for    0.620(Ac.)
Total runoff =      3.737(CFS)   Total area =        1.70(Ac.)


+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      274.000 to Point/Station      278.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
_______________________________________________________________________
Upstream point/station elevation =    32.300(Ft.)
Downstream point/station elevation =    31.060(Ft.)
Pipe length  =    90.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     3.737(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     3.737(CFS)
Normal flow depth in pipe =    8.85(In.)
Flow top width inside pipe =   10.56(In.)
Critical Depth =    9.87(In.)
Pipe flow velocity =      6.02(Ft/s)
Travel time through pipe =    0.25 min.
Time of concentration (TC) =    12.99 min.
```

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Process from Point/Station      274.000 to Point/Station      278.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 2 in normal stream number 1
Stream flow area =      1.700(Ac.)
Runoff from this stream =      3.737(CFS)
Time of concentration =   12.99 min.
Rainfall intensity =     3.067(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      280.000 to Point/Station      282.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  331.000(Ft.)
Highest elevation =   48.100(Ft.)
Lowest elevation =   43.300(Ft.)
Elevation difference =    4.800(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    11.57 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 331.000^.5)/( 1.450^(1/3)]=  11.57
Rainfall intensity (I) =      3.200(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.613(CFS)
Total initial stream area =        0.720(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      282.000 to Point/Station      278.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    36.900(Ft.)
Downstream point/station elevation =    31.560(Ft.)
Pipe length  =   419.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.613(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     1.613(CFS)
Normal flow depth in pipe =    6.46(In.)
Flow top width inside pipe =    8.10(In.)
Critical Depth =    7.01(In.)
Pipe flow velocity =      4.76(Ft/s)
Travel time through pipe =    1.47 min.
Time of concentration (TC) =    13.04 min.
```

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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      282.000 to Point/Station      278.000
**** CONFLUENCE OF MINOR STREAMS ****
```

```
Along Main Stream number: 2 in normal stream number 2
Stream flow area =      0.720(Ac.)
Runoff from this stream =      1.613(CFS)
Time of concentration =   13.04 min.
Rainfall intensity =     3.063(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1        3.737     12.99            3.067
2        1.613     13.04            3.063
Qmax(1) =
        1.000 *    1.000 *     3.737) +
        1.000 *    0.996 *     1.613) + =      5.343
Qmax(2) =
        0.998 *    1.000 *     3.737) +
        1.000 *    1.000 *     1.613) + =      5.344

Total of 2 streams to confluence:
Flow rates before confluence point:
       3.737       1.613
Maximum flow rates at confluence using above data:
        5.343        5.344
Area of streams before confluence:
        1.700        0.720
Results of confluence:
Total flow rate =      5.344(CFS)
Time of concentration =    13.041 min.
Effective stream area after confluence =      2.420(Ac.)


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Process from Point/Station      278.000 to Point/Station      284.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
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Upstream point/station elevation =    30.960(Ft.)
Downstream point/station elevation =    27.800(Ft.)
Pipe length  =    77.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.344(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     5.344(CFS)
Normal flow depth in pipe =    7.69(In.)
Flow top width inside pipe =   11.52(In.)
Critical Depth =   11.20(In.)
```

```
Pipe flow velocity =     10.06(Ft/s)
Travel time through pipe =    0.13 min.
Time of concentration (TC) =    13.17 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      286.000 to Point/Station      284.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.17 min.
Rainfall intensity =      3.052(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.859(CFS) for    0.870(Ac.)
Total runoff =      7.203(CFS)   Total area =       3.29(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      284.000 to Point/Station      288.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    27.800(Ft.)
Downstream point/station elevation =    22.300(Ft.)
Pipe length  =   255.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     7.203(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     7.203(CFS)
Normal flow depth in pipe =    9.77(In.)
Flow top width inside pipe =   14.29(In.)
Critical Depth =   12.87(In.)
Pipe flow velocity =      8.50(Ft/s)
Travel time through pipe =    0.50 min.
Time of concentration (TC) =    13.67 min.


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Process from Point/Station      290.000 to Point/Station      288.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    13.67 min.
Rainfall intensity =      3.010(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.813(CFS) for    1.810(Ac.)
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Total runoff =     11.016(CFS)   Total area =        5.10(Ac.)


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Process from Point/Station      292.000 to Point/Station      288.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =    13.67 min.
Rainfall intensity =      3.010(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.096(CFS) for    0.520(Ac.)
Total runoff =     12.112(CFS)   Total area =        5.62(Ac.)


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Process from Point/Station      288.000 to Point/Station      294.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.200(Ft.)
Downstream point/station elevation =    15.800(Ft.)
Pipe length  =   485.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    12.112(CFS)
Nearest computed pipe diameter  =     21.00(In.)
Calculated individual pipe flow  =    12.112(CFS)
Normal flow depth in pipe =   13.24(In.)
Flow top width inside pipe =   20.27(In.)
Critical Depth =   15.57(In.)
Pipe flow velocity =      7.57(Ft/s)
Travel time through pipe =    1.07 min.
Time of concentration (TC) =    14.74 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      294.000 to Point/Station      268.000
**** CONFLUENCE OF MAIN STREAMS ****
______________________________________________________________________
The following data inside Main Stream is listed:
In Main Stream number: 2
Stream flow area =      5.620(Ac.)
Runoff from this stream =     12.112(CFS)
Time of concentration =   14.74 min.
Rainfall intensity =     2.925(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)
```

```
1       61.067     25.98            2.274
2       12.112     14.74            2.925
Qmax(1) =
        1.000 *    1.000 *    61.067) +
        0.778 *    1.000 *    12.112) + =      70.484
Qmax(2) =
        1.000 *    0.567 *    61.067) +
        1.000 *    1.000 *    12.112) + =      46.749

Total of 2 main streams to confluence:
Flow rates before confluence point:
      61.067      12.112
Maximum flow rates at confluence using above data:
       70.484       46.749
Area of streams before confluence:
       43.190        5.620


Results of confluence:
Total flow rate =     70.484(CFS)
Time of concentration =    25.979 min.
Effective stream area after confluence  =     48.810(Ac.)


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Process from Point/Station      268.000 to Point/Station      296.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    10.000(Ft.)
Downstream point/station elevation =     8.000(Ft.)
Pipe length  =   245.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    70.484(CFS)
Nearest computed pipe diameter  =     39.00(In.)
Calculated individual pipe flow  =    70.484(CFS)
Normal flow depth in pipe =   30.19(In.)
Flow top width inside pipe =   32.62(In.)
Critical Depth =   31.96(In.)
Pipe flow velocity =     10.23(Ft/s)
Travel time through pipe =    0.40 min.
Time of concentration (TC) =    26.38 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      300.000 to Point/Station      302.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
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```
Initial subarea flow distance  =  272.000(Ft.)
Highest elevation =   66.500(Ft.)
Lowest elevation =   53.000(Ft.)
Elevation difference =   13.500(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     6.96 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 272.000^.5)/( 4.963^(1/3)]=   6.96
Rainfall intensity (I) =      3.854(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      2.833(CFS)
Total initial stream area =       1.050(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      302.000 to Point/Station      304.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    41.600(Ft.)
Downstream point/station elevation =    41.100(Ft.)
Pipe length  =    50.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.833(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.833(CFS)
Normal flow depth in pipe =    8.09(In.)
Flow top width inside pipe =   11.25(In.)
Critical Depth =    8.65(In.)
Pipe flow velocity =      5.03(Ft/s)
Travel time through pipe =    0.17 min.
Time of concentration (TC) =     7.13 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      306.000 to Point/Station      304.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     7.13 min.
Rainfall intensity =      3.820(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.460(CFS) for    0.920(Ac.)
Total runoff =      5.293(CFS)   Total area =       1.97(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      304.000 to Point/Station      308.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
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```
Upstream point/station elevation =    41.100(Ft.)
Downstream point/station elevation =    39.500(Ft.)
Pipe length  =   166.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.293(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     5.293(CFS)
Normal flow depth in pipe =   10.48(In.)
Flow top width inside pipe =   13.77(In.)
Critical Depth =   11.19(In.)
Pipe flow velocity =      5.78(Ft/s)
Travel time through pipe =    0.48 min.
Time of concentration (TC) =     7.61 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      310.000 to Point/Station      312.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     7.61 min.
Rainfall intensity =      3.729(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.767(CFS) for    1.060(Ac.)
Total runoff =      8.060(CFS)   Total area =        3.03(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      312.000 to Point/Station      308.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     7.61 min.
Rainfall intensity =      3.729(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.375(CFS) for    0.910(Ac.)
Total runoff =     10.435(CFS)   Total area =        3.94(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      308.000 to Point/Station      314.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    39.000(Ft.)
Downstream point/station elevation =    37.900(Ft.)
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```
Pipe length  =   112.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    10.435(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =    10.435(CFS)
Normal flow depth in pipe =   14.79(In.)
Flow top width inside pipe =   13.78(In.)
Critical Depth =   14.91(In.)
Pipe flow velocity =      6.72(Ft/s)
Travel time through pipe =    0.28 min.
Time of concentration (TC) =     7.88 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      316.000 to Point/Station      314.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     7.88 min.
Rainfall intensity =      3.680(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.494(CFS) for    0.580(Ac.)
Total runoff =     11.929(CFS)   Total area =       4.52(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      314.000 to Point/Station      318.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    37.400(Ft.)
Downstream point/station elevation =    35.700(Ft.)
Pipe length  =   176.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    11.929(CFS)
Nearest computed pipe diameter  =     21.00(In.)
Calculated individual pipe flow  =    11.929(CFS)
Normal flow depth in pipe =   13.78(In.)
Flow top width inside pipe =   19.95(In.)
Critical Depth =   15.44(In.)
Pipe flow velocity =      7.14(Ft/s)
Travel time through pipe =    0.41 min.
Time of concentration (TC) =     8.29 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      320.000 to Point/Station      318.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
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Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =     8.29 min.
Rainfall intensity =      3.611(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.503(CFS) for    0.990(Ac.)
Total runoff =     14.432(CFS)   Total area =       5.51(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      322.000 to Point/Station      318.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =     8.29 min.
Rainfall intensity =      3.611(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.073(CFS) for    0.820(Ac.)
Total runoff =     16.505(CFS)   Total area =       6.33(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      318.000 to Point/Station      324.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    35.200(Ft.)
Downstream point/station elevation =    33.700(Ft.)
Pipe length  =   149.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    16.505(CFS)
Nearest computed pipe diameter  =     24.00(In.)
Calculated individual pipe flow  =    16.505(CFS)
Normal flow depth in pipe =   15.19(In.)
Flow top width inside pipe =   23.14(In.)
Critical Depth =   17.57(In.)
Pipe flow velocity =      7.88(Ft/s)
Travel time through pipe =    0.32 min.
Time of concentration (TC) =     8.61 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      326.000 to Point/Station      324.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
```

```
[MULTI - UNITS area type                     ]
Time of concentration =     8.61 min.
Rainfall intensity =      3.563(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.594(CFS) for    1.040(Ac.)
Total runoff =     19.098(CFS)   Total area =       7.37(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      328.000 to Point/Station      324.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     8.61 min.
Rainfall intensity =      3.563(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.845(CFS) for    0.740(Ac.)
Total runoff =     20.944(CFS)   Total area =       8.11(Ac.)


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Process from Point/Station      324.000 to Point/Station      330.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    33.200(Ft.)
Downstream point/station elevation =    28.400(Ft.)
Pipe length  =   430.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    20.944(CFS)
Nearest computed pipe diameter  =     24.00(In.)
Calculated individual pipe flow  =    20.944(CFS)
Normal flow depth in pipe =   17.41(In.)
Flow top width inside pipe =   21.42(In.)
Critical Depth =   19.67(In.)
Pipe flow velocity =      8.58(Ft/s)
Travel time through pipe =    0.84 min.
Time of concentration (TC) =     9.44 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      332.000 to Point/Station      330.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     9.44 min.
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```
Rainfall intensity =      3.445(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.760(CFS) for    0.730(Ac.)
Total runoff =     22.704(CFS)   Total area =       8.84(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      334.000 to Point/Station      330.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =     9.44 min.
Rainfall intensity =      3.445(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.242(CFS) for    0.930(Ac.)
Total runoff =     24.946(CFS)   Total area =       9.77(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      336.000 to Point/Station      336.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =     9.44 min.
Rainfall intensity =      3.445(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      5.763(CFS) for    2.390(Ac.)
Total runoff =     30.709(CFS)   Total area =      12.16(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      330.000 to Point/Station      336.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    28.300(Ft.)
Downstream point/station elevation =    27.800(Ft.)
Pipe length  =    48.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    30.709(CFS)
Nearest computed pipe diameter  =     27.00(In.)
Calculated individual pipe flow  =    30.709(CFS)
Normal flow depth in pipe =   21.47(In.)
Flow top width inside pipe =   21.79(In.)
Critical Depth =   22.97(In.)
Pipe flow velocity =      9.06(Ft/s)
```

```
Travel time through pipe =    0.09 min.
Time of concentration (TC) =     9.53 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      338.000 to Point/Station      336.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =     9.53 min.
Rainfall intensity =      3.433(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      0.673(CFS) for    0.280(Ac.)
Total runoff =     31.382(CFS)   Total area =       12.44(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      336.000 to Point/Station      340.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    27.700(Ft.)
Downstream point/station elevation =    26.300(Ft.)
Pipe length  =   139.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    31.382(CFS)
Nearest computed pipe diameter  =     27.00(In.)
Calculated individual pipe flow  =    31.382(CFS)
Normal flow depth in pipe =   22.36(In.)
Flow top width inside pipe =   20.37(In.)
Critical Depth =   23.18(In.)
Pipe flow velocity =      8.91(Ft/s)
Travel time through pipe =    0.26 min.
Time of concentration (TC) =     9.79 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      336.000 to Point/Station      340.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     12.440(Ac.)
Runoff from this stream =     31.382(CFS)
Time of concentration =    9.79 min.
Rainfall intensity =     3.400(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      342.000 to Point/Station      344.000
**** INITIAL AREA EVALUATION ****
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________________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  345.000(Ft.)
Highest elevation =   53.700(Ft.)
Lowest elevation =   49.900(Ft.)
Elevation difference =    3.800(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    12.95 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 345.000^.5)/( 1.101^(1/3)]=  12.95
Rainfall intensity (I) =      3.071(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.505(CFS)
Total initial stream area =        0.700(Ac.)


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Process from Point/Station      344.000 to Point/Station      346.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
________________________________________________________________________
Upstream point/station elevation =    42.600(Ft.)
Downstream point/station elevation =    38.300(Ft.)
Pipe length  =   433.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.505(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     1.505(CFS)
Normal flow depth in pipe =    6.75(In.)
Flow top width inside pipe =    7.79(In.)
Critical Depth =    6.78(In.)
Pipe flow velocity =      4.23(Ft/s)
Travel time through pipe =    1.71 min.
Time of concentration (TC) =    14.66 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      348.000 to Point/Station      346.000
**** SUBAREA FLOW ADDITION ****
________________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    14.66 min.
Rainfall intensity =      2.931(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.749(CFS) for    1.340(Ac.)
Total runoff =      4.254(CFS)   Total area =        2.04(Ac.)
```

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Process from Point/Station      346.000 to Point/Station      350.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    38.200(Ft.)
Downstream point/station elevation =    36.200(Ft.)
Pipe length  =   192.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     4.254(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     4.254(CFS)
Normal flow depth in pipe =    8.77(In.)
Flow top width inside pipe =   14.78(In.)
Critical Depth =   10.02(In.)
Pipe flow velocity =      5.71(Ft/s)
Travel time through pipe =    0.56 min.
Time of concentration (TC) =    15.22 min.


+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      352.000 to Point/Station      350.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    15.22 min.
Rainfall intensity =      2.889(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      3.964(CFS) for    1.960(Ac.)
Total runoff =      8.218(CFS)   Total area =        4.00(Ac.)


+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      350.000 to Point/Station      354.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    36.100(Ft.)
Downstream point/station elevation =    33.000(Ft.)
Pipe length  =   308.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     8.218(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =     8.218(CFS)
Normal flow depth in pipe =   11.95(In.)
Flow top width inside pipe =   17.00(In.)
Critical Depth =   13.32(In.)
Pipe flow velocity =      6.59(Ft/s)
Travel time through pipe =    0.78 min.
Time of concentration (TC) =    15.99 min.
```

++
Process from Point/Station 354.000 to Point/Station 356.000
**** SUBAREA FLOW ADDITION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type]
Time of concentration = 15.99 min.
Rainfall intensity = 2.833(In/Hr) for a 100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff = 2.360(CFS) for 1.190(Ac.)
Total runoff = 10.578(CFS) Total area = 5.19(Ac.)

++
Process from Point/Station 356.000 to Point/Station 340.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****

Upstream point/station elevation = 33.000(Ft.)
Downstream point/station elevation = 26.300(Ft.)
Pipe length = 57.00(Ft.) Manning's N = 0.013
No. of pipes = 1 Required pipe flow = 10.578(CFS)
Nearest computed pipe diameter = 12.00(In.)
Calculated individual pipe flow = 10.578(CFS)
Normal flow depth in pipe = 8.63(In.)
Flow top width inside pipe = 10.79(In.)
Critical depth could not be calculated.
Pipe flow velocity = 17.51(Ft/s)
Travel time through pipe = 0.05 min.
Time of concentration (TC) = 16.05 min.

++
Process from Point/Station 356.000 to Point/Station 340.000
**** CONFLUENCE OF MINOR STREAMS ****

Along Main Stream number: 1 in normal stream number 2
Stream flow area = 5.190(Ac.)
Runoff from this stream = 10.578(CFS)
Time of concentration = 16.05 min.
Rainfall intensity = 2.829(In/Hr)
Summary of stream data:

Stream No.	Flow rate (CFS)	TC (min)	Rainfall Intensity (In/Hr)
1	31.382	9.79	3.400

```
2       10.578     16.05            2.829
Qmax(1) =
        1.000 *    1.000 *    31.382) +
        1.000 *    0.610 *    10.578) + =      37.837
Qmax(2) =
        0.832 *    1.000 *    31.382) +
        1.000 *    1.000 *    10.578) + =      36.693

Total of 2 streams to confluence:
Flow rates before confluence point:
      31.382      10.578
Maximum flow rates at confluence using above data:
       37.837       36.693
Area of streams before confluence:
       12.440        5.190
Results of confluence:
Total flow rate =     37.837(CFS)
Time of concentration =     9.793 min.
Effective stream area after confluence =     17.630(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      340.000 to Point/Station      358.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    26.200(Ft.)
Downstream point/station elevation =    24.800(Ft.)
Pipe length  =   191.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    37.837(CFS)
Nearest computed pipe diameter  =     33.00(In.)
Calculated individual pipe flow  =    37.837(CFS)
Normal flow depth in pipe =   23.06(In.)
Flow top width inside pipe =   30.28(In.)
Critical Depth =   24.57(In.)
Pipe flow velocity =      8.53(Ft/s)
Travel time through pipe =    0.37 min.
Time of concentration (TC) =    10.17 min.


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Process from Point/Station      340.000 to Point/Station      358.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     17.630(Ac.)
Runoff from this stream =     37.837(CFS)
Time of concentration =   10.17 min.
Rainfall intensity =     3.354(In/Hr)


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Process from Point/Station      360.000 to Point/Station      360.000
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**** USER DEFINED FLOW INFORMATION AT A POINT ****
______________________________________________________________________
User specified 'C' value of 0.550 given for subarea
Rainfall intensity (I) =      2.552(In/Hr) for a   100.0 year storm
User specified values are as follows:
TC =  20.50 min.  Rain intensity =       2.55(In/Hr)
Total area =       89.000(Ac.)  Total runoff =   120.000(CFS)


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Process from Point/Station      360.000 to Point/Station      358.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     89.000(Ac.)
Runoff from this stream =    120.000(CFS)
Time of concentration =   20.50 min.
Rainfall intensity =     2.552(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1       37.837     10.17            3.354
2      120.000     20.50            2.552
Qmax(1) =
        1.000 *    1.000 *    37.837) +
        1.000 *    0.496 *   120.000) + =      97.346
Qmax(2) =
        0.761 *    1.000 *    37.837) +
        1.000 *    1.000 *   120.000) + =     148.790

Total of 2 streams to confluence:
Flow rates before confluence point:
      37.837     120.000
Maximum flow rates at confluence using above data:
       97.346      148.790
Area of streams before confluence:
       17.630       89.000
Results of confluence:
Total flow rate =    148.790(CFS)
Time of concentration =    20.500 min.
Effective stream area after confluence =    106.630(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      358.000 to Point/Station      362.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.800(Ft.)
Downstream point/station elevation =    24.600(Ft.)
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```
Pipe length  =    32.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   148.790(CFS)
Nearest computed pipe diameter  =     54.00(In.)
Calculated individual pipe flow  =   148.790(CFS)
Normal flow depth in pipe =   42.28(In.)
Flow top width inside pipe =   44.52(In.)
Critical Depth =   42.95(In.)
Pipe flow velocity =     11.13(Ft/s)
Travel time through pipe =    0.05 min.
Time of concentration (TC) =    20.55 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      364.000 to Point/Station      362.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    20.55 min.
Rainfall intensity =      2.549(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      4.551(CFS) for    2.550(Ac.)
Total runoff =    153.340(CFS)   Total area =      109.18(Ac.)


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Process from Point/Station      362.000 to Point/Station      366.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.600(Ft.)
Downstream point/station elevation =    21.400(Ft.)
Pipe length  =   134.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   153.340(CFS)
Nearest computed pipe diameter  =     42.00(In.)
Calculated individual pipe flow  =   153.340(CFS)
Normal flow depth in pipe =   33.94(In.)
Flow top width inside pipe =   33.08(In.)
Critical depth could not be calculated.
Pipe flow velocity =     18.42(Ft/s)
Travel time through pipe =    0.12 min.
Time of concentration (TC) =    20.67 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      368.000 to Point/Station      366.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
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Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    20.67 min.
Rainfall intensity =      2.543(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      4.930(CFS) for    2.770(Ac.)
Total runoff =    158.271(CFS)   Total area =      111.95(Ac.)


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Process from Point/Station      366.000 to Point/Station      370.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.400(Ft.)
Downstream point/station elevation =    15.900(Ft.)
Pipe length  =   534.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   158.271(CFS)
Nearest computed pipe diameter  =     51.00(In.)
Calculated individual pipe flow  =   158.271(CFS)
Normal flow depth in pipe =   38.67(In.)
Flow top width inside pipe =   43.67(In.)
Critical Depth =   44.27(In.)
Pipe flow velocity =     13.71(Ft/s)
Travel time through pipe =    0.65 min.
Time of concentration (TC) =    21.32 min.


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Process from Point/Station      372.000 to Point/Station      370.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    21.32 min.
Rainfall intensity =      2.507(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.088(CFS) for    1.190(Ac.)
Total runoff =    160.359(CFS)   Total area =      113.14(Ac.)


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Process from Point/Station      370.000 to Point/Station      374.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    15.900(Ft.)
Downstream point/station elevation =    15.090(Ft.)
Pipe length  =    73.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =   160.359(CFS)
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Nearest computed pipe diameter  =     48.00(In.)
Calculated individual pipe flow  =   160.359(CFS)
Normal flow depth in pipe =   42.75(In.)
Flow top width inside pipe =   29.96(In.)
Critical Depth =   44.04(In.)
Pipe flow velocity =     13.58(Ft/s)
Travel time through pipe =    0.09 min.
Time of concentration (TC) =    21.41 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      370.000 to Point/Station      374.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =    113.140(Ac.)
Runoff from this stream =    160.359(CFS)
Time of concentration =   21.41 min.
Rainfall intensity =     2.502(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      376.000 to Point/Station      378.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  542.000(Ft.)
Highest elevation =   49.200(Ft.)
Lowest elevation =   40.000(Ft.)
Elevation difference =    9.200(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    14.05 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 542.000^.5)/( 1.697^(1/3)]=  14.05
Rainfall intensity (I) =      2.978(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      2.127(CFS)
Total initial stream area =        1.020(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      380.000 to Point/Station      378.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
```

```
[MULTI - UNITS area type                     ]
Time of concentration =    14.05 min.
Rainfall intensity =      2.978(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      1.355(CFS) for    0.650(Ac.)
Total runoff =      3.482(CFS)   Total area =       1.67(Ac.)


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Process from Point/Station      378.000 to Point/Station      382.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    40.000(Ft.)
Downstream point/station elevation =    32.000(Ft.)
Pipe length  =   142.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     3.482(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     3.482(CFS)
Normal flow depth in pipe =    6.60(In.)
Flow top width inside pipe =    7.96(In.)
Critical depth could not be calculated.
Pipe flow velocity =     10.04(Ft/s)
Travel time through pipe =    0.24 min.
Time of concentration (TC) =    14.29 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      384.000 to Point/Station      382.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    14.29 min.
Rainfall intensity =      2.960(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      2.755(CFS) for    1.330(Ac.)
Total runoff =      6.237(CFS)   Total area =       3.00(Ac.)


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Process from Point/Station      382.000 to Point/Station      374.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    25.000(Ft.)
Downstream point/station elevation =    15.090(Ft.)
Pipe length  =   170.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     6.237(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     6.237(CFS)
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Normal flow depth in pipe =    7.57(In.)
Flow top width inside pipe =   11.58(In.)
Critical depth could not be calculated.
Pipe flow velocity =     11.94(Ft/s)
Travel time through pipe =    0.24 min.
Time of concentration (TC) =    14.53 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      382.000 to Point/Station      374.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      3.000(Ac.)
Runoff from this stream =      6.237(CFS)
Time of concentration =   14.53 min.
Rainfall intensity =     2.941(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                  (In/Hr)


1      160.359     21.41            2.502
2        6.237     14.53            2.941
Qmax(1) =
        1.000 *    1.000 *   160.359) +
        0.851 *    1.000 *     6.237) + =     165.665
Qmax(2) =
        1.000 *    0.678 *   160.359) +
        1.000 *    1.000 *     6.237) + =     115.039

Total of 2 streams to confluence:
Flow rates before confluence point:
     160.359       6.237
Maximum flow rates at confluence using above data:
      165.665      115.039
Area of streams before confluence:
      113.140        3.000
Results of confluence:
Total flow rate =    165.665(CFS)
Time of concentration =    21.408 min.
Effective stream area after confluence =    116.140(Ac.)


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Process from Point/Station      374.000 to Point/Station      386.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    15.090(Ft.)
Downstream point/station elevation =    10.000(Ft.)
Pipe length  =    59.00(Ft.)   Manning's N = 0.013
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```
No. of pipes = 1  Required pipe flow  =   165.665(CFS)
Nearest computed pipe diameter  =     33.00(In.)
Calculated individual pipe flow  =   165.665(CFS)
Normal flow depth in pipe =   29.70(In.)
Flow top width inside pipe =   19.80(In.)
Critical depth could not be calculated.
Pipe flow velocity =     29.40(Ft/s)
Travel time through pipe =    0.03 min.
Time of concentration (TC) =    21.44 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      400.000 to Point/Station      402.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  336.000(Ft.)
Highest elevation =   33.500(Ft.)
Lowest elevation =   30.500(Ft.)
Elevation difference =    3.000(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    13.71 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 336.000^.5)/( 0.893^(1/3)]=  13.71
Rainfall intensity (I) =      3.006(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.031(CFS)
Total initial stream area =        0.490(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      402.000 to Point/Station      404.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    30.500(Ft.)
Downstream point/station elevation =    30.000(Ft.)
Pipe length  =    48.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.031(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     1.031(CFS)
Normal flow depth in pipe =    5.08(In.)
Flow top width inside pipe =    8.92(In.)
Critical Depth =    5.59(In.)
Pipe flow velocity =      4.01(Ft/s)
Travel time through pipe =    0.20 min.
Time of concentration (TC) =    13.91 min.
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Process from Point/Station      402.000 to Point/Station      404.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      0.490(Ac.)
Runoff from this stream =      1.031(CFS)
Time of concentration =   13.91 min.
Rainfall intensity =     2.990(In/Hr)


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Process from Point/Station      410.000 to Point/Station      412.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  357.000(Ft.)
Highest elevation =   33.500(Ft.)
Lowest elevation =   30.000(Ft.)
Elevation difference =    3.500(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    13.69 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 357.000^.5)/( 0.980^(1/3)]=  13.69
Rainfall intensity (I) =      3.007(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.221(CFS)
Total initial stream area =        0.580(Ac.)


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Process from Point/Station      412.000 to Point/Station      414.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    25.700(Ft.)
Downstream point/station elevation =    24.500(Ft.)
Pipe length  =   229.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     1.221(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     1.221(CFS)
Normal flow depth in pipe =    5.81(In.)
Flow top width inside pipe =   11.99(In.)
Critical Depth =    5.60(In.)
Pipe flow velocity =      3.24(Ft/s)
Travel time through pipe =    1.18 min.
Time of concentration (TC) =    14.87 min.
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      414.000 to Point/Station      414.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    14.87 min.
Rainfall intensity =      2.915(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      0.816(CFS) for    0.400(Ac.)
Total runoff =      2.037(CFS)   Total area =       0.98(Ac.)


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Process from Point/Station      414.000 to Point/Station      416.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.500(Ft.)
Downstream point/station elevation =    23.700(Ft.)
Pipe length  =    40.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.037(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     2.037(CFS)
Normal flow depth in pipe =    6.49(In.)
Flow top width inside pipe =    8.07(In.)
Critical Depth =    7.76(In.)
Pipe flow velocity =      5.97(Ft/s)
Travel time through pipe =    0.11 min.
Time of concentration (TC) =    14.98 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      418.000 to Point/Station      416.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Time of concentration =    14.98 min.
Rainfall intensity =      2.906(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.700
Subarea runoff =      4.537(CFS) for    2.230(Ac.)
Total runoff =      6.574(CFS)   Total area =       3.21(Ac.)


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Process from Point/Station      418.000 to Point/Station      416.000
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**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      3.210(Ac.)
Runoff from this stream =      6.574(CFS)
Time of concentration =   14.98 min.
Rainfall intensity =     2.906(In/Hr)


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Process from Point/Station      420.000 to Point/Station      422.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  883.000(Ft.)
Highest elevation =   40.500(Ft.)
Lowest elevation =   23.500(Ft.)
Elevation difference =   17.000(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =    17.20 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 883.000^.5)/( 1.925^(1/3)]=  17.20
Rainfall intensity (I) =      2.752(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      5.239(CFS)
Total initial stream area =        2.720(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      422.000 to Point/Station      424.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    17.600(Ft.)
Downstream point/station elevation =    17.000(Ft.)
Pipe length  =   119.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.239(CFS)
Nearest computed pipe diameter  =     18.00(In.)
Calculated individual pipe flow  =     5.239(CFS)
Normal flow depth in pipe =   11.12(In.)
Flow top width inside pipe =   17.49(In.)
Critical Depth =   10.57(In.)
Pipe flow velocity =      4.57(Ft/s)
Travel time through pipe =    0.43 min.
Time of concentration (TC) =    17.63 min.


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Process from Point/Station      422.000 to Point/Station      424.000
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**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 3
Stream flow area =      2.720(Ac.)
Runoff from this stream =      5.239(CFS)
Time of concentration =   17.63 min.
Rainfall intensity =     2.723(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)



1        1.031     13.91            2.990
2        6.574     14.98            2.906
3        5.239     17.63            2.723
Qmax(1) =
        1.000 *    1.000 *     1.031) +
        1.000 *    0.928 *     6.574) +
        1.000 *    0.789 *     5.239) + =      11.263
Qmax(2) =
        0.972 *    1.000 *     1.031) +
        1.000 *    1.000 *     6.574) +
        1.000 *    0.850 *     5.239) + =      12.028
Qmax(3) =
        0.911 *    1.000 *     1.031) +
        0.937 *    1.000 *     6.574) +
        1.000 *    1.000 *     5.239) + =      12.338

Total of 3 streams to confluence:
Flow rates before confluence point:
       1.031       6.574       5.239
Maximum flow rates at confluence using above data:
       11.263       12.028       12.338
Area of streams before confluence:
        0.490        3.210        2.720
Results of confluence:
Total flow rate =     12.338(CFS)
Time of concentration =    17.632 min.
Effective stream area after confluence =      6.420(Ac.)


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Process from Point/Station      500.000 to Point/Station      502.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Initial subarea flow distance  =  320.000(Ft.)
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Highest elevation =   33.000(Ft.)
Lowest elevation =   29.800(Ft.)
Elevation difference =    3.200(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     8.05 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.8500)*( 320.000^.5)/( 1.000^(1/3)]=   8.05
Rainfall intensity (I) =      3.651(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =      4.035(CFS)
Total initial stream area =        1.300(Ac.)


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Process from Point/Station      502.000 to Point/Station      504.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    33.000(Ft.)
Downstream point/station elevation =    31.700(Ft.)
Pipe length  =   130.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     4.035(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     4.035(CFS)
Normal flow depth in pipe =    8.59(In.)
Flow top width inside pipe =   14.84(In.)
Critical Depth =    9.76(In.)
Pipe flow velocity =      5.55(Ft/s)
Travel time through pipe =    0.39 min.
Time of concentration (TC) =     8.44 min.


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Process from Point/Station      504.000 to Point/Station      504.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Time of concentration =     8.44 min.
Rainfall intensity =      3.588(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      4.972(CFS) for    1.630(Ac.)
Total runoff =      9.007(CFS)   Total area =        2.93(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      520.000 to Point/Station      504.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
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Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Time of concentration =     8.44 min.
Rainfall intensity =      3.588(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      2.166(CFS) for    0.710(Ac.)
Total runoff =     11.172(CFS)   Total area =       3.64(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      522.000 to Point/Station      504.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Time of concentration =     8.44 min.
Rainfall intensity =      3.588(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      3.996(CFS) for    1.310(Ac.)
Total runoff =     15.168(CFS)   Total area =       4.95(Ac.)


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Process from Point/Station      504.000 to Point/Station      506.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    21.800(Ft.)
Downstream point/station elevation =    20.600(Ft.)
Pipe length  =   120.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    15.168(CFS)
Nearest computed pipe diameter  =     21.00(In.)
Calculated individual pipe flow  =    15.168(CFS)
Normal flow depth in pipe =   16.45(In.)
Flow top width inside pipe =   17.30(In.)
Critical Depth =   17.31(In.)
Pipe flow velocity =      7.50(Ft/s)
Travel time through pipe =    0.27 min.
Time of concentration (TC) =     8.71 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      508.000 to Point/Station      506.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
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Decimal fraction soil group D = 1.000
[COMMERCIAL area type                       ]
Time of concentration =     8.71 min.
Rainfall intensity =      3.548(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      1.990(CFS) for    0.660(Ac.)
Total runoff =     17.158(CFS)   Total area =       5.61(Ac.)


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Process from Point/Station      506.000 to Point/Station      510.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    20.600(Ft.)
Downstream point/station elevation =    19.800(Ft.)
Pipe length  =   152.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    17.158(CFS)
Nearest computed pipe diameter  =     24.00(In.)
Calculated individual pipe flow  =    17.158(CFS)
Normal flow depth in pipe =   20.81(In.)
Flow top width inside pipe =   16.29(In.)
Critical Depth =   17.91(In.)
Pipe flow velocity =      5.93(Ft/s)
Travel time through pipe =    0.43 min.
Time of concentration (TC) =     9.13 min.


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Process from Point/Station      524.000 to Point/Station      510.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                       ]
Time of concentration =     9.13 min.
Rainfall intensity =      3.487(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      3.438(CFS) for    1.160(Ac.)
Total runoff =     20.596(CFS)   Total area =       6.77(Ac.)


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Process from Point/Station      506.000 to Point/Station      510.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      6.770(Ac.)
Runoff from this stream =     20.596(CFS)
Time of concentration =    9.13 min.
Rainfall intensity =     3.487(In/Hr)
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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      530.000 to Point/Station      532.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Initial subarea flow distance  =  230.000(Ft.)
Highest elevation =   34.000(Ft.)
Lowest elevation =   31.700(Ft.)
Elevation difference =    2.300(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     6.82 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.8500)*( 230.000^.5)/( 1.000^(1/3)]=   6.82
Rainfall intensity (I) =      3.883(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =      2.674(CFS)
Total initial stream area =        0.810(Ac.)


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Process from Point/Station      532.000 to Point/Station      534.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    25.000(Ft.)
Downstream point/station elevation =    20.000(Ft.)
Pipe length  =   240.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.674(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.674(CFS)
Normal flow depth in pipe =    6.14(In.)
Flow top width inside pipe =   12.00(In.)
Critical Depth =    8.41(In.)
Pipe flow velocity =      6.61(Ft/s)
Travel time through pipe =    0.60 min.
Time of concentration (TC) =     7.43 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      534.000 to Point/Station      534.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
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```
Time of concentration =     7.43 min.
Rainfall intensity =      3.761(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      4.924(CFS) for    1.540(Ac.)
Total runoff =      7.597(CFS)   Total area =        2.35(Ac.)


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Process from Point/Station      534.000 to Point/Station      510.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    20.000(Ft.)
Downstream point/station elevation =    18.100(Ft.)
Pipe length  =    51.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     7.597(CFS)
Nearest computed pipe diameter  =     15.00(In.)
Calculated individual pipe flow  =     7.597(CFS)
Normal flow depth in pipe =    8.46(In.)
Flow top width inside pipe =   14.88(In.)
Critical Depth =   13.14(In.)
Pipe flow velocity =     10.66(Ft/s)
Travel time through pipe =    0.08 min.
Time of concentration (TC) =     7.51 min.


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Process from Point/Station      534.000 to Point/Station      510.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      2.350(Ac.)
Runoff from this stream =      7.597(CFS)
Time of concentration =    7.51 min.
Rainfall intensity =     3.746(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1       20.596      9.13            3.487
2        7.597      7.51            3.746
Qmax(1) =
        1.000 *    1.000 *    20.596) +
        0.931 *    1.000 *     7.597) + =      27.667
Qmax(2) =
        1.000 *    0.822 *    20.596) +
        1.000 *    1.000 *     7.597) + =      24.530

Total of 2 streams to confluence:
Flow rates before confluence point:
      20.596       7.597
```

```
Maximum flow rates at confluence using above data:
       27.667       24.530
Area of streams before confluence:
        6.770        2.350
Results of confluence:
Total flow rate =     27.667(CFS)
Time of concentration =     9.134 min.
Effective stream area after confluence =      9.120(Ac.)


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Process from Point/Station      510.000 to Point/Station      510.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                       ]
Time of concentration =     9.13 min.
Rainfall intensity =      3.487(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      0.830(CFS) for    0.280(Ac.)
Total runoff =     28.496(CFS)   Total area =       9.40(Ac.)


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Process from Point/Station      510.000 to Point/Station      536.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    15.600(Ft.)
Downstream point/station elevation =    14.400(Ft.)
Pipe length  =   318.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    28.496(CFS)
Nearest computed pipe diameter  =     33.00(In.)
Calculated individual pipe flow  =    28.496(CFS)
Normal flow depth in pipe =   23.95(In.)
Flow top width inside pipe =   29.44(In.)
Critical Depth =   21.27(In.)
Pipe flow velocity =      6.17(Ft/s)
Travel time through pipe =    0.86 min.
Time of concentration (TC) =     9.99 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      538.000 to Point/Station      536.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
```

```
[COMMERCIAL area type                          ]
Time of concentration =     9.99 min.
Rainfall intensity =      3.375(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      1.205(CFS) for    0.420(Ac.)
Total runoff =     29.701(CFS)   Total area =       9.82(Ac.)


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Process from Point/Station      536.000 to Point/Station      540.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    14.400(Ft.)
Downstream point/station elevation =    14.000(Ft.)
Pipe length  =    47.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    29.701(CFS)
Nearest computed pipe diameter  =     27.00(In.)
Calculated individual pipe flow  =    29.701(CFS)
Normal flow depth in pipe =   23.25(In.)
Flow top width inside pipe =   18.67(In.)
Critical Depth =   22.68(In.)
Pipe flow velocity =      8.16(Ft/s)
Travel time through pipe =    0.10 min.
Time of concentration (TC) =    10.09 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      536.000 to Point/Station      540.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      9.820(Ac.)
Runoff from this stream =     29.701(CFS)
Time of concentration =   10.09 min.
Rainfall intensity =     3.363(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      550.000 to Point/Station      552.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                          ]
Initial subarea flow distance  =  263.000(Ft.)
Highest elevation =   32.000(Ft.)
Lowest elevation =   29.400(Ft.)
Elevation difference =    2.600(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     7.33 min.
```

```
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.8500)*( 263.000^.5)/( 0.989^(1/3)]=   7.33
Rainfall intensity (I) =      3.781(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =      2.603(CFS)
Total initial stream area =       0.810(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      552.000 to Point/Station      554.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    25.000(Ft.)
Downstream point/station elevation =    24.200(Ft.)
Pipe length  =    76.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.603(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.603(CFS)
Normal flow depth in pipe =    7.49(In.)
Flow top width inside pipe =   11.62(In.)
Critical Depth =    8.30(In.)
Pipe flow velocity =      5.05(Ft/s)
Travel time through pipe =    0.25 min.
Time of concentration (TC) =     7.58 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      556.000 to Point/Station      554.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Time of concentration =     7.58 min.
Rainfall intensity =      3.734(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      2.920(CFS) for    0.920(Ac.)
Total runoff =      5.523(CFS)   Total area =       1.73(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      554.000 to Point/Station      540.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    24.200(Ft.)
Downstream point/station elevation =    14.000(Ft.)
Pipe length  =   104.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     5.523(CFS)
Nearest computed pipe diameter  =      9.00(In.)
Calculated individual pipe flow  =     5.523(CFS)
```

```
Normal flow depth in pipe =    8.10(In.)
Flow top width inside pipe =    5.40(In.)
Critical depth could not be calculated.
Pipe flow velocity =     13.18(Ft/s)
Travel time through pipe =    0.13 min.
Time of concentration (TC) =     7.71 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      554.000 to Point/Station      540.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      1.730(Ac.)
Runoff from this stream =      5.523(CFS)
Time of concentration =    7.71 min.
Rainfall intensity =     3.710(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                   (In/Hr)


1       29.701     10.09            3.363
2        5.523      7.71            3.710
Qmax(1) =
        1.000 *    1.000 *    29.701) +
        0.906 *    1.000 *     5.523) + =      34.708
Qmax(2) =
        1.000 *    0.764 *    29.701) +
        1.000 *    1.000 *     5.523) + =      28.214

Total of 2 streams to confluence:
Flow rates before confluence point:
      29.701       5.523
Maximum flow rates at confluence using above data:
       34.708       28.214
Area of streams before confluence:
        9.820        1.730
Results of confluence:
Total flow rate =     34.708(CFS)
Time of concentration =    10.089 min.
Effective stream area after confluence =     11.550(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      540.000 to Point/Station      558.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    14.000(Ft.)
Downstream point/station elevation =    13.000(Ft.)
Pipe length  =   200.00(Ft.)   Manning's N = 0.013
```

```
No. of pipes = 1  Required pipe flow  =    34.708(CFS)
Nearest computed pipe diameter  =     33.00(In.)
Calculated individual pipe flow  =    34.708(CFS)
Normal flow depth in pipe =   25.13(In.)
Flow top width inside pipe =   28.13(In.)
Critical Depth =   23.54(In.)
Pipe flow velocity =      7.15(Ft/s)
Travel time through pipe =    0.47 min.
Time of concentration (TC) =    10.56 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      560.000 to Point/Station      558.000
**** SUBAREA FLOW ADDITION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                               ]
Time of concentration =    10.56 min.
Rainfall intensity =      3.309(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.850
Subarea runoff =      4.725(CFS) for    1.680(Ac.)
Total runoff =     39.433(CFS)   Total area =       13.23(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      558.000 to Point/Station      562.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    13.000(Ft.)
Downstream point/station elevation =    12.000(Ft.)
Pipe length  =    89.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    39.433(CFS)
Nearest computed pipe diameter  =     30.00(In.)
Calculated individual pipe flow  =    39.433(CFS)
Normal flow depth in pipe =   22.41(In.)
Flow top width inside pipe =   26.09(In.)
Critical Depth =   25.38(In.)
Pipe flow velocity =     10.03(Ft/s)
Travel time through pipe =    0.15 min.
Time of concentration (TC) =    10.70 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      558.000 to Point/Station      562.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     13.230(Ac.)
Runoff from this stream =     39.433(CFS)
```

```
Time of concentration =   10.70 min.
Rainfall intensity =     3.292(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      570.000 to Point/Station      572.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                        ]
Initial subarea flow distance  =  271.000(Ft.)
Highest elevation =   32.000(Ft.)
Lowest elevation =   27.800(Ft.)
Elevation difference =    4.200(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     6.40 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.8500)*( 271.000^.5)/( 1.550^(1/3)]=   6.40
Rainfall intensity (I) =      3.980(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =      2.503(CFS)
Total initial stream area =        0.740(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      572.000 to Point/Station      574.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
______________________________________________________________________
Upstream point/station elevation =    23.000(Ft.)
Downstream point/station elevation =    20.200(Ft.)
Pipe length  =   448.00(Ft.)   Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     2.503(CFS)
Nearest computed pipe diameter  =     12.00(In.)
Calculated individual pipe flow  =     2.503(CFS)
Normal flow depth in pipe =    8.81(In.)
Flow top width inside pipe =   10.60(In.)
Critical Depth =    8.13(In.)
Pipe flow velocity =      4.05(Ft/s)
Travel time through pipe =    1.84 min.
Time of concentration (TC) =     8.24 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      572.000 to Point/Station      574.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      0.740(Ac.)
Runoff from this stream =      2.503(CFS)
```

```
Time of concentration =    8.24 min.
Rainfall intensity =     3.620(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      580.000 to Point/Station      582.000
**** INITIAL AREA EVALUATION ****
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                     ]
Initial subarea flow distance  =  270.000(Ft.)
Highest elevation =   30.200(Ft.)
Lowest elevation =   23.000(Ft.)
Elevation difference =    7.200(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) =     8.53 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*( 270.000^.5)/( 2.667^(1/3)]=   8.53
Rainfall intensity (I) =      3.574(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
Subarea runoff =      1.576(CFS)
Total initial stream area =       0.630(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      580.000 to Point/Station      582.000
**** CONFLUENCE OF MINOR STREAMS ****
______________________________________________________________________
Along Main Stream number: 1 in normal stream number 3
Stream flow area =      0.630(Ac.)
Runoff from this stream =      1.576(CFS)
Time of concentration =    8.53 min.
Rainfall intensity =     3.574(In/Hr)
Summary of stream data:

Stream   Flow rate      TC           Rainfall Intensity
 No.       (CFS)       (min)                (In/Hr)


1       39.433     10.70            3.292
2        2.503      8.24            3.620
3        1.576      8.53            3.574
Qmax(1) =
        1.000 *    1.000 *    39.433) +
        0.910 *    1.000 *     2.503) +
        0.921 *    1.000 *     1.576) + =      43.162
Qmax(2) =
        1.000 *    0.770 *    39.433) +
        1.000 *    1.000 *     2.503) +
```

```
        1.000 *    0.966 *     1.576) + =      34.398
Qmax(3) =
        1.000 *    0.797 *    39.433) +
        0.988 *    1.000 *     2.503) +
        1.000 *    1.000 *     1.576) + =      35.480

Total of 3 streams to confluence:
Flow rates before confluence point:
      39.433       2.503       1.576
Maximum flow rates at confluence using above data:
       43.162       34.398       35.480
Area of streams before confluence:
       13.230        0.740        0.630
Results of confluence:
Total flow rate =     43.162(CFS)
Time of concentration =    10.703 min.
Effective stream area after confluence =     14.600(Ac.)
End of computations, total study area =         306.980 (Ac.)
```

