APPENDIX G

Stormwater Report



STORMWATER REPORT

PREPARED FOR:

TransMontaigne Partners LLC





PREPARED BY:

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MARTINEZ FACILITY RAIL RESTORATION
MARTINEZ, CA

100% DESIGN PHASE

FEBRUARY 23, 2024

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1. Introduction

TransMontaigne Partners, LLC (TransMontaigne) is a leading provider of terminaling, storage, transportation and related services to the energy industry. They own and operate a diversified network of midstream terminals located in strategic markets throughout the United States. The Martinez, CA terminal is situated strategically to serve as a storage and transportation hub for Bay Area refiners for renewable and petroleum energy products and related feed and blend stocks.

TransMontaigne acquired the approximate 255-acre industrial site from Plains All-American Pipelines in early 2018. The scope of improvements include construction of new track and associated rail in the location of the former rail line on the south side of the Martinez Terminal, connecting the existing UPRR railroad tracks south of Waterfront Road. The rail spur will be located within the existing Martinez Terminal property and within UPRR right-of-way.

This report summarizes the drainage analysis performed at the 100% design level for the TransMontaigne rail service reinstatement project. This report and associated calculations are provided to demonstrate for UPRR that the drainage design for the corridor is feasible, with ditches and pipe systems sized to comply with UPRR hydrologic and hydraulic design criteria.

1.1 Revisions

The following is a summary showing the revision tracking for the Drainage Report:

Table 1 – Revision Summary Table

Revision	**A**	**Previous Revisions**	
Date	2/23/2024	Rev	Date
Description	100% Design		
Prepared By	Zhaoyang Wang, PE		
Checked By	Allene Rieger, PE		
Approved By	Jon Marshall, PE		

1.2 Terms and Definitions

Caltrans	California Department of Transportation
CN	Curve Number
FEMA	Federal Emergency Management Agency
HDM	Highway Design Manual
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
NOAA	National Oceanic and Atmospheric Administration
Row, R/W	Right-of-Way
SCS	Soil Conservation Service
SPCC	Spill Prevention Control and Countermeasure

TR-55	Technical Release 55
UPRR	Union Pacific Railroad
USDA	United States Department of Agriculture

1.3 Project Location

The project is located on an approximate 255-acre heavy industrial site in Martinez, CA in the County of Contra Costa. The property is bounded by Waterfront Rd and UPRR Right-of-Way to the south, County, State and Private (Copart, Inc.) lands to the east, the Carquinez Strait and Tidelands to the north, and State lands to the west. (See **Figure 1**).

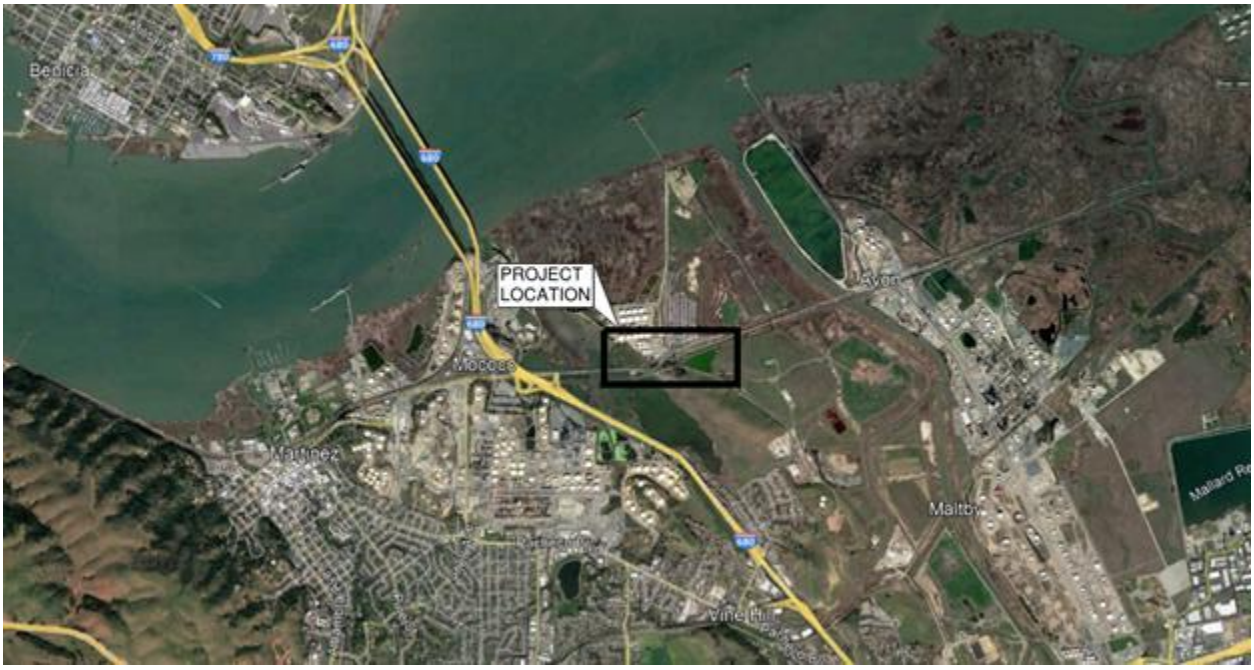


Figure 1 - Site Location Map

1.4 Project Stakeholders

List design team and agency stakeholders.

1.4.1 Design Team

- Owner: TransMontaigne, Abhi Bobde - Project Engineer
- Prime Consultant / Civil Engineer: JMA Civil, Inc., Jon Marshall, P.E. – Principal Engineer
- Structural Engineer Retaining Walls: ARW, Dave Pierson, PE – Sr. Principal
- Structural Engineer Crash Walls: TY Lin, Bob Fish, PE – Associate Vice President
- Geotechnical Engineer: Geocon, Shane Rodacker – Vice President
- Survey: Cinquini & Passarino, Jim Dickey – Principal PLS

1.4.2 Agency Stakeholders

- City of Martinez: Building and Grading Permits, Fire Department Access/Response

- Contra Costa County: Preparation of Environmental Impact Report (EIR) under California Environmental Quality Act
- State of California Regional Water Quality Division: Storm water handling and disposal both during construction and for the facility build out

1.5 Applicable Codes and Standards

This report and the resulting design shall comply with the following standards, including all addenda, specifications, and recommended practices.

- Union Pacific Railroad Main Line Track Standard, latest edition
- Union Pacific Railroad Industry Track Standard, February 1, 2024
- Union Pacific Railroad Guidelines for Railroad Grade Separation Projects, January 5, 2016
- California Department of Transportation (Caltrans): Highway Design Manual, July 1, 2020, Seventh Edition
- United States Department of Agriculture (USDA) Natural Resources Conservation Services, Conservation Engineering Division, Technical Release 55 (TR-55, Urban Hydrology for Small Watersheds), June 1986

2. Records Review and Data Collection

JMA performed a detailed review of record drawings, reports and prior studies relevant to the project. The list of documents reviewed is described in **Table 2**.

Table 2 - Record Documents

No.	Record Name	Description
1	TransMontaigne Operating Company LP Spill Prevention Control and Countermeasure (SPCC) Plan, Martinez Terminal, August 2019	2019 SPCC Plan for the Martinez Terminal

2.1 Project Survey Datum

Below is the survey datum that all invert and elevation data are based on:

- Horizontal: California State Plane Zone 3, NAD 1983, Epoh 2017.50, US Survey Feet
- Vertical: NAVD88

2.2 Flood Hazard Analysis

The location where the proposed industry track ties-in to UPRR main track is within Zone AE (Special Flood Hazard Areas) with a Base Flood Elevation (BFE) of 10'. The proposed industry track then transitions to Zone X – (Areas Determined to be Outside the 0.2% Annual Chance Floodplain). Shortly after crossing under Waterfront Road overpass, the industry track is located near the boundary between Zone X and Zone AE, with a BFE is 9'.

See **Appendix A1** for the FEMA Flood Hazard Map.

3. Stormwater Analysis Approach

The SCS Curve Number Method is used to calculate the total runoff and peak outflow for both existing and proposed conditions, which is computed in the U.S. Army Corps of Engineer's HEC-HMS software.

Manning's equation is used to check the capacity of the proposed storm pipes.

4. Existing Condition Analysis

4.1 Rainfall Data

Rainfall data for the project site, determined using NOAA Atlas 14, Point Precipitation Frequency Estimates, are included in **Appendix B**.

4.2 Tributary Areas

The existing drainage areas are presented in **Exhibit A2.** See **Table 3** below for a description of the existing drainage areas.

Table 3 - Existing Drainage Areas

Drainage Area	Area (Acre)	Description
DA-1	1.85	Drainage area north of the existing UPRR main track and east of Waterfront Road overpass. This area drains from north to south until the runoff is collected at the toe of the existing UPRR trackbed, then drains from west to east along the toe of the trackbed into an existing ponding area (Pond-1).
DA-2	0.33	Drainage area north of the existing UPRR main track and west of Waterfront Road overpass. This area drains from north to south until the runoff is collected at the toe of the existing UPRR trackbed, then drains from east to west along the toe of the trackbed into an existing ponding area (Pond-2).
DA-3	2.33	This drainage area consists of the existing unused rail spur area and an existing TransMontaigne operating area. This area drains from north to south across the operating area, then crosses the existing fence and enters the existing rail spur area. The runoff then is combined with that originated from the existing rail spur area, and continues to drain from north to south into an existing ponding area (Pond-2).

4.3 Rainfall-Runoff Losses

The U.S. Army Corps of Engineer's HEC-HMS software was used for the hydrologic calculations and to model the rainfall-runoff losses. The SCS Curve Number (CN) method was used as the rainfall loss method in the HEC model. The SCS CN method estimates the total rainfall losses as a function of the cumulative precipitation, soil type and land use.

The SCS CN method requires the following inputs:

- **Curve Number (CN)**: The curve number that represents soil type and land use for the drainage area. Per USDA Soil Map, attached in Appendix A4, the soil group in the project area consists of Group C and D. The curve numbers are then calculated using TR-55 Table 2-2a; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.
- **Initial Abstractions (I_a, inches)**: The amount of precipitation that falls before runoff begins. The initial abstraction is determined based on the curve number, using TR-55 Table 4-1; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.
- **Impervious Area (%)**: The percentage of directly connected impervious area, defined as any impervious surface that is either directly connected to the drainage area discharge point or flows directly into a pipe or impervious conduit to the discharge point. As the curve number is calculated using a weight method, there are no additional impervious areas that have not been accounted for.
- **Time of Concentration (Tc)/Lag**: Time of concentration is the time it takes run-off to travel from the hydraulically most distant point of the drainage area to the downstream element. The time of concentration is calculated using TR-55 Chapter 3; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.
  The lag time is calculated using the following equation:
  Lag, L (min) = Tc (min) X 0.6.
- **Rainfall Distribution:** The rainfall distribution is decided using TR-55 Figure B-2; see **Appendix C1**. The determined rainfall distribution is SCS Type IA.

4.4 Runoff Data

The results of the peak runoff and total runoff volume from the site drainage area for the proposed conditions are summarized in **Table 4**. A detailed report is presented in **Appendix C3**.

Table 4 - Existing Runoff Data

Drainage Area Name	Total Runoff (AC-FT)			Peak Discharge (CFS)		
	2-yr 24-hr	50-yr 24-hr	100-yr 24-hr	2-yr 24-hr	50-yr 24-hr	100-yr 24-hr
DA-1	0.15965	0.52396	0.61441	0.41852	1.53248	1.80800
DA-2	0.02652	0.09031	0.10630	0.07227	0.27796	0.32948
DA-3	0.28209	0.77664	0.89509	0.87666	2.43142	2.79671
TOTAL	**0.46826**	**1.39091**	**1.6158**	**-**	**-**	**-**

5. Proposed Condition Analysis

5.1 Rainfall Data

Rainfall data for the proposed conditions is the same as that used for the existing condition analysis.

5.2 Tributary Areas

The proposed drainage areas are presented in **Exhibit A3.** See **Table 5** below for a description of the proposed drainage areas.

Table 5 - Proposed Drainage Areas

Drainage Area	Area (Acre)	Description
DA-1	0.42	This area drains from south to north and enters and existing ponding area (Pond-1). The trackbed of the proposed industry lead has been designed in a way not to obstruct runoff from the existing UPRR track from entering Pond-1.
DA-2	1.42	Runoff from the existing UPRR track and the proposed industry lead flows from south to north and enters a proposed ditch (Ditch-1). The trackbed of the proposed industry lead has been designed in a way not to obstruct runoff from the existing UPRR track from entering Ditch-1. Runoff from north of the proposed industry lead flows from north to south and also enters Ditch-1. Ditch-1 drains to an existing ponding area (Pond-1).

Drainage Area	Area (Acre)	Description
DA-3	1.32	Runoff from the existing UPRR track and the proposed industry lead flows from south to north and enters a proposed pipe (SD-1). The trackbed of the proposed industry lead has been designed in a way not to obstruct runoff from the existing UPRR track from entering SD-1. Runoff from north of the proposed industry lead flows from north to south and enter the drainage system constructed behind the face of the proposed retaining wall, then also enters SD-1 at the base of the retaining wall. SD-1 drains to a proposed sump (Sump-1) and will be pumped by TransMontaigne.
DA-4	0.78	This drainage area represents the proposed unloading area. Runoff from this area will enter the two proposed underdrains (UD-1 and UD-2), which flows from west to east and enters a proposed pipe (SD-2). Some of the runoff does not enter the underdrains but the proposed secondary containment area, which once cleared of any spill also flows into SD-2. SD-2 drains to a proposed sump (Sump-1) and will be pumped by TransMontaigne.
DA-5	0.58	This drainage area represents the existing TrasnMontaigne operating area. Due to proposed curb and retaining wall, runoff will be intercepted and flow along the base of curb and retaining wall, and enters the proposed sump (Sump-1)

5.3 Rainfall-Runoff Losses

The U.S. Army Corps of Engineer's HEC-HMS software was used for the hydrologic calculations and to model the rainfall-runoff losses. The SCS Curve Number (CN) method was used as the rainfall loss method in the HEC model. The SCS CN method estimates the total rainfall losses as a function of the cumulative precipitation, soil type and land use.

The SCS CN method requires the following inputs:

- **Curve Number (CN)**: The curve numbers are determined using the same methodology as that for the existing condition. The curve numbers are calculated using TR-55 Table 2-2a; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.

- **Initial Abstractions (I_a, inches)**: The initial abstraction is determined using the same methodology as that for the existing condition, using TR-55 Table 4-1; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.
- **Impervious Area (%)**: As the curve number is calculated using a weight method, there are no additional impervious areas that have not been accounted for.
- **Time of Concentration (Tc)/Lag**: The time of concentration is determined using the same methodology as that for the existing condition, using TR-55 Chapter 3; see **Appendix C1**. Detailed calculations can be found in **Appendix C2**.
  The lag time is calculated using the following equation:
  Lag, L (min) = Tc (min) X 0.6.
- **Rainfall Distribution:** The rainfall distribution is decided using TR-55 Figure B-2; see **Appendix C1**. The determined rainfall distribution is SCS Type IA; same as existing.

5.4 Runoff Data

The results of the peak runoff and total runoff volume from the site drainage area for the proposed conditions are summarized in **Table 6**. A detailed report is presented in **Appendix C4**. Note that drainage area DA-4 is equally split into two (2) sub drainage areas, DA-4-1 and DA-4-2, due to two (2) underdrains being present in the unloading area.

Table 6 – Proposed Runoff Data

Drainage Area Name	Total Runoff (AC-FT)			Peak Discharge (CFS)		
	2-yr 24-hr	50-yr 24-hr	100-yr 24-hr	2-yr 24-hr	50-yr 24-hr	100-yr 24-hr
DA-1	0.04377	0.13048	0.15154	0.13181	0.41162	0.47778
DA-2	0.12738	0.40949	0.47928	0.35729	1.25420	1.47228
DA-3	0.12541	0.39128	0.45661	0.35420	1.19388	1.39629
DA-4-1	0.04567	0.12807	0.14785	0.14153	0.40287	0.46378
DA-4-2	0.04567	0.12807	0.14785	0.14153	0.40287	0.46378
DA-5	0.09048	0.21752	0.24743	0.28006	0.65447	0.74168
TOTAL	**0.47838**	**1.40491**	**1.63056**	**-**	**-**	**-**

5.5 Terminal Drainage Conditions

Drainage areas DA-1 and DA-2 will drain into an existing ponding area (Pond-1), as is in the existing condition.

Drainage areas DA-3, DA-4 and DA-5 will eventually drain into a proposed sump located on TransMontaigne property, and will be pumped by TransMontaigne. The pump design will be by TransMontaigne.

5.6 Comparison of Runoff in the Existing and Proposed Conditions

See **Table 7** below for a comparison of existing and proposed runoff and peak flows into the ponding areas under a 100-year, 24-hour storm.

Table 7 - Runoff and Peak Flow Comparison

Ponding Area	Tributary Areas, Existing Condition	Tributary Areas, Proposed Condition	Total Runoff, Existing Condition (AC-FT)	Peak Discharge, Existing Condition (CFS)	Total Runoff, Proposed Condition (AC-FT)	Peak Discharge, Proposed Condition (CFS)
Pond-1	DA-1	DA-1, DA-2	0.61441	1.80800	0.63082	1.95006
Pond-2	DA-2, DA-3	None	1.00139	3.12619	0	0

It can be seen that compared to the existing condition, the total runoff to Pond-1 increased by 2.67% while the peak discharge increased by 7.86%, which are insignificant; runoff to Pond-2 is eliminated in the proposed condition entirely.

6. Hydraulic Analysis

The capacity of the proposed ditches, culverts and underdrains are analyzed using the Manning's equation, for 100-year 24-hour flow.

$$Q = \frac{1.49}{n} * A * R^{\left(\frac{2}{3}\right)} * S^{\left(\frac{1}{2}\right)}$$

Where:

Q or Q_{CAP} = Volumetric flow rate passing through the pipe in cfs.

A = Cross-sectional area of flow normal to the flow direction in ft^2

S = Bottom slope of the channel in ft/ft

n = Manning Roughness coefficient. Manning's value has been obtained from Table 9 in Alameda County Hydraulics and Hydrology Manual found in **Appendix F**.

R = Hydraulic Radius = A/P

P = Wetted perimeter of the cross-sectional area of flow in ft.

Q_{REQ} = Peak flow for 100-year storm event

The results are presented in **Table 8** and **Table 9** below.

Table 8 – Pipe Capacity Summary

Pipe Name	Tributary Drainage Areas	Peak flow 100 Year Q_{REQ} (cfs)	Pipe Dia. D (in)	Manning's (n)	Slope S (ft/ft)	Flow Velocity (fps)	Capacity Q_{CAP} (cfs)	$Q_{CAP}>Q_{REQ}$
SD-1	DA-3	1.40	10	0.01	0.005	3.69	2.01	Yes

Pipe Name	Tributary Drainage Areas	Peak flow 100 Year Q_{REQ} (cfs)	Pipe Dia. D (in)	Manning's (n)	Slope S (ft/ft)	Flow Velocity (fps)	Capacity Q_{CAP} (cfs)	$Q_{CAP}>Q_{REQ}$
UD-1	DA-4-1	0.46	6	0.01	0.005	2.63	0.52	Yes
UD-2	DA-4-2	0.46	6	0.01	0.005	2.63	0.52	Yes
SD-2	DA3, DA-4	2.32	12	0.012	0.005	3.47	2.73	Yes

Table 9 - Ditch Capacity Summary

Ditch Name	Tributary Drainage Areas	Peak flow 100 Year Q_{REQ} (cfs)	Bottom Width (ft)	Side Slope (H:V)	Ditch Depth (ft)	Manning's (n)	Slope S (ft/ft)	Flow Velocity (fps)	Capacity Q_{CAP} (cfs)	$Q_{CAP}>Q_{REQ}$
Ditch-1	DA-2	1.47	4	2	2.5	0.025	0.0014	2.89	65.05	Yes

It can be seen that all pipes and ditches have adequate capacity to accommodate 100-year, 24-hour flows.