APPENDIX B

HEC-RAS RESULTS

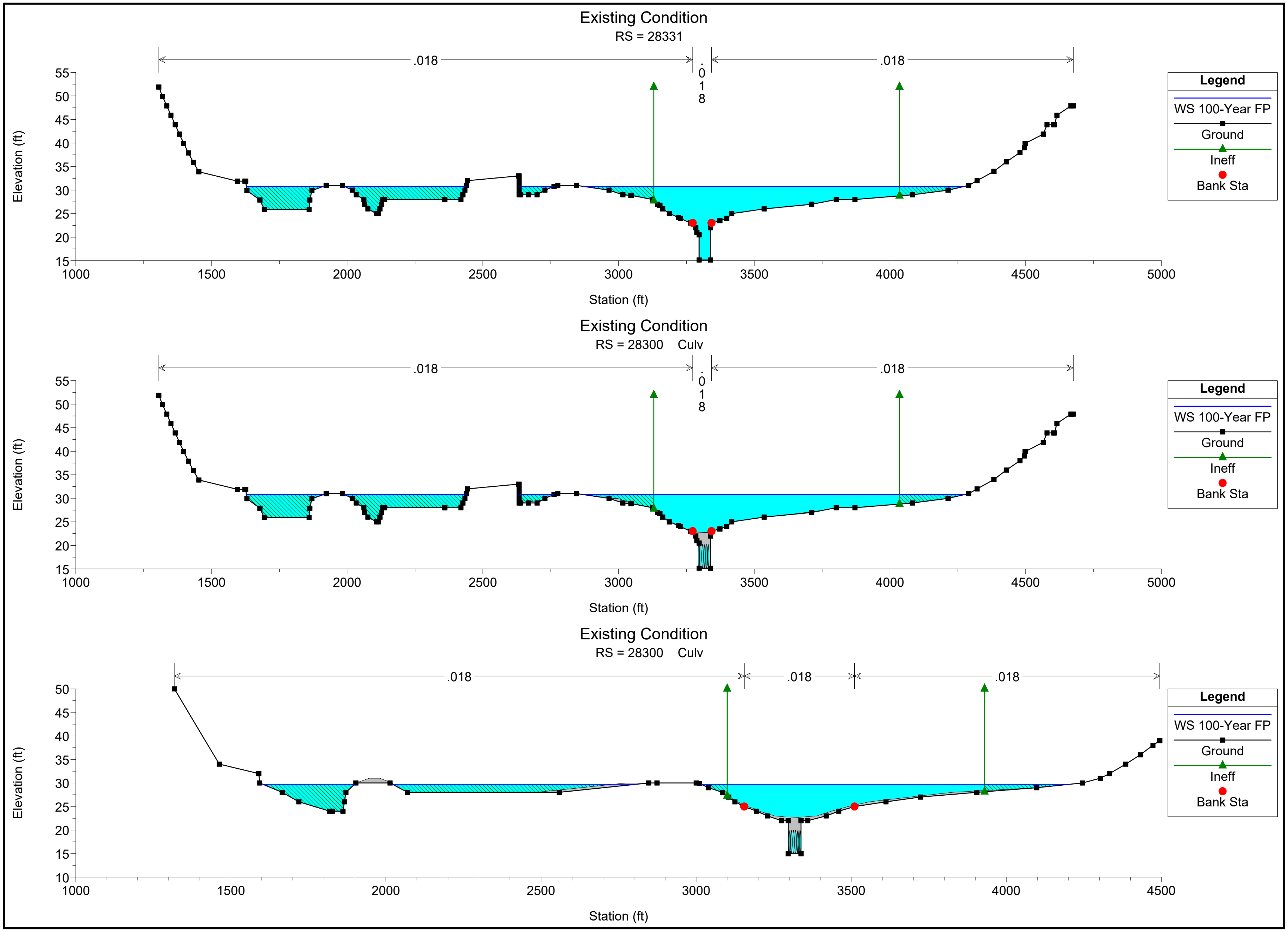
Existing Condition 100-Year Floodplain

HEC-RAS Plan: Existing Con River: RIVER-1 Reach: Reach-1 Profile: 100-Year FP

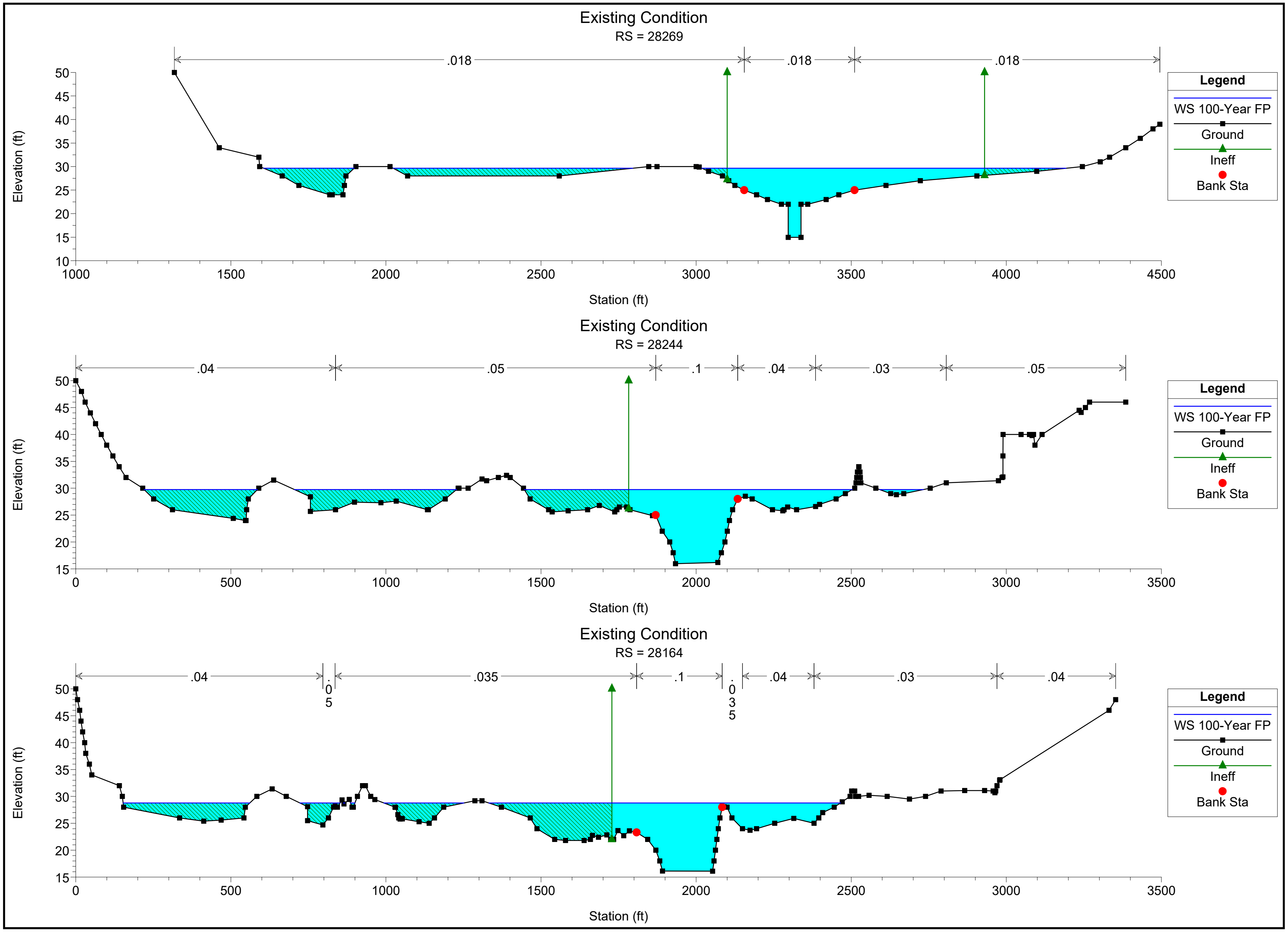
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	28331	100-Year FP	36000.00	15.14	30.79	30.20	32.06	0.000933	12.46	4537.27	2263.72	0.61
Reach-1	28300		Culvert									
Reach-1	28269	100-Year FP	36000.00	14.97	29.64		31.11	0.001213	10.59	4012.61	2236.61	0.69
Reach-1	28244	100-Year FP	36000.00	15.96	29.74		30.83	0.013101	8.35	4290.53	2085.01	0.44
Reach-1	28164	100-Year FP	36000.00	16.10	28.77		29.94	0.009489	6.88	4537.66	1947.47	0.37
Reach-1	28064	100-Year FP	36000.00	15.45	28.80	25.28	29.41	0.001906	3.41	6848.76	2252.34	0.17
Reach-1	27929	100-Year FP	36000.00	15.28	28.75	23.34	29.17	0.001076	2.68	7818.35	1894.80	0.13
Reach-1	27759	100-Year FP	36000.00	15.18	28.63	22.93	28.95	0.001018	2.61	8686.16	2108.05	0.13
Reach-1	27589	100-Year FP	36000.00	15.18	28.51	23.54	28.78	0.000723	2.15	9624.37	1808.95	0.11
Reach-1	27429	100-Year FP	36000.00	14.80	28.33	23.09	28.63	0.001256	2.91	8900.63	1508.38	0.14
Reach-1	27259	100-Year FP	36000.00	14.78	28.25	23.15	28.44	0.000685	2.17	11149.14	1922.99	0.11
Reach-1	27069	100-Year FP	36000.00	14.80	28.02	23.89	28.27	0.001042	3.37	9080.30	1699.76	0.17
Reach-1	26951	100-Year FP	36000.00	14.66	27.96	23.84	28.17	0.000774	4.02	9651.02	1660.01	0.21
Reach-1	26944		Bridge									
Reach-1	26937	100-Year FP	36000.00	14.66	27.95	23.59	28.15	0.000680	3.87	10011.45	1663.69	0.20
Reach-1	26799	100-Year FP	36000.00	14.74	27.70	24.13	28.02	0.001063	5.43	8379.40	1540.03	0.30
Reach-1	26614	100-Year FP	36000.00	14.60	27.50	23.71	27.83	0.000946	5.45	8126.55	1378.24	0.29
Reach-1	26379	100-Year FP	36000.00	14.45	27.06	24.08	27.54	0.001599	6.01	6504.08	1250.87	0.31
Reach-1	26174	100-Year FP	36000.00	14.24	26.92	23.59	27.21	0.001065	5.04	8541.02	1610.84	0.26
Reach-1	25914	100-Year FP	36000.00	13.93	26.78	22.72	26.97	0.000634	3.88	10691.21	1877.86	0.20
Reach-1	25654	100-Year FP	36000.00	13.50	26.47	23.52	26.74	0.001080	5.02	8857.46	1752.00	0.26
Reach-1	25354	100-Year FP	36000.00	13.31	26.37	20.98	26.52	0.000397	3.19	11833.85	1665.36	0.16
Reach-1	25181	100-Year FP	36000.00	13.20	26.27	21.13	26.45	0.000463	3.40	11041.38	1658.93	0.17
Reach-1	25001	100-Year FP	36000.00	12.69	26.14	21.12	26.35	0.000581	3.95	10067.91	1489.26	0.19
Reach-1	24804	100-Year FP	36000.00	12.52	26.06	21.96	26.28	0.000735	4.17	9565.97	1532.01	0.21
Reach-1	24797		Bridge									
Reach-1	24790	100-Year FP	36000.00	12.51	26.03	21.93	26.26	0.000761	4.24	9500.73	1522.56	0.21
Reach-1	24581	100-Year FP	36000.00	12.60	25.75	21.59	26.05	0.001201	6.68	9805.50	1306.15	0.33
Reach-1	24401	100-Year FP	36000.00	10.30	25.31	21.76	25.74	0.002967	5.29	7168.12	1333.64	0.26
Reach-1	24226	100-Year FP	36000.00	9.09	24.98	19.11	25.30	0.001771	3.36	8744.82	1343.58	0.17
Reach-1	24019	100-Year FP	36000.00	8.90	24.62	19.72	24.92	0.001816	3.32	8635.15	1602.77	0.17
Reach-1	23800	100-Year FP	36000.00	8.99	24.21	18.86	24.65	0.004053	4.85	6863.03	1424.58	0.25
Reach-1	23796	100-Year FP	36000.00	8.21	24.13	16.83	24.51	0.000485	5.62	8734.85	1502.47	0.26
Reach-1	23650	100-Year FP	36000.00	8.20	24.17	17.49	24.47	0.000415	5.11	9395.73	1489.04	0.24
Reach-1	23636	100-Year FP	36000.00	8.21	24.05	17.79	24.39	0.001535	4.94	7954.38	1475.97	0.23
Reach-1	23470	100-Year FP	36000.00	8.21	23.78	17.90	24.14	0.001817	5.08	7592.02	1373.19	0.25
Reach-1	23461	100-Year FP	36000.00	8.21	23.76	17.60	24.09	0.001291	4.93	8027.36	1399.39	0.23
Reach-1	23220	100-Year FP	36000.00	8.20	23.60	17.27	24.00	0.001312	5.71	7553.63	1612.72	0.27

HEC-RAS Plan: Existing Con River: RIVER-1 Reach: Reach-1 Profile: 100-Year FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	23210	100-Year FP	36000.00	8.21	23.17	17.03	23.83	0.002213	7.03	6055.21	1194.05	0.34
Reach-1	23200	100-Year FP	36000.00	8.21	23.00	17.16	23.75	0.002466	7.48	5762.65	1136.57	0.36
Reach-1	23171	100-Year FP	36000.00	8.20	22.60	17.87	23.37	0.005478	7.58	5285.13	1266.44	0.39
Reach-1	22880	100-Year FP	36000.00	8.20	22.36	18.74	23.06	0.004647	7.46	5745.10	1268.35	0.38
Reach-1	22870	100-Year FP	36000.00	8.20	22.53	16.36	22.84	0.002048	5.62	8961.97	1837.95	0.28
Reach-1	22860	100-Year FP	36000.00	-1.00	22.08		22.68	0.001153	6.62	6103.01	682.64	0.28
Reach-1	22850	100-Year FP	36000.00	-1.00	22.15	13.10	22.64	0.000303	5.74	6451.27	727.71	0.24