List of Appendices

Appendix A: Exhibits and Drawings

Appendix B: Hydrologic Data

Appendix C: Calculations

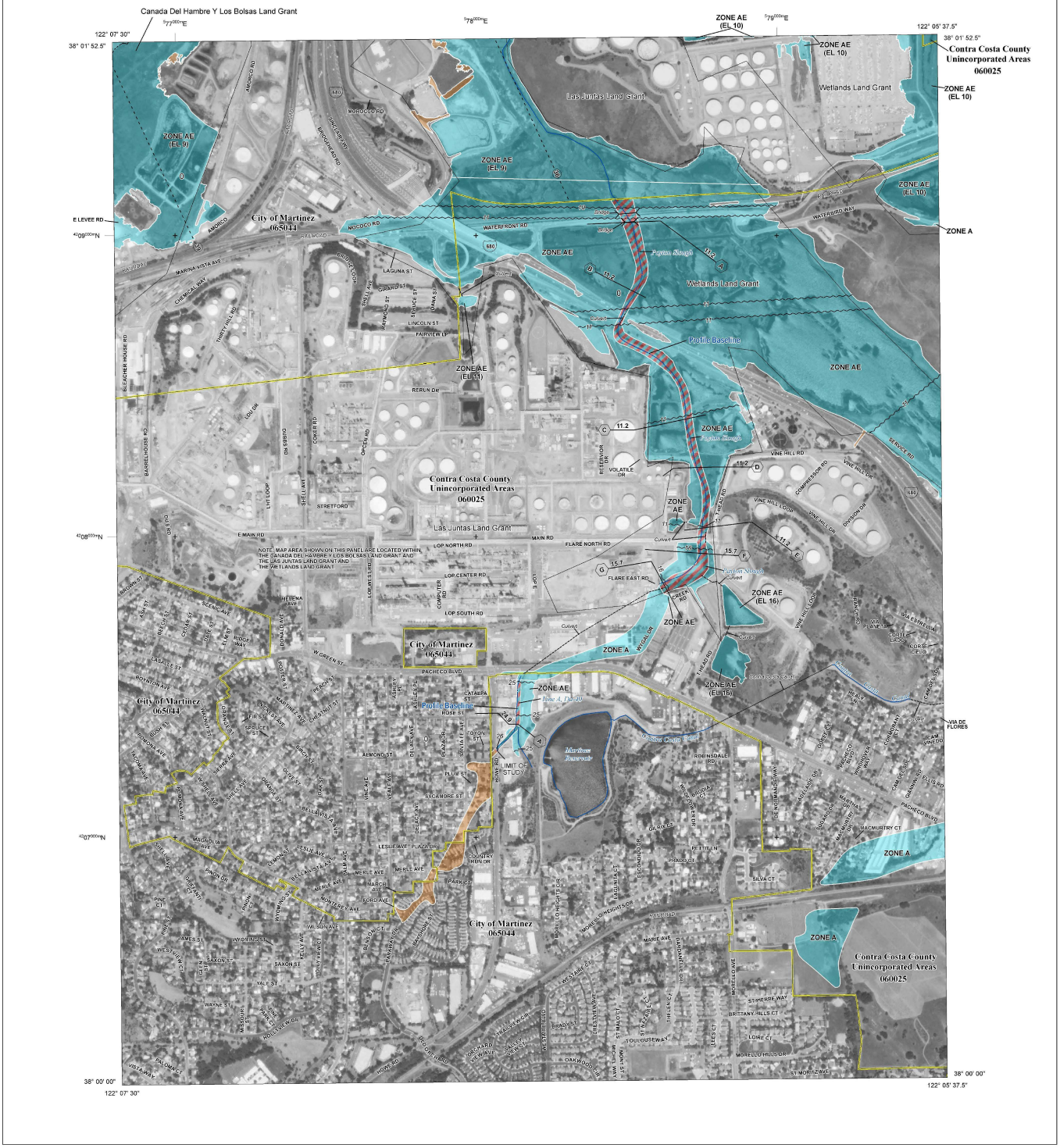
TransMontaigne Partners LLC



APPENDIX A

Exhibits and Drawings

JMA CIVIL



FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR ZONE DESCRIPTIONS AND INDEX MAP
THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT
HTTP://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A,V, A99* With BFE or Depth *Zone AE, AO, AH, VE, AR* Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X* Future Conditions 1% Annual Chance Flood Hazard *Zone X* Area with Reduced Flood Risk due to Levee See Notes. *Zone X*
OTHER AREAS	NO SCREEN Areas Determined to be Outside the 0.2% Annual Chance Floodplain *Zone X* Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer Levee, Dike, or Floodwall
OTHER FEATURES	18.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation (BFE) Coastal Transect Coastal Transect Baseline Profile Baseline Hydrographic Feature 513 Base Flood Elevation Line (BFE) Limit of Study Jurisdiction Boundary

NOTES TO USERS

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

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

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

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

Base map information shown on this FIRM was provided in digital format by the USDA National Agriculture Imagery Program (NAIP). This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2012.

SCALE

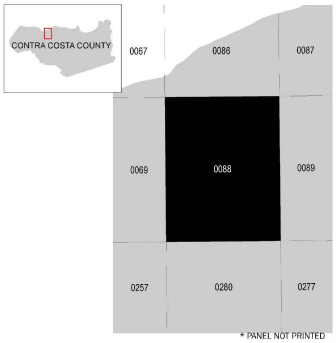
Map Projection:
NAD 1983 UTM Zone 10N;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet 1:6,000

0 500 1,000 2,000 Feet

0 125 250 500 Meters

PANEL LOCATOR



* PANEL NOT PRINTED

FEMA
National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

CONTRA COSTA COUNTY, California
And Incorporated Areas

PANEL 88 OF 602

FEMA

Panel Contains:

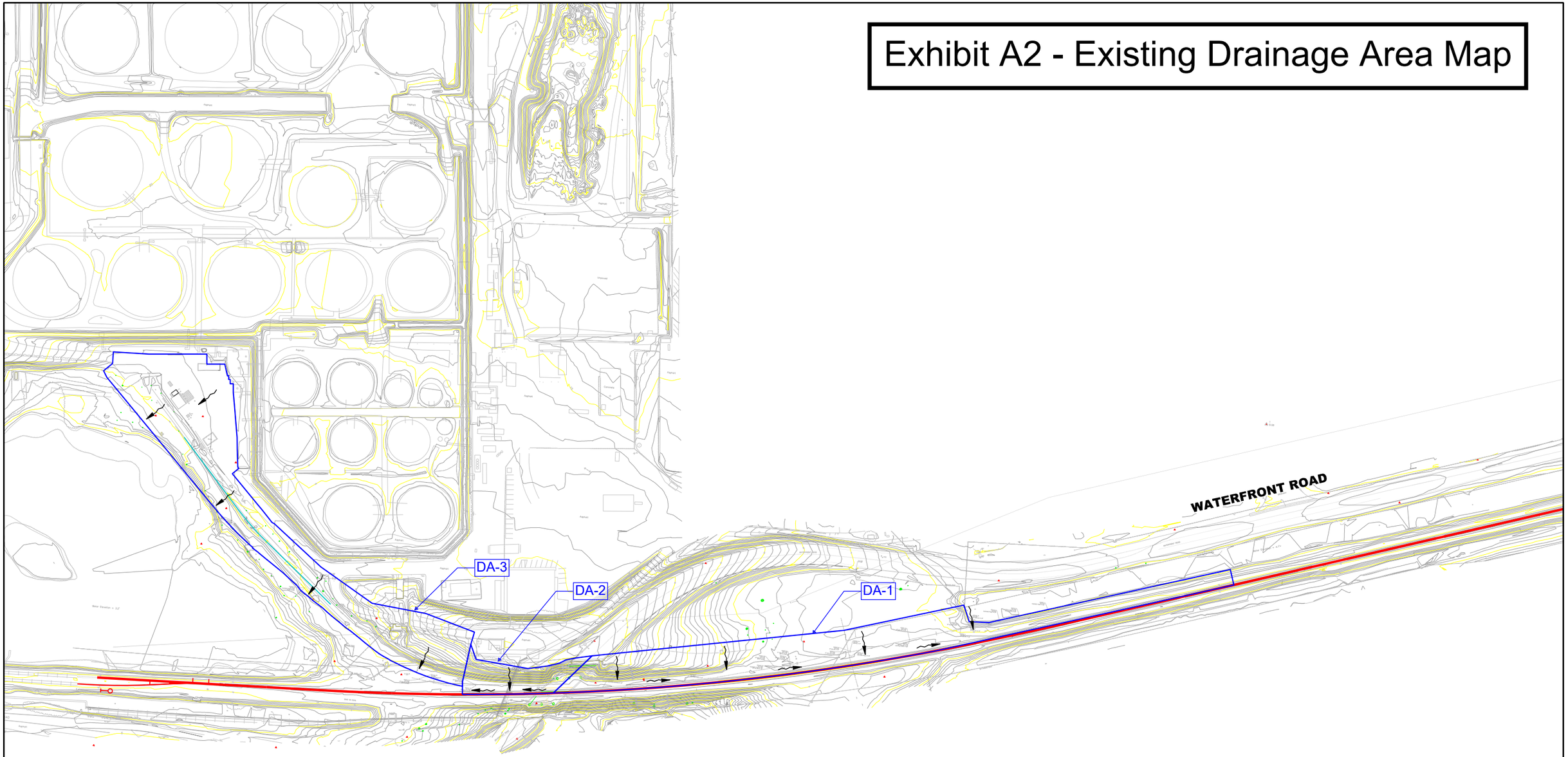
COMMUNITY	NUMBER	PANEL	SUFFIX
CONTRA COSTA COUNTY	060025	0088	H
MARTINEZ, CITY OF	065044	0088	H

VERSION NUMBER
2.3.3.2

MAP NUMBER
06013C0088H

EFFECTIVE DATE
March 21, 2017

Exhibit A2 - Existing Drainage Area Map

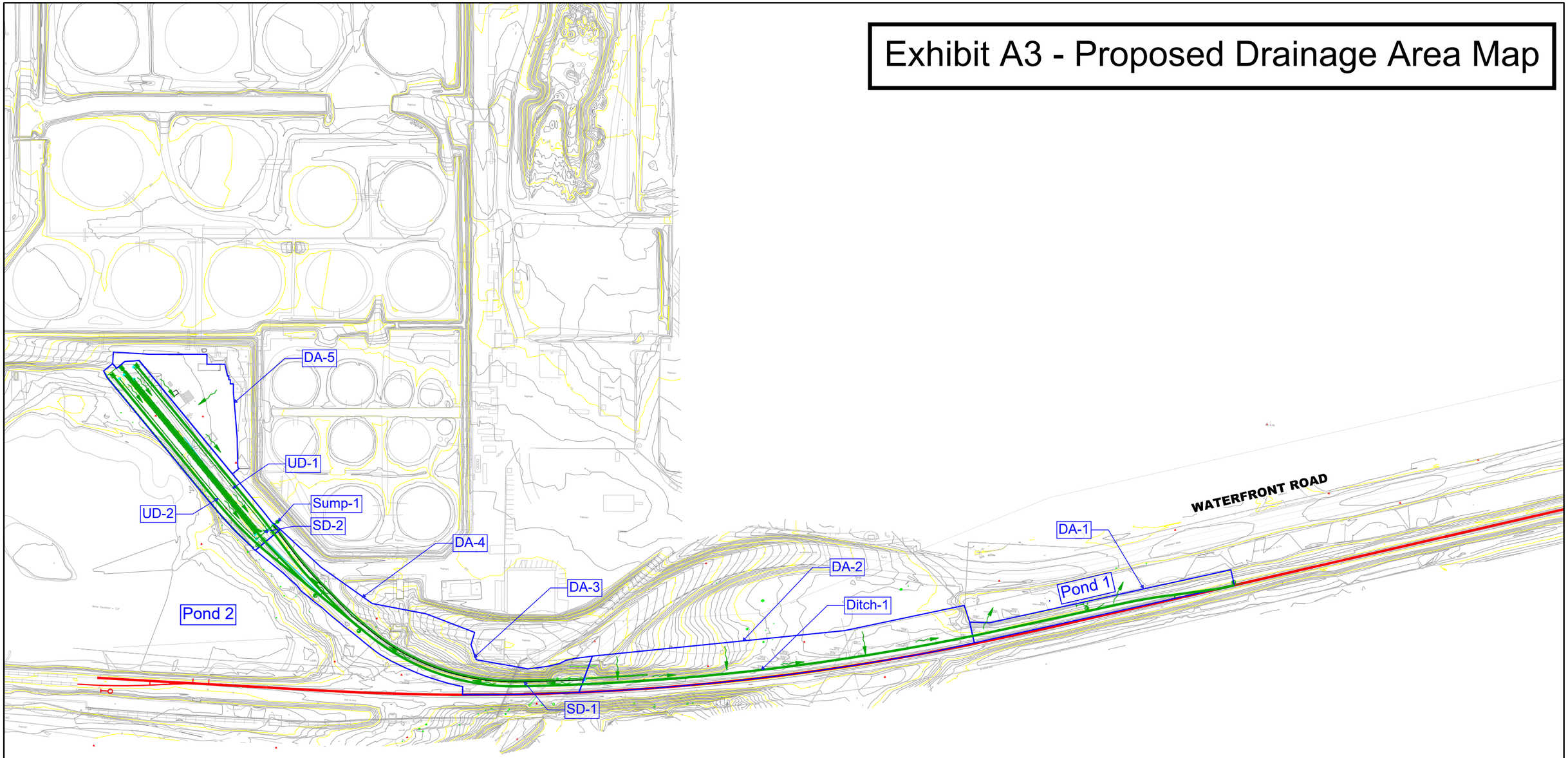


SUBCONSULTANT:	SUBCONSULTANT:	PRIME CONSULTANT: JMA CIVIL, 383 4th Street, Suite 201, Oakland, CA 94607, T: 925.400.4356, www.jmacivil.com	PROFESSIONAL SEAL:	ISSUE: DRAFT, NOT FOR CONSTRUCTION, -, 2/27/2024	REVISIONS: MARK / DATE / DESCRIPTION	TRANSMONTAIGNE MOCOCO INDUSTRIAL DEVELOPMENT PROJECT, 2801 WATERFRONT DR., MARTINEZ, CA 94553	SHEET TITLE: Existing Drainage Areas	PROJ NO: 19151; SCALE: AS NOTED; DATE: 2/27/2024; DESIGNED BY: ABR; SHEET NO. Exhibit A2; SHEET 1 OF 1

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Exhibit A3 - Proposed Drainage Area Map



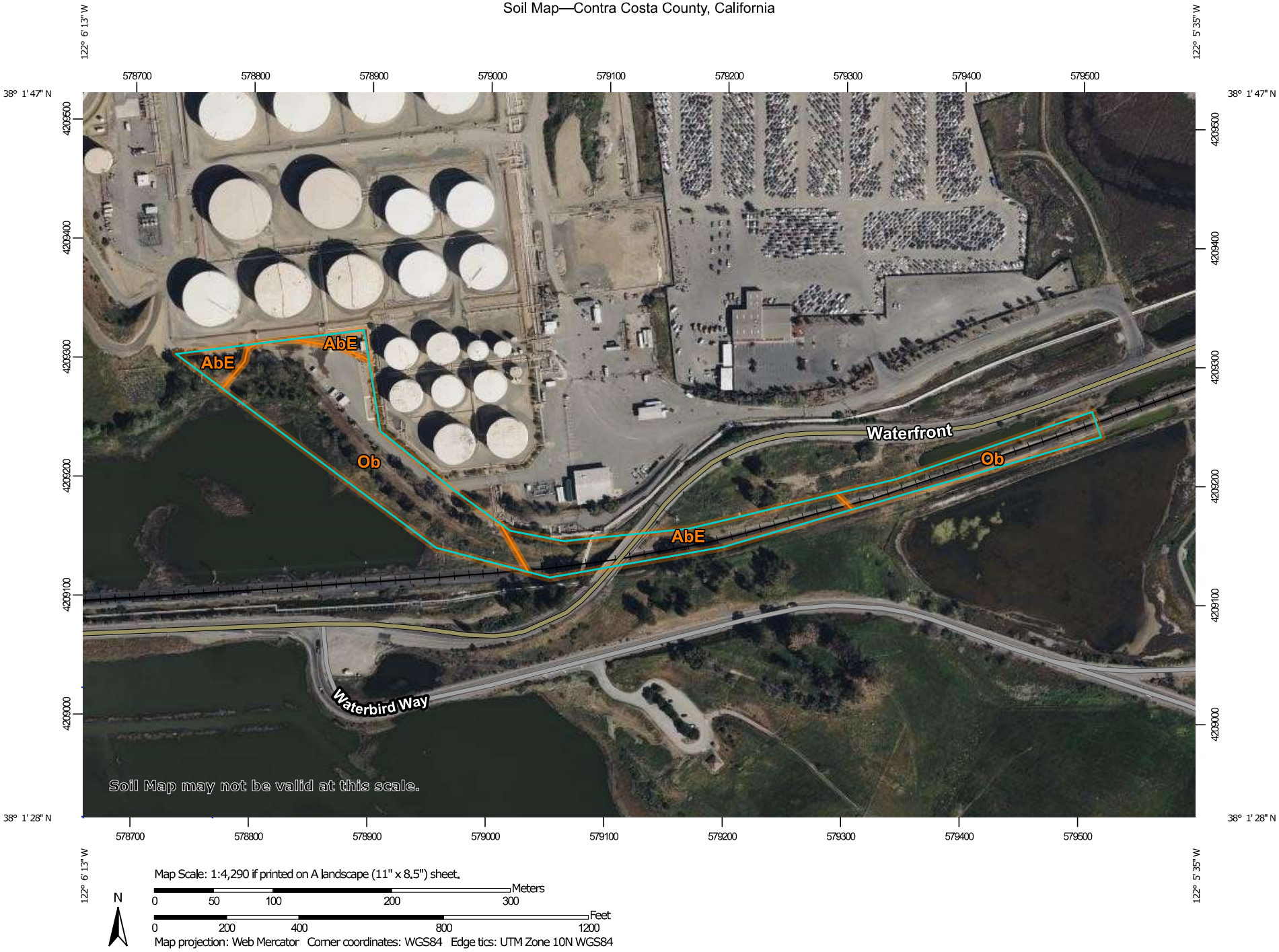
SUBCONSULTANT:	SUBCONSULTANT:	JMA CIVIL 383 4th Street, Suite 201 Oakland, CA 94607 T: 925.400.4356 www.jmacivil.com PRIME CONSULTANT:	PROFESSIONAL SEAL:	DRAFT NOT FOR CONSTRUCTION - 2/27/2024 ISSUE:	REVISIONS: MARK / DATE / DESCRIPTION	TRANSMONTAIGNE MOCOCO INDUSTRIAL DEVELOPMENT PROJECT 2801 WATERFRONT DR. MARTINEZ, CA 94553	SHEET TITLE: Proposed Drainage Areas PROJ NO: 19151 SCALE: AS NOTED DATE: 2/27/2024 DESIGNED BY: ABR SHEET NO. Exhibit A3 SHEET 1 OF 1

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Exhibit A4 - USDA Soil Map

Soil Map—Contra Costa County, California



Map Scale: 1:4,290 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

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

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 20, Sep 12, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2022—Apr 25, 2022

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AbE	Altamont clay, 15 to 30 percent slopes, MLRA 15	2.1	28.9%
Ob	Omni silty clay	5.1	71.1%
Totals for Area of Interest		**7.1**	**100.0%**

Contra Costa County, California

AbE—Altamont clay, 15 to 30 percent slopes, MLRA 15

Map Unit Setting

National map unit symbol: 2w626
Elevation: 10 to 1,730 feet
Mean annual precipitation: 12 to 25 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 320 to 360 days
Farmland classification: Not prime farmland

Map Unit Composition

Altamont and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Altamont

Setting

Landform: Hillslopes, mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from sandstone and shale

Typical profile

A - 0 to 14 inches: clay
Bss - 14 to 26 inches: clay
Bkss - 26 to 39 inches: clay
Bk - 39 to 48 inches: silty clay
Cr - 48 to 58 inches:

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R015XD001CA - CLAYEY

Hydric soil rating: No

Minor Components

Rincon

Percent of map unit: 3 percent
Landform: Depressions, drainageways
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: No

Linne

Percent of map unit: 3 percent
Landform: Mountain slopes, hillslopes
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Capay

Percent of map unit: 3 percent
Landform: Depressions, drainageways
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: No

Diablo

Percent of map unit: 3 percent
Landform: Hillslopes, mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Pescadero

Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave, convex
Across-slope shape: Concave
Hydric soil rating: Yes

Fontana

Percent of map unit: 1 percent
Landform: Hillslopes, mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Clear lake

Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave, linear
Across-slope shape: Concave

Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 20, Sep 12, 2023

Contra Costa County, California

Ob—Omni silty clay

Map Unit Setting

National map unit symbol: h9b7
Elevation: 10 to 100 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Omni and similar soils: 85 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Omni

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 8 inches: silty clay
H2 - 8 to 38 inches: clay
H3 - 38 to 60 inches: stratified loamy sand to sandy clay loam to clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 30 to 48 inches
Frequency of flooding: Rare
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 4w

Hydrologic Soil Group: D
Ecological site: R017XY903CA - Stream Channels and Floodplains
Hydric soil rating: Yes

Minor Components

Marcuse
Percent of map unit: 5 percent
Landform: Rims
Landform position (three-dimensional): Rise
Hydric soil rating: Yes

Reyes
Percent of map unit: 5 percent
Landform: Marshes
Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 20, Sep 12, 2023

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APPENDIX B

Hydrologic Data

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Appendix B - Point Precipitation Frequency Estimates