Existing Condition
RS = 28331
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 28300 Culv
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 28300 Culv
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta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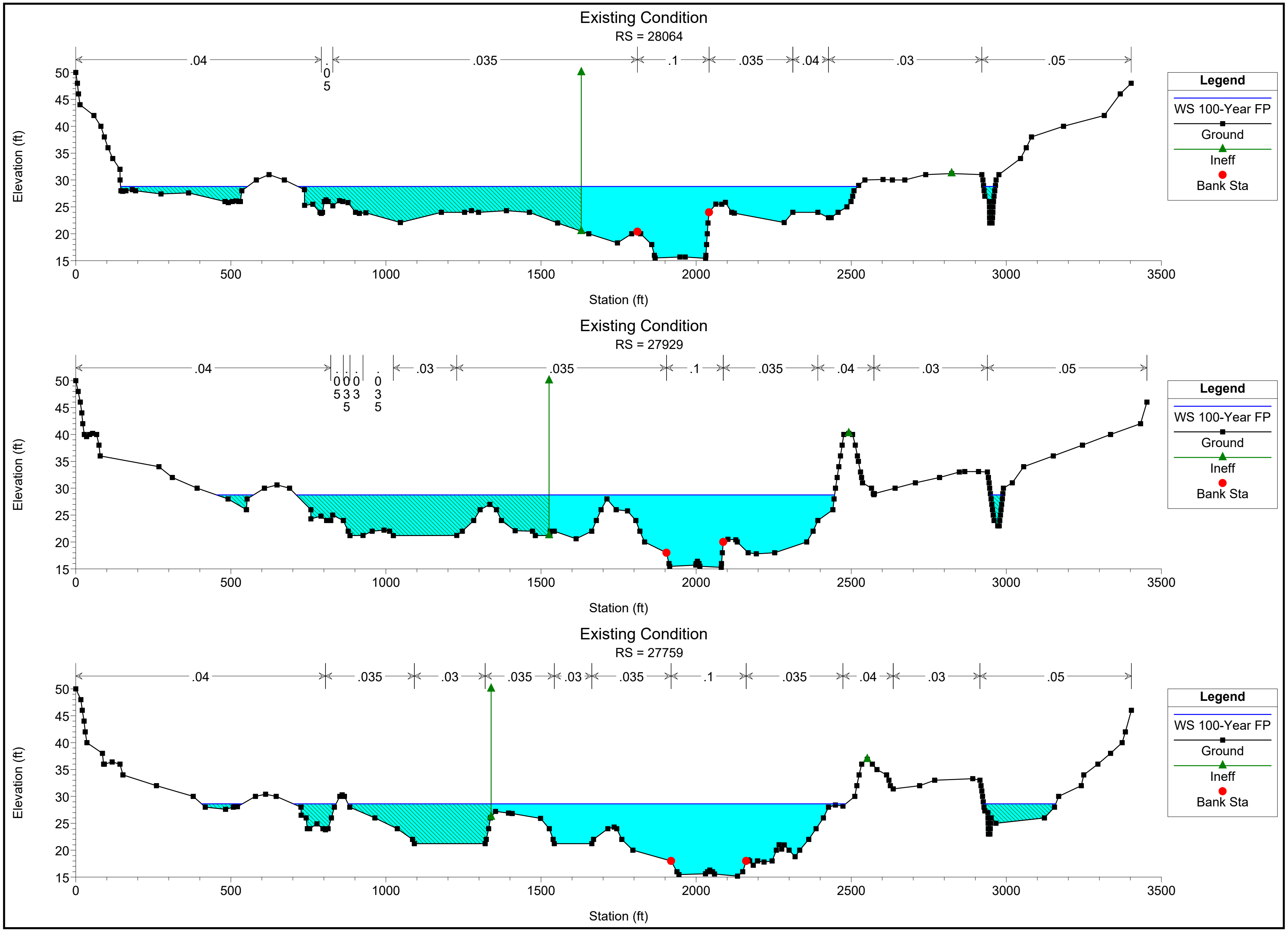
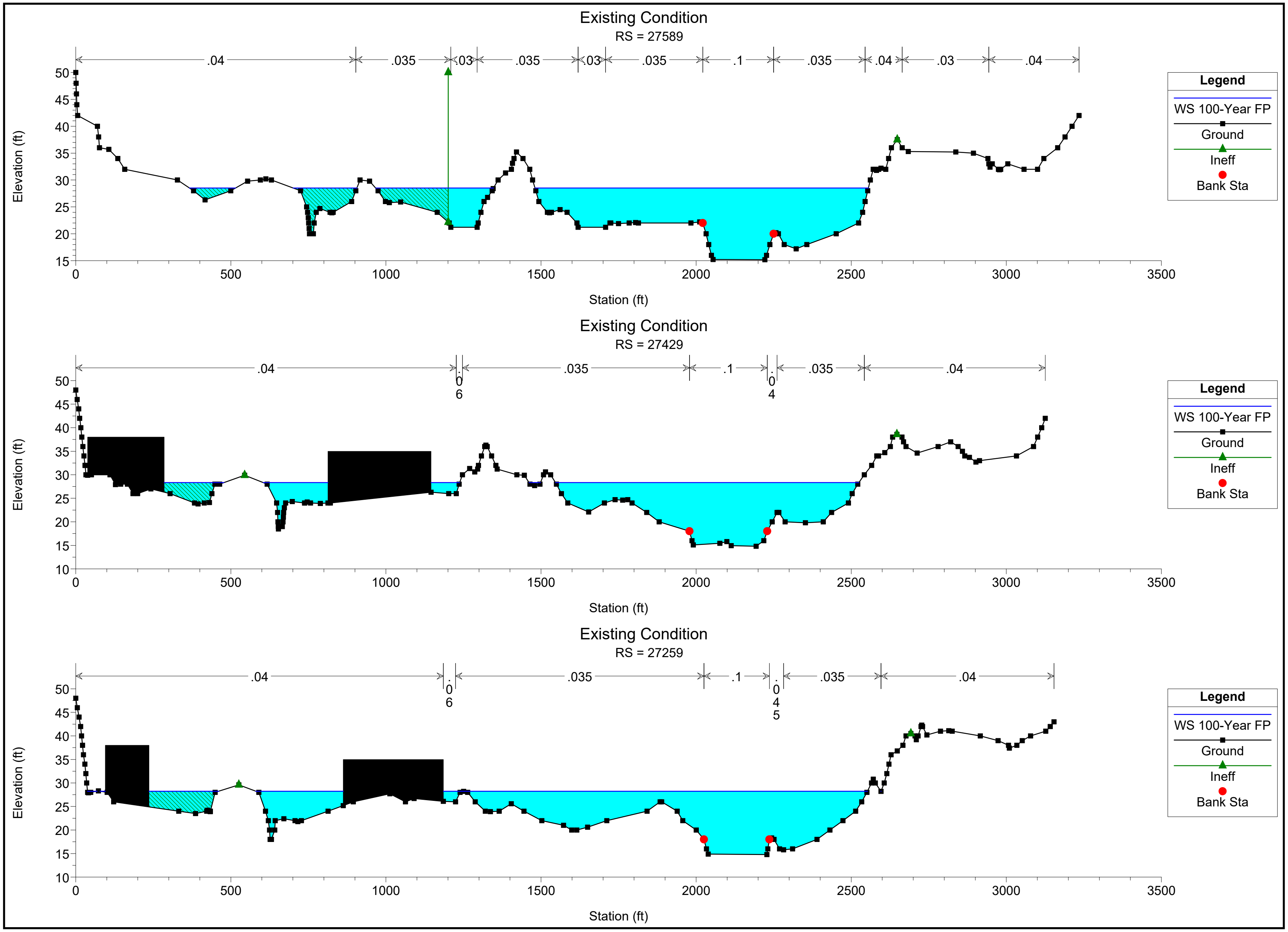
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 28244
.04
.05
.1
.04
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 28164
.04
.05
.035
.1
.035
.04
.03
.04
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 28064
.04
.035
.1
.035
.04
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 27929
.04
.03
.035
.1
.035
.04
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 27759
.04
.035
.03
.035
.03
.035
.1
.035
.04
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 27429
.04 .06 .035 .1 .04 .035 .04
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 27259
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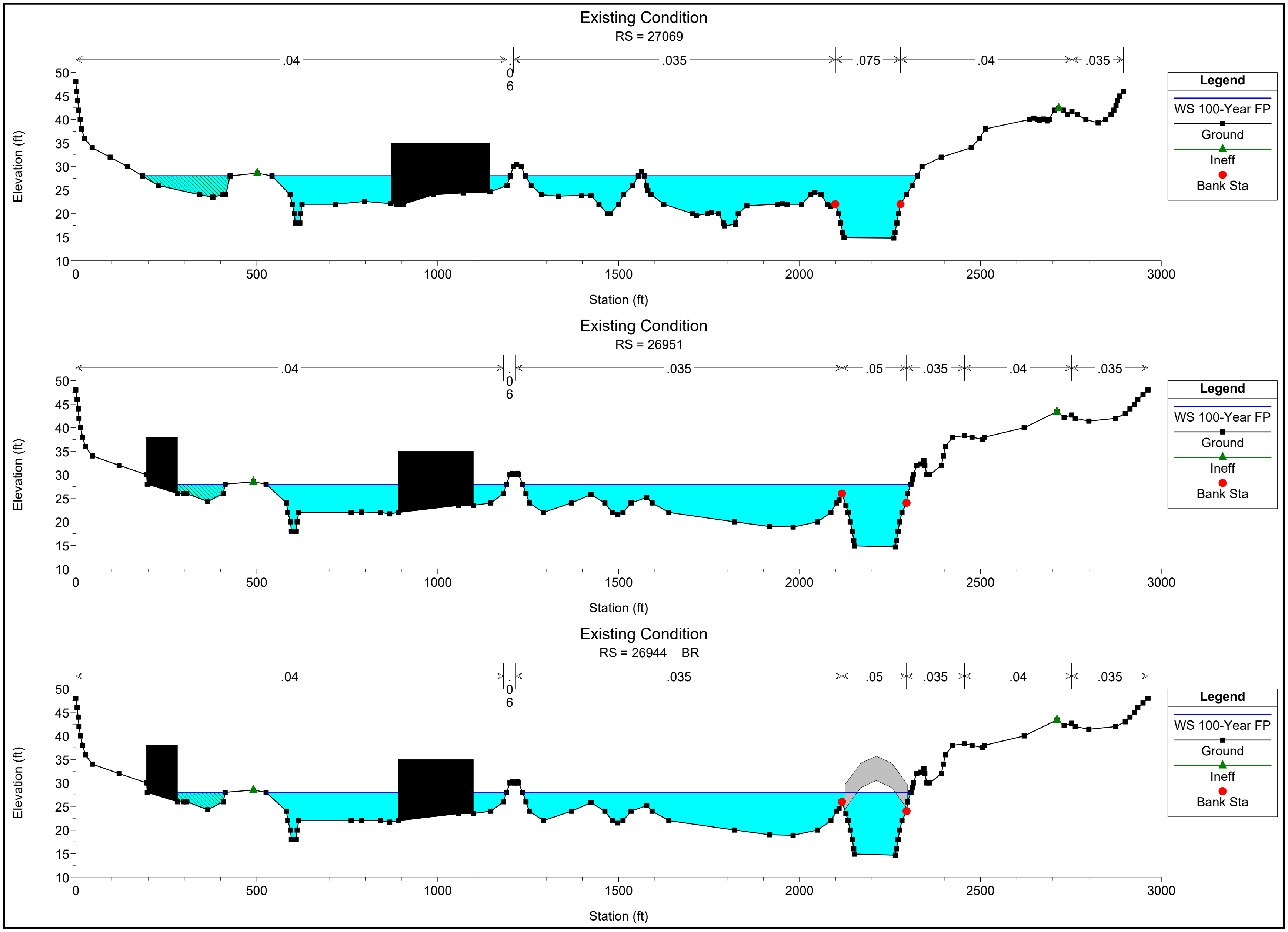
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
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.04
.06
.035
.075
.04
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26951
.04
.06
.035
.05
.035
.04
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26944 BR
.04
.06
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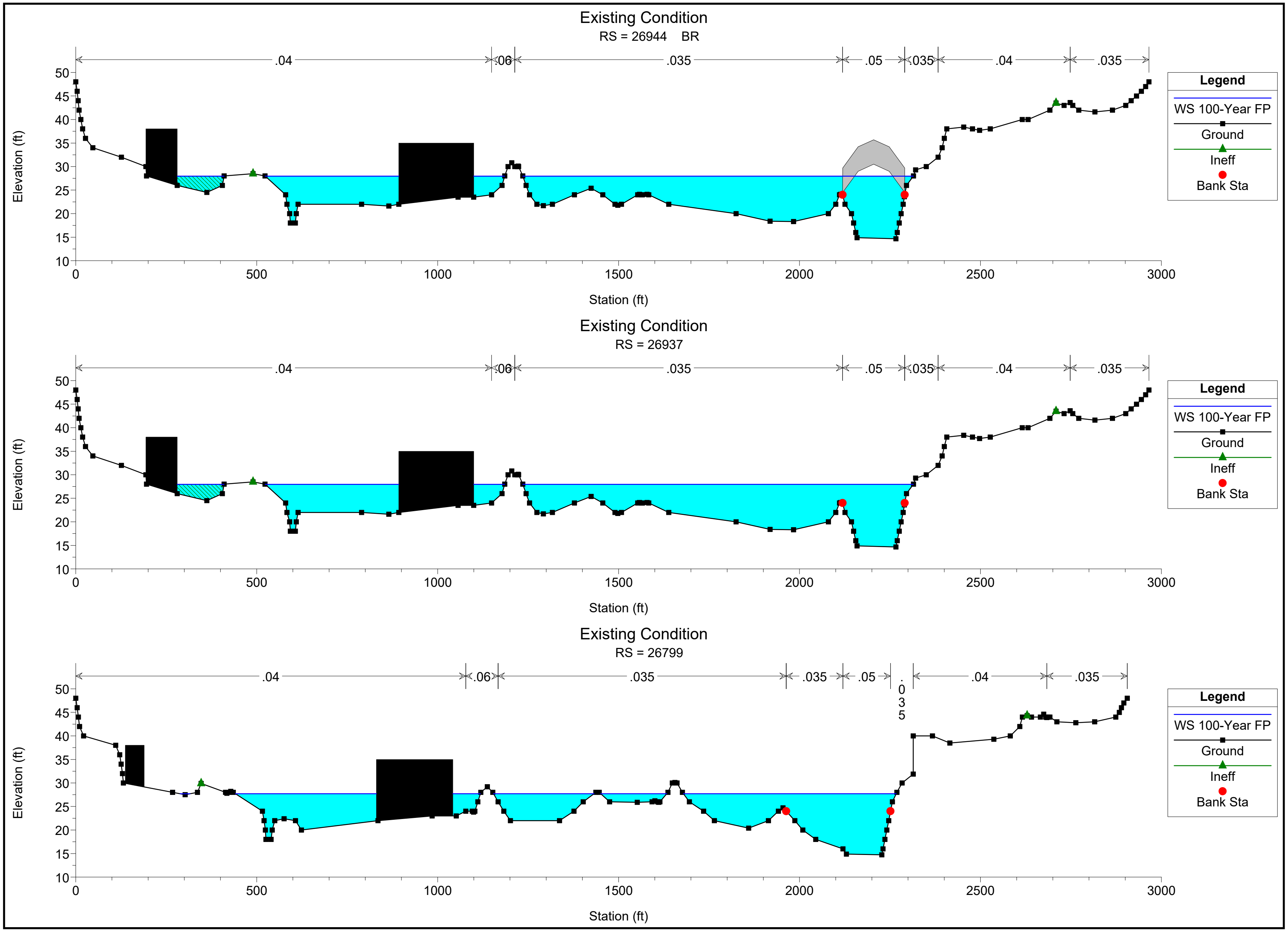
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26937
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.06
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26799
.04
.06
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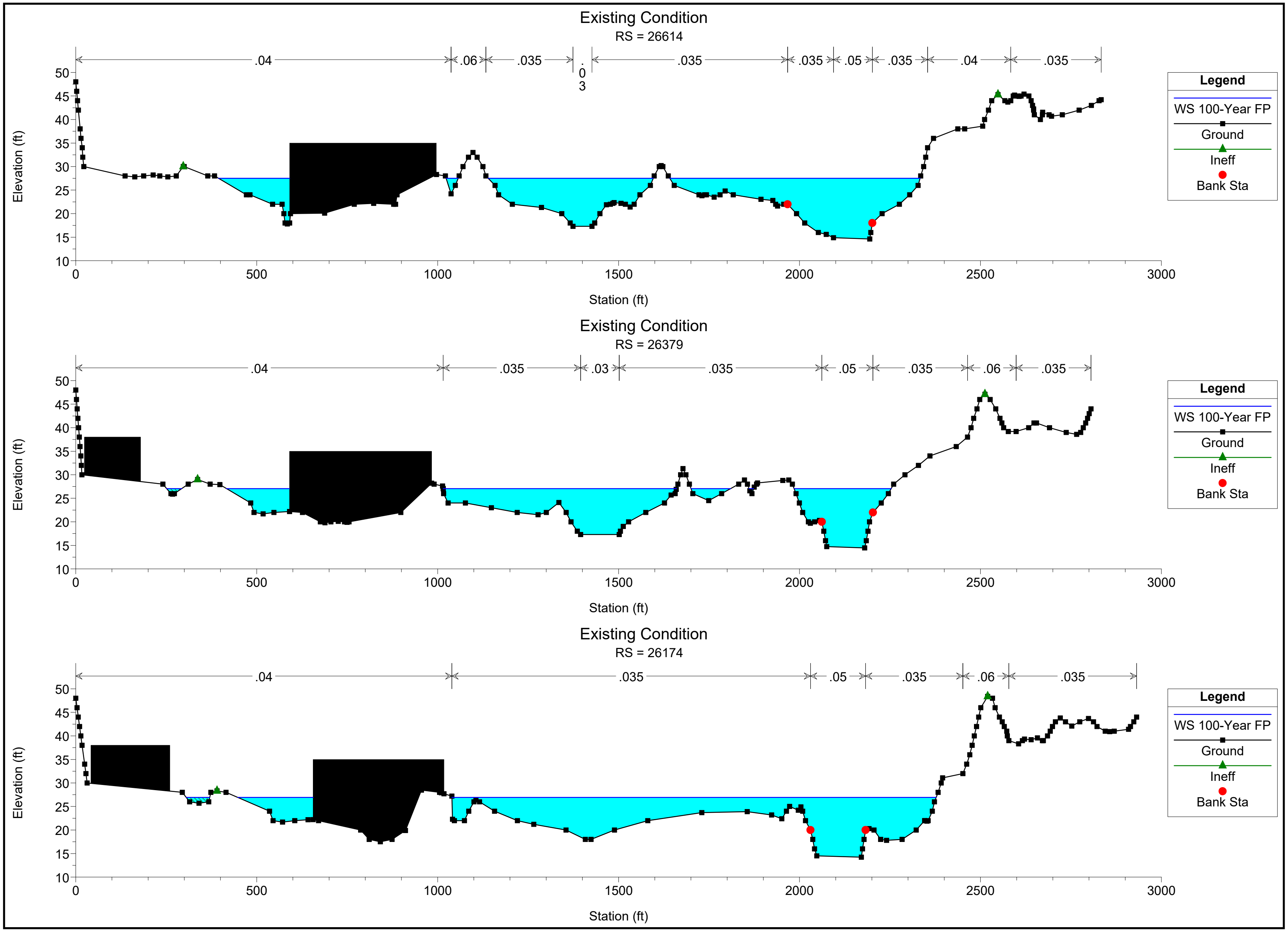
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26379
.04
.035
.03
.035
.05
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.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 26174
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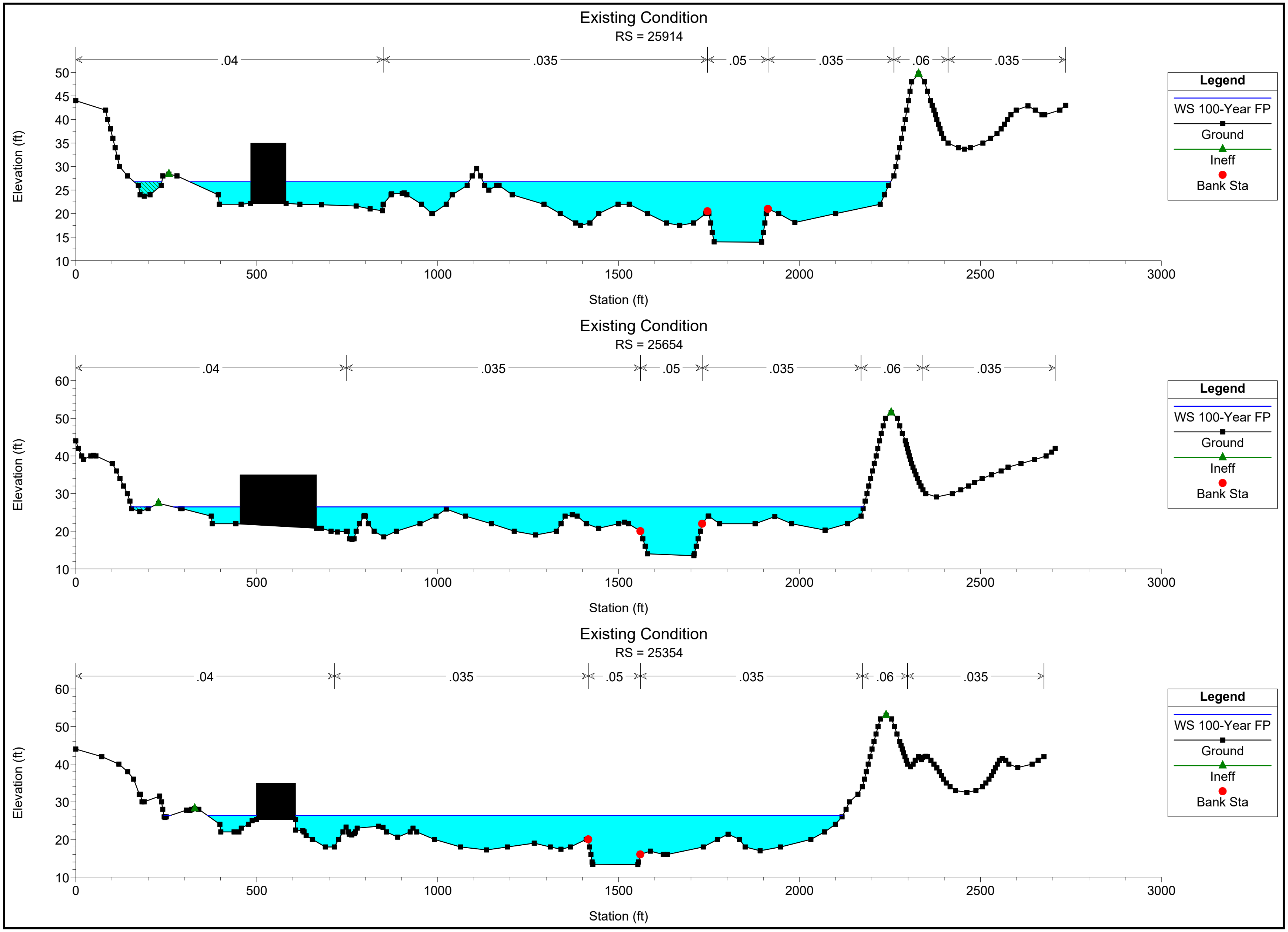
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
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.05
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.06
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 25654
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.035
.05
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 25354
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.06
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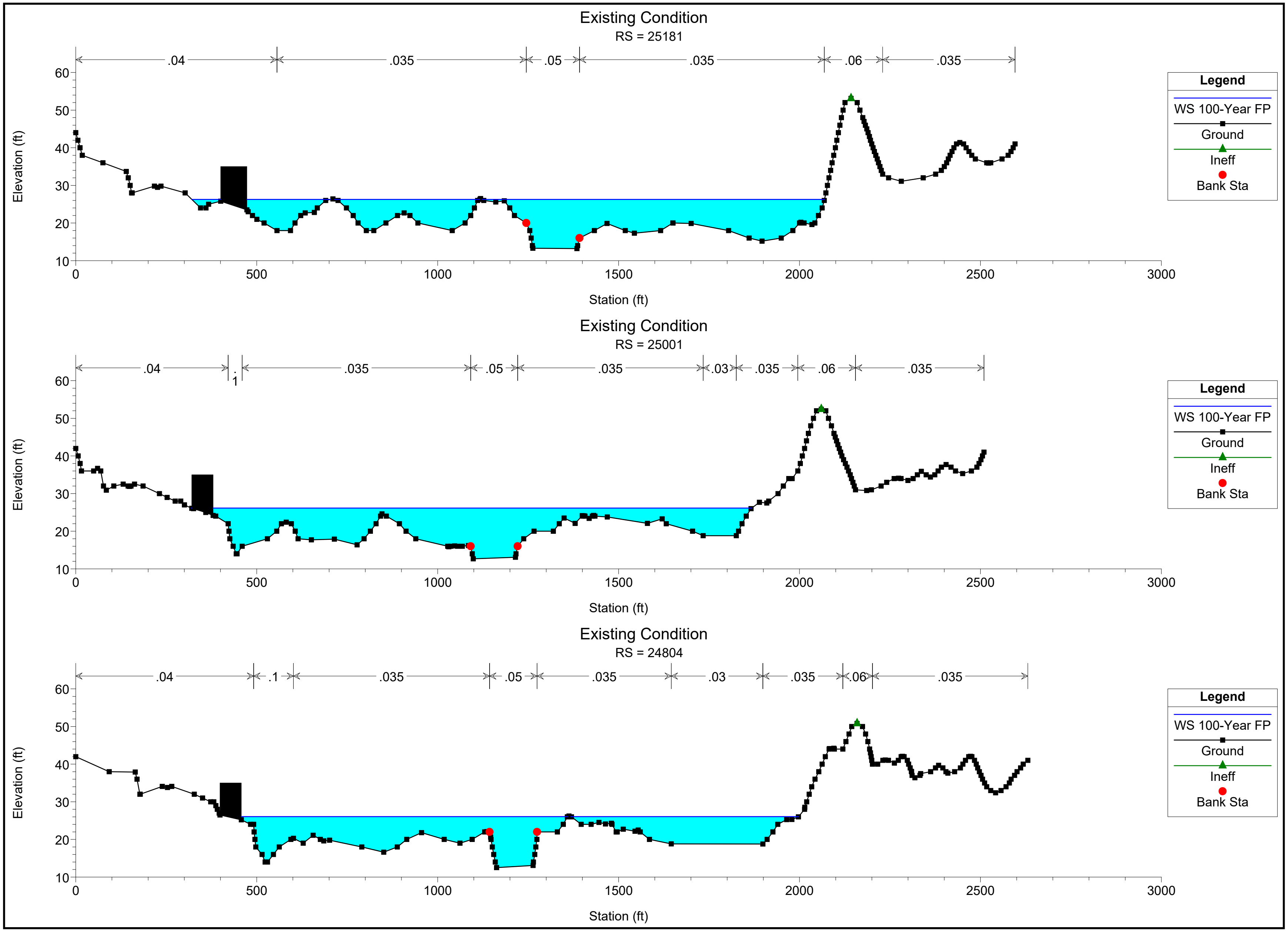
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
RS = 25181
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 25001
.04
.1
.035
.05
.035
.03
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 24804
.04
.1
.035
.05
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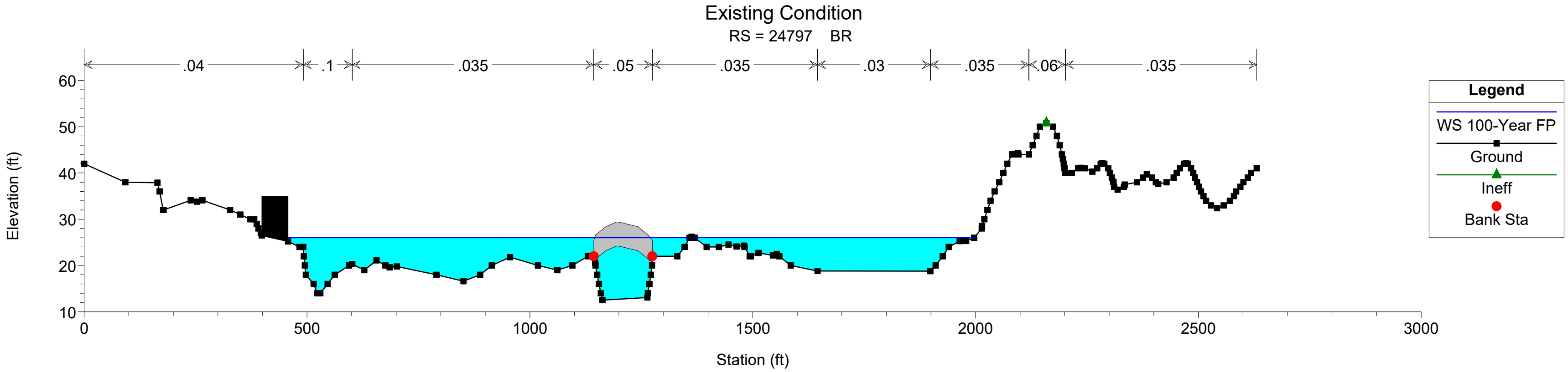
.03
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 24797 BR
.04
.1
.035
.05
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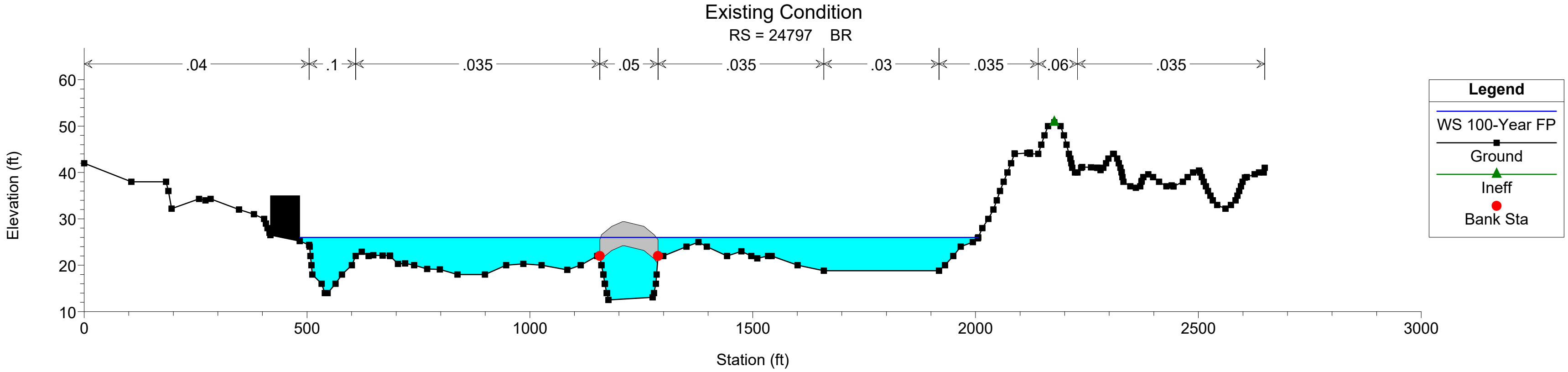
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 24797 BR
.04
.1
.035
.05
.035
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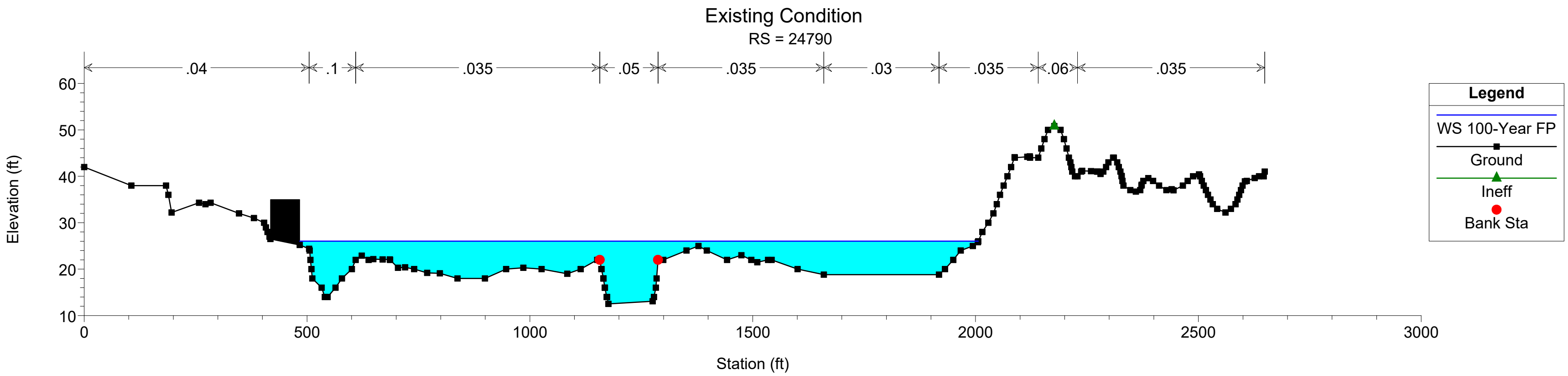
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 24790
.04
.1
.035
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.035
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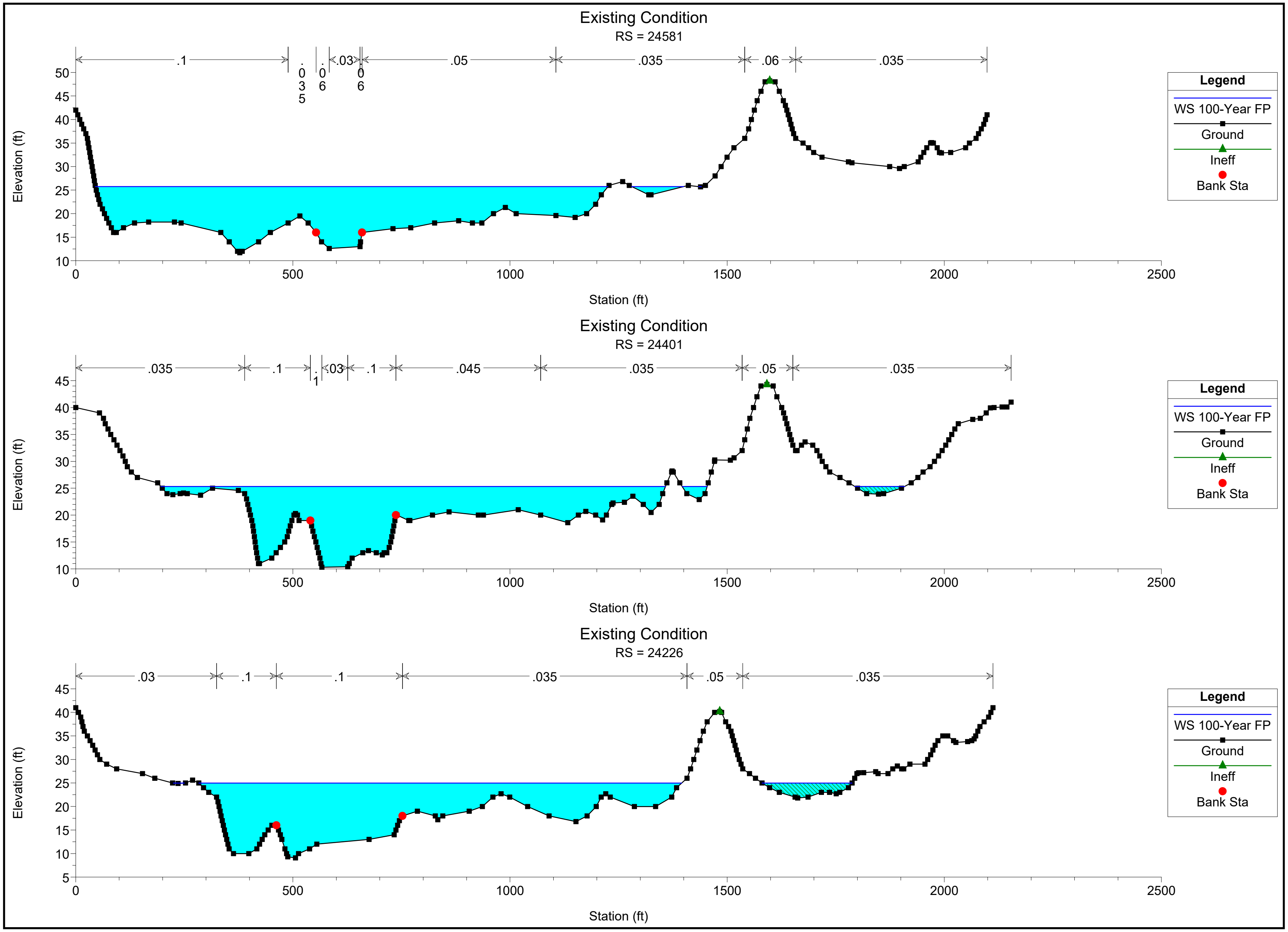
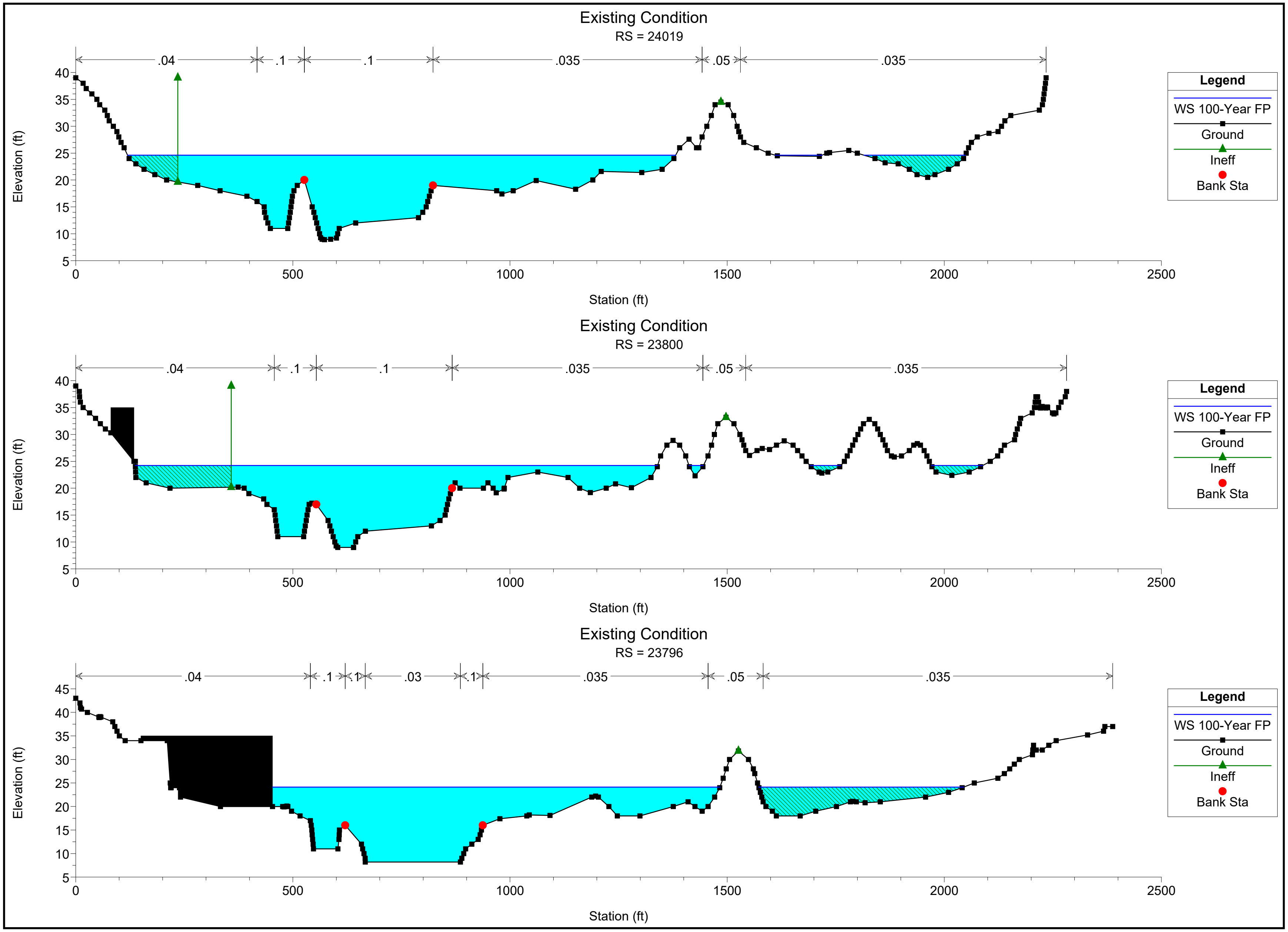
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 24581
.1
.035
.06
.03
.06
.05
.035
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 24401
.035
.1
.1
.03
.1
.045
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 24226
.03
.1
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 24019
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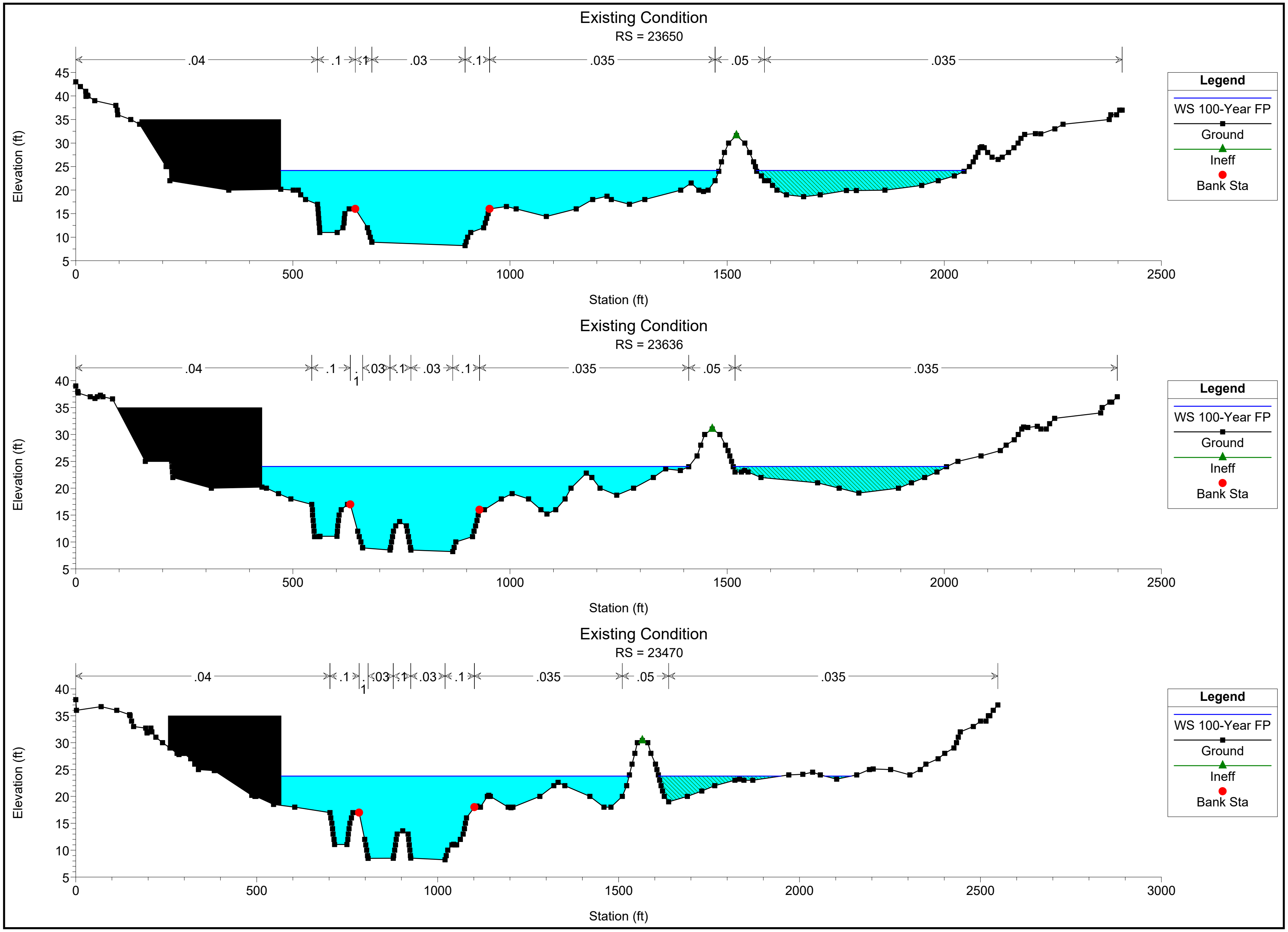
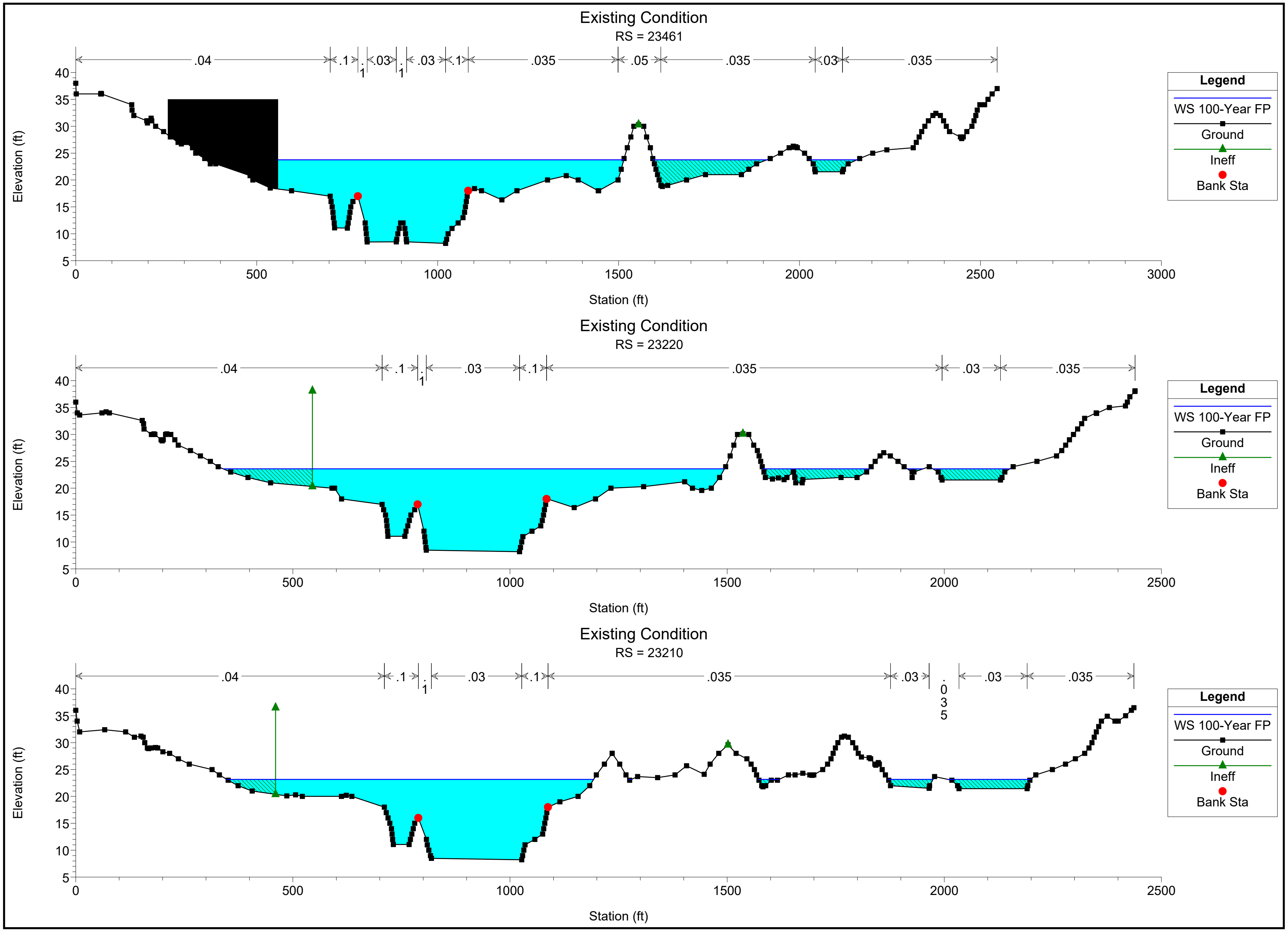
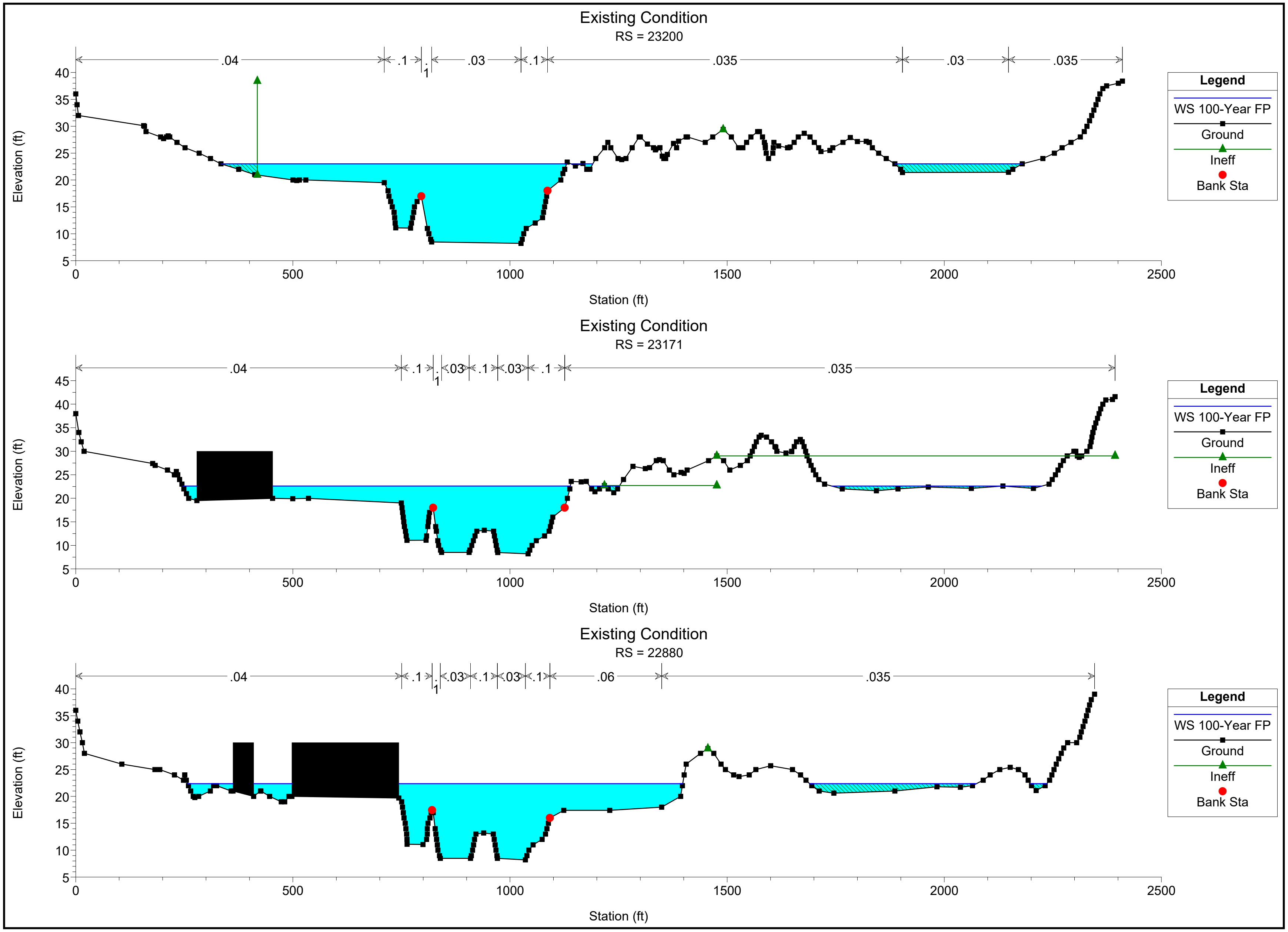
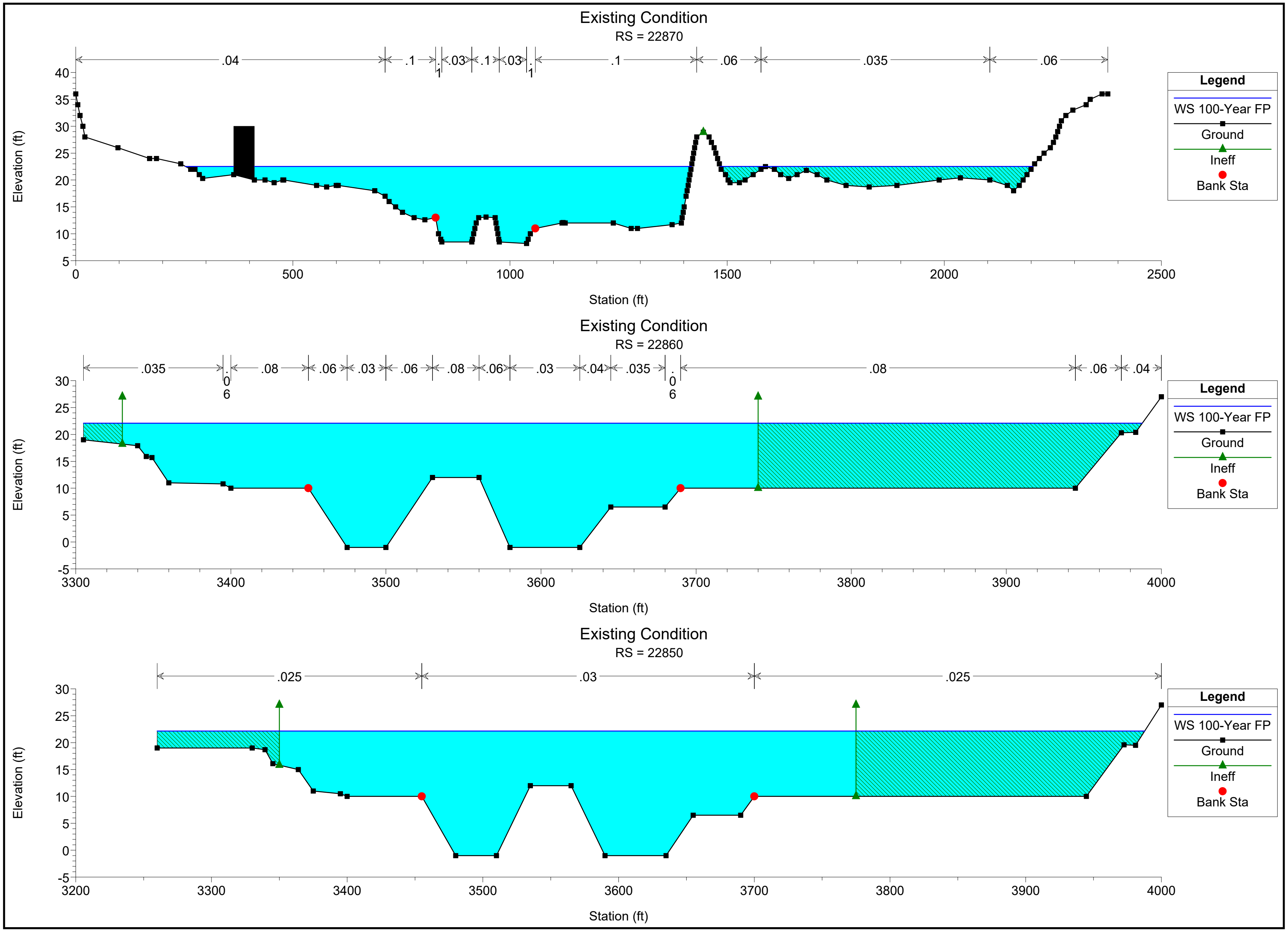
.1
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23800
.04
.1
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23796
.04
.1
.1
.03
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
RS = 23650
.04
.1
.1
.03
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23636
.04
.1
.1
.03
.1
.03
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23470
.04
.1
.1
.03
.1
.03
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
RS = 23461
.04
.1
.03
.03
.1
.035
.05
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23220
.04
.1
.03
.1
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23210
.04
.1
.03
.1
.035
.03
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta



Existing Condition
RS = 23200
.04
.1
1
.03
.1
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 23171
.04
.1
1
.03
.1
.03
.1
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 22880
.04
.1
1
.03
.1
.03
.1
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta


Existing Condition
RS = 22870
.04
.1
.03
.1
.03
.1
.06
.035
.06
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 22860
.035
.08
.06
.03
.06
.08
.06
.03
.04
.035
.08
.06
.04
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta
Existing Condition
RS = 22850
.025
.03
.025
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
Ground
Ineff
Bank Sta

Proposed Condition 100-Year Floodplain and Floodway

HEC-RAS Plan: PC Schmidt 6-20-19 River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach-1	28331	100-Year FP	30.46		31.98	905.00	6612.86	13374.20	16012.94		3273.16	3345.51	
Reach-1	28331	100-Year FW	30.46	0.00	31.98	905.00	6612.88	13378.35	16008.77		3273.16	3345.51	
Reach-1	28300 BR U	100-Year FP	30.59		31.85	905.00	8287.95	6098.95	21613.10		3273.16	3345.51	
Reach-1	28300 BR U	100-Year FW	30.59	0.00	31.85	905.00	8287.95	6098.95	21613.10		3273.16	3345.51	
Reach-1	28300 BR D	100-Year FP	29.65		31.54	830.00	1763.72	26047.16	8189.12		3155.00	3511.00	
Reach-1	28300 BR D	100-Year FW	29.65	0.00	31.54	830.00	1763.72	26047.16	8189.12		3155.00	3511.00	
Reach-1	28269	100-Year FP	29.18		30.92	830.00	1182.52	29170.04	5647.44		3155.00	3511.00	
Reach-1	28269	100-Year FW	29.38	0.19	30.96	830.00	1229.61	28713.35	6057.04		3155.00	3511.00	
Reach-1	28244	100-Year FP	29.31		30.58	715.35	3209.97	25469.48	7320.56		1869.78	2134.20	
Reach-1	28244	100-Year FW	29.47	0.16	30.67	715.67	3279.18	24920.82	7800.01		1869.78	2134.20	
Reach-1	28164	100-Year FP	28.65		29.47	801.07	7875.39	14229.80	13894.81		1864.66	2084.05	
Reach-1	28164	100-Year FW	28.92	0.27	29.68	802.45	7848.74	13890.91	14260.36		1864.66	2084.05	
Reach-1	28064	100-Year FP	28.44		28.95	833.08	14012.49	8666.79	13320.72		1856.85	2041.57	
Reach-1	28064	100-Year FW	28.73	0.29	29.20	851.13	13878.76	8566.42	13554.82		1856.85	2041.57	
Reach-1	27929	100-Year FP	28.25		28.71	752.73	14880.81	6355.39	14763.79		1897.84	2087.62	
Reach-1	27929	100-Year FW	28.56	0.31	28.99	754.22	14726.39	6321.69	14951.92		1897.84	2087.62	
Reach-1	27759	100-Year FP	27.97		28.52	754.89	22535.65	6187.59	7276.76		1919.43	2161.10	
Reach-1	27759	100-Year FW	28.26	0.28	28.81	805.62	23130.37	6380.47	6489.16		1919.43	2161.10	
Reach-1	27589	100-Year FP	27.98		28.36	840.28	26359.24	4263.20	5377.56		2021.36	2249.97	
Reach-1	27589	100-Year FW	28.29	0.30	28.65	844.29	26275.32	4280.23	5444.45		2021.36	2249.97	
Reach-1	27429	100-Year FP	27.96		28.25	831.45	26602.67	5642.21	3755.12		1978.79	2229.17	
Reach-1	27429	100-Year FW	28.27	0.31	28.54	833.03	26536.28	5652.01	3811.71		1978.79	2229.17	
Reach-1	27259	100-Year FP	27.89		28.13	820.84	29713.86	4909.97	1376.17		2025.15	2236.10	
Reach-1	27259	100-Year FW	28.21	0.31	28.43	822.51	29655.11	4929.89	1415.01		2025.15	2236.10	
Reach-1	27069	100-Year FP	27.60		27.94	927.54	23414.77	12262.36	322.87		2099.20	2279.39	
Reach-1	27069	100-Year FW	27.95	0.35	28.26	930.30	23541.19	12105.96	352.85		2099.20	2279.39	
Reach-1	26951	100-Year FP	27.36		27.76	1024.48	24343.00	11642.74	14.26		2117.58	2296.08	
Reach-1	26951	100-Year FW	27.74	0.38	28.10	1027.33	24570.19	11410.09	19.72		2117.58	2296.08	
Reach-1	26944 BR U	100-Year FP	27.37		27.74	969.84	26232.55	9761.70	5.75		2117.58	2296.08	
Reach-1	26944 BR U	100-Year FW	27.75	0.38	28.09	965.40	26703.50	9286.89	9.61		2117.58	2296.08	
Reach-1	26944 BR D	100-Year FP	27.36		27.71	981.73	26543.31	9425.02	31.67		2119.16	2290.79	

HEC-RAS Plan: PC Schmidt 6-20-19   River: RIVER-1   Reach: Reach-1 (Continued)

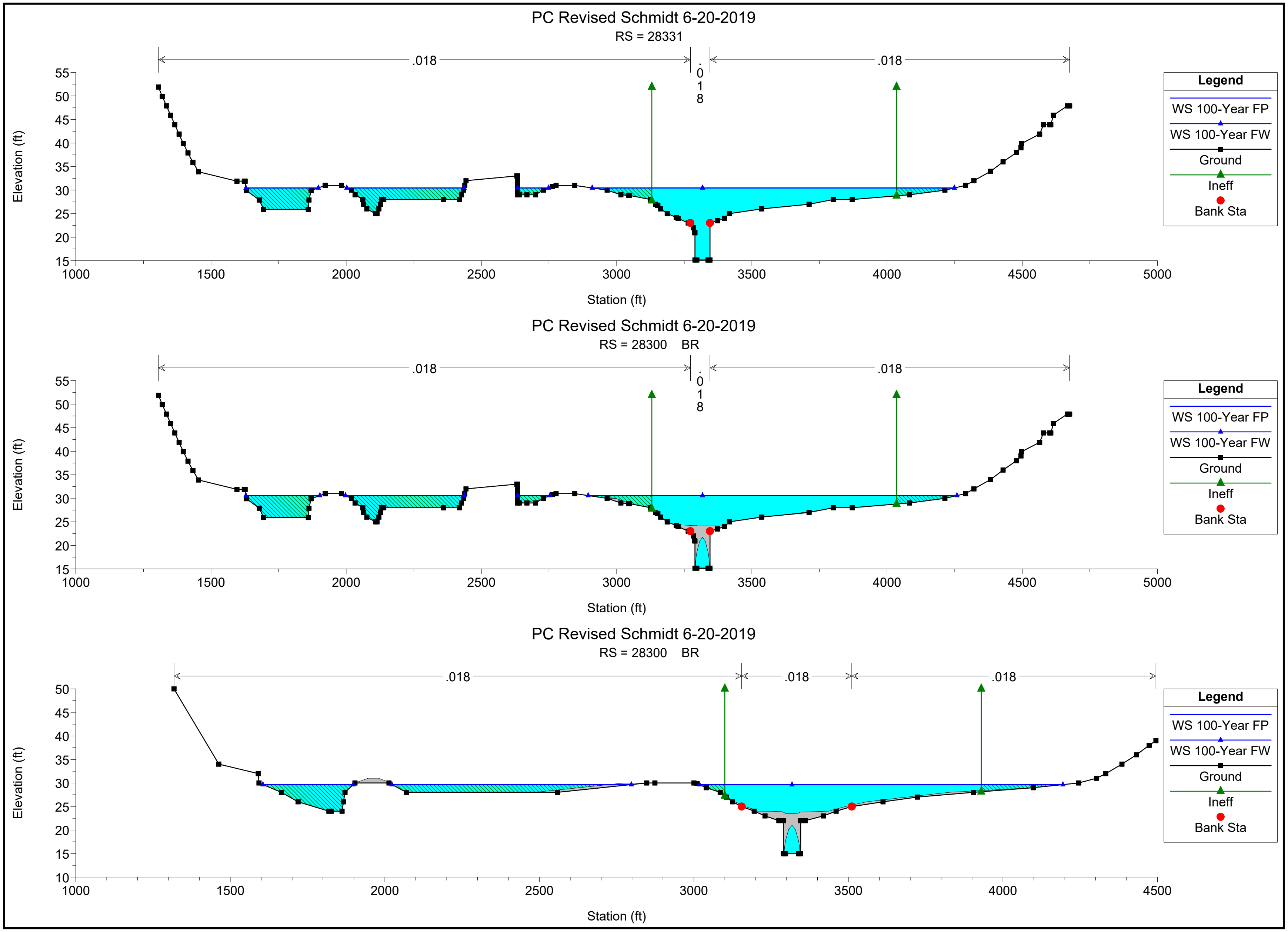
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach-1	26944 BR D	100-Year FW	27.74	0.38	28.06	985.37	27009.43	8947.21	43.36		2119.16	2290.79	
Reach-1	26937	100-Year FP	27.33		27.71	1035.67	24505.88	11465.28	28.84		2119.16	2290.79	
Reach-1	26937	100-Year FW	27.72	0.39	28.06	1046.45	24728.41	11232.36	39.23		2119.16	2290.79	
Reach-1	26799	100-Year FP	27.16		27.44	1112.90	27641.88	8339.56	18.56		2120.03	2251.44	
Reach-1	26799	100-Year FW	27.57	0.41	27.83	1067.40	27674.89	8299.29	25.82	1182.43	2120.03	2251.44	
Reach-1	26614	100-Year FP	26.94		27.21	1107.84	27623.22	7157.32	1219.47		2088.81	2201.24	
Reach-1	26614	100-Year FW	27.38	0.44	27.62	1100.71	27722.83	7030.69	1246.48	1156.65	2088.81	2201.24	
Reach-1	26379	100-Year FP	26.56		26.89	1141.33	26505.90	9269.97	224.13		2061.91	2202.88	
Reach-1	26379	100-Year FW	27.06	0.50	27.35	1052.16	26674.20	9069.17	256.64	1183.49	2061.91	2202.88	
Reach-1	26174	100-Year FP	26.34		26.58	1188.18	26342.04	8634.28	1023.68		2030.20	2182.66	
Reach-1	26174	100-Year FW	26.84	0.50	27.09	930.60	25964.32	8917.18	1118.50	1313.31	2030.20	2182.66	
Reach-1	25914	100-Year FP	26.26		26.39	1543.72	29302.98	5547.72	1149.30		1745.88	1912.86	
Reach-1	25914	100-Year FW	26.73	0.47	26.92	849.05	28593.16	6100.50	1306.34	1146.70	1745.88	1912.86	
Reach-1	25654	100-Year FP	26.20		26.31	1399.21	30340.95	4267.81	1391.25		1560.52	1723.66	
Reach-1	25654	100-Year FW	26.71	0.50	26.82	1128.68	29994.14	4483.40	1522.46	764.60	1560.52	1723.66	
Reach-1	25354	100-Year FP	26.14		26.23	1370.40	23427.16	4865.29	7707.55		1416.29	1560.15	
Reach-1	25354	100-Year FW	26.62	0.48	26.74	988.03	21656.77	5562.95	8780.27	858.78	1416.29	1560.15	
Reach-1	25181	100-Year FP	26.09		26.18	1358.22	22058.79	4941.77	8999.44		1245.02	1392.26	
Reach-1	25181	100-Year FW	26.55	0.46	26.68	964.39	18241.39	6283.97	11474.64	789.86	1245.02	1392.26	
Reach-1	25001	100-Year FP	26.01		26.12	1196.28	24323.25	5036.68	6640.07		1091.45	1221.27	
Reach-1	25001	100-Year FW	26.39	0.38	26.58	850.97	20145.11	6786.71	9068.18	727.71	1091.45	1221.27	
Reach-1	24804	100-Year FP	25.97		26.09	1234.84	21877.61	5044.42	9077.97		1143.55	1274.88	
Reach-1	24804	100-Year FW	26.33	0.35	26.52	869.87	16780.38	6779.67	12439.95	823.33	1143.55	1274.88	
Reach-1	24797 BR U	100-Year FP	25.96		26.09	1109.25	23913.98	2170.30	9915.72		1143.55	1274.88	
Reach-1	24797 BR U	100-Year FW	26.30	0.33	26.52	748.27	19042.33	2874.31	14083.36	823.33	1143.55	1274.88	
Reach-1	24797 BR D	100-Year FP	25.95		26.08	1100.42	24285.48	2126.08	9588.44		1156.87	1287.61	
Reach-1	24797 BR D	100-Year FW	26.29	0.33	26.51	746.72	19122.95	2891.95	13985.10	841.99	1156.87	1287.61	
Reach-1	24790	100-Year FP	25.96		26.08	1225.76	22277.02	4923.38	8799.60		1156.87	1287.61	
Reach-1	24790	100-Year FW	26.30	0.34	26.50	868.25	16867.78	6779.45	12352.77	841.99	1156.87	1287.61	
Reach-1	24581	100-Year FP	25.73		25.98	1069.19	7594.06	5234.72	23171.22		557.01	659.35	
Reach-1	24581	100-Year FW	26.09	0.36	26.38	798.65	5505.99	5618.08	24875.93	316.92	557.01	659.35	

HEC-RAS Plan: PC Schmidt 6-20-19 River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach-1	24401	100-Year FP	25.28		25.79	1055.92	5725.04	14388.17	15886.80		540.23	737.32	
Reach-1	24401	100-Year FW	25.74	0.46	26.21	902.19	5337.37	13951.73	16710.90	355.35	540.23	737.32	
Reach-1	24226	100-Year FP	24.98		25.30	1136.75	5657.45	12215.75	18126.80		461.93	752.35	
Reach-1	24226	100-Year FW	25.52	0.53	25.80	1105.24	5480.13	11661.02	18858.85	296.55	461.93	752.35	
Reach-1	24019	100-Year FP	24.62		24.92	1146.40	9938.22	11912.92	14148.86		526.41	822.79	
Reach-1	24019	100-Year FW	25.08	0.47	25.44	998.88	5425.71	13323.58	17250.70	385.63	526.41	822.79	
Reach-1	23800	100-Year FP	24.21		24.65	1015.36	9342.75	17723.89	8933.36		554.02	866.71	
Reach-1	23800	100-Year FW	24.79	0.58	25.18	992.33	8410.85	17073.32	10515.83	389.04	554.02	866.71	
Reach-1	23796	100-Year FP	24.13		24.51	1030.53	2674.65	25947.32	7378.03		620.44	937.35	
Reach-1	23796	100-Year FW	24.72	0.59	25.07	962.60	1905.11	25805.81	8289.07	523.23	620.44	937.35	
Reach-1	23650	100-Year FP	24.17		24.47	1009.04	2452.49	22884.38	10663.13		643.67	953.07	
Reach-1	23650	100-Year FW	24.75	0.58	25.04	926.18	1444.42	22989.16	11566.42	556.82	643.67	953.07	
Reach-1	23636	100-Year FP	24.05		24.39	983.15	5644.14	20588.06	9767.81		632.41	929.84	
Reach-1	23636	100-Year FW	24.61	0.56	24.96	882.19	3142.49	21332.33	11525.19	535.11	632.41	929.84	
Reach-1	23470	100-Year FP	23.78		24.14	961.52	6654.86	21472.79	7872.35		783.13	1101.53	
Reach-1	23470	100-Year FW	24.33	0.55	24.72	852.48	3474.34	22857.53	9668.13	678.61	783.13	1101.53	
Reach-1	23461	100-Year FP	23.76		24.09	955.66	5871.45	20896.93	9231.62		779.72	1084.50	
Reach-1	23461	100-Year FW	24.31	0.55	24.67	834.02	2828.09	22212.69	10959.22	682.52	779.72	1084.50	
Reach-1	23220	100-Year FP	23.60		24.00	948.81	5488.50	23841.56	6669.94		787.22	1084.14	
Reach-1	23220	100-Year FW	24.15	0.55	24.58	807.18	2797.27	25118.59	8084.15	690.22	787.22	1084.14	
Reach-1	23210	100-Year FP	23.17		23.83	738.53	5956.99	28518.99	1524.02		788.88	1087.42	
Reach-1	23210	100-Year FW	23.62	0.45	24.39	548.05	2943.08	31136.13	1920.79	706.15	788.88	1087.42	
Reach-1	23200	100-Year FP	23.00		23.75	759.24	5897.64	29429.48	672.87		795.69	1086.53	
Reach-1	23200	100-Year FW	23.37	0.37	24.30	482.10	2725.43	32609.85	664.72	711.06	795.69	1086.53	
Reach-1	23171	100-Year FP	22.60		23.37	750.60	8765.04	27019.83	215.13		822.96	1126.04	
Reach-1	23171	100-Year FW	22.72	0.13	23.84	457.15	3909.35	31717.36	373.28	752.46	822.96	1126.04	
Reach-1	22880	100-Year FP	22.36		23.06	846.48	4415.59	24475.28	7109.13		820.50	1091.75	
Reach-1	22880	100-Year FW	22.67	0.30	23.41	639.88	2784.28	25356.45	7859.27	758.47	820.50	1091.75	
Reach-1	22870	100-Year FP	22.53		22.84	1117.78	7301.00	16525.34	12173.66		828.78	1058.18	
Reach-1	22870	100-Year FW	22.75	0.22	23.20	659.35	2217.47	19409.57	14372.96	758.82	828.78	1058.18	

HEC-RAS Plan: PC Schmidt 6-20-19   River: RIVER-1   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach-1	22860	100-Year FP	22.08		22.68	410.00	5788.93	28204.05	2007.02		3450.00	3690.00	
Reach-1	22860	100-Year FW	22.48	0.39	23.05	410.00	5922.85	28047.32	2029.83	3275.00	3450.00	3690.00	3960.00
Reach-1	22850	100-Year FP	22.15		22.64	425.00	5843.61	25175.90	4980.49		3455.00	3700.00	
Reach-1	22850	100-Year FW	22.54	0.39	23.00	425.00	5940.17	25025.41	5034.41	3275.00	3455.00	3700.00	3960.00


PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
WS 100-Year FW
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 28300 BR
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.018
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
WS 100-Year FW
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
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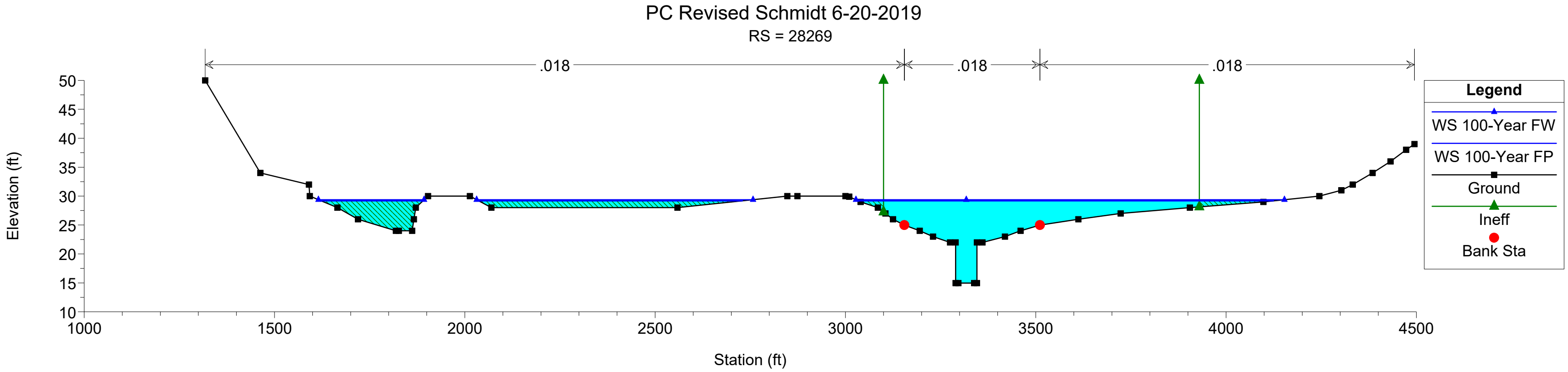
Elevation (ft)
Station (ft)
Legend
WS 100-Year FP
WS 100-Year FW
Ground
Ineff
Bank Sta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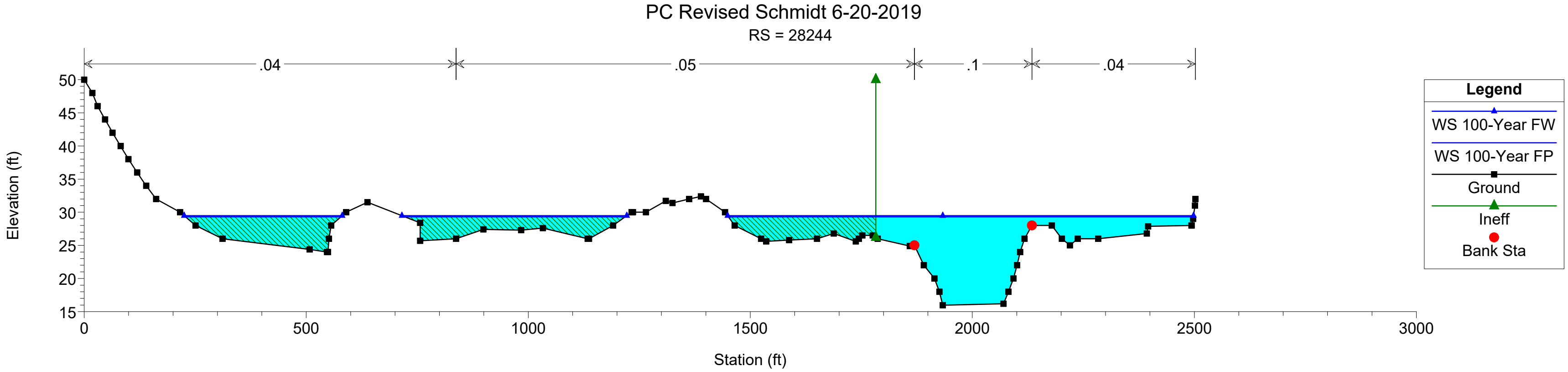
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta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Station (ft)
Legend
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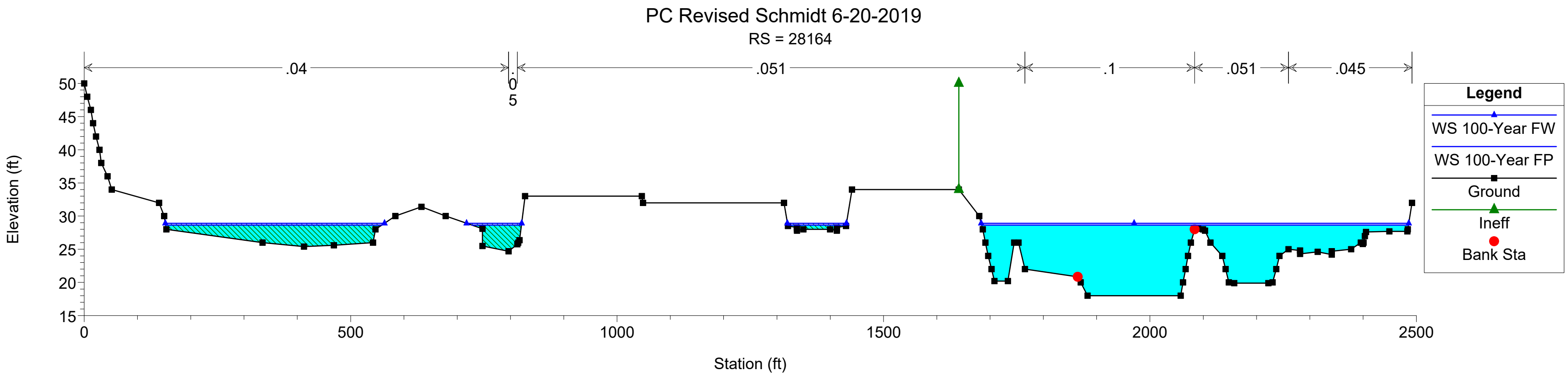
WS 100-Year FP
Ground
Ineff
Bank Sta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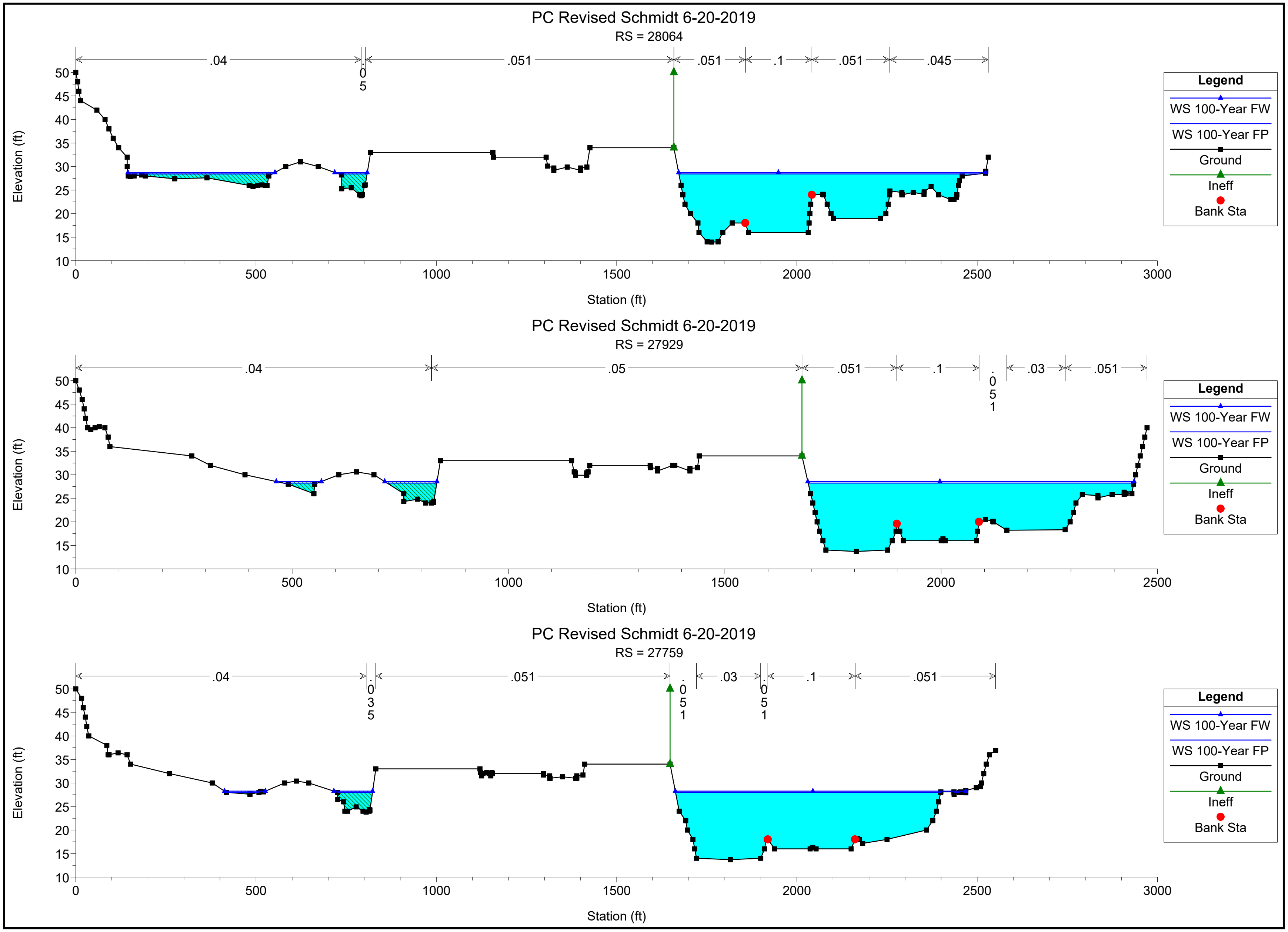
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta


PC Revised Schmidt 6-20-2019
RS = 28064
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 27929
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.05
.051
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.03
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 27759
.04
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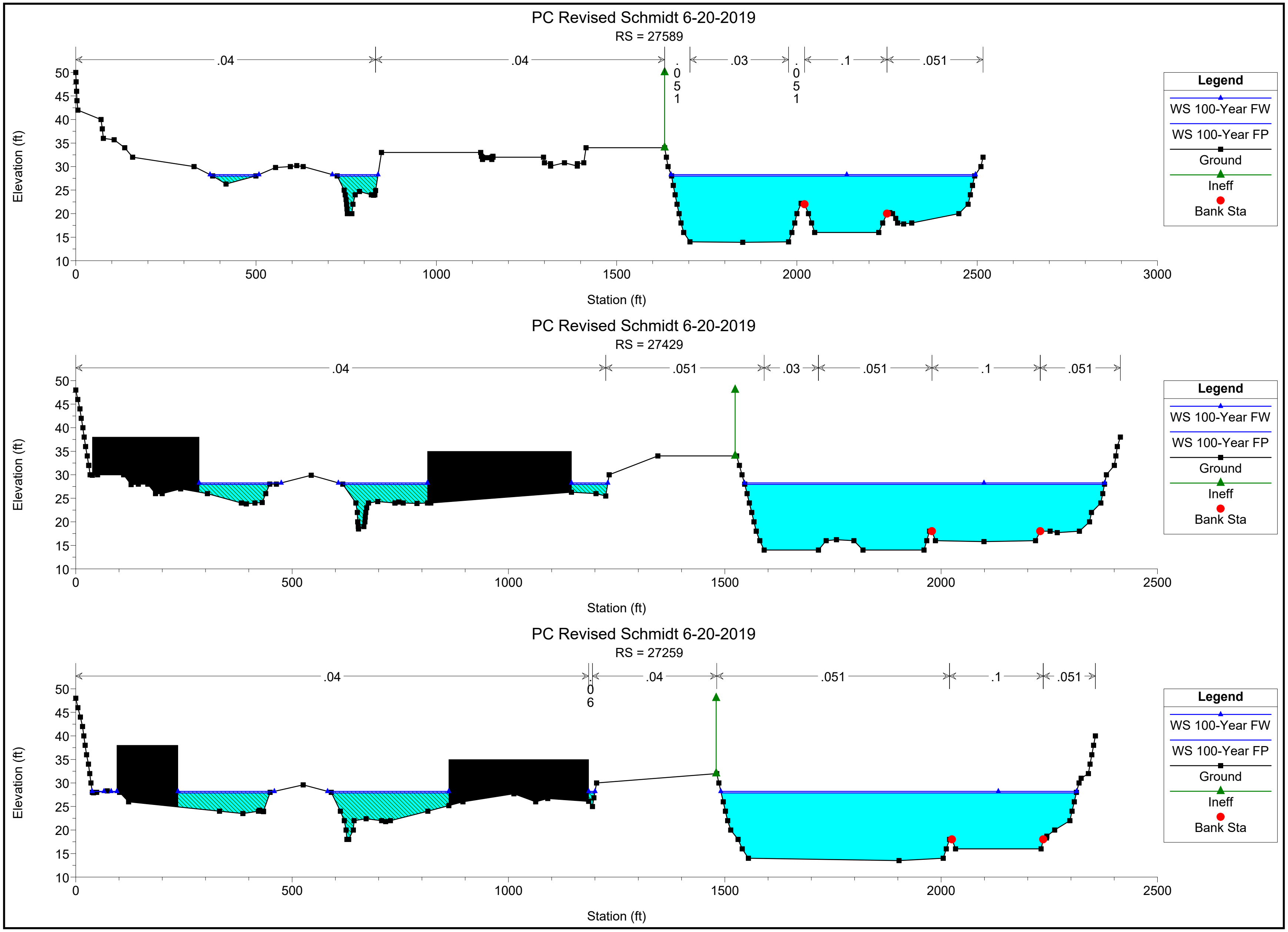
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta



PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 27429
.04
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.03
.051
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 27259
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.06
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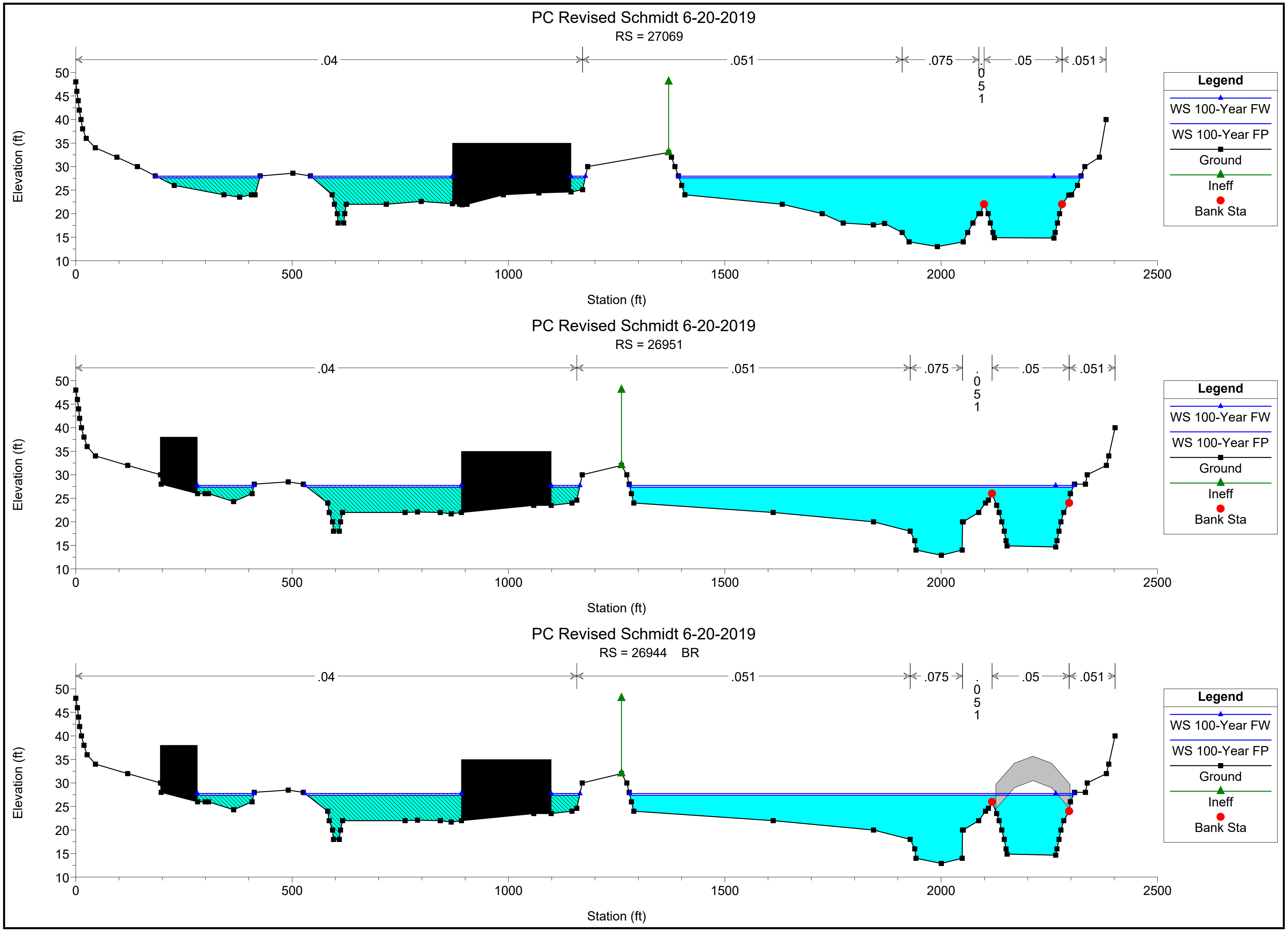
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta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Legend
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WS 100-Year FP
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
PC Revised Schmidt 6-20-2019
RS = 26951
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.051
.075
.051
.05
.051
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
PC Revised Schmidt 6-20-2019
RS = 26944 BR
.04
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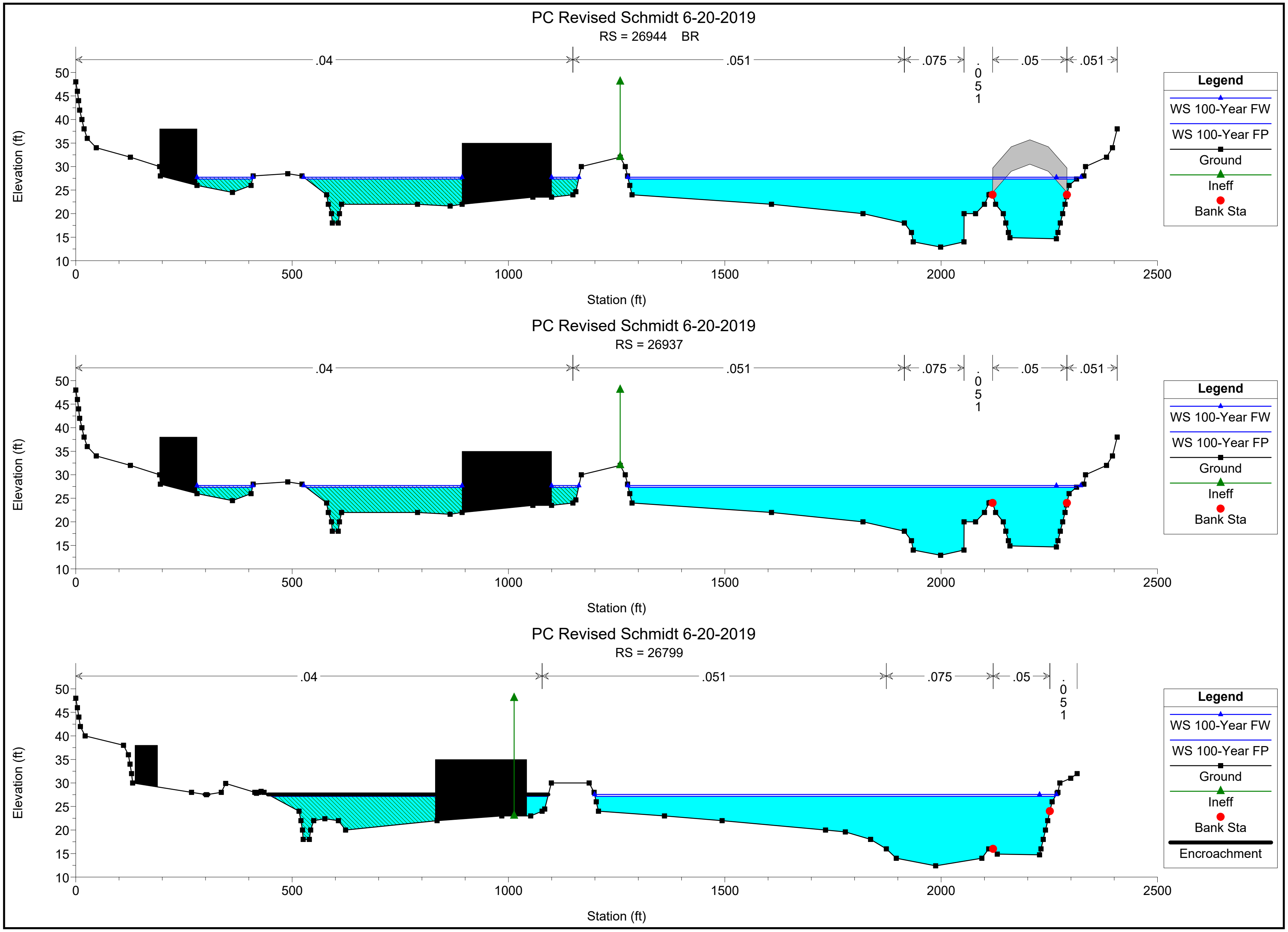
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 26937
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.05
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019
RS = 26799
.04
.051
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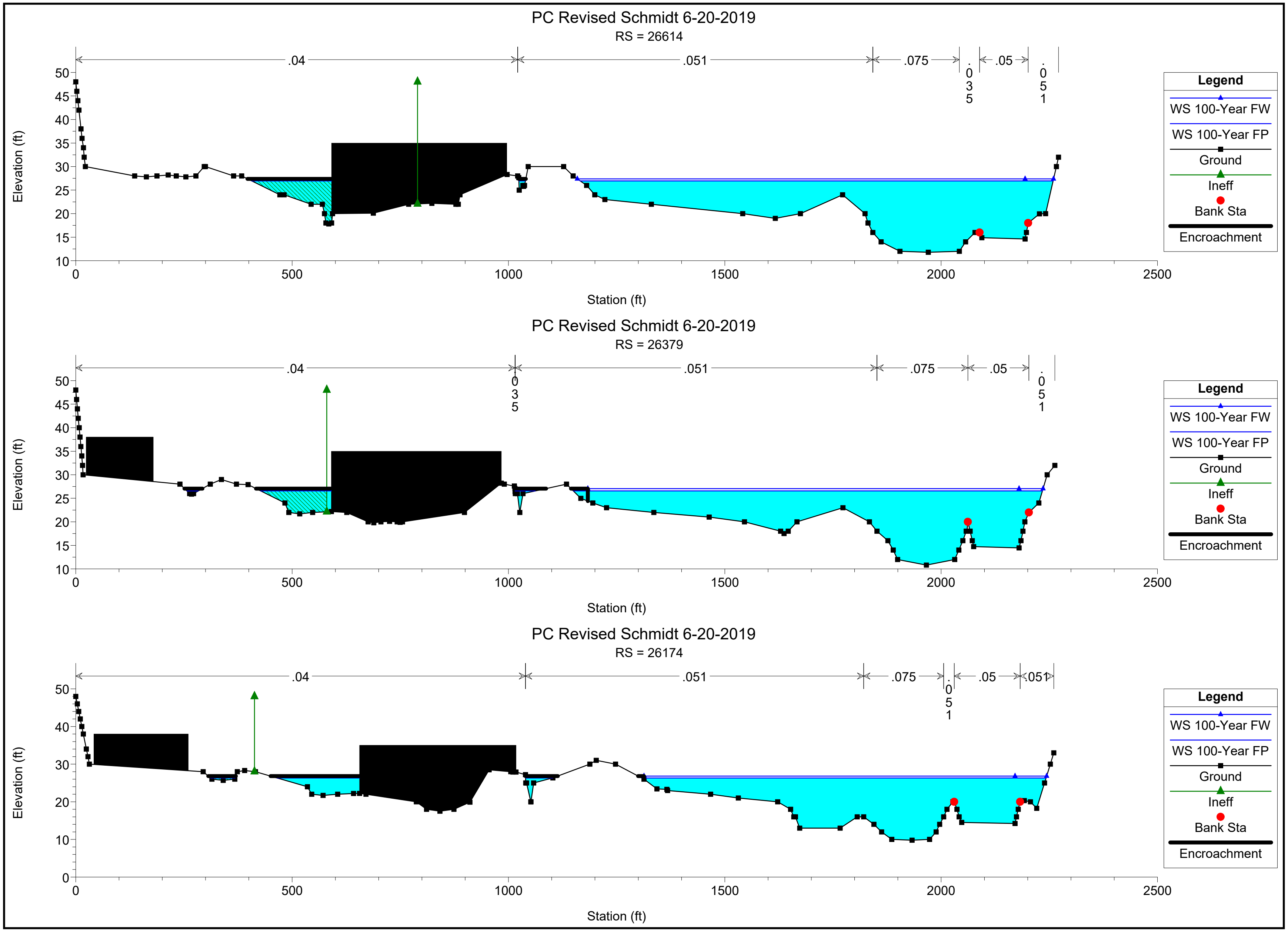
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 26379
.04
.035
.051
.075
.05
.051
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 26174
.04
.051
.075
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Elevation (ft)
Station (ft)
Legend
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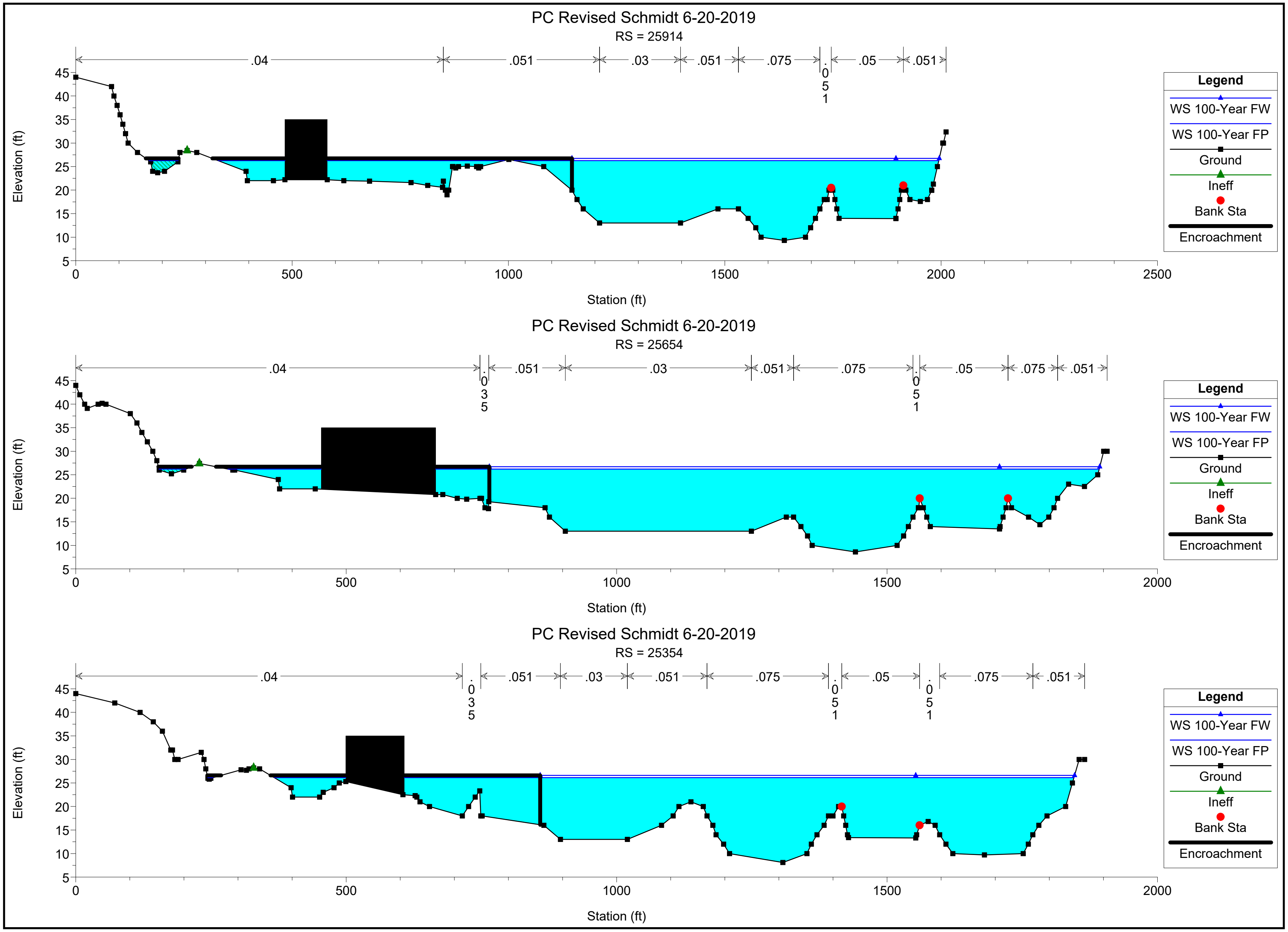
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment


PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
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WS 100-Year FW
WS 100-Year FP
Ground
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Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 25654
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.051
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 25354
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Elevation (ft)
Station (ft)
Legend
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WS 100-Year FP
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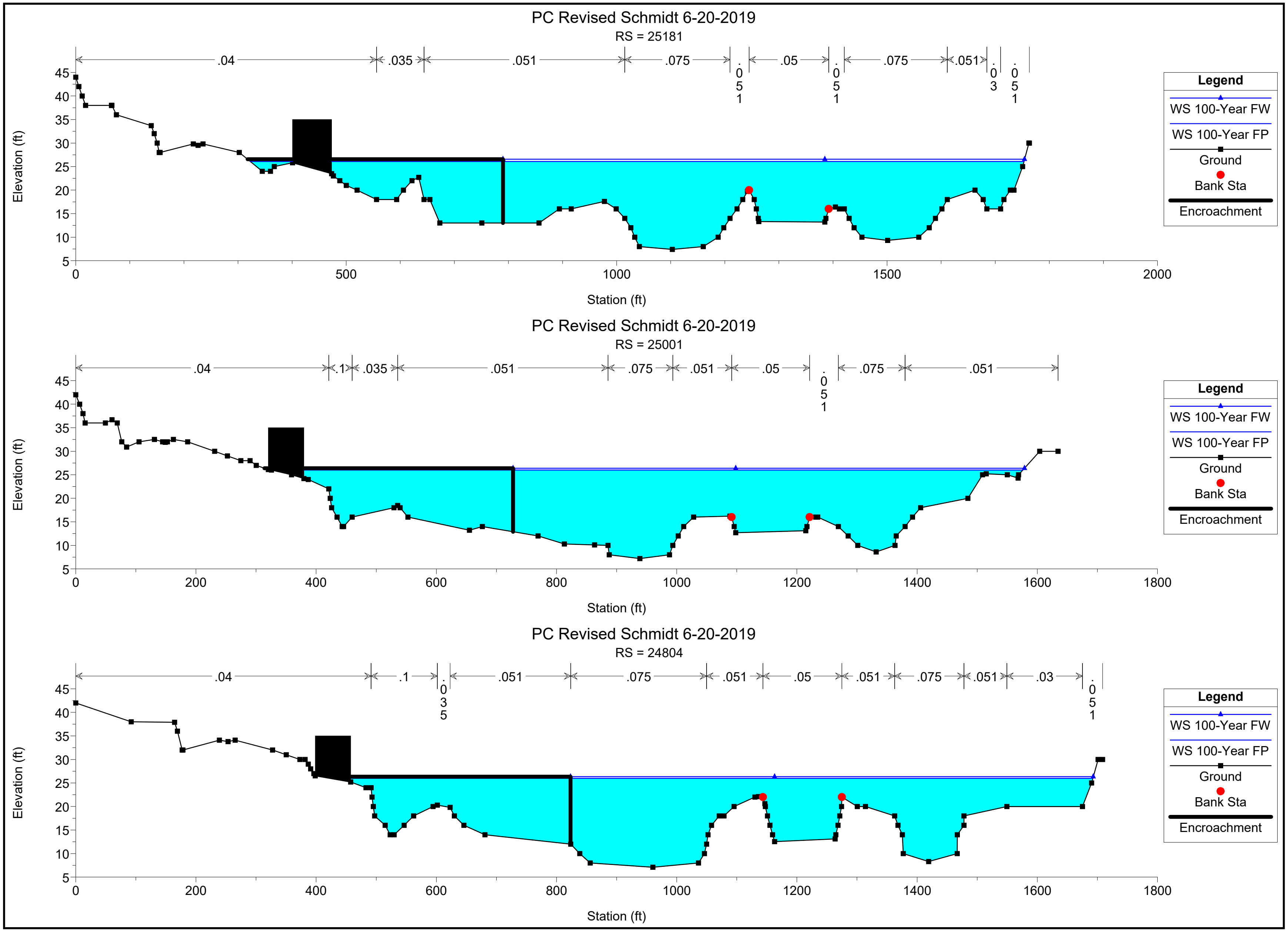
Ineff
Bank Sta
Encroachment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WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 25001
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 24804
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Station (ft)
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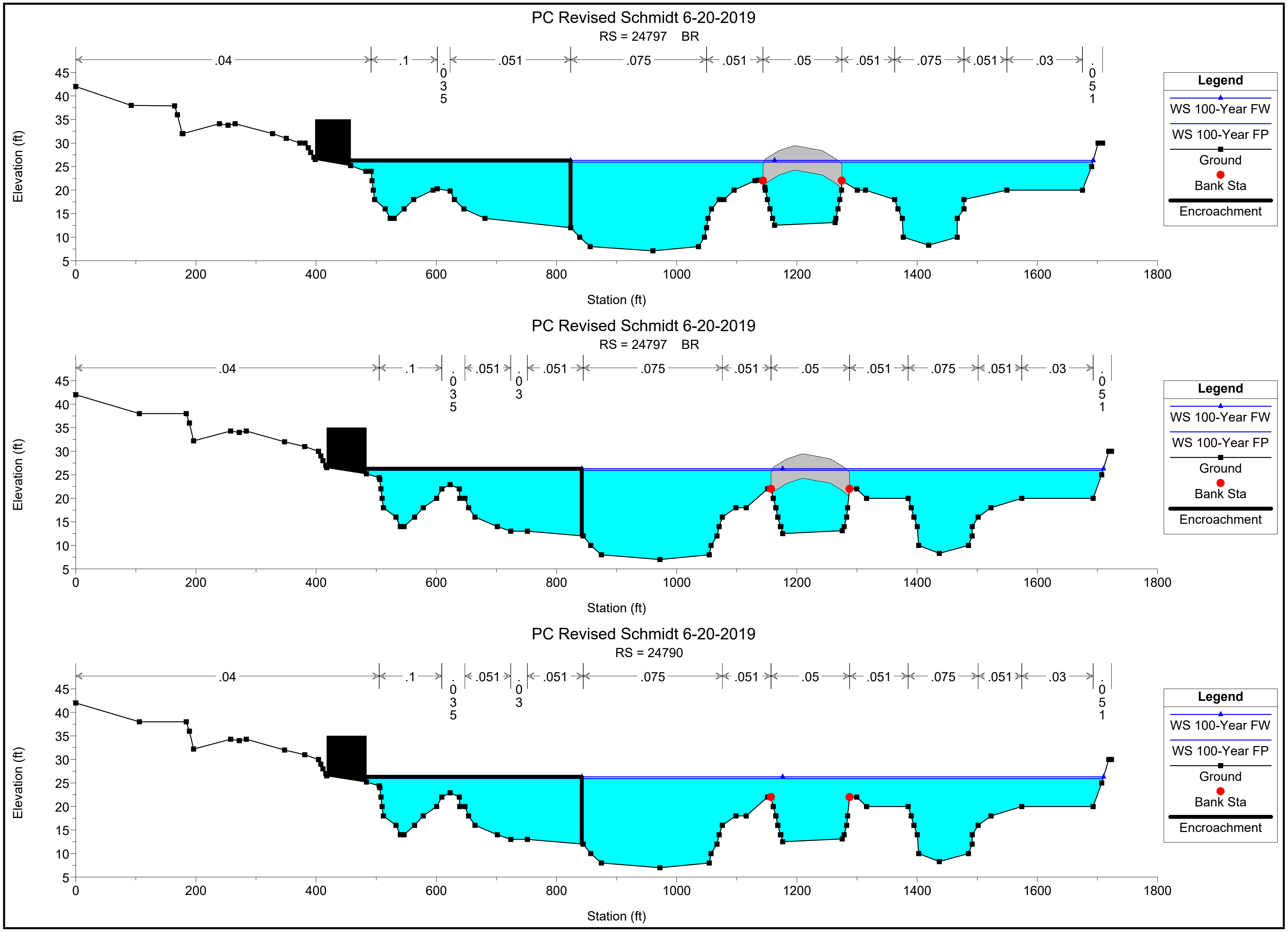
WS 100-Year FP
Ground
Bank Sta
Encroachment



PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 24797 BR
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 24790
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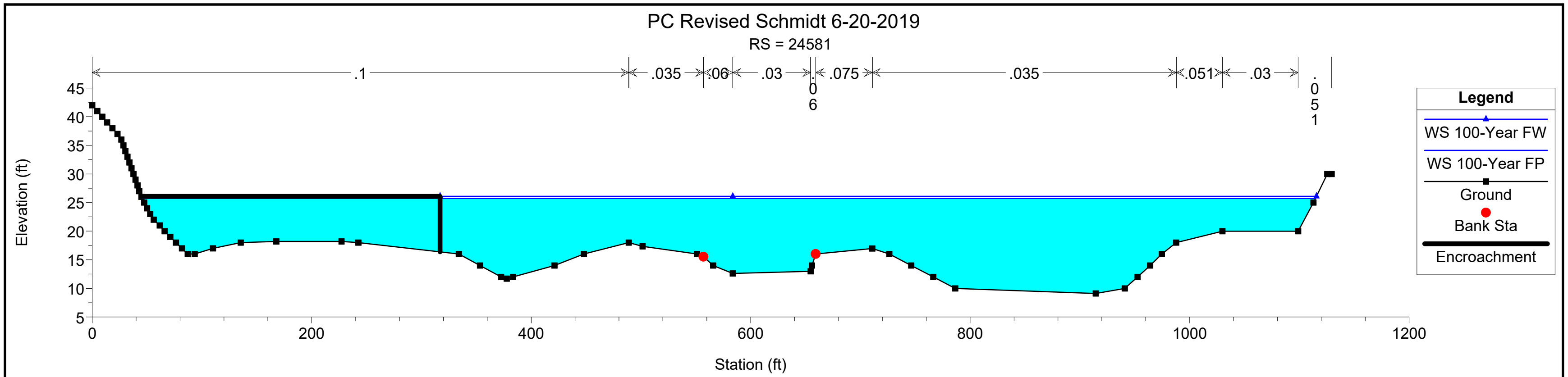
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment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Elevation (ft)
Station (ft)
Legend
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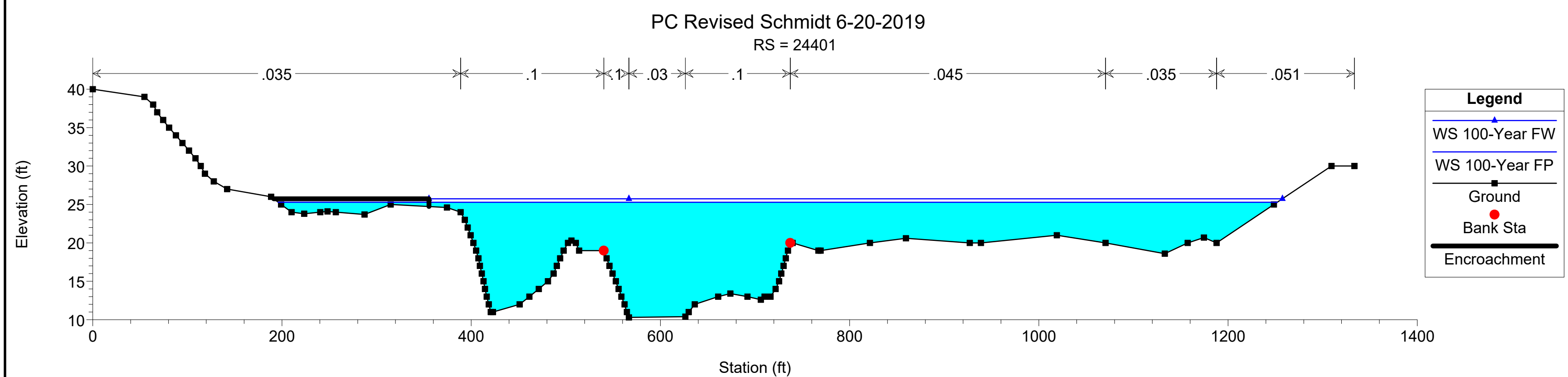
WS 100-Year FP
Ground
Bank Sta
Encroachment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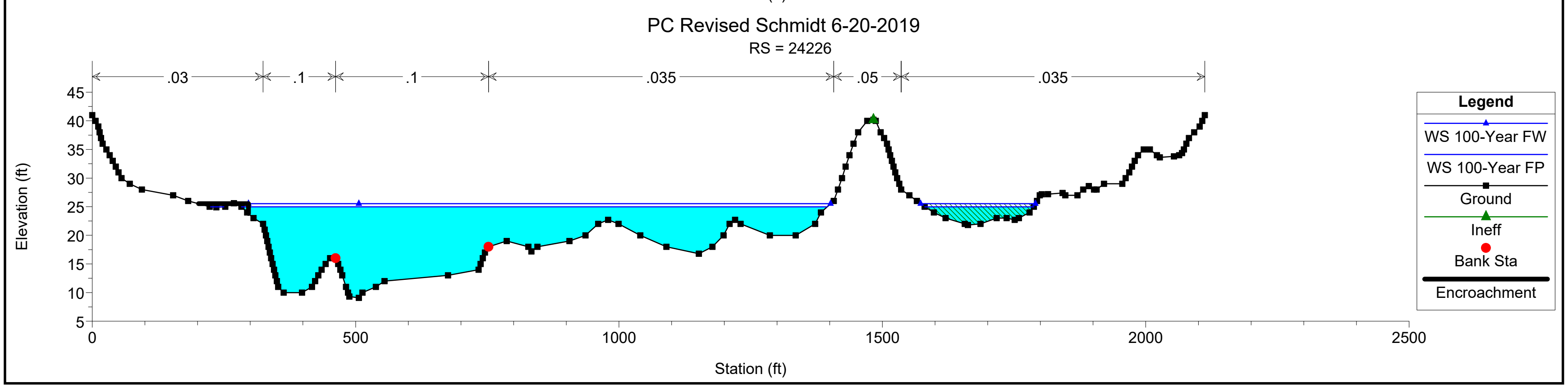
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Bank Sta
Encroachment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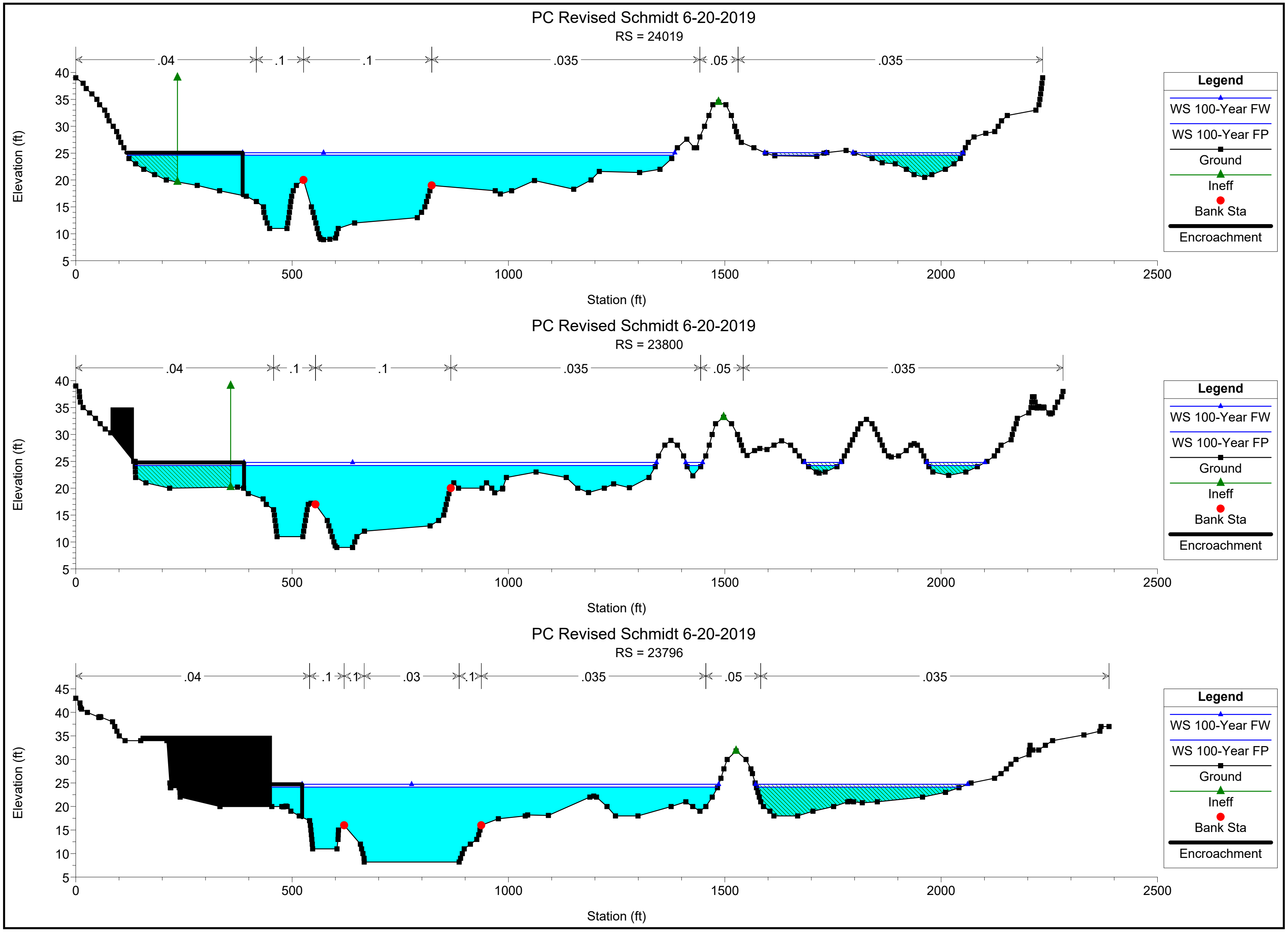
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment



PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23800
.04
.1
.1
.035
.05
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23796
.04
.1
.1
.03
.1
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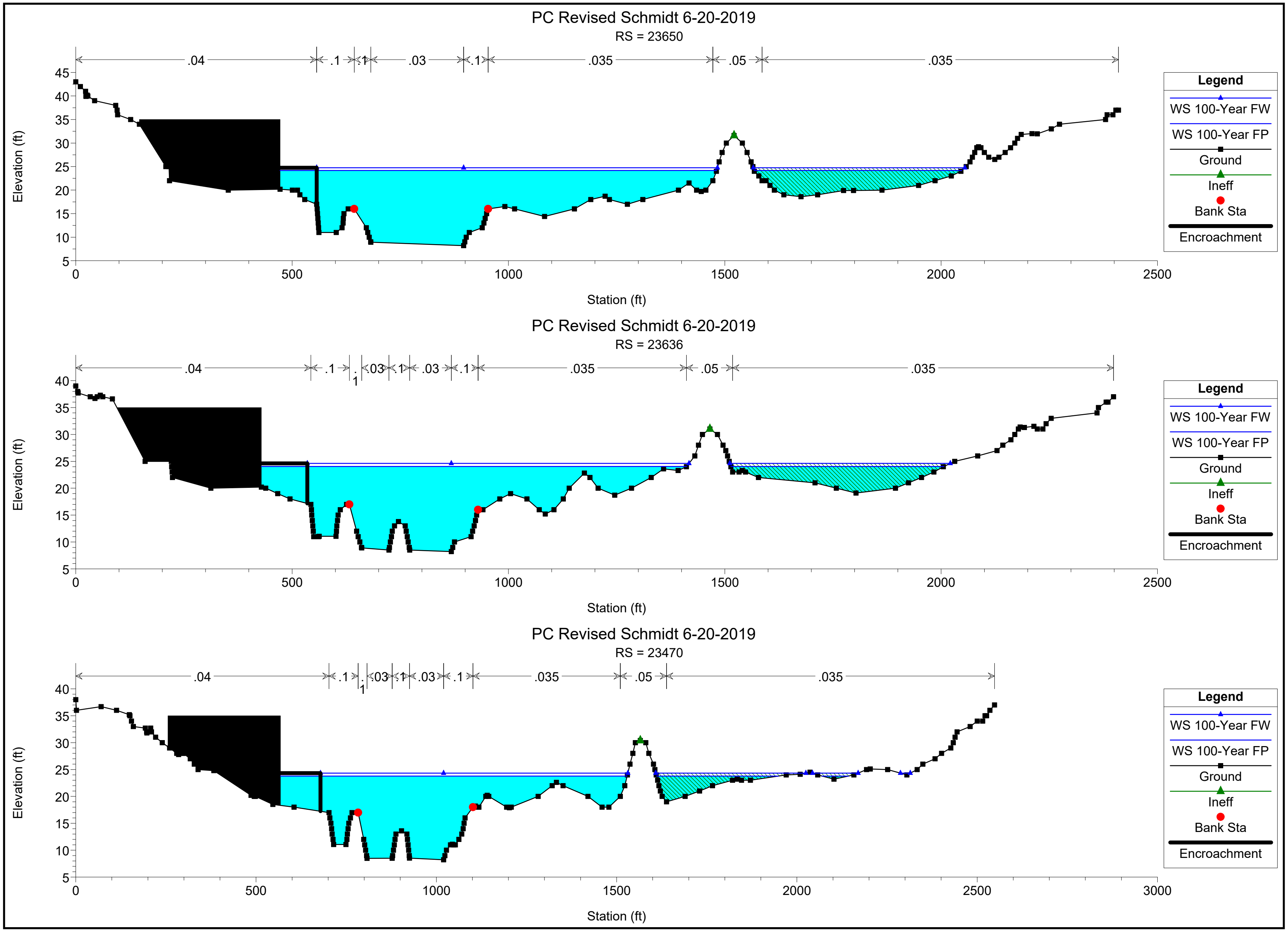
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment



PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
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WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23636
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
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Station (ft)
Legend
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WS 100-Year FP
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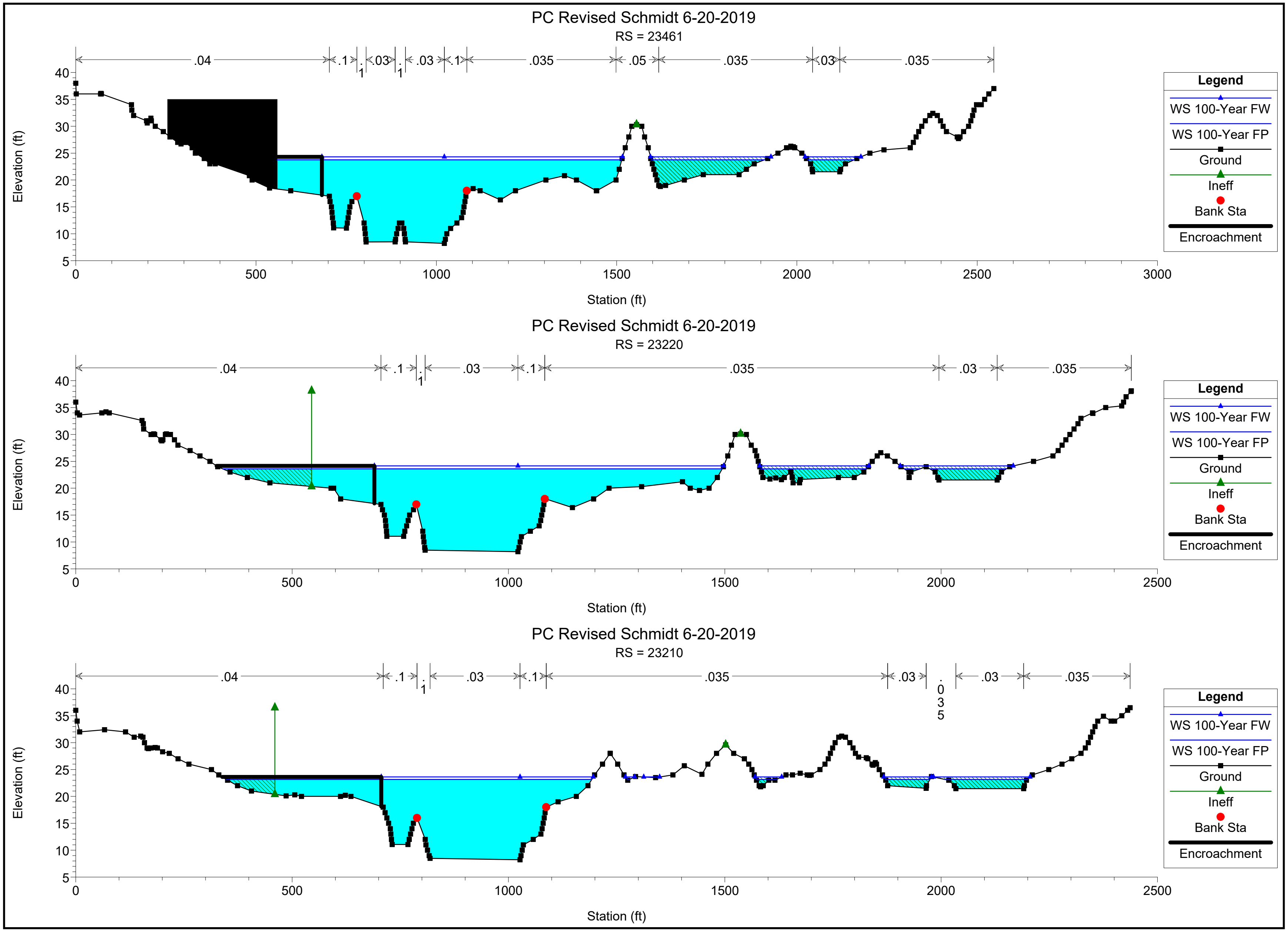
Bank Sta
Encroachment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WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23220
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23210
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Station (ft)
Legend
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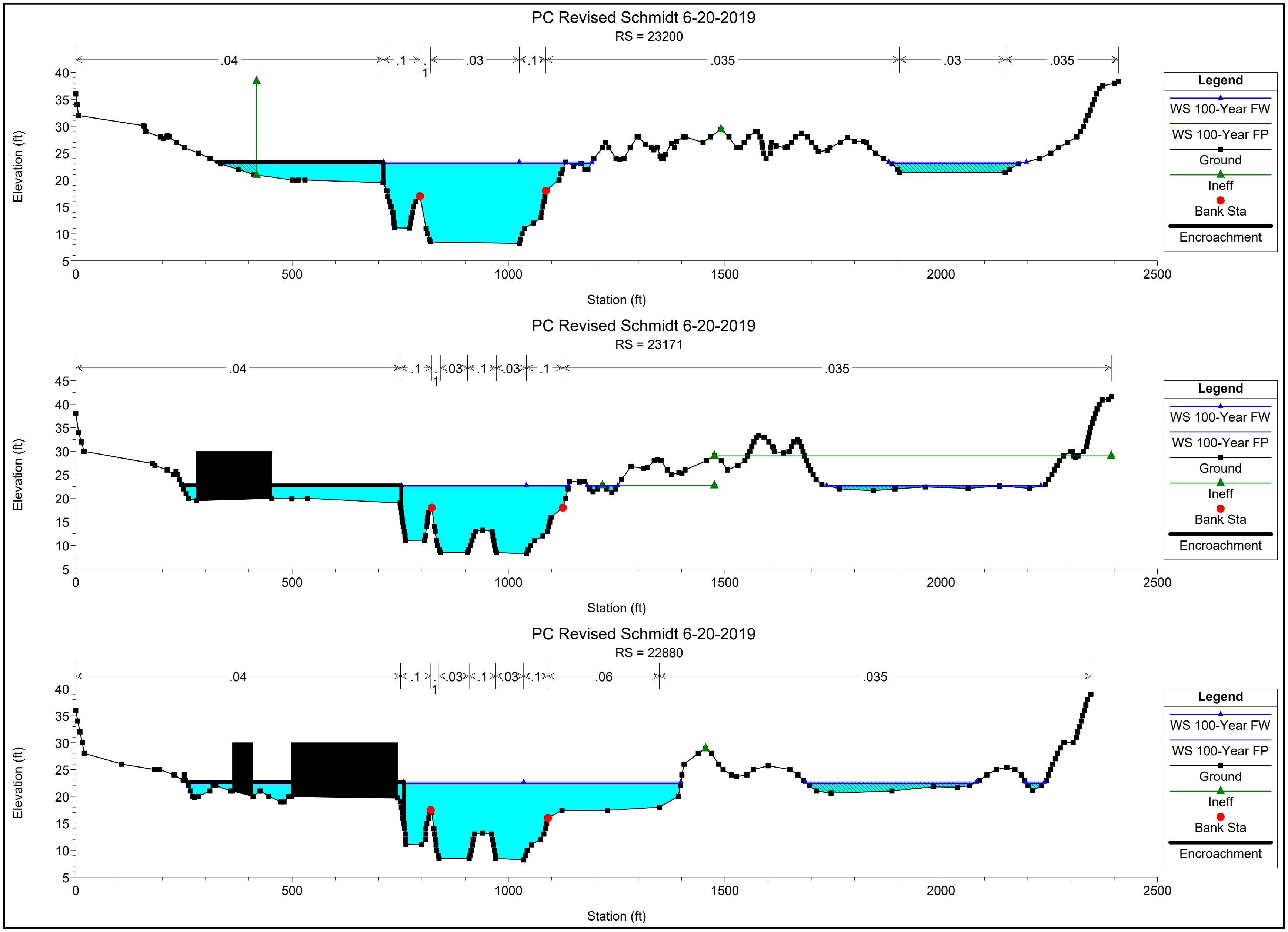
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment



PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 23171
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.1
.03
.1
.03
.1
.035
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 22880
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.1
.1
.03
.1
.03
.1
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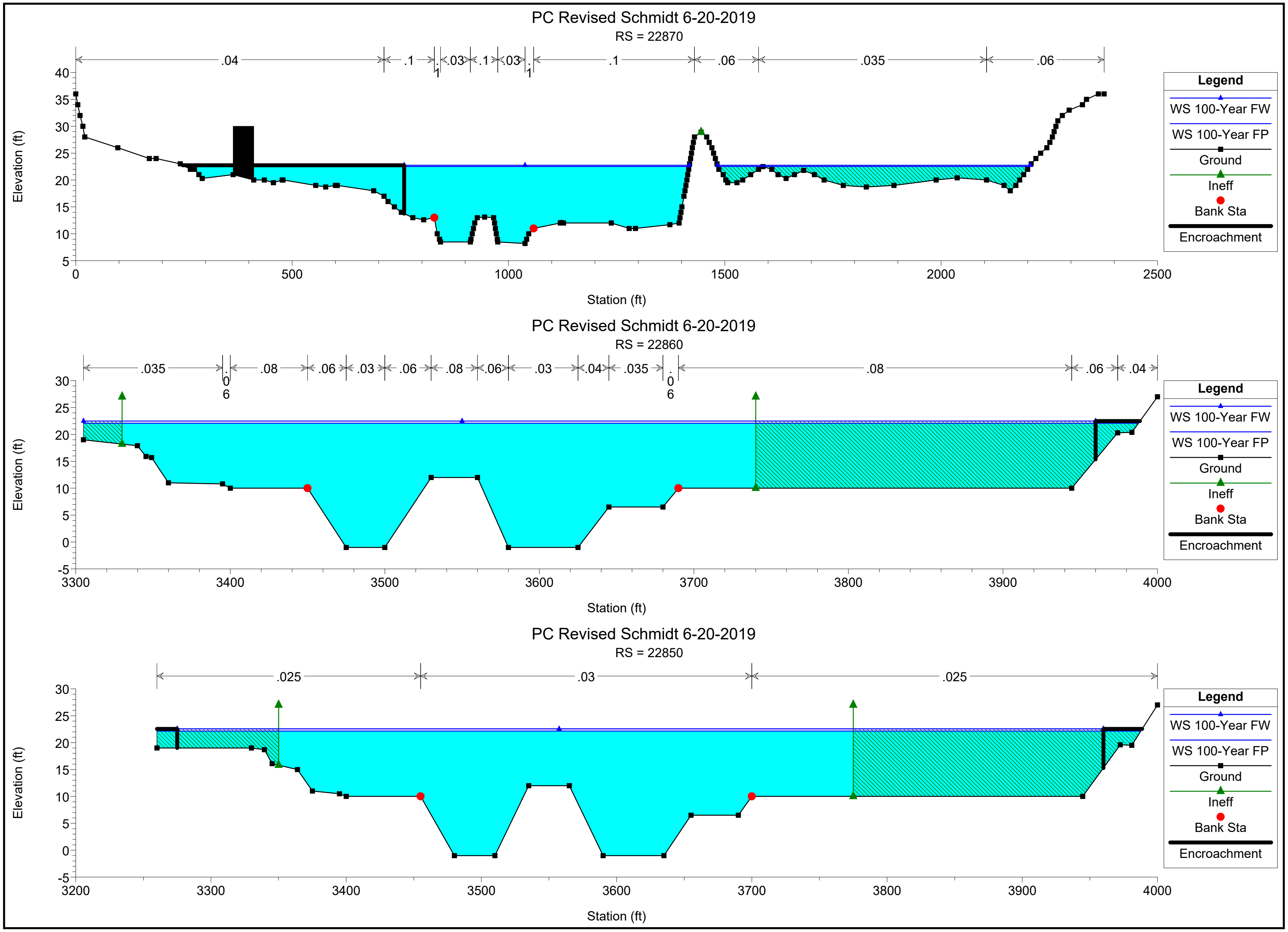
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment


PC Revised Schmidt 6-20-2019
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Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 22860
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019
RS = 22850
Elevation (ft)
Station (ft)
Legend
WS 100-Year FW
WS 100-Year FP
Ground
Ineff
Bank Sta
Encroachment

BRIDGE/CULVERT CAPACITY ANALYSES

HEC-RAS Plan: PC bridge capacity   River: RIVER-1   Reach: Reach-1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	28331	PF 1	4000.00	15.14	28.14	20.55	28.23	0.000061	2.91	2277.10	1340.81	0.15
Reach-1	28331	PF 2	10000.00	15.14	27.57	26.29	28.34	0.000538	8.35	1893.16	876.92	0.45
Reach-1	28331	PF 3	20000.00	15.14	28.87	28.82	30.20	0.000934	11.87	2892.66	1606.65	0.60
Reach-1	28300		Bridge	Fashion Valley Road arch culvert								
Reach-1	28269	PF 1	4000.00	14.97	21.92	20.38	23.56	0.001572	10.28	389.05	56.02	0.69
Reach-1	28269	PF 2	10000.00	14.97	24.86	24.86	26.36	0.003480	9.80	1020.73	431.15	1.00
Reach-1	28269	PF 3	20000.00	14.97	26.84	26.84	28.69	0.002327	11.11	1947.13	769.00	0.89
Reach-1	28244	PF 1	4000.00	15.96	22.55		22.75	0.006485	3.57	1119.52	215.78	0.28
Reach-1	28244	PF 2	10000.00	15.96	24.63		25.25	0.014374	6.29	1590.98	308.83	0.43
Reach-1	28244	PF 3	20000.00	15.96	26.80		27.97	0.021165	8.86	2376.49	1280.92	0.54
Reach-1	28164	PF 1	4000.00	18.00	20.58	20.58	21.43	0.079207	7.54	545.22	310.46	0.85
Reach-1	28164	PF 2	10000.00	18.00	23.02		23.78	0.023699	6.44	1509.76	447.92	0.52
Reach-1	28164	PF 3	20000.00	18.00	25.75		26.49	0.013760	6.51	2957.22	844.37	0.43
Reach-1	28064	PF 1	4000.00	16.00	19.77		19.98	0.004610	2.39	1273.40	476.22	0.22
Reach-1	28064	PF 2	10000.00	16.00	22.79		23.04	0.002613	2.64	2797.66	527.24	0.18
Reach-1	28064	PF 3	20000.00	16.00	25.51		25.87	0.002583	3.29	4544.33	820.96	0.19
Reach-1	27929	PF 1	4000.00	16.00	19.56		19.67	0.001247	1.17	1775.65	539.02	0.11
Reach-1	27929	PF 2	10000.00	16.00	22.67		22.82	0.000906	1.54	3588.07	601.06	0.11
Reach-1	27929	PF 3	20000.00	16.00	25.35		25.64	0.001078	2.12	5228.87	705.82	0.12
Reach-1	27759	PF 1	4000.00	16.00	19.44		19.55	0.000421	0.68	2116.37	627.74	0.07
Reach-1	27759	PF 2	10000.00	16.00	22.53		22.71	0.000425	1.06	4196.30	692.91	0.07
Reach-1	27759	PF 3	20000.00	16.00	25.19		25.50	0.000579	1.55	6077.66	793.69	0.09
Reach-1	27589	PF 1	4000.00	16.00	19.41		19.48	0.000229	0.48	2448.53	676.03	0.05
Reach-1	27589	PF 2	10000.00	16.00	22.52		22.64	0.000253	0.77	4815.59	830.23	0.06
Reach-1	27589	PF 3	20000.00	16.00	25.18		25.39	0.000348	1.16	6990.03	914.00	0.07
Reach-1	27429	PF 1	4000.00	15.80	19.39		19.43	0.000287	0.57	2935.30	781.25	0.05
Reach-1	27429	PF 2	10000.00	15.80	22.50		22.58	0.000296	0.89	5362.03	813.56	0.06
Reach-1	27429	PF 3	20000.00	15.80	25.16		25.31	0.000420	1.33	7507.51	1090.36	0.08

HEC-RAS Plan: PC bridge capacity   River: RIVER-1   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	27259	PF 1	4000.00	16.00	19.36		19.38	0.000237	0.51	3381.08	746.75	0.05
Reach-1	27259	PF 2	10000.00	16.00	22.47		22.52	0.000295	0.88	5765.56	922.11	0.06
Reach-1	27259	PF 3	20000.00	16.00	25.11		25.23	0.000447	1.36	7879.38	1262.74	0.08
Reach-1	27069	PF 1	4000.00	14.80	19.20		19.29	0.001391	2.79	1749.99	513.78	0.25
Reach-1	27069	PF 2	10000.00	14.80	22.27		22.41	0.001211	3.58	3518.12	860.74	0.25
Reach-1	27069	PF 3	20000.00	14.80	24.85		25.08	0.001352	4.73	5638.75	1328.86	0.28
Reach-1	26951	PF 1	4000.00	14.66	18.85	16.28	19.06	0.003252	4.08	1119.60	303.42	0.37
Reach-1	26951	PF 2	10000.00	14.66	21.89	18.13	22.20	0.002943	5.37	2381.66	668.89	0.38
Reach-1	26951	PF 3	20000.00	14.66	24.52	20.75	24.87	0.002675	5.97	4572.73	1379.82	0.38
Reach-1	26944		Bridge	Easterly golf cart/pedestrian bridge								
Reach-1	26937	PF 1	4000.00	14.66	18.82		19.01	0.003098	3.92	1173.33	323.02	0.36
Reach-1	26937	PF 2	10000.00	14.66	21.88		22.15	0.002714	4.94	2547.62	739.96	0.36
Reach-1	26937	PF 3	20000.00	14.66	24.51		24.82	0.002405	5.72	4782.59	1383.07	0.36
Reach-1	26799	PF 1	4000.00	14.74	18.57		18.66	0.001551	2.71	1708.44	437.09	0.25
Reach-1	26799	PF 2	10000.00	14.74	21.68		21.83	0.001432	3.82	3382.82	713.87	0.27
Reach-1	26799	PF 3	20000.00	14.74	24.30		24.51	0.001534	4.85	5749.12	1405.34	0.29
Reach-1	26614	PF 1	4000.00	14.60	18.34		18.42	0.001088	2.24	1762.56	389.45	0.21
Reach-1	26614	PF 2	10000.00	14.60	21.46		21.60	0.001095	3.44	3434.81	763.18	0.24
Reach-1	26614	PF 3	20000.00	14.60	24.07		24.26	0.001189	4.47	5873.03	1173.78	0.26
Reach-1	26379	PF 1	4000.00	14.45	17.97		18.08	0.002122	2.92	1448.08	343.95	0.29
Reach-1	26379	PF 2	10000.00	14.45	21.07		21.26	0.001993	4.21	2882.53	635.68	0.31
Reach-1	26379	PF 3	20000.00	14.45	23.64		23.91	0.002013	5.33	5117.61	1126.17	0.33
Reach-1	26174	PF 1	4000.00	14.24	17.78		17.83	0.000673	1.67	2272.89	500.59	0.16
Reach-1	26174	PF 2	10000.00	14.24	20.88		20.97	0.000834	2.80	4020.63	685.37	0.20
Reach-1	26174	PF 3	20000.00	14.24	23.39		23.57	0.001134	4.12	6173.61	1013.62	0.25
Reach-1	25914	PF 1	4000.00	13.93	17.70	13.47	17.73	0.000222	1.02	3113.50	726.49	0.10
Reach-1	25914	PF 2	10000.00	13.93	20.80	14.89	20.85	0.000235	1.50	5577.73	832.28	0.11
Reach-1	25914	PF 3	20000.00	13.93	23.30	16.25	23.40	0.000325	2.21	8347.88	1258.78	0.13

HEC-RAS Plan: PC bridge capacity   River: RIVER-1   Reach: Reach-1 (Continued)