NOAA Atlas 14, Volume 6, Version 2
Location name: Martinez, California, USA*
Latitude: 38.0272°, Longitude: -122.1024°
Elevation: 2 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.104** (0.092-0.119)	**0.130** (0.115-0.149)	**0.165** (0.145-0.190)	**0.195** (0.170-0.226)	**0.238** (0.199-0.287)	**0.272** (0.222-0.338)	**0.309** (0.244-0.395)	**0.348** (0.266-0.460)	**0.403** (0.293-0.560)	**0.447** (0.312-0.648)
10-min	**0.150** (0.132-0.171)	**0.186** (0.164-0.213)	**0.237** (0.208-0.272)	**0.280** (0.243-0.324)	**0.341** (0.285-0.412)	**0.390** (0.318-0.484)	**0.443** (0.350-0.566)	**0.498** (0.381-0.659)	**0.577** (0.420-0.802)	**0.641** (0.447-0.928)
15-min	**0.181** (0.160-0.207)	**0.225** (0.199-0.258)	**0.286** (0.252-0.329)	**0.338** (0.294-0.392)	**0.412** (0.345-0.498)	**0.472** (0.385-0.585)	**0.535** (0.423-0.684)	**0.603** (0.461-0.797)	**0.698** (0.508-0.970)	**0.775** (0.541-1.12)
30-min	**0.249** (0.220-0.284)	**0.309** (0.273-0.354)	**0.393** (0.346-0.452)	**0.465** (0.404-0.539)	**0.566** (0.473-0.685)	**0.649** (0.528-0.804)	**0.735** (0.581-0.940)	**0.828** (0.633-1.10)	**0.959** (0.697-1.33)	**1.06** (0.743-1.54)
60-min	**0.350** (0.309-0.400)	**0.435** (0.384-0.498)	**0.553** (0.486-0.635)	**0.653** (0.569-0.758)	**0.796** (0.665-0.962)	**0.912** (0.743-1.13)	**1.03** (0.817-1.32)	**1.16** (0.890-1.54)	**1.35** (0.980-1.87)	**1.50** (1.04-2.17)
2-hr	**0.518** (0.458-0.592)	**0.641** (0.566-0.733)	**0.808** (0.711-0.928)	**0.949** (0.827-1.10)	**1.15** (0.959-1.39)	**1.31** (1.06-1.62)	**1.47** (1.16-1.88)	**1.65** (1.26-2.18)	**1.89** (1.38-2.63)	**2.09** (1.46-3.02)
3-hr	**0.651** (0.575-0.744)	**0.806** (0.712-0.923)	**1.02** (0.894-1.17)	**1.19** (1.04-1.38)	**1.44** (1.20-1.74)	**1.64** (1.33-2.03)	**1.84** (1.46-2.35)	**2.06** (1.57-2.72)	**2.35** (1.71-3.27)	**2.59** (1.81-3.75)
6-hr	**0.924** (0.817-1.06)	**1.16** (1.02-1.32)	**1.47** (1.29-1.68)	**1.73** (1.50-2.00)	**2.09** (1.74-2.52)	**2.37** (1.93-2.94)	**2.66** (2.10-3.40)	**2.97** (2.27-3.92)	**3.39** (2.46-4.71)	**3.72** (2.60-5.39)
12-hr	**1.20** (1.06-1.37)	**1.54** (1.36-1.76)	**2.00** (1.76-2.29)	**2.38** (2.07-2.76)	**2.90** (2.42-3.51)	**3.31** (2.70-4.11)	**3.74** (2.95-4.77)	**4.18** (3.20-5.52)	**4.79** (3.48-6.66)	**5.27** (3.68-7.63)
24-hr	**1.58** (1.43-1.78)	**2.10** (1.90-2.37)	**2.79** (2.51-3.15)	**3.35** (3.00-3.82)	**4.13** (3.59-4.85)	**4.74** (4.04-5.67)	**5.36** (4.47-6.55)	**6.00** (4.88-7.53)	**6.89** (5.39-8.97)	**7.58** (5.75-10.2)
2-day	**2.02** (1.83-2.28)	**2.74** (2.48-3.09)	**3.67** (3.31-4.16)	**4.43** (3.97-5.05)	**5.45** (4.74-6.40)	**6.23** (5.31-7.46)	**7.02** (5.85-8.59)	**7.83** (6.36-9.82)	**8.91** (6.98-11.6)	**9.75** (7.40-13.1)
3-day	**2.34** (2.12-2.64)	**3.19** (2.88-3.60)	**4.29** (3.87-4.85)	**5.17** (4.63-5.89)	**6.34** (5.51-7.45)	**7.23** (6.17-8.65)	**8.12** (6.77-9.94)	**9.02** (7.34-11.3)	**10.2** (8.01-13.3)	**11.1** (8.45-15.0)
4-day	**2.60** (2.36-2.93)	**3.56** (3.22-4.02)	**4.78** (4.32-5.41)	**5.76** (5.16-6.56)	**7.05** (6.12-8.28)	**8.02** (6.83-9.59)	**8.98** (7.49-11.0)	**9.95** (8.09-12.5)	**11.2** (8.79-14.6)	**12.2** (9.25-16.4)

7-day	**3.21** (2.91-3.62)	**4.36** (3.95-4.92)	**5.82** (5.25-6.58)	**6.96** (6.24-7.94)	**8.46** (7.35-9.93)	**9.56** (8.15-11.4)	**10.6** (8.87-13.0)	**11.7** (9.53-14.7)	**13.1** (10.3-17.1)	**14.1** (10.7-19.0)
10-day	**3.59** (3.25-4.05)	**4.86** (4.39-5.48)	**6.45** (5.81-7.29)	**7.68** (6.88-8.76)	**9.28** (8.07-10.9)	**10.5** (8.91-12.5)	**11.6** (9.67-14.2)	**12.7** (10.3-16.0)	**14.2** (11.1-18.4)	**15.2** (11.5-20.5)
20-day	**4.78** (4.33-5.39)	**6.42** (5.80-7.24)	**8.44** (7.61-9.55)	**9.99** (8.94-11.4)	**12.0** (10.4-14.1)	**13.4** (11.4-16.0)	**14.8** (12.3-18.1)	**16.1** (13.1-20.2)	**17.8** (13.9-23.2)	**19.0** (14.4-25.6)
30-day	**5.85** (5.30-6.60)	**7.79** (7.04-8.79)	**10.2** (9.16-11.5)	**12.0** (10.7-13.6)	**14.3** (12.4-16.8)	**15.9** (13.6-19.0)	**17.5** (14.6-21.4)	**19.0** (15.4-23.8)	**20.9** (16.3-27.2)	**22.2** (16.9-29.9)
45-day	**7.17** (6.49-8.08)	**9.42** (8.52-10.6)	**12.2** (11.0-13.8)	**14.2** (12.7-16.2)	**16.8** (14.6-19.8)	**18.7** (15.9-22.4)	**20.5** (17.1-25.0)	**22.1** (18.0-27.8)	**24.2** (19.0-31.6)	**25.7** (19.5-34.6)
60-day	**8.60** (7.78-9.69)	**11.2** (10.1-12.6)	**14.3** (12.9-16.1)	**16.6** (14.9-18.9)	**19.5** (17.0-22.9)	**21.6** (18.4-25.8)	**23.5** (19.6-28.8)	**25.4** (20.7-31.9)	**27.7** (21.7-36.1)	**29.3** (22.3-39.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

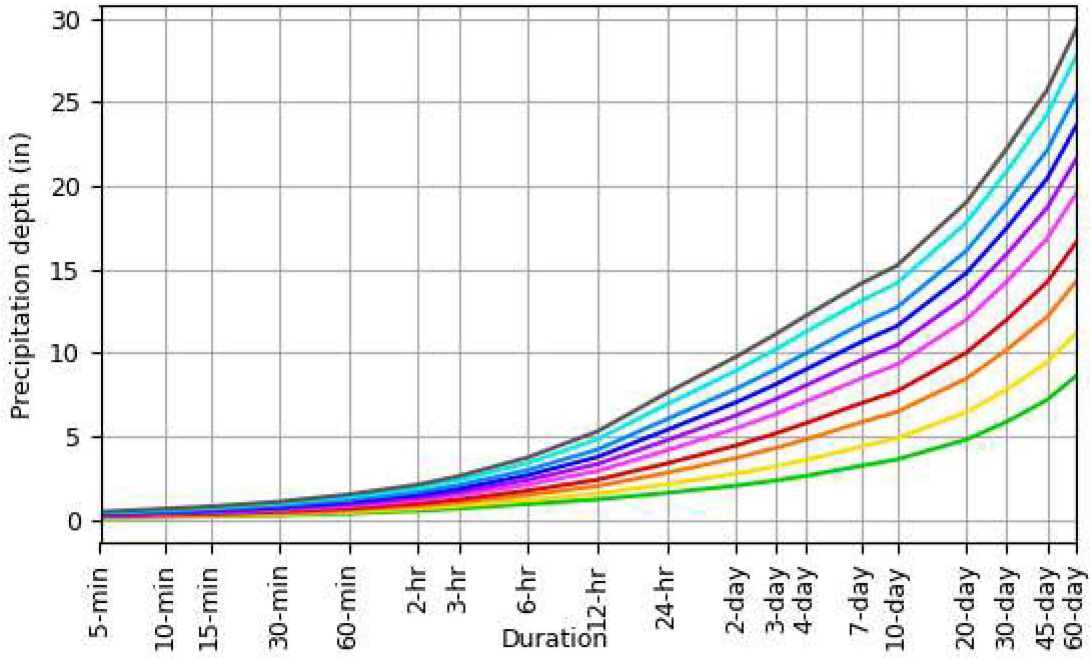
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

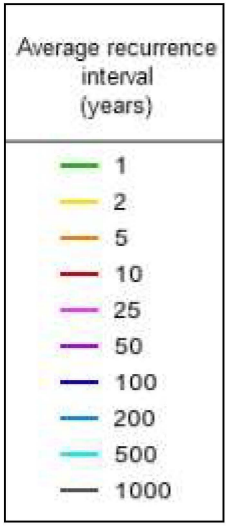
Please refer to NOAA Atlas 14 document for more information.

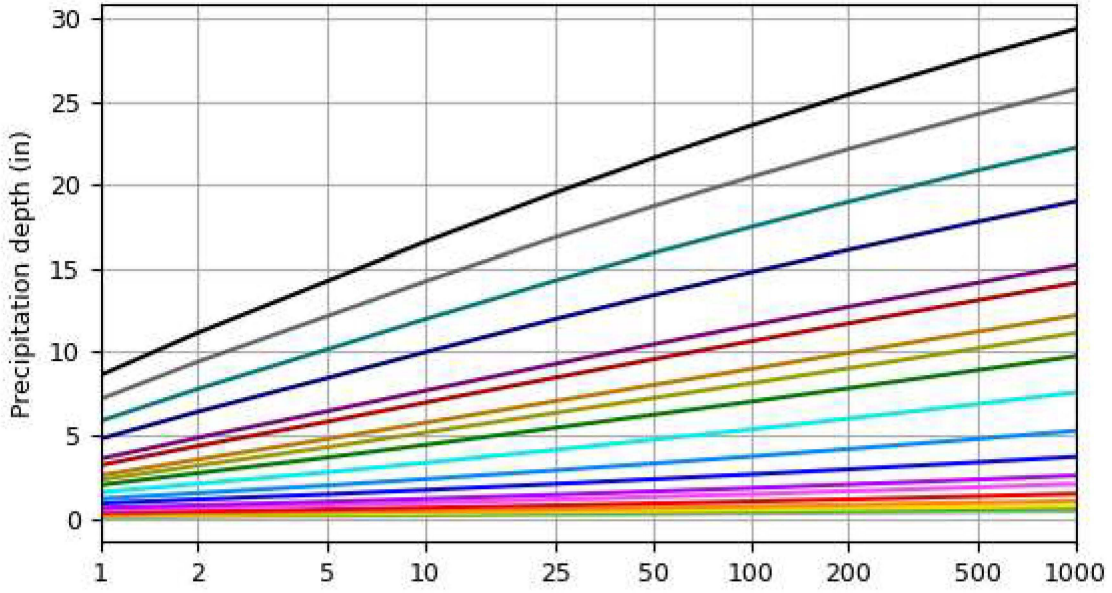
Back to Top

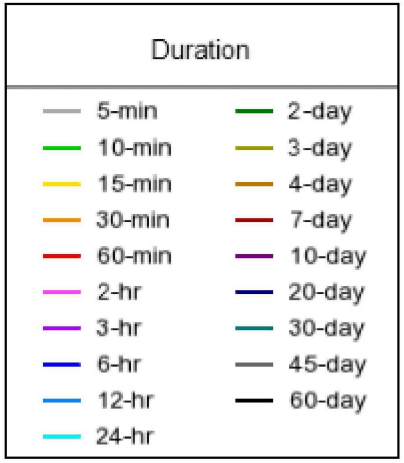
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 38.0272°, Longitude: -122.1024°









Average recurrence interval (years)

NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Tue Feb 27 21:47:19 2024

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Maps & aerials

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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APPENDIX C

Calculations

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Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Existing Open Spaces — Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Existing Operating Area — Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Railroad Trackbed — Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Prop. Unloading Area — Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Chapter 3 Time of Concentration and Travel Time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

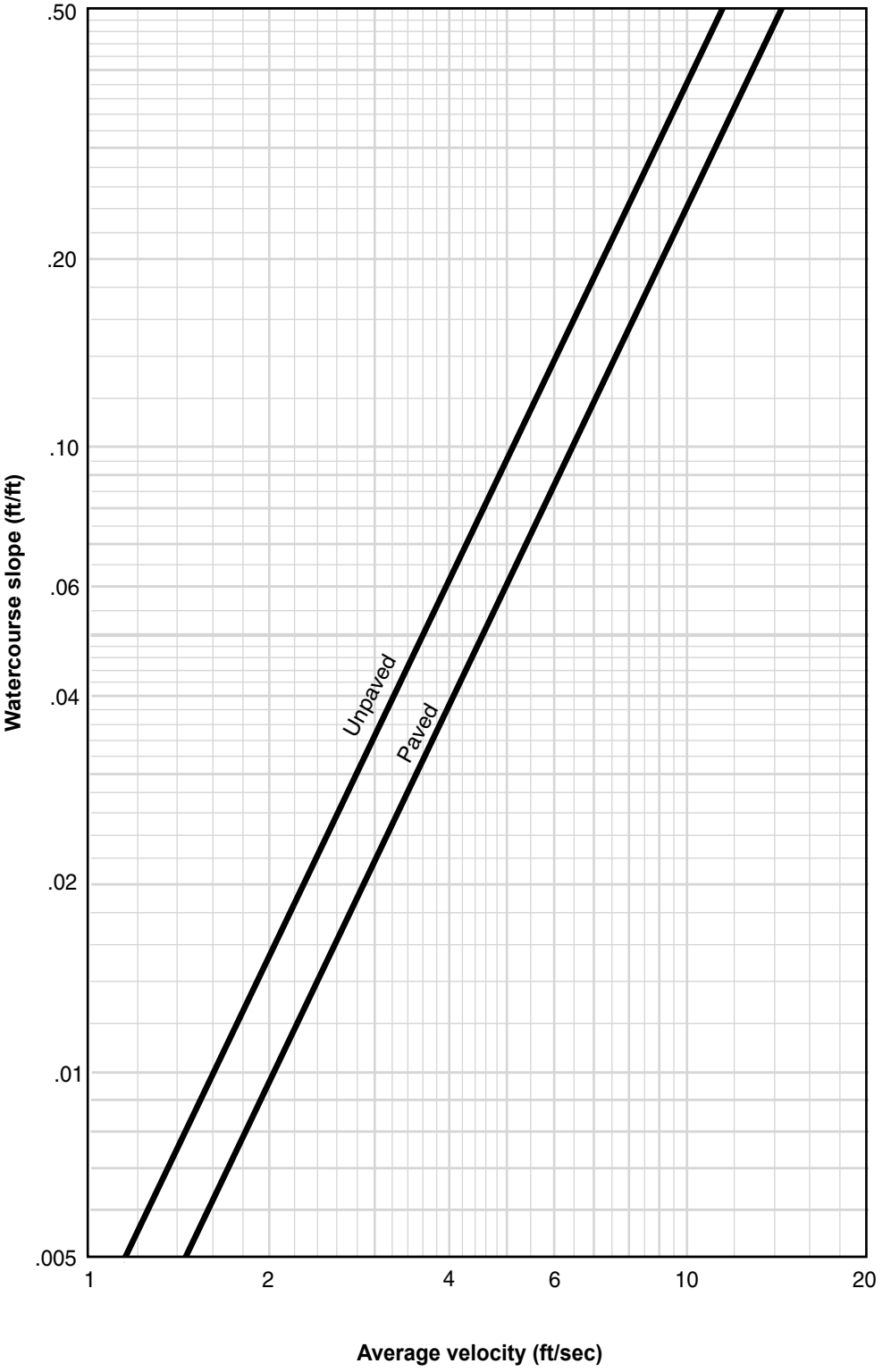
Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1/]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2/]	0.24
Bermudagrass .	0.41
Range (natural)	0.13
Woods:[3/]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- The minimum T_c used in TR-55 is 0.1 hour.

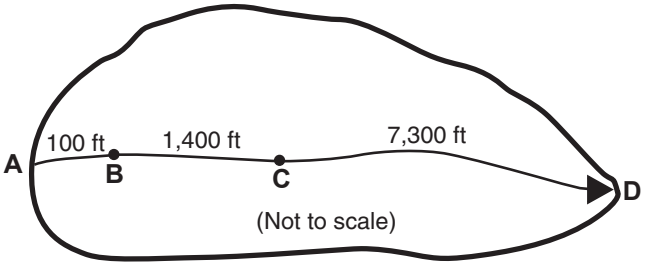
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft. Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1,400 ft. Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7,300 ft.

See figure 3-2 for the computations made on worksheet 3.



Chapter 4 Graphical Peak Discharge Method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is:

$$q_p = q_u A_m Q F_p \qquad \text{[eq. 4-1]}$$

where:

q_p = peak discharge (cfs)
q_u = unit peak discharge (csm/in)
A_m = drainage area (mi^2)
Q = runoff (in)
F_p = pond and swamp adjustment factor

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a / P is then computed.

If the computed I_a / P ratio is outside the range in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a / P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a / P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

Figure 4-1 Variation of I_a / P for P and CN

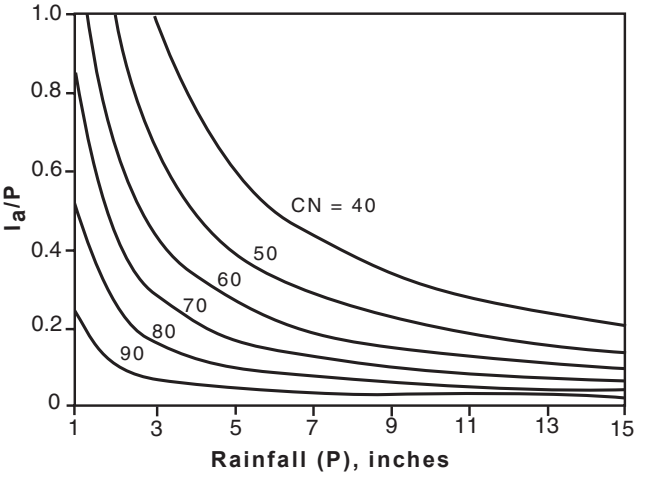
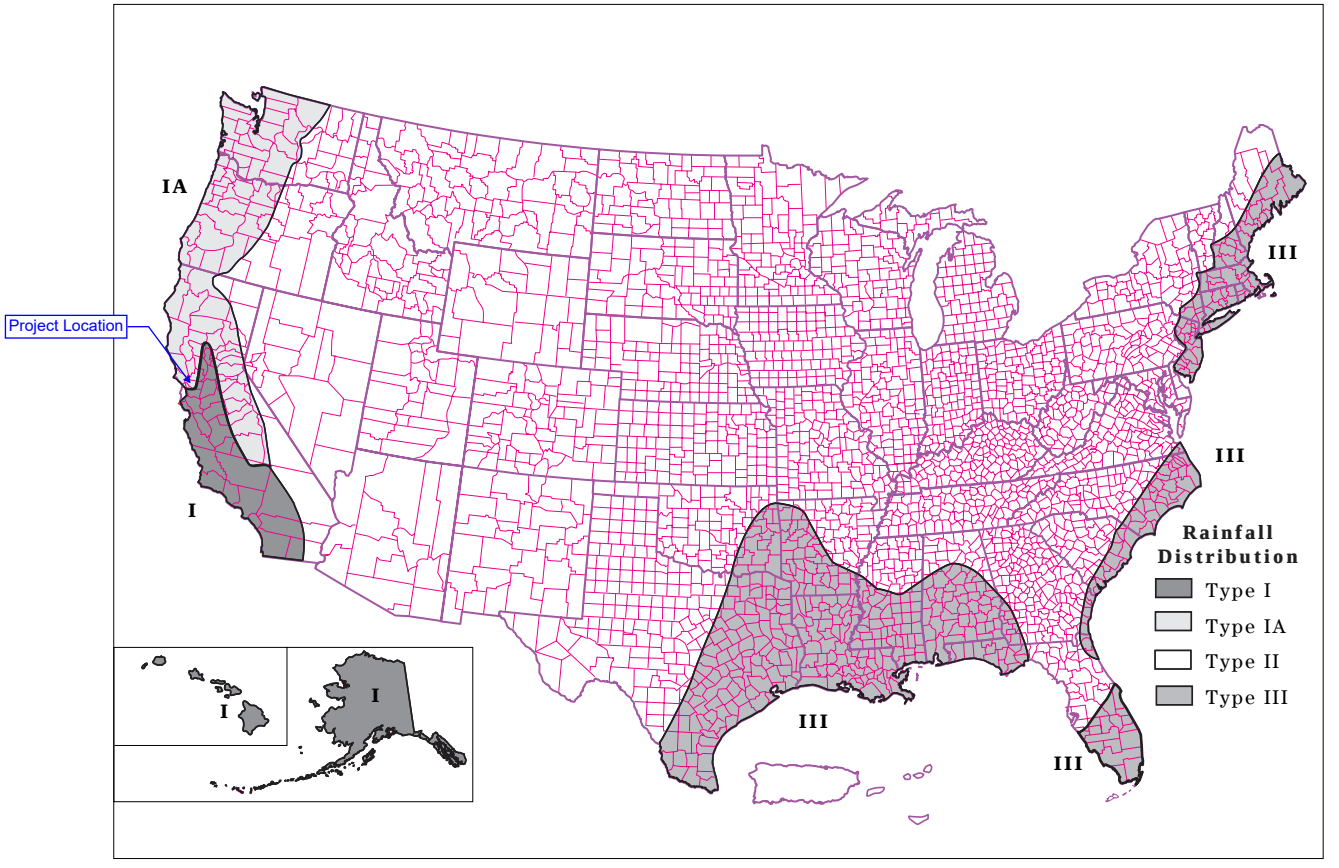