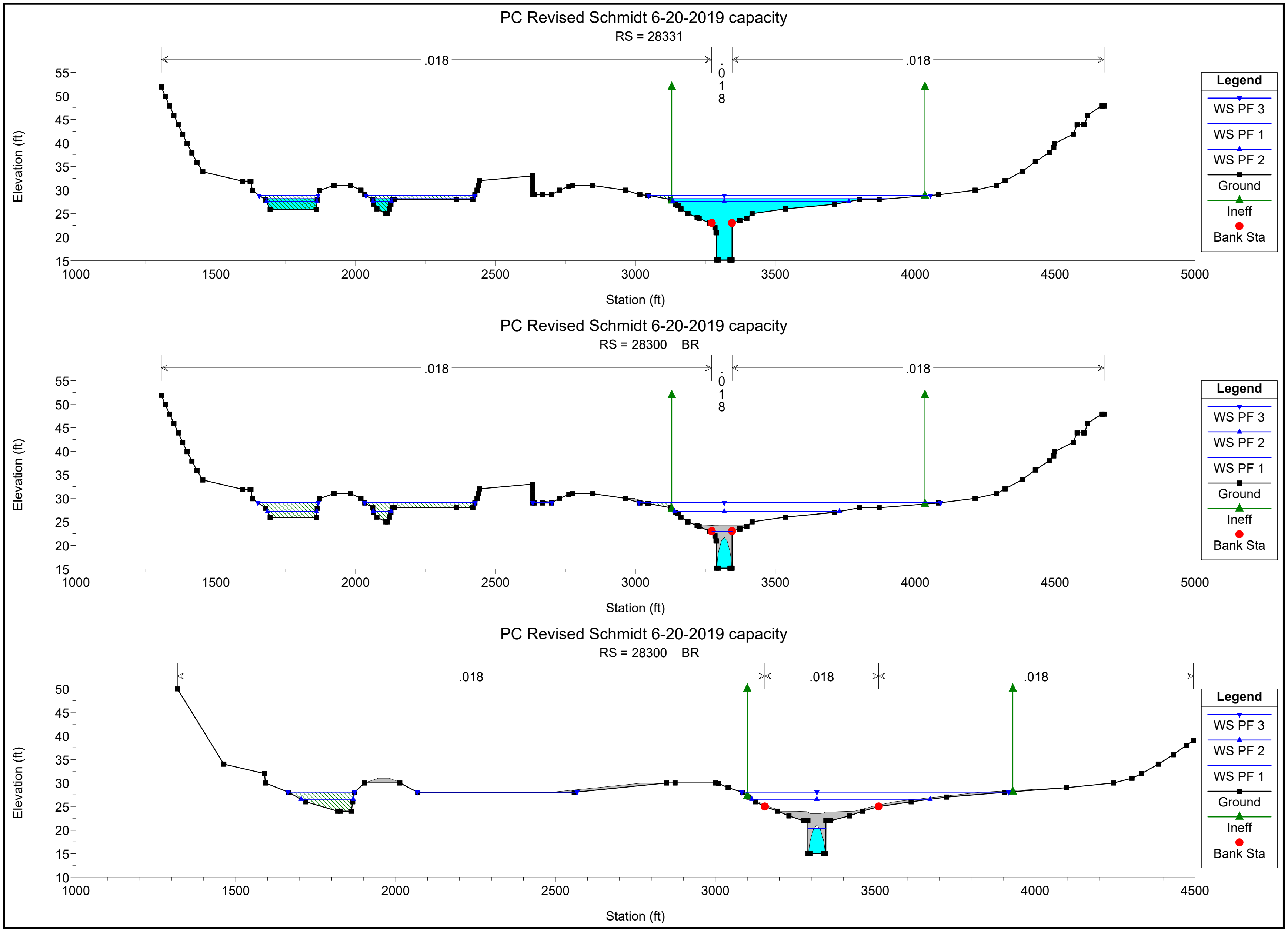
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	25654	PF 1	4000.00	13.50	17.67	12.00	17.69	0.000099	0.69	4218.92	910.08	0.06
Reach-1	25654	PF 2	10000.00	13.50	20.77	14.12	20.81	0.000114	1.08	7344.94	1055.85	0.08
Reach-1	25654	PF 3	20000.00	13.50	23.26	15.29	23.33	0.000166	1.62	10439.80	1285.54	0.10
Reach-1	25354	PF 1	4000.00	13.31	17.64	11.36	17.65	0.000133	0.87	4416.07	922.62	0.08
Reach-1	25354	PF 2	10000.00	13.31	20.73	13.28	20.76	0.000177	1.44	7118.94	961.27	0.10
Reach-1	25354	PF 3	20000.00	13.31	23.21	14.66	23.27	0.000238	2.04	10695.93	1292.82	0.12
Reach-1	25181	PF 1	4000.00	13.20	17.62		17.63	0.000131	0.87	4777.90	965.33	0.08
Reach-1	25181	PF 2	10000.00	13.20	20.70		20.73	0.000229	1.61	6952.81	947.00	0.11
Reach-1	25181	PF 3	20000.00	13.20	23.18		23.23	0.000240	2.03	11242.62	1269.64	0.12
Reach-1	25001	PF 1	4000.00	12.69	17.60		17.61	0.000123	0.90	4588.62	948.52	0.07
Reach-1	25001	PF 2	10000.00	12.69	20.64		20.69	0.000242	1.77	6053.85	759.93	0.11
Reach-1	25001	PF 3	20000.00	12.69	23.12		23.18	0.000246	2.16	10364.97	1097.80	0.12
Reach-1	24804	PF 1	4000.00	12.52	17.58	10.00	17.60	0.000130	0.90	4404.93	725.61	0.08
Reach-1	24804	PF 2	10000.00	12.52	20.60	11.53	20.66	0.000368	2.05	5339.95	794.61	0.14
Reach-1	24804	PF 3	20000.00	12.52	23.09	13.79	23.15	0.000335	2.34	9964.41	1192.40	0.14
Reach-1	24797		Bridge	Westerly golf cart/pedestrian bridge								
Reach-1	24790	PF 1	4000.00	12.51	17.58		17.59	0.000123	0.88	4415.58	742.55	0.07
Reach-1	24790	PF 2	10000.00	12.51	20.60		20.65	0.000373	2.06	5348.23	807.28	0.14
Reach-1	24790	PF 3	20000.00	12.51	23.08		23.15	0.000319	2.28	9912.80	1194.92	0.13
Reach-1	24581	PF 1	4000.00	12.60	17.51		17.56	0.000179	1.30	2780.51	744.83	0.11
Reach-1	24581	PF 2	10000.00	12.60	20.50		20.59	0.000236	2.11	4811.40	783.43	0.14
Reach-1	24581	PF 3	20000.00	12.60	22.93		23.07	0.000327	3.01	8069.22	1053.96	0.17
Reach-1	24401	PF 1	4000.00	10.30	17.31		17.47	0.003981	3.37	1286.74	268.66	0.26
Reach-1	24401	PF 2	10000.00	10.30	20.11		20.45	0.005577	5.10	2235.99	551.52	0.33
Reach-1	24401	PF 3	20000.00	10.30	22.50		22.91	0.004857	5.73	4081.36	823.43	0.32
Reach-1	24226	PF 1	4000.00	9.09	16.75	13.33	16.83	0.002956	2.17	1826.62	406.59	0.18
Reach-1	24226	PF 2	10000.00	9.09	19.55	14.82	19.68	0.002940	2.96	3398.76	733.61	0.20
Reach-1	24226	PF 3	20000.00	9.09	22.02	16.48	22.24	0.002520	3.35	5565.75	1022.89	0.19

HEC-RAS Plan: PC bridge capacity   River: RIVER-1   Reach: Reach-1 (Continued)

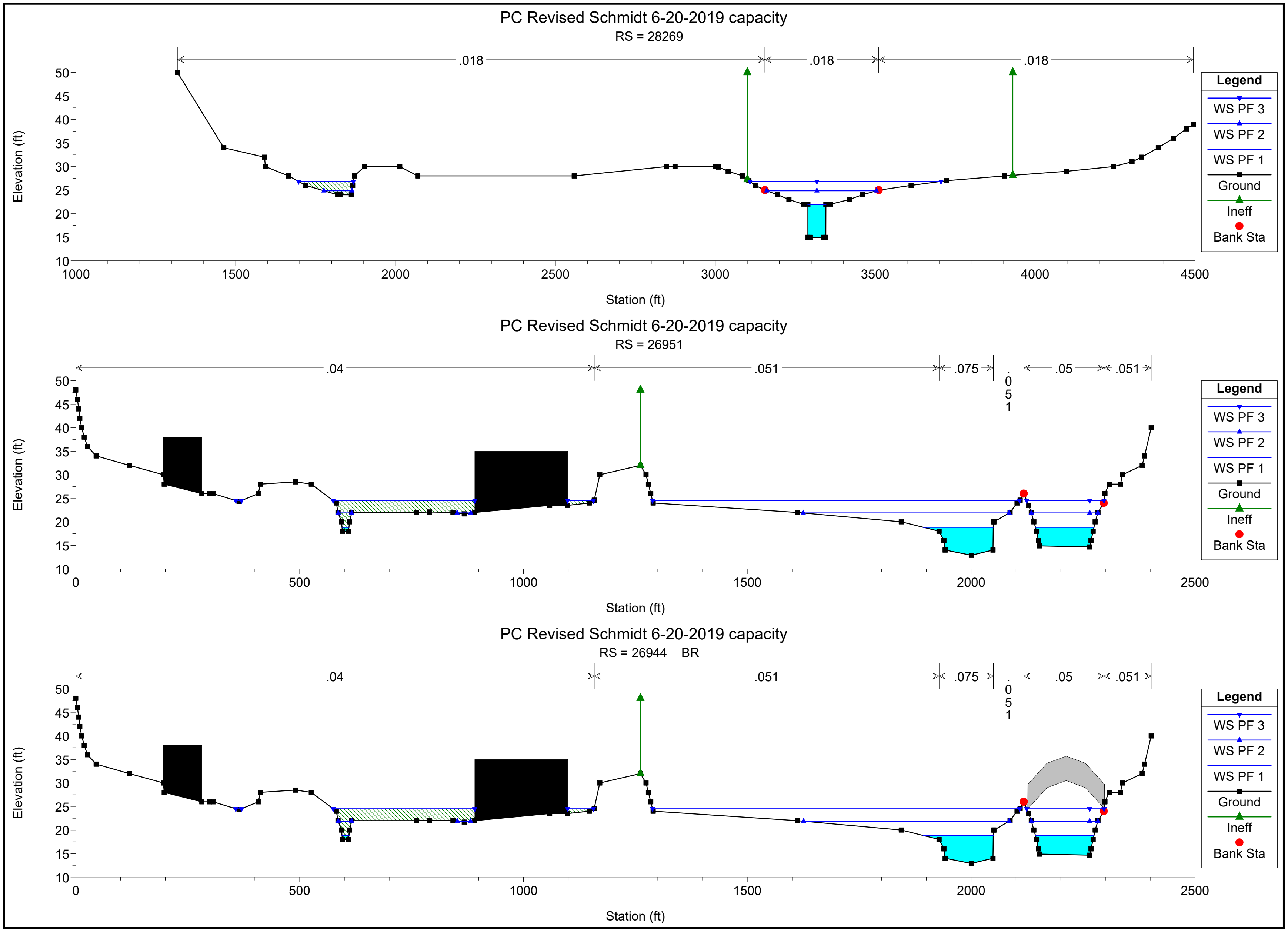
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	24019	PF 1	4000.00	8.90	15.70	13.42	15.86	0.008071	3.21	1261.91	341.81	0.29
Reach-1	24019	PF 2	10000.00	8.90	18.42	14.92	18.71	0.007875	4.38	2341.57	529.96	0.31
Reach-1	24019	PF 3	20000.00	8.90	21.35	16.85	21.60	0.003579	3.78	4976.78	1091.78	0.22
Reach-1	23800	PF 1	4000.00	8.99	14.55	13.32	14.83	0.020982	4.10	944.80	341.40	0.45
Reach-1	23800	PF 2	10000.00	8.99	17.54	14.80	17.90	0.012213	4.91	2068.08	421.45	0.38
Reach-1	23800	PF 3	20000.00	8.99	20.64	16.61	21.11	0.008832	5.61	3655.39	921.21	0.35
Reach-1	23796	PF 1	4000.00	8.21	14.59	10.37	14.68	0.000254	2.42	1818.87	362.37	0.18
Reach-1	23796	PF 2	10000.00	8.21	17.50	12.22	17.71	0.000424	3.81	2978.72	457.84	0.24
Reach-1	23796	PF 3	20000.00	8.21	20.56	14.32	20.91	0.000529	5.03	5163.57	1101.44	0.27
Reach-1	23650	PF 1	4000.00	8.20	14.56	10.75	14.66	0.000319	2.56	1713.77	368.64	0.20
Reach-1	23650	PF 2	10000.00	8.20	17.49	12.57	17.69	0.000445	3.77	3250.54	661.54	0.24
Reach-1	23650	PF 3	20000.00	8.20	20.60	14.58	20.87	0.000464	4.60	5836.82	1269.33	0.25
Reach-1	23636	PF 1	4000.00	8.21	14.47	11.15	14.59	0.002030	2.81	1518.22	344.05	0.23
Reach-1	23636	PF 2	10000.00	8.21	17.34	12.94	17.58	0.002570	4.14	2673.75	499.54	0.27
Reach-1	23636	PF 3	20000.00	8.21	20.46	14.92	20.76	0.002120	4.77	4747.86	982.41	0.26
Reach-1	23470	PF 1	4000.00	8.21	14.10	11.02	14.25	0.002686	3.13	1343.25	328.48	0.27
Reach-1	23470	PF 2	10000.00	8.21	16.81	12.95	17.13	0.003713	4.66	2277.81	367.08	0.32
Reach-1	23470	PF 3	20000.00	8.21	19.96	15.00	20.37	0.003356	5.51	4128.30	852.85	0.32
Reach-1	23461	PF 1	4000.00	8.21	14.05	10.79	14.18	0.001737	2.93	1441.48	330.41	0.24
Reach-1	23461	PF 2	10000.00	8.21	16.73	12.69	17.03	0.002657	4.52	2380.51	397.21	0.30
Reach-1	23461	PF 3	20000.00	8.21	19.90	14.68	20.28	0.002310	5.31	4411.28	915.73	0.29
Reach-1	23220	PF 1	4000.00	8.20	13.97	10.53	14.09	0.001177	2.87	1481.22	330.51	0.23
Reach-1	23220	PF 2	10000.00	8.20	16.59	12.45	16.90	0.001967	4.54	2397.80	383.31	0.30
Reach-1	23220	PF 3	20000.00	8.20	19.69	14.49	20.14	0.002013	5.69	4089.90	638.79	0.31
Reach-1	23210	PF 1	4000.00	8.21	13.84	10.58	13.97	0.001414	2.98	1422.59	327.72	0.24
Reach-1	23210	PF 2	10000.00	8.21	16.37	12.50	16.70	0.002368	4.69	2302.10	365.85	0.32
Reach-1	23210	PF 3	20000.00	8.21	19.31	14.53	19.91	0.002861	6.40	3457.85	466.55	0.36
Reach-1	23200	PF 1	4000.00	8.21	13.79	10.59	13.93	0.001431	3.03	1393.64	318.19	0.25
Reach-1	23200	PF 2	10000.00	8.21	16.28	12.49	16.63	0.002408	4.84	2218.83	349.93	0.32

HEC-RAS Plan: PC bridge capacity   River: RIVER-1   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	23200	PF 3	20000.00	8.21	19.16	14.52	19.82	0.003081	6.69	3281.54	391.86	0.38
Reach-1	23171	PF 1	4000.00	8.20	13.35	11.34	13.62	0.007805	4.24	996.83	312.60	0.41
Reach-1	23171	PF 2	10000.00	8.20	15.60	13.41	16.16	0.009146	6.18	1719.03	329.14	0.47
Reach-1	23171	PF 3	20000.00	8.20	18.30	15.34	19.23	0.011130	7.99	2667.82	376.17	0.52
Reach-1	22880	PF 1	4000.00	8.20	12.69	11.36	13.13	0.009367	5.39	787.27	254.74	0.51
Reach-1	22880	PF 2	10000.00	8.20	14.34	13.47	15.37	0.021662	8.34	1270.53	309.14	0.71
Reach-1	22880	PF 3	20000.00	8.20	15.44	15.44	18.00	0.042008	13.17	1614.73	319.99	1.01
Reach-1	22870	PF 1	4000.00	8.20	11.36	11.36	12.54	0.027579	8.73	475.46	269.06	0.96
Reach-1	22870	PF 2	10000.00	8.20	13.33	13.33	14.46	0.031229	9.44	1427.75	627.03	0.87
Reach-1	22870	PF 3	20000.00	8.20	14.70	14.70	16.37	0.032728	11.97	2312.54	659.12	0.94
Reach-1	22860	PF 1	4000.00	-1.00	5.29		5.95	0.004387	6.52	613.58	125.22	0.52
Reach-1	22860	PF 2	10000.00	-1.00	9.25		10.20	0.004786	7.84	1275.53	195.55	0.54
Reach-1	22860	PF 3	20000.00	-1.00	12.49		13.89	0.007009	9.72	2271.02	595.11	0.60
Reach-1	22850	PF 1	4000.00	-1.00	5.25	3.09	5.86	0.002001	6.24	640.72	129.94	0.50
Reach-1	22850	PF 2	10000.00	-1.00	9.22	6.08	10.11	0.002000	7.57	1321.46	200.32	0.52
Reach-1	22850	PF 3	20000.00	-1.00	12.58	9.41	13.72	0.002003	8.87	2432.66	581.53	0.54



PC Revised Schmidt 6-20-2019 capacity
RS = 28331
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 1
WS PF 2
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019 capacity
RS = 28300 BR
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019 capacity
RS = 28300 BR
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta


PC Revised Schmidt 6-20-2019 capacity
RS = 28269
.018
.018
.018
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019 capacity
RS = 26951
.04
.051
.075
.051
.05
.051
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019 capacity
RS = 26944 BR
.04
.051
.075
.051
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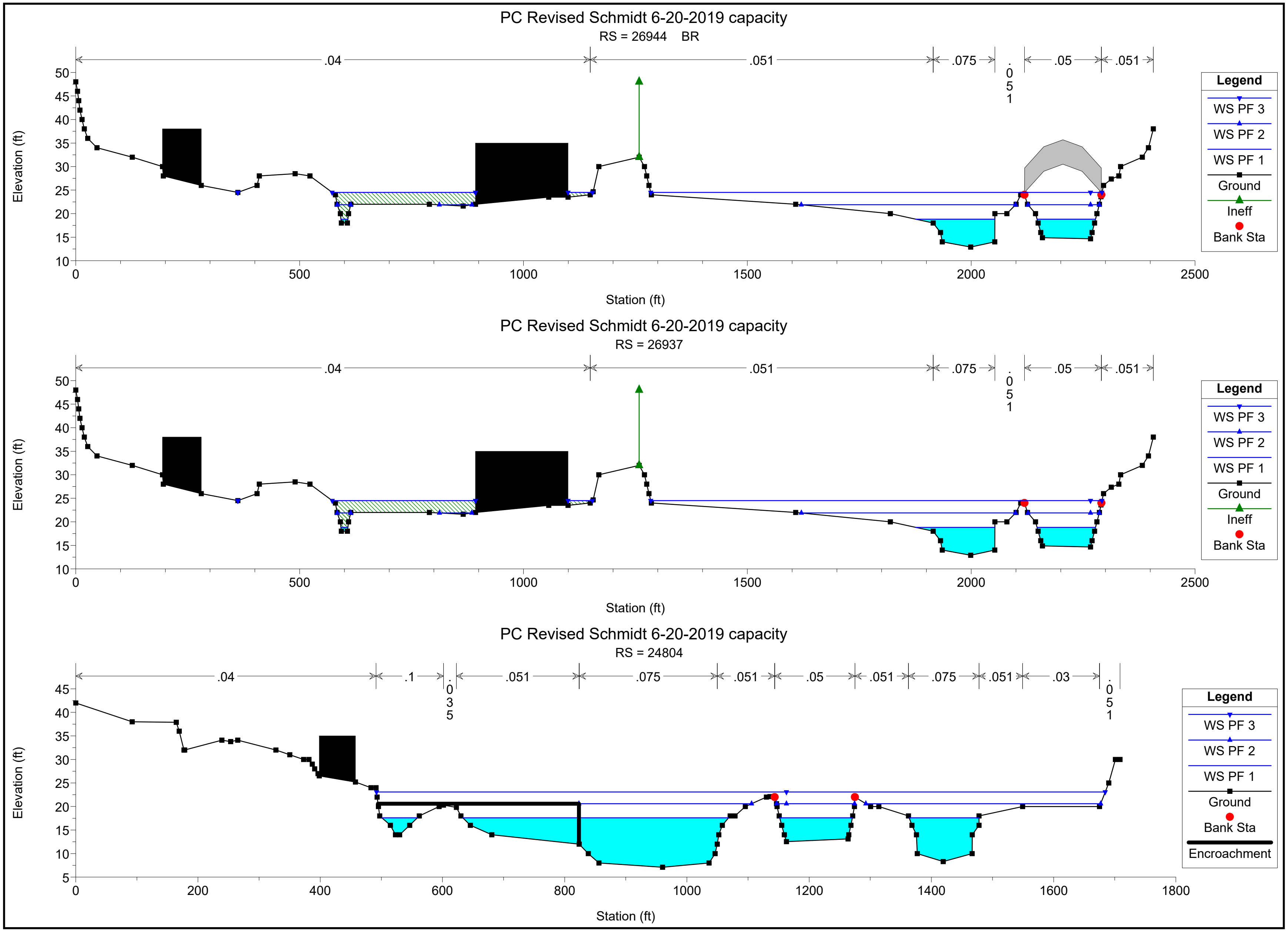
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta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RS = 26944 BR
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Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta
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.075
.051
.05
.051
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Ineff
Bank Sta
PC Revised Schmidt 6-20-2019 capacity
RS = 24804
.04
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.075
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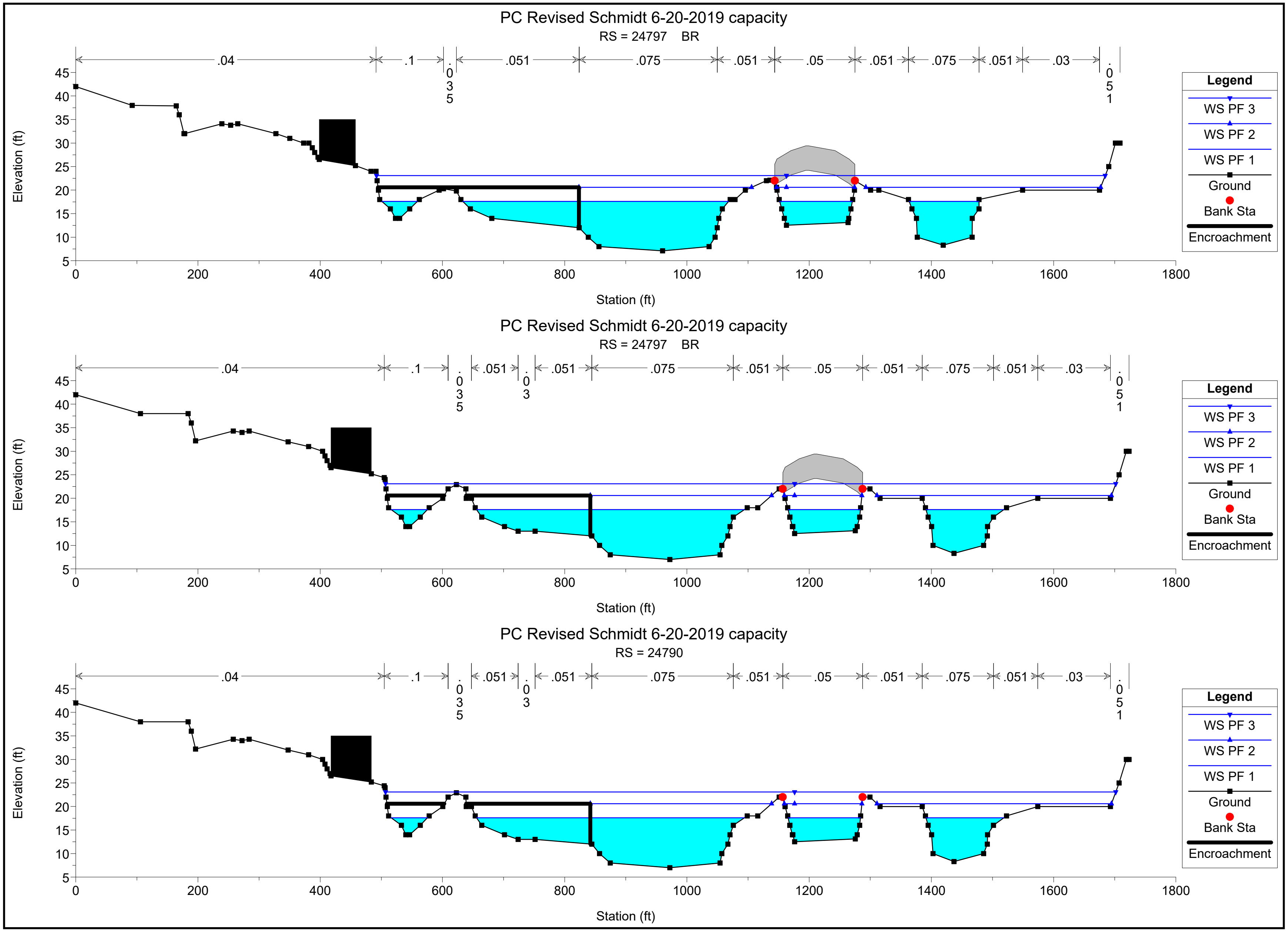
.03
.051
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
Encroachment



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.1
.035
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.075
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.051
.075
.051
.03
.051
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019 capacity
RS = 24797 BR
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.035
.051
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.075
.051
.05
.051
.075
.051
.03
.051
Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
Encroachment
PC Revised Schmidt 6-20-2019 capacity
RS = 24790
.04
.1
.035
.051
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.051
.075
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.075
.051
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Elevation (ft)
Station (ft)
Legend
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
Encroachment

CITY OF SAN DIEGO
TOPOGRAPHIC SURVEY

- LEGEND -

Horizontal Control Monument Second Order or Better

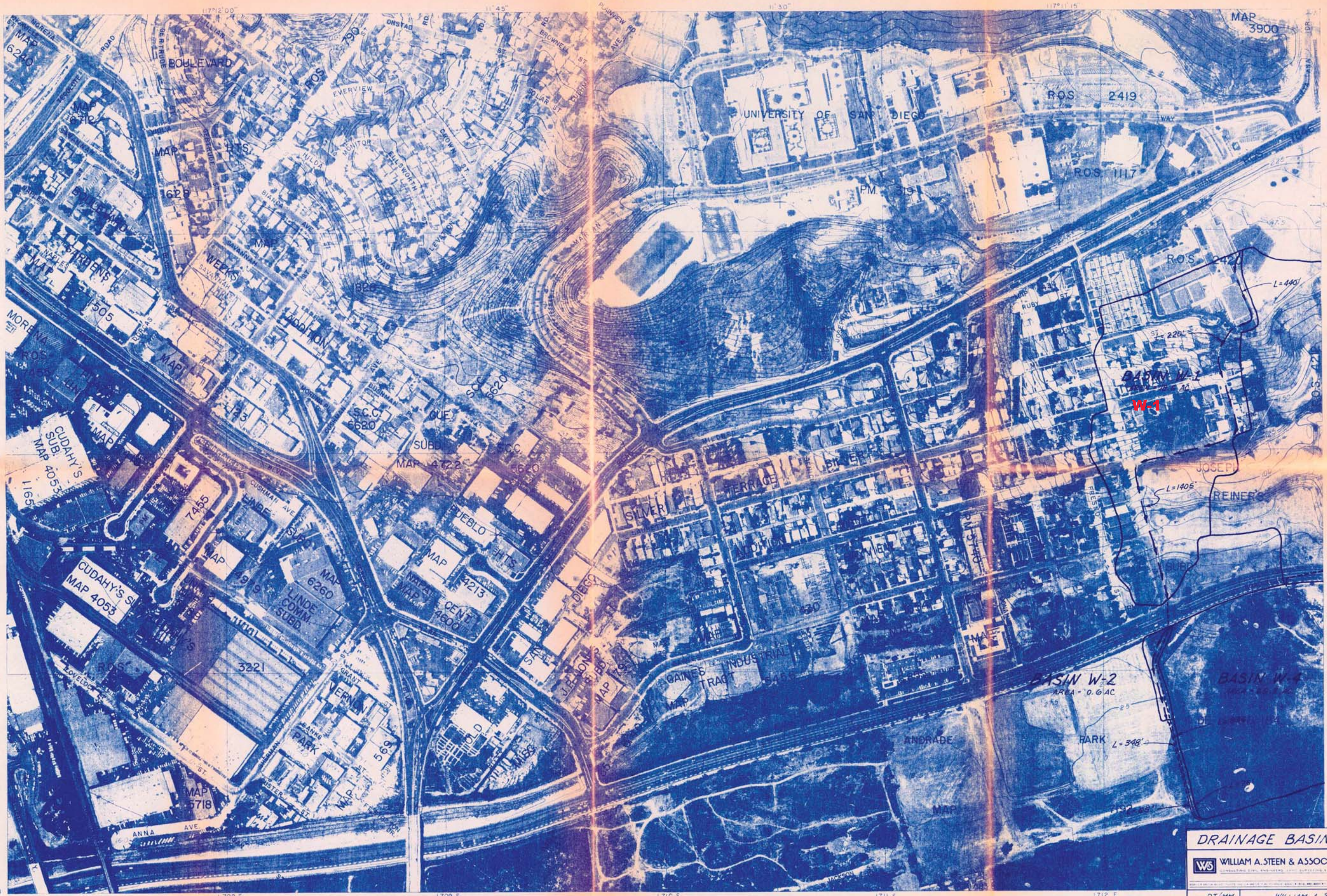
Geographic Tick

CITY OF SAN DIEGO — City Boundary Line

Subdivision / Parcel Map Boundary Line

Rancho Boundary Line

Pueblo Lot Line / Section Line



PREPARED UNDER THE DIRECTION OF THE CITY ENGINEER OF THE CITY OF SAN DIEGO CALIFORNIA

MAP CONTROL DATA FURNISHED BY THE CITY OF SAN DIEGO

HORIZONTAL CONTROL IS BASED ON NORTH AMERICAN 1927 DATUM

LAND LINES SHOWN ARE APPROXIMATE

TOPOGRAPHY COMPILED BY PHOTO-GRAMETRIC METHODS FROM PHOTO GRAPHY DATED 8-1-78

WESTERN AERIAL SURVEYS
RIVERSIDE CALIFORNIA

ORTHOPHOTO IMAGE PREPARED FROM PHOTOGRAPHY DATED 8-1-78

CITY OF SAN DIEGO, CALIFORNIA

SCALE 1 INCH = 200 FEET
DATUM IS MEAN SEA LEVEL

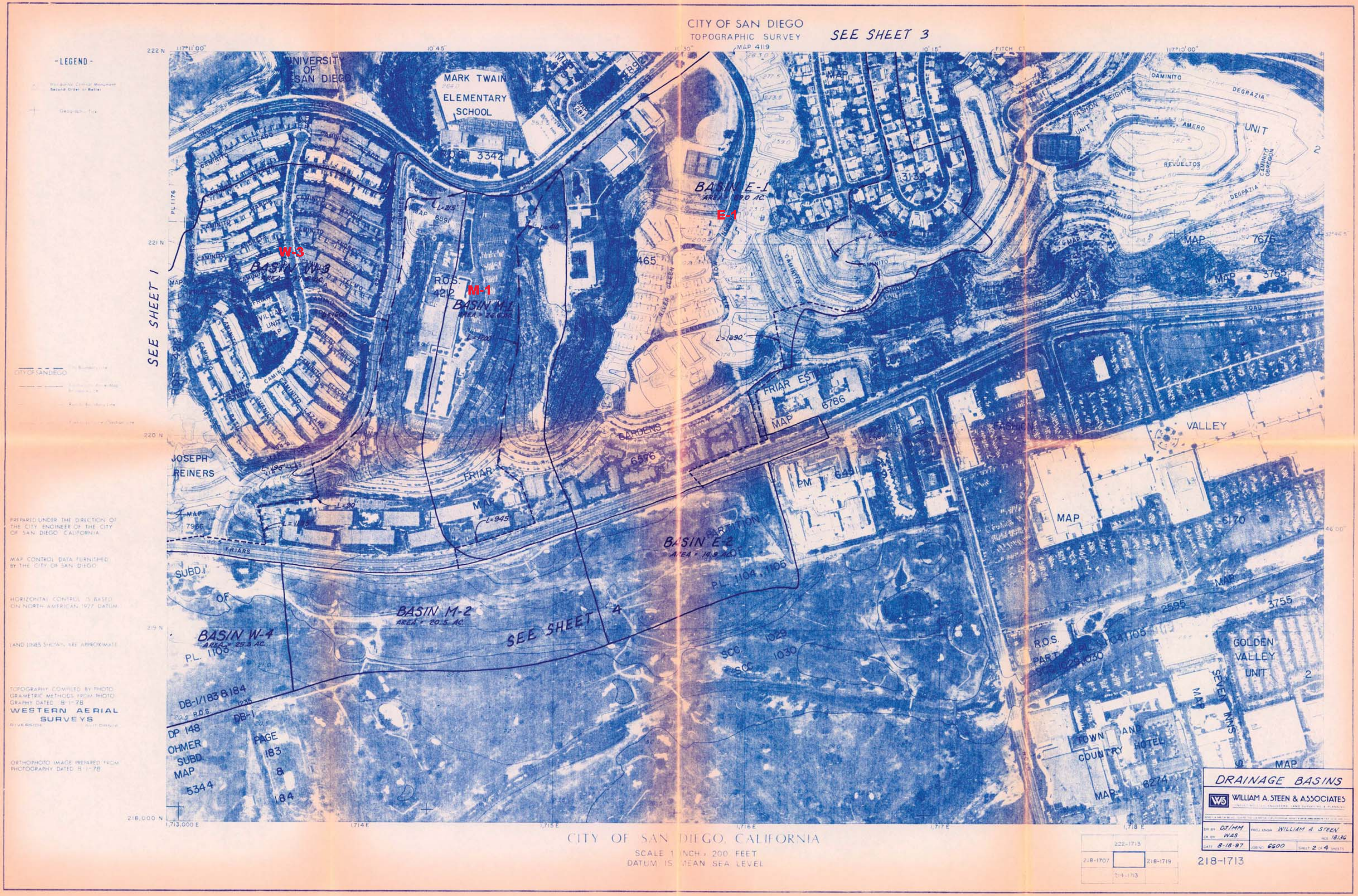
	222-1707	
218-1701		218-1713
	214-1707	

218-1707

DRAINAGE BASINS

WILLIAM A. STEEN & ASSOCIATES

DR. BY DJ/MM CK. BY WAS	PROJ. ENGR. WILLIAM A STEEN RCE 18136	
DATE 8-18-97	JOB NO. 6600	SHEET 1 OF 4 SHEETS


CITY OF SAN DIEGO
TOPOGRAPHIC SURVEY
SEE SHEET 3
MAP 4119
-LEGEND-
SEE SHEET 1
SEE SHEET 4
UNIVERSITY OF SAN DIEGO
MARK TWAIN ELEMENTARY SCHOOL
3342
BASIN E-1
E-1
W-3
BASIN W-3
M-1
BASIN M-1
R.O.S. 4212
MAP 6591
465
3136
MAP 7676
MAP 3755
FRIAR EST
MAP 6786
VALLEY
GARDENS
6576
FRIAR
MAP
JOSEPH REINERS
MAP 7966
FRIARS
SUBD. OF
BASIN E-2
AREA = 14.9 AC.
PL. 1104, 1105
BASIN M-2
AREA = 20.5 AC.
BASIN W-4
AREA = 25.3 AC.
PL. 1103
SCC 1029
SCC 1030
DB-1/183 & 184
DB-1
DP 148
OHMER SUBD. MAP 5344
PAGE 183 & 184
MAP 6170
MAP 3755
2595
R.O.S.
GOLDEN VALLEY UNIT 2
TOWN AND COUNTRY HOTEL
MAP 6274
MAP
DEGRAZIA
UNIT 2
REVUELTOS
PREPARED UNDER THE DIRECTION OF THE CITY ENGINEER OF THE CITY OF SAN DIEGO, CALIFORNIA
MAP CONTROL DATA FURNISHED BY THE CITY OF SAN DIEGO
HORIZONTAL CONTROL IS BASED ON NORTH AMERICAN 1927 DATUM
LAND LINES SHOWN ARE APPROXIMATE
TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM PHOTOGRAPHY DATED 8-1-78
WESTERN AERIAL SURVEYS
ORTHOPHOTO IMAGE PREPARED FROM PHOTOGRAPHY DATED 8-1-78
CITY OF SAN DIEGO, CALIFORNIA
SCALE 1 INCH = 200 FEET
DATUM IS MEAN SEA LEVEL
222-1713
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218-1719
214-1713
218-1713
DRAINAGE BASINS
WILLIAM A. STEEN & ASSOCIATES
WILLIAM A. STEEN
8-18-97
6600
SHEET 2 OF 4 SHEETS