Table 4-1 I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Appendix C2 - Data to be used with the SCS Runoff Method in HEC-HMS

Existing Conditions							Proposed Conditions						
Trib Area	Description	CN	Areas		tc (min)	lag (min)	Trib Area	Description	CN	Areas		tc (min)	lag (min)
			Acre	Square Mile						Acres	Square Mile		
DA-1	East of Waterfront Rd	87.88	1.85	0.00289063	18.3	11.0	DA-1	Ind. Lead Drain to Pond-1	91.00	0.42	0.00065625	5.00	3.00
DA-2	West of Waterfront Rd	86.52	0.33	0.00051563	7.6	4.6	DA-2	Ind. Lead Drain to Ditch-1	88.27	1.42	0.00221875	10.94	6.56
DA-3	Ex. Operating Area and Spur	93.43	2.33	0.00364063	5.0	3.0	DA-3	Ind. Lead Drain to SD-1	89.24	1.32	0.00206250	13.06	7.83
							DA-4	Unloading Area	93.00	0.78	0.00121875	5.00	3.00
							DA-5	Ex. Operating Area	98.00	0.58	0.00090625	6.25	3.75
		Total	**4.51**	**0.00704688**					**Total**	**4.52**	**0.00706250**		

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Existing DA-1	ABR	2/23/2024

Check one: [X] Present [ ] Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area [■] acres [ ] mi2 [ ] %	Product of CN X Area
Group D	Existing and Proposed Railroad Trackbed	91			0.24	21.89161054
Group D	Open Area	89			0.56	49.98448311
Group C	Existing and Proposed Railroad Trackbed	89			0.20	17.65289256
Group C	Open Area	86			0.85	73.05376107
	* Use only one CN source per line			**Totals**	1.85	162.5827473

CN(weighted) = Total product / total area = 162.5827473 / 1.85 = 87.88257

Use CN	87.8826
Ia (in)	0.273

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.039	3.411	4.000

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Existing DA-2	ABR	2/23/2024

Check one: [X] Present [ ] Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area [■] acres [ ] mi2 [ ] %	Product of CN X Area
Group C	Existing and Proposed Railroad Trackbed	89			0.06	5.138095041
Group C	Open Area	86			0.27	23.41509917
	Totals				0.33	28.55319421

* Use only one CN source per line

CN(weighted) = Total product / total area = 28.55319421 / 0.33 = 86.52483

Use CN	86.5248
Ia (in)	0.299

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	0.956	3.276	3.858

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Existing DA-3	ABR	2/23/2024

Check one: [X] Present [ ] Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area [■] acres [ ] mi2 [ ] %	Product of CN X Area
Group D	Existing Operating Area	98			1.15	112.4772727
Group D	Open Area	89			1.18	105.2222727

* Use only one CN source per line

Totals 2.33 217.6995455

CN(weighted) = Total product / total area = 217.6995455 / 2.33 = 93.43328

Use CN 93.4333

Ia (in) 0.128

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.442	3.990	4.600

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Existing DA-1	Checked	ABR	Date	2/23/2024

Check one: ☒ Present ☐ Developed

Check one: ☒ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Open Area				
1. Surface description (table 3-1)			Dense Grass				
2. Manning's roughness coefficient, n (table 3-1)			0.240				
3. Flow length, L (total L ≤ 300 ft)		ft	30.000	35.000			
4. Two-year 24-hour rainfall, p2		in	2.100	2.100			
5. Land slope, s		ft/ft	0.020	0.629			
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P2^{0.5}*s^{0.4}}$	Compute Tt	hr	0.112058	+ 0.0319205	=	0.144	

Shallow concentrated flow

	Segment ID	Trackbed Toe				
7. Surface description (paved or unpaved)			Paved			
8. Flow length, L	ft	842.000				
9. Watercourse slope, s	ft/ft	0.005				
10. Average velocity, V (figure 3-1)	ft/s	1.450				
11. Tt = $\frac{L}{3600\,V}$ Compute Tt	hr	0.161303	+ 0	=	0.1613	

Channel flow

	Segment ID					
12. Cross sectional flow area, a	ft^2					
13. Wetted perimeter, Pw	ft					
14. Hydraulic radius, r = a/Pw Compute r	ft					
15. Channel slope, s	ft/ft					
16. Manning's roughness coefficient, n						
17. V = $\frac{1.49*r^{(2/3)}*s^{(1/2)}}{n}$ Compute V	$\frac{ft}{s}$					
18. Flow length, L	ft					
19. Tt = $\frac{L}{3600\,V}$ Compute Tt	hr	0	+ 0	=	0	

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.3053

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Existing DA-2	Checked	ABR	Date	2/23/2024

Check one: [X] Present [ ] Developed

Check one: [X] Tc [ ] Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Open Area				
1. Surface description (table 3-1)			Dense Grass				
2. Manning's roughness coefficient, n (table 3-1)			0.240				
3. Flow length, L (total L ≤ 300 ft)		ft	10.000	29.000			
4. Two-year 24-hour rainfall, p2		in	2.100	2.100			
5. Land slope, s		ft/ft	0.010	0.862			
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$	Compute Tt	hr	0.061398	+ 0.0242024	=	0.0856	

Shallow concentrated flow

		Segment ID	Trackbed Toe				
7. Surface description (paved or unpaved)			Paved				
8. Flow length, L		ft	217.000				
9. Watercourse slope, s		ft/ft	0.005				
10. Average velocity, V (figure 3-1)		ft/s	1.450				
11. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0.041571	+ 0	=	0.0416	

Channel flow

		Segment ID					
12. Cross sectional flow area, a		ft^2					
13. Wetted perimeter, Pw		ft					
14. Hydraulic radius, r = a/Pw	Compute r	ft					
15. Channel slope, s		ft/ft					
16. Manning's roughness coefficient, n							
17. V = $\frac{1.49\,r^{(2/3)} s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$					
18. Flow length, L		ft					
19. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0	+ 0	=	0	

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.1272

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Existing DA-3	Checked	ABR	Date	2/23/2024

Check one: [X] Present [ ] Developed

Check one: [X] Tc [ ] Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Operating	Open Area		
1. Surface description (table 3-1)			Asphalt	Short Grass		
2. Manning's roughness coefficient, n (table 3-1)			0.011	0.150		
3. Flow length, L (total L ≤ 300 ft)		ft	147.000	57.000		
4. Two-year 24-hour rainfall, p2		in	2.100	2.100		
5. Land slope, s		ft/ft	0.014	0.051		
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P2^{0.5}*s^{0.4}}$	Compute Tt	hr	0.038815	+ 0.0109444	=	0.0498

Shallow concentrated flow

		Segment ID				
7. Surface description (paved or unpaved)						
8. Flow length, L		ft				
9. Watercourse slope, s		ft/ft				
10. Average velocity, V (figure 3-1)		ft/s				
11. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0	+ 0	=	0

Channel flow

		Segment ID				
12. Cross sectional flow area, a		ft^2				
13. Wetted perimeter, Pw		ft				
14. Hydraulic radius, r = a/Pw	Compute r	ft				
15. Channel slope, s		ft/ft				
16. Manning's roughness coefficient, n						
17. V = $\frac{1.49*r^{(2/3)}*s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$				
18. Flow length, L		ft				
19. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0	+ 0	=	0

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.0833

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Proposed DA-1	ABR	2/23/2024

Check one: ☐ Present ☒ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area ☒ acres ☐ mi2 ☐ %	Product of CN X Area
Group D	Existing and Proposed Railroad Trackbed	91			0.42	38.22

* Use only one CN source per line

Totals 0.42 38.22

CN(weighted) = Total product / total area = 38.22 / 0.42 = 91

Use CN 91

Ia (in) 0.198

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.252	3.730	4.332

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Proposed DA-2	ABR	2/23/2024

Check one: ☐ Present ☒ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area ☒ acres ☐ mi2 ☐ %	Product of CN X Area
Group D	Existing and Proposed Railroad Trackbed	91			0.21	19.39451079
Group D	Open Area	89			0.20	17.68586915
Group C	Existing and Proposed Railroad Trackbed	89			0.52	46.36630303
Group C	Open Area	86			0.49	41.89801148
				Totals	1.42	125.3446944

* Use only one CN source per line

CN(weighted) = Total product / total area = 125.3446944 / 1.42 = 88.27091

Use CN	88.2709
Ia (in)	0.247

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.064	3.450	4.040

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Proposed DA-3	ABR	2/23/2024

Check one: ☐ Present ☒ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area ☒ acres ☐ mi2 ☐ %	Product of CN X Area
Group D	Existing and Proposed Railroad Trackbed	91			0.42	37.77575872
Group D	Open Area	89			0.56	49.87471327
Group C	Existing and Proposed Railroad Trackbed	89			0.17	15.29831543
Group C	Open Area	86			0.17	14.84364738
				Totals	1.32	117.7924348