CITY OF SAN DIEGO
TOPOGRAPHIC SURVEY

- LEGEND -

PREPARED UNDER THE DIRECTION OF THE CITY ENGINEER OF THE CITY OF SAN DIEGO CALIFORNIA

MAP CONTROL DATA FURNISHED BY THE CITY OF SAN DIEGO

HORIZONTAL CONTROL IS BASED ON NORTH AMERICAN 1927 DATUM

LAND LINES SHOWN ARE APPROXIMATE

TOPOGRAPHY COMPILED BY PHOTOGRAMETRIC METHODS FROM PHOTOGRAPHY DATED 8-1-78

WESTERN AERIAL SURVEYS
RIVERSIDE CALIFORNIA

ORTHOPHOTO IMAGE PREPARED FROM PHOTOGRAPHY DATED 8-1-78

CITY OF SAN DIEGO, CALIFORNIA
SCALE 1 INCH = 200 FEET
DATUM IS MEAN SEA LEVEL

SEE SHEET 2

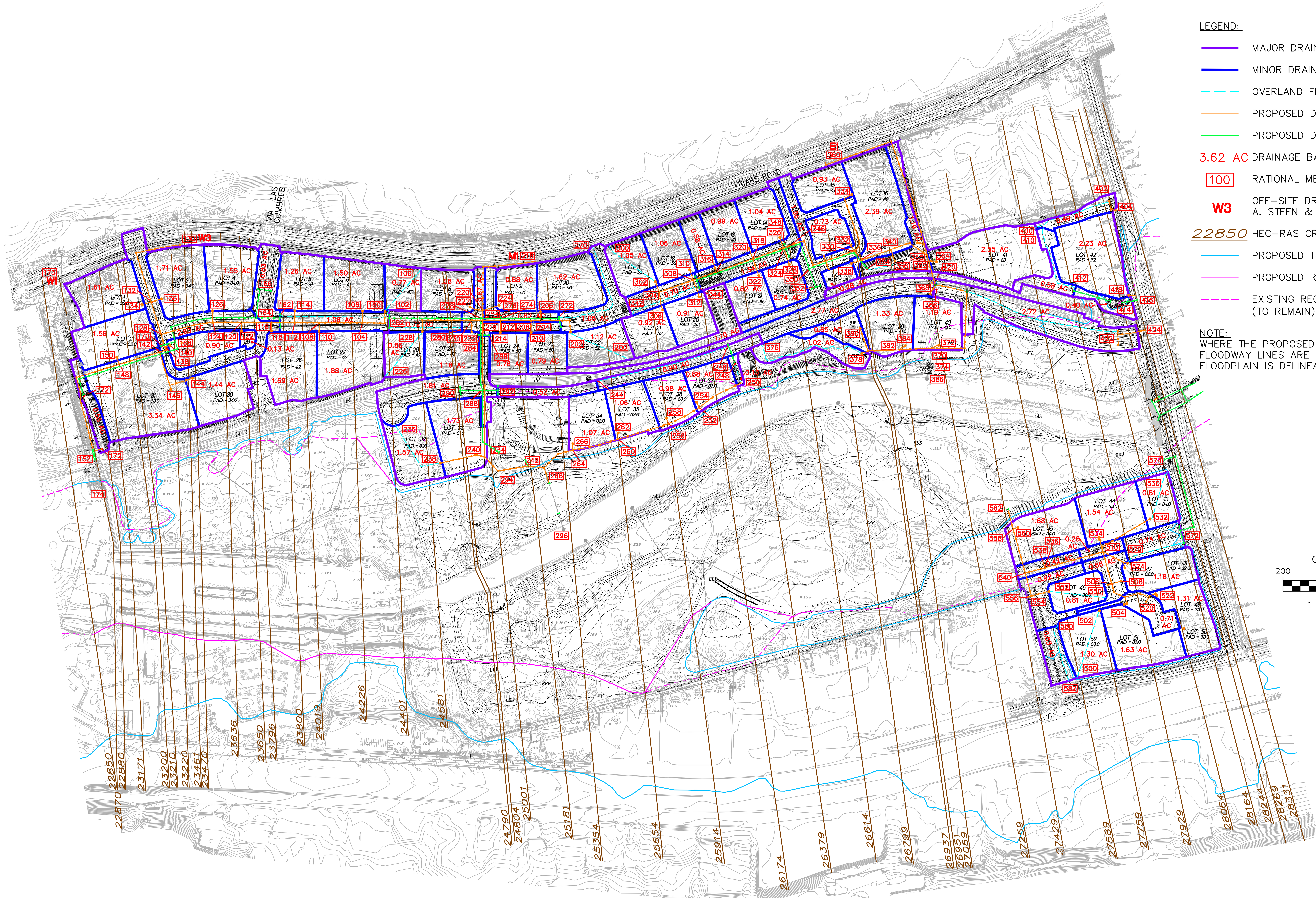
	226-1713	
222-1707		222-1719
	218-1713	

222-1713

DRAINAGE BASINS

WILLIAM A. STEEN & ASSOCIATES
CONSULTING CIVIL ENGINEERS, LAND SURVEYING & PLANNING

DR BY DJ/MM CK BY WAS	PROJ ENGR WILLIAM A STEEN RCE 18136	
DATE 8-18-97	JOB NO 6600	SHEET 3 OF 4 SHEETS



LEGEND:

- MAJOR DRAINAGE BASIN BOUNDARY
- MINOR DRAINAGE BASIN BOUNDARY
- OVERLAND FLOW PATH
- PROPOSED DRAINAGE SYSTEM FOR LOTS
- PROPOSED DRAINAGE SYSTEM FOR STREETS
- 3.62 AC DRAINAGE BASIN AREA
- 100 RATIONAL METHOD NODE NUMBER
- W3 OFF-SITE DRAINAGE BASIN PER WILLIAM A. STEEN & ASSOCIATES STUDY
- 22850 HEC-RAS CROSS-SECTION
- PROPOSED 100-YEAR FLOODPLAIN
- PROPOSED REGULATORY FLOODWAY
- EXISTING REGULATORY FLOODWAY (TO REMAIN)

NOTE:
WHERE THE PROPOSED 100-YEAR FLOODPLAIN AND FLOODWAY LINES ARE COINCIDENT, ONLY THE FLOODPLAIN IS DELINEATED.

GRAPHIC SCALE

200 0 100 200 400

1 INCH = 200 FEET

RATIONAL METHOD AND HEC-RAS WORK MAP

ATTACHMENT 6
GEOTECHNICAL AND GROUNDWATER INVESTIGATION REPORT

Attach project's geotechnical and groundwater investigation report. Refer to Appendix C.4 to determine the reporting requirements.

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NMG
Geotechnical, Inc.

February 20, 2018

Project No. 11077-02
DSD No. 581984

To: SD Riverwalk, LLC
4747 Executive Drive, Suite 410
San Diego, California 92121

Attention: Ms. Lynne Lyons

Subject: Infiltration Feasibility Conditions at Riverwalk Redevelopment Project, San Diego, California

References: NMG Geotechnical, Inc., 2017, Preliminary Geotechnical Investigation and Planning Study Proposed Mixed-Use Redevelopment Project at Riverwalk Golf Course, City of San Diego, California, Project No. 11077-01, dated September 25, 2017.

NMG Geotechnical, Inc., 2018, Addendum Geotechnical Report, Review of Vesting Tentative Map and Response to the City of San Diego Review Comments for the Proposed Riverwalk Redevelopment Project, San Diego, California, Project 11077-02, dated February 20, 2018.

INTRODUCTION AND BACKGROUND

As requested, NMG Geotechnical, Inc. (NMG) has prepared this letter to address the potential use of storm water infiltration BMPs for the Riverwalk Redevelopment project in the City of San Diego, California. NMG has performed a planning level evaluation of storm water infiltration feasibility in accordance with the Storm Water Standards, Part 1: BMP Design Manual, prepared by the City of San Diego, dated November 2017. The referenced reports present the findings from our investigation and laboratory testing. This letter was prepared to provide a summary of our findings, conclusions and recommendation related to the use infiltration BMPs.

The simple feasibility criteria presented in the City's design manual states that Full and Partial Infiltration BMPs:

- Shall not be placed at a site with existing fill materials greater than 5 feet thick;
- Shall not be proposed within 10 feet of utilities, structures or retaining walls;
- Shall not be proposed within 50 feet of natural slopes or a distance of 1.5H from graded fill slopes where H is the height of slope;

- Shall not be proposed within 100 feet of contaminated soil or groundwater; or
- Where there are other impairments.

In addition, the design manual indicates that infiltration should not be proposed where the following conditions occur:

- Less than a 10-foot separation between the bottom of the infiltration BMP and the groundwater table or where groundwater mounding could occur;
- The near-surface soils mapped by the USDA have a Hydrologic Group C or D type soil;
- The site has a geotechnical factor where infiltration may increase adverse effects, such as consolidation/collapse, expansive soils, liquefaction, adverse slope stability, potential soil piping, etc.;
- Where infiltration could damage underground utilities and vaults, wires/conduit and above-ground wiring, etc.; and
- Several other issues as listed in Section C.2 of the Design Manual.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results obtained from the laboratory hydraulic conductivity testing of proposed fill material (NMG, 2018), design infiltration rates for the compacted fill are between 0.01 and 0.50 inches per hour. Per the design manual, these infiltration values are below the reliable rates for Full Infiltration BMPs, but would be allowed for Partial Infiltration BMPs if there were no other constraints at the site, as discussed in detail in the referenced NMG, 2018 report and summarized below.

The anticipated remedial grading for the majority of the residential and commercial development will include remedial removals down to saturated alluvium. This will result in less than 3 to 4 feet separation between the bottom of the fill and the groundwater table. Also, the fill thicknesses will generally be greater than 5 feet. Both the fill thickness and separation between the BMP and groundwater table will not meet the requirements of the design manual.

The planned development may include podium-type buildings with subterranean parking levels, retaining walls, and underground utilities. Infiltration is not recommended in these areas per the design manual. There is also a potential for long-term seepage and drainage problems in the subterranean levels if infiltration BMPs were implemented next to the buildings.

Our prior experience in consolidated terrace materials, with respect to infiltration, has resulted in generally very low infiltration rates that are not reliable and typically the result of fracture permeability. The soils overlying the terrace materials are also classified as Type D (USDA, 1973), and confirmed to be generally silty and clayey sands during prior exploration. In addition, drilling was very difficult in the terrace materials and slow drilling rates and refusal was encountered in most of the borings drilled into these deposits.

Based on review of available groundwater data presented in our prior report (NMG, 2017), maintaining the minimum 10-foot vertical separation from the bottom of a proposed infiltration system to the groundwater table, even in the areas with less than 5 feet of planned fill, is not feasible given the existing site conditions (i.e., topography, existing golf course undocumented fill).

More importantly, the alluvium at the site is potentially liquefiable and mitigation measures to reduce the potential adverse impacts are significant. Installation of infiltration BMPs can raise the groundwater table or result in mounding, locally, which will negatively impact this geotechnical hazard.

Based on the above, the use of Full or Partial Infiltration BMPs at the site is not considered geotechnically acceptable or suitable at the subject site.

Also, based on the City's design manual, Appendix C, Sections C.1.1 and C.2.1, the worksheets C.4-1 and C.4-2 are not required with the submission of this letter.

If you have any questions regarding this report, please call our office. We appreciate the opportunity to provide our services.

Respectfully submitted,

NMG GEOTECHNICAL, INC.

Anthony Zepeda, CEG 2681
Project Geologist

Reza Saberi, GE 3071
Principal Engineer

Terri Wright, CEG 1342
Principal Geologist

AZ/TW/RS/grd

Distribution: (1) Addressee (E-Mail)
(1) Mr. Ted Shaw, Atlantis Group (E-Mail)
(1) Mr. Wayne Chang, Chang Consultants (E-Mail)

NMG Geotechnical, Inc.

DRAFT

January 31, 2018

Project No. 11077-02

To: SD Riverwalk, LLC
4747 Executive Drive, Suite 410
San Diego, California 92121

Attention: Ms. Lynne Lyons

Subject: Addendum Geotechnical Report and Response to the City of San Diego Review Comments for the Proposed Riverwalk Redevelopment Project, San Diego, California

INTRODUCTION

As requested, NMG Geotechnical, Inc. (NMG) has prepared this addendum report to address the City's review comments (City of San Diego, 2017a) pertaining to geologic/geotechnical issues, including:

- Addressing the potential storm water infiltration BMPs in accordance with the City's Storm Water Standards BMP Design Manual (City of San Diego, 2017b);
- Updating the geotechnical maps and cross-sections with Limits of Remedial Grading;
- Further evaluation of the potential impacts to adjacent roadways and structures; and,
- Response to City review comments.

We have also reviewed the updated Vesting Tentative Tract grading plan prepared by William Steen and Associates, received on January 24, 2018. This plan was used as the base for our updated geotechnical map and remedial measures map. This addendum report includes our review of the updated grading plan, additional supplemental information, response to City's comments, and provides updated geotechnical and remedial maps and cross-sections. This report is an addendum to the referenced NMG report and should be used concurrent with our prior geotechnical report (NMG, 2017). The data and geotechnical recommendations for the project grading and construction included in the prior report remain valid and should be implemented during design, grading and construction.

ATTACHMENTS

Figure 1 – Geologic Map by Kennedy and Tan 2008 – Rear of Text
Figure 2 – Geologic Map by Kennedy 1975 – Rear of Text
Plate 1 – Updated Preliminary Geotechnical Map – In Pocket
Plates 2 through 4 – Cross-Sections 1-1' through 18-18' – In Pocket
Plate 5 – Updated Remedial Measures and Ground Improvement Map – In Pocket
Appendix A – References
Appendix B – MIR Response Matrix and Cyclic Issues Geology and Geotechnical Comments
Appendix C – Additional Laboratory Test Results
Appendix D – Slope Stability Analysis

SCOPE OF WORK

Our scope of work for this addendum report and supplemental study includes the following:

- **Review of Revised Storm Water Standards:** We reviewed the recently published (November 2017) City of San Diego Storm Water Standards. This document (Part 1: BMP Design Manual, City of San Diego, 2017b) provided updates to geotechnical and groundwater investigation requirements and approved infiltration rate assessment methods for planning and design level selection, and design of storm water BMP's.

- **Supplemental Laboratory Testing:** Laboratory testing was performed for selected bulk and in-situ soil samples collected from borings excavated during our last geotechnical exploration (NMG, 2017). The additional laboratory testing included grain size distribution, maximum density and optimum moisture content, and hydraulic conductivity (permeability). The laboratory test results are presented in Appendix C.

- **Geotechnical Review and Analysis:** Geotechnical review and analysis was performed based on the updated 100-scale vesting tentative tract grading plan. The geotechnical analysis included evaluation and review of the updated plan, preparation and review of new and revised cross-sections, assessment of the supplemental laboratory testing data, and engineering analysis. The cross-sections were updated to highlight the planned fill and the recommended remedial grading and ground improvement. The map and cross-sections were also updated to show the Limits of Remedial Grading.

- **Report Preparation:** This report presents additional data, maps and cross-sections, findings and conclusions that address the City's review comments and the updated grading plan. This report should be used in combination with the prior geotechnical report (NMG, 2017) for design, grading and construction.

- **Project Meetings and Design Coordination:** NMG attended project planning meetings and collaborated with the SD Riverwalk design team, the project civil engineer, and other project consultants as part of this study.

FINDINGS AND DISCUSSIONS

Updated Vesting Tentative Tract Grading

The vesting tentative tract map in our referenced report (NMG, 2017) was updated with the following design and construction changes:

- The fill slope near the river on Lots 17 and 18 was pulled back approximately 30 feet from the river. The proposed building on Lot 18 was also modified and reduced in size to be 30 feet further away from the river. The proposed buildings will consist of multi-stories, some with subterranean levels of parking and some with at-grade parking structures.

- The southerly commercial development was significantly modified. Approximately 6.5 acres of the pad area was removed. The building layouts and types were also modified significantly. We understand that the stand-alone buildings will be on the order of 5 to 10 stories and two larger footprint multi-level parking structures are planned in the central area. The western portion of the new pad does not show buildings or parking lot at this time. We understand that this portion of the pad will have structures and a parking lot, but the locations may be decided at a later date. We are showing remedial removals on the cross-sections; however, the locations and need for ground improvements will be determined once the building locations are known.

- Our maps and cross-sections have been updated with the current plan and the Limits of Remedial Grading have been added, as shown on Plates 1 through 5.

Updated Geologic Mapping

As suggested by the City reviewer and documented in the review comments, we have reviewed the more recent mapping by California Geological Survey and the U.S. Geological Survey (Kennedy and Tan, 2008). This mapping is shown in a new Figure 1 in this report. We have also included the Figure 2 from our prior report with minor revision to the property boundary and have titled it "Geologic Map after Kenney 1975" for comparison purposes. The 2008 map (Figure 1) shows the onsite geology essentially the same as the prior mapping by Kennedy (1975; Figure 2). However, some of the geologic mapping has changed to the north of Friars Road. The bedding attitudes to the north of the site were modified, but the bedding still generally strikes north and dips 5 to 7 degrees east.

The previously mapped Bay Point Formation, as shown on Kennedy (1975) to the northwest of the site, is now mapped as the Nestor marine terrace deposit (Qop6) which also indicates this unit is about 120,000 years old with an elevation of 33 to 72 feet msl. Therefore, we conclude that a different bedrock formation, other than the Bay Point Formation, underlies the site at depth. The very dense sandstone bedrock encountered in Boring B-5 at a depth of 55 feet (elevation of +3 feet above mean sea level) and Boring SB-102 at a depth of 62 feet (elevation of -27 feet below sea level) may be another bedrock unit, such as the Scripps Formation. This bedrock will not be encountered during the future grading or construction. The change in formation name does not impact our geotechnical evaluation and analysis.

Supplemental Laboratory Testing

NMG conducted supplemental laboratory testing on bulk and in-situ samples collected during prior phases of exploration in order to evaluate the potential for infiltration of storm water at the site. Laboratory test results are included in Appendix C.

Grain-size distribution tests were conducted on seven selected samples collected within the relatively sandy alluvium. The fines content (passing No. 200 sieve) varied from 4 to 64 percent.

Maximum density and optimum moisture content testing was performed on three near-surface (upper 5 feet) bulk samples in order to remold samples to 90 percent relative compaction, representative of the future compacted fill. The samples had maximum dry density and optimum moisture contents ranging from 107 to 127.5 pounds per cubic foot (pcf) and 10 to 14 percent, respectively.

These three bulk samples were compacted to approximately 90 percent of the maximum dry density to simulate compacted fill. Permeability testing was then performed on these three compacted samples for evaluation of shallow fill materials with respect to storm water infiltration. One sample (Boring B-27, Sample B-1) was tested per ASTM D-2434, due to its low fines content. Two additional samples (Boring B-19, Sample B-1 and Boring B-26, Sample B-1) were over the 10 percent fines criteria (per ASTM D-2434) and were tested per ASTM D-5084. Based on the results of these tests, the hydraulic conductivity (permeability) was found to range from 0.027 to 1.01 inches per hour.

Infiltration Feasibility

General: NMG has performed a planning level evaluation of storm water infiltration feasibility in accordance with the City of San Diego Storm Water Standards (Part 1: BMP Design Manual, City of San Diego, 2017b). The simple feasibility criteria presented in the document state that Full and Partial Infiltration BMPs:

- Shall not be placed at a site with existing fill materials greater than 5 feet thick;
- Shall not be proposed within 10 feet of utilities, structures or retaining walls;
- Shall not be proposed within 50 feet of natural slopes or a distance of 1.5H from graded fill slopes where H is the height of slope;
- Shall not be proposed within 100 feet of contaminated soil or groundwater; or
- Where there are other impairments.

In addition, the guidance document indicates that infiltration should not be proposed where the following conditions occur:

- Less than a 10-foot separation between the bottom of the infiltration BMP and the groundwater table or where groundwater mounding could occur;

- The near-surface soils mapped by the USDA have a Hydrologic Group C or D type soil;
- The site has a geotechnical factor where infiltration may increase adverse effects, such as consolidation/collapse, expansive soils, liquefaction, adverse slope stability, potential soil piping, etc.;
- Where infiltration could damage underground utilities and vaults, wires/conduit and above-ground wiring, etc.; and
- Several other issues as listed in Section C.2 of the Design Manual.

The following discussion includes our assessment of infiltration feasibility for areas underlain by different earth units and per the above guidelines.

Areas Underlain by Compacted Fill: For the evaluation of compacted fill, NMG performed the above laboratory testing and the results are included in Appendix C. Hydraulic conductivity was estimated directly from laboratory testing of remolded fill samples. The BMP Design Manual indicates that for purposes of infiltration assessment, saturated hydraulic conductivity and infiltration rate can be assumed to be equal. The laboratory tests indicate that the hydraulic conductivity ranges from 0.027 to 1.01 inches per hour for silty sandy fill compacted to approximately 90 percent relative compaction. Applying a minimum factor of safety of 2, as recommended, the infiltration rates will be in the range 0.01 to 0.50 inches per hour. In addition, based on our experience with sandy soils, we anticipate the actual relative compaction of the fill will be somewhat higher and typically in the range of 90 to 95 percent. The higher relative compaction will result in lower infiltration rates. These infiltration values are below the reliable rates for Full Infiltration BMPs, as discussed in the guideline. Partial Infiltration BMPs would be allowed if there were no other factors. However, other constraints exist and are discussed below:

- The thickness of compacted fill throughout most of the residential and commercial developments will be more than 5 feet;
- Fill will generally be placed to within 3 to 4 feet of the groundwater table in areas of alluvium;
- Many of the buildings and lower level parking will be subterranean and potential infiltration near these buildings could produce long-term seepage and drainage problems; and
- There will be numerous retaining walls and utilities placed around and beneath the buildings and roadways.

Areas Underlain by River Terrace Deposits: The terrace materials in the northern portion of the site are dense, consolidated, and a mixture of cobble and fine-grained matrix. It was difficult to drive the California sampler to collect in-situ samples and drive samples typically had high blow counts for only a few inches of recovery. The drilling rig often encountered refusal at shallow depths (10 to 20 feet deep). Also, groundwater was not encountered in the majority of borings drilled through Terrace deposits and is generally deeper than in alluvium. Infiltration rates in these types of material are anticipated to be very low.

The USDA soil mapping for the topsoil overlying the terrace deposits is also the Huerhuero-Urban land complex which is classified as hydrologic group Type D (USDA, 1973). Our field exploration confirms that this unit generally consists of silty and clayey sandy matrix around river cobbles.

Grading and construction issues regarding potential infiltration in areas underlain by terrace deposits include:

- The thickness of compacted fill around the planned buildings overlying the terrace deposits will typically be more than 5 feet thick.
- Many of the buildings and lower level parking will be subterranean and potential infiltration near these buildings could produce long-term seepage and drainage problems.
- There will be numerous retaining walls and utilities placed around and beneath the buildings and roadways.
- Due to the difficulty of drilling into the terrace deposits, field testing and installation of dry well infiltration BMPs would be very difficult to implement.

Areas Underlain by Alluvium: The natural soils overlying the alluvium throughout the remainder of the site are mapped as the Tujunga sand and are classified as hydrologic group Type A (USDA, 1973). Also, based on the grain size test results, this material is permeable and considered acceptable for infiltration BMPs. We understand that during the mid-1990s, fill was imported during regrading of the golf course. Throughout much of the golf course, the upper 1 to 10 feet is composed of imported compacted fill from off-site sources (USD and I-15 near University Drive). This material is generally finer grained and is believed to reduce the overall infiltration of the native soils.

Within the residential and commercial development areas, the remedial removals will extend to just above the groundwater table. In addition, the ground improvements (such as geopiers, soil mixing or stone columns) will be installed into the saturated alluvium below the buildings (see Plates 2 through 5).

There is also a significant potential for liquefaction of the alluvium throughout the site. Infiltration into the alluvium may raise the groundwater table locally, which would increase the potential for liquefaction and seismically induced settlements.

In the park areas, we understand that the grading will level out the existing contoured mounds, resulting in about 4 to 8 feet of fill over the park site. Since the groundwater is shallow in this area, potential infiltration BMPs would have less than the required 10 feet of separation between the bottom of the BMP and the groundwater table. We anticipate that the majority of the park area will continue to be irrigated and some of the applied water will infiltrate down through the shallow fill and into the alluvium.

Limits of Remedial Grading

The Limits of Remedial Grading were added to Plates 1 and 5 of this report. These limits typically extend between 10 and 30 feet (measured horizontally) outside the toe of fill slope daylight line near the river. The limits also extend to the perimeter property lines, street right-of-way lines, and to the trolley easement lines. The cross-sections were updated to highlight the general grading and remedial grading conditions, including the design fill (in green), the recommended remedial removals that will be replaced with compacted fill (in yellow), and the approximate areas of recommended ground improvement (in orange). The depths of the removals and ground improvements are consistent with the recommendations in our prior report (NMG, 2017) and as shown on the Updated Remedial Measures and Ground Improvement Map (Plate 5).

Settlement of Existing Sewer, Trolley Line and Perimeter Roads

We have prepared 18 cross-sections for this report, 13 of which involve grading over the 78-inch- diameter trunk sewer line. Cross-Sections 1-1', 4-4', 5-5' and 6-6' do not have any design fill placed over the sewer line, and Cross-Sections 2-2' and 16-16' show design cuts of 8 to 14 feet over the pipeline. Cross-Sections 3-3', 9-9', 10-10' and 11-11' show between 5 to 10 feet of fill planned over the pipeline; however, the pipe is underlain by dense terrace deposits and/or bedrock. Cross-Sections 7-7', 8-8' and 15-15' show between 8 and 13 feet of planned fill over the pipeline, with between 23 to 40 feet of alluvium under the pipeline. These latter three cross-sections represent the conditions with the most potential for settlement under the sewer pipeline and the trolley line.

After reviewing our prior analysis, the most settlement calculated for the sewer line and trolley line occurred in the area of Cross-Section 7-7' (rather than Cross-Section 11-11' as stated in our prior report). Cross-Section 7-7' shows 10 feet of fill over the pipeline and the most saturated alluvium (40 feet) underlying the pipeline and therefore, was used for the settlement analysis. For purposes of preliminary analysis, up to 60 feet of alluvium was assumed under the pipeline (rather than 40 feet) and the potential total settlement was calculated to be less than 0.75 inches below the sewer pipeline and 0.35 inches under the trolley line.

The same cross-sections show the conditions of planned fill next to the northern side of the trolley line. The fill on the north side of the trolley line generally varies between 0 and 5 feet thick within 30 horizontal feet of the trolley easement. The potential settlement associated with this fill is considered minor.

Settlement potential of perimeter roads and adjacent buildings is also anticipated to be minor as a result of the proposed grading. The impact to adjacent properties will need to be evaluated during the design phase and once the foundation loads from the proposed structures are calculated. Based on our review of the current project plans, we anticipated little to no settlement impacts to the adjacent properties.

Temporary Slope Stability Related to Existing Streets and Structures

As previously discussed, the cross-sections were updated with the recommended remedial measures and they show the temporary slopes needed to complete the grading and installation of ground improvements. Several additional 40-scale cross-sections were prepared around the perimeter of the site and next to the trolley line to show the existing conditions and the temporary slopes. We have analyzed the temporary slope stability associated with the remedial removals and grading as shown on Cross-Section 15-15'. This cross-section represents the highest temporary cut slope below the trolley line. Our analysis indicates that for the temporary conditions, the slopes associated with grading and remedial removals next to the trolley line will have a minimum factor of safety of 1.37. The slope stability analysis is included in Appendix D of this report.

CONCLUSIONS AND RECOMMENDATIONS

1. General Conclusion and Recommendation

Based on this geotechnical study, the site is considered geotechnically suitable for the proposed mixed-use development provided the preliminary recommendations in this report and our prior report are implemented during design, grading and construction.

The recommendations in the referenced report remain valid for design, grading and construction. The conclusions and recommendations in this report are in addition to those previously provided or are modified to accommodate the updated grading plan. In addition, information was added to the maps and cross-sections based on these recommendations and the updated plan. The information and recommendations provided herein also address the geotechnical review comments prepared by the City of San Diego (also see Appendix B).

2. Storm Water Infiltration Feasibility

Based on the results obtained from the laboratory hydraulic conductivity testing of proposed fill material, design infiltration rates for the compacted fill are between 0.01 and 0.50 inches per hour. Per the design manual, these infiltration values are below the reliable rates for Full Infiltration BMPs, but would be allowed for Partial Infiltration BMPs if there were no other constraints at the site, as discussed previously and summarized below.

The anticipated remedial grading for the majority of the residential and commercial development will include remedial removals down to saturated alluvium. This will result in less than 3 to 4 feet separation between the bottom of the fill and the groundwater table. Also, the fill thicknesses will generally be greater than 5 feet. Both the fill thickness and separation between the BMP and groundwater table will not meet the requirements of the design manual.

The planned development includes structures some of which are podium type buildings with subterranean parking levels, retaining walls, and underground utilities. Infiltration is not recommended in these areas per the design manual. There is also a potential for long-term seepage and drainage problems in the subterranean levels if infiltration BMPs were implemented next to the buildings.

Our prior experience in consolidated and well-graded terrace materials, with respect to infiltration, has resulted in generally very low infiltration rates that are not reliable and typically the result of fracture permeability. The soils overlying the terrace materials are also classified as Type D (USDA, 1973), and confirmed to be generally silty and clayey sands during prior exploration. In addition, drilling was very difficult in the terrace materials and slow drilling rates and refusal was encountered in most of the borings drilled into these deposits.

Based on review of available groundwater data presented in our prior report (NMG, 2017), maintaining the minimum 10-foot vertical separation from the bottom of a proposed infiltration system to the groundwater table, even in the areas with less than 5 feet of planned fill, is not feasible given the existing site conditions (i.e., topography, existing golf course undocumented fill).

More importantly, the alluvium at the site is potentially liquefiable and mitigation measures to reduce the potential adverse impacts are significant. Installation of infiltration BMPs can potentially raise the groundwater table or result in mounding, locally, which will negatively impact this geotechnical hazard.

Based on the above, the use of Full or Partial Infiltration BMPs at the site is not considered geotechnically acceptable or suitable.

3. Grading Adjacent to Roadways, Structures and Trolley Line

Temporary Slopes: In general, the temporary slopes needed for the remedial removals and ground improvement should be excavated as follows:

- Within the compacted fill and terrace deposits, the temporary slopes may be excavated at 1H:1V inclination, as shown on the cross-sections.
- For slopes adjacent to the trolley easement or existing structures, the temporary slopes should not be steeper than 1.5H:1V.

Based on our review, the highest temporary slope at 1.5H:1V inclination will be on the order of 40 feet. Slope stability analysis for this condition shows a minimum factor of safety of 1.37, which is considered geotechnically acceptable. The temporary slope stability should also be reviewed and approved by the Metropolitan Transit System (MTS) prior to excavation and grading.

These temporary slopes should be mapped by the geotechnical consultant as they are being excavated. They will be open for a period of time to install the ground improvements and should also be monitored periodically during that time.

Staged Grading and Ground Improvements: There are a few areas in the northwest portion of the site where the buildings are planned close to the adjacent roadways and trolley line. In these areas, the recommended temporary slopes cannot be excavated to the elevations indicated on Plate 5, to allow the installation of the ground improvements under the buildings. The grading and ground improvements in these areas will need to be installed with staged construction, or shoring would be needed. The ground improvements are shown on the cross-sections (Plates 2 through 4) to be under the buildings, extending to a minimum of 5 feet outside the building edge, and to the recommended elevations shown on Plate 5. The temporary slope excavations will need an additional 5 to 10 feet of horizontal work space at the bottom to install the ground improvements.

We suggest that the remedial grading and ground improvement operations be staged with an increased thickness of ground improvements along the perimeter of the lots as shown on Cross-Sections 1-1', 6-6', 7-7', 8-8' and 16-16'. Excavations will need to be made down to a temporary level bench that extends at least 10 feet outside the building edge, in order to install the ground improvements. Upon the installation of the longer ground improvements, the grading contractor may excavate down to the removal elevation shown on Plate 5, at the recommended slope angles, in order to complete the ground improvements. This staged grading is anticipated to be needed in the northwestern portion of the site, around the north and west sides of Lot 1 and below the trolley line easement on Lots 6, 8, 10, 16, 17 and 22.

Alternatively, these areas would need temporary shoring installed to complete the remedial grading and installation of the ground improvement. Shoring recommendations are provided in our prior report (NMG, 2017).

4. Potential Settlement of 78-inch Trunk Sewer and Trolley Line

Based on our settlement analysis and as discussed previously, the maximum potential total settlement under the sewer pipeline is on the order of 0.75 inches and below the trolley line is 0.35 inches. The existing sewer line and trolley line are anticipated to tolerate these amounts of settlement. However, this should be reviewed and approved by the pipeline owner and MTS prior to grading and construction.

5. Fill Compaction for the Areas within the Flood Zone

A comment by the City reviewer stated that that fill placed to create building pads within a Special Flood Hazard Area must be compacted to 95 percent of the maximum density obtainable with the Standard Proctor Test Fill method per the ASTM D-698.

Fill placed and compacted to 90 percent relative compaction per ASTM D-1557 (Modified Proctor) as recommended is considered equivalent to, if not denser, than fill compacted to 95 percent of the maximum density obtained with the Standard Proctor Test (ASTM D-698) considering the nature of the onsite soils. Thus, it is our geotechnical opinion that fill placed in accordance with our recommendations is suitable for the intended use. Fill slopes within the flood zone will also be provided with erosion protection that will satisfy the applicable agency(s).

6. General Grading for the Park

We understand that the future park grading will be a general reshaping of the existing golf course, with leveling of many existing mounds to create a natural landscaped area with trails. The majority of the park will be considered non-structural, and therefore, remedial grading and ground improvements are not shown for this area (Plates 2 through 5). The reworked fill will need to be compacted to a minimum of 90 percent relative compaction per ASTM D-1557.

Once the locations of structures are determined, the areas will need to be reviewed and geotechnical recommendations for remedial grading and ground improvements will be given at that time. Where concrete trails are recommended, there should be at least 2 feet of compacted fill below the pavement. Where non-habitable structures (such as restrooms) are planned, remedial removals will need to be performed; however, ground improvement may not be needed. Where habitable structures are planned, additional ground improvement should be anticipated.

7. Additional Investigation and Plan Reviews

Additional geotechnical evaluation and investigation are recommended during the design phase of work for the following areas:

- Along both sides of the trolley line in the area of Lots 6, 8, 10 and 16, in order to further evaluate the contact between alluvium and bedrock and to determine the extent of ground improvement needed below the proposed buildings. We will attempt to obtain the historic topographic maps prior to grading of the trolley embankments. We will also attempt to acquire the geologic data collected during the grading operations for the trolley embankment to better determine the alluvium/bedrock contact. Excavation of additional borings may be necessary during the design phase of work to supplement the collected data and/or if the prior reports and information are not available.
- Along the northwest side of Lot 1, in order to evaluate the alluvium and terrace contact and to better determine the extent of ground improvement needed in this area.
- Within the park areas, where/if structures are planned. This will be determined once the park plan becomes available.

NMG should also review the project plans during the design phase including but not limited to the following:

- Grading plans, including rough and precise grading plans;
- Foundation and structural plans;
- Ground improvement plans;
- Shoring and retaining wall plans; and
- Street and utility plans.

Geotechnical review reports will be prepared for these plan reviews, which will be submitted to the City for review and approval.

If you have any questions regarding this report, please call our office. We appreciate the opportunity to provide our services.

Respectfully submitted,

NMG GEOTECHNICAL, INC.

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TW/RS/grd

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APPENDIX A

REFERENCES

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