* Use only one CN source per line

CN(weighted) = Total product / total area = 117.7924348 / 1.32 = 89.23669

Use CN	89.2367
Ia (in)	0.222

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.127	3.548	4.143

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Proposed DA-4	ABR	2/23/2024

Check one: ☐ Present ☒ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area ☒ acres ☐ mi2 ☐ %	Product of CN X Area
Group D	Proposed Unloading Area	93			0.78	72.54

* Use only one CN source per line

Totals 0.78 72.54

CN(weighted) = Total product / total area = 72.54 / 0.78 = 93

Use CN 93

Ia (in) 0.151

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.406	3.943	4.552

Worksheet 2: Runoff curve number and runoff

Project	By	Date
TransMontaigne	ZW	2/23/2024
Location	**Checked**	**Date**
Proposed DA-5	ABR	2/23/2024

Check one: ☐ Present ☒ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN* Table 2-2	CN* Figure 2-3	CN* Figure 2-4	Area ☒ acres ☐ mi2 ☐ %	Product of CN X Area
Group D	Existing Operating Area	98			0.58	56.84

* Use only one CN source per line

Totals 0.58 56.84

CN(weighted) = Total product / total area = 56.84 / 0.58 = 98

Use CN 98

Ia (in) 0.041

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	50	100
Rainfall, P (24-hour)	in	2.1	4.74	5.36
Runoff, Q (use P and CN with table 2-1, figure 2-1, or equation 2-3 and 2-4)	in	1.874	4.504	5.123

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Proposed DA-1	Checked	ABR	Date	2/23/2024

Check one: ☐ Present ☒ Developed

Check one: ☒ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Trackbed				
1. Surface description (table 3-1)			Gravel				
2. Manning's roughness coefficient, n (table 3-1)			0.011				
3. Flow length, L (total L ≤ 300 ft)		ft	43				
4. Two-year 24-hour rainfall, p2		in	2.1				
5. Land slope, s		ft/ft	0.02				
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P2^{0.5}*s^{0.4}}$	Compute Tt	hr	0.01269	+	0	=	0.0127

Shallow concentrated flow

		Segment ID					
7. Surface description (paved or unpaved)							
8. Flow length, L		ft					
9. Watercourse slope, s		ft/ft					
10. Average velocity, V (figure 3-1)		ft/s					
11. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0	+	0	=	0

Channel flow

		Segment ID					
12. Cross sectional flow area, a		ft^2					
13. Wetted perimeter, Pw		ft					
14. Hydraulic radius, r = a/Pw	Compute r	ft					
15. Channel slope, s		ft/ft					
16. Manning's roughness coefficient, n							
17. V = $\frac{1.49*r^{(2/3)}*s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$					
18. Flow length, L		ft					
19. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0	+	0	=	0

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.0833

Worksheet 3: Time of Concentration (Tc) or Travel time (T_t)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Proposed DA-2	Checked	ABR	Date	2/23/2024

Check one: ☐ Present ☒ Developed

Check one: ☒ Tc ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Open Area				
1. Surface description (table 3-1)			Dense Grass				
2. Manning's roughness coefficient, n (table 3-1)			0.240				
3. Flow length, L (total L ≤ 300 ft)		ft	30.000	15.000			
4. Two-year 24-hour rainfall, p2		in	2.100	2.100			
5. Land slope, s		ft/ft	0.020	0.833			
6. $Tt = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$	Compute Tt	hr	0.112	+ 0.014	=	0.1265	

Shallow concentrated flow

		Segment ID					
7. Surface description (paved or unpaved)							
8. Flow length, L		ft					
9. Watercourse slope, s		ft/ft					
10. Average velocity, V (figure 3-1)		ft/s					
11. $Tt = \frac{L}{3600\,V}$	Compute Tt	hr	0.000	+ 0.000	=	0	

Channel flow

		Segment ID	Ditch	Ditch			
12. Cross sectional flow area, a		ft^2	22.500	22.500			
13. Wetted perimeter, Pw		ft	15.180	15.180			
14. Hydraulic radius, r = a/Pw	Compute r	ft	1.482	1.482			
15. Channel slope, s		ft/ft	0.005	0.001			
16. Manning's roughness coefficient, n			0.025	0.025			
17. $V = \frac{1.49 r^{(2/3)} s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$	5.479	2.899			
18. Flow length, L		ft	462.000	338.000			
19. $Tt = \frac{L}{3600\,V}$	Compute Tt	hr	0.023	+ 0.032	=	0.0558	

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.1823

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Proposed DA-3	Checked	ABR	Date	2/23/2024

Check one: ☐ Present ☒ Developed

Check one: ☒ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Open Area				
1. Surface description (table 3-1)			Dense Grass				
2. Manning's roughness coefficient, n (table 3-1)			0.240				
3. Flow length, L (total L ≤ 300 ft)		ft	10.000	32.000			
4. Two-year 24-hour rainfall, p2		in	2.100	2.100			
5. Land slope, s		ft/ft	0.010	0.547			
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P2^{0.5}*s^{0.4}}$	Compute Tt	hr	0.061	+ 0.031	=	0.0928	

Shallow concentrated flow

		Segment ID					
7. Surface description (paved or unpaved)							
8. Flow length, L		ft					
9. Watercourse slope, s		ft/ft					
10. Average velocity, V (figure 3-1)		ft/s					
11. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0.000	+ 0.000	=	0	

Channel flow

		Segment ID	Pipe				
12. Cross sectional flow area, a		ft^2	0.545				
13. Wetted perimeter, Pw		ft	2.618				
14. Hydraulic radius, r = a/Pw	Compute r	ft	0.208				
15. Channel slope, s		ft/ft	0.005				
16. Manning's roughness coefficient, n			0.022				
17. V = $\frac{1.49*r^{(2/3)}*s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$	1.683				
18. Flow length, L		ft	756.000				
19. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0.125	+ 0.000	=	0.1248	

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.2176

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Proposed DA-4	Checked	ABR	Date	2/23/2024

Check one: ☐ Present ☒ Developed

Check one: ☒ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Unloading				
1. Surface description (table 3-1)			Gravel				
2. Manning's roughness coefficient, n (table 3-1)			0.011				
3. Flow length, L (total L ≤ 300 ft)		ft	18.250				
4. Two-year 24-hour rainfall, p2		in	2.100				
5. Land slope, s		ft/ft	0.020				
6. Tt = $\frac{0.007\,(nL)^{0.8}}{P2^{0.5}*s^{0.4}}$	Compute Tt	hr	0.006	+	0.000	=	0.0064

Shallow concentrated flow

		Segment ID					
7. Surface description (paved or unpaved)							
8. Flow length, L		ft					
9. Watercourse slope, s		ft/ft					
10. Average velocity, V (figure 3-1)		ft/s					
11. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0.000	+	0.000	=	0

Channel flow

		Segment ID	Pipe	Pipe			
12. Cross sectional flow area, a		ft^2	0.196	0.349			
13. Wetted perimeter, Pw		ft	1.571	2.094			
14. Hydraulic radius, r = a/Pw	Compute r	ft	0.125	0.167			
15. Channel slope, s		ft/ft	0.005	0.005			
16. Manning's roughness coefficient, n			0.010	0.022			
17. V = $\frac{1.49*r^{(2/3)}*s^{(1/2)}}{n}$	Compute V	$\frac{ft}{s}$	2.634	1.450			
18. Flow length, L		ft	430.000	56.000			
19. Tt = $\frac{L}{3600\,V}$	Compute Tt	hr	0.045	+	0.011	=	0.0561

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.0833

Worksheet 3: Time of Concentration (Tc) or Travel time (Tt)

Project	TransMontaigne	By	ZW	Date	2/23/2024
Location	Proposed DA-5	Checked	ABR	Date	2/23/2024

Check one: ☐ Present ☒ Developed

Check one: ☒ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

		Segment ID	Operating				
1. Surface description (table 3-1)			Asphalt				
2. Manning's roughness coefficient, n (table 3-1)			0.011				
3. Flow length, L (total L ≤ 300 ft)		ft	115.000				
4. Two-year 24-hour rainfall, p2		in	2.100				
5. Land slope, s		ft/ft	0.017				
6. $Tt = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$	Compute Tt	hr	0.029	+	0.000	=	0.0295

Shallow concentrated flow

		Segment ID	Curb				
7. Surface description (paved or unpaved)			Paved				
8. Flow length, L		ft	390.000				
9. Watercourse slope, s		ft/ft	0.005				
10. Average velocity, V (figure 3-1)		ft/s	1.450				
11. $Tt = \frac{L}{3600\,V}$	Compute Tt	hr	0.075	+	0.000	=	0.0747

Channel flow

		Segment ID					
12. Cross sectional flow area, a		ft^2					
13. Wetted perimeter, Pw		ft					
14. Hydraulic radius, r = a/Pw	Compute r	ft					
15. Channel slope, s		ft/ft					
16. Manning's roughness coefficient, n							
17. $V = \frac{1.49 r^{(2/3)} s^{(1/2)}}{n}$	Compute V	ft/s					
18. Flow length, L		ft					
19. $Tt = \frac{L}{3600\,V}$	Compute Tt	hr	0.000	+	0.000	=	0

20. Watershed or subarea Tc or Tt (add steps 6, 11, and 19; if less than 5 min, use 5 min) Hr 0.1042

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Manning's Roughness Coefficients

Manning's roughness coefficients for some common materials.

The Manning's roughness coefficient is used in the Manning's equation to calculate flow in open channels.

Coefficients for some commonly used surface materials:

Manning's Roughness Coefficients vs. Channel Type

Surface Material	Manning's Roughness Coefficient - *n* -
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick and cement mortar sewers	0.015
Canvas	0.012
Cast or Ductile iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011

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Surface Material	Manning's Roughness Coefficient - *n* -
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011
Rubble Masonry	0.017 - 0.022
Steel - Coal-tar enamel	0.010
Steel - smooth	0.012
Steel - New unlined	0.011
Steel - Riveted	0.019
Vitrified clay sewer pipe	0.013 - 0.015
Wood - planed	0.012
Wood - unplaned	0.013
Wood stave pipe, small diameter	0.011 - 0.012
Wood stave pipe, large diameter	0.012 - 0.013

Related Topics

- **Fluid Mechanics**

  The study of fluids - liquids and gases. Involving velocity, pressure, density and temperature as functions of space and time.

Related Documents

- **AWWA C115 - Ductile-Iron Threaded Pipe - Dimensions**

  Dimensions of threaded ductile-iron pipe according AWWA C115.
- **AWWA C151 - Ductile-Iron Pipe Centrifugally Cast - Dimensions**

  Dimensions of ductile-iron pipes according AWWA C151/A.21.51.
- **Fluid Mechanics - Imperial and SI Units vs. Dimensions**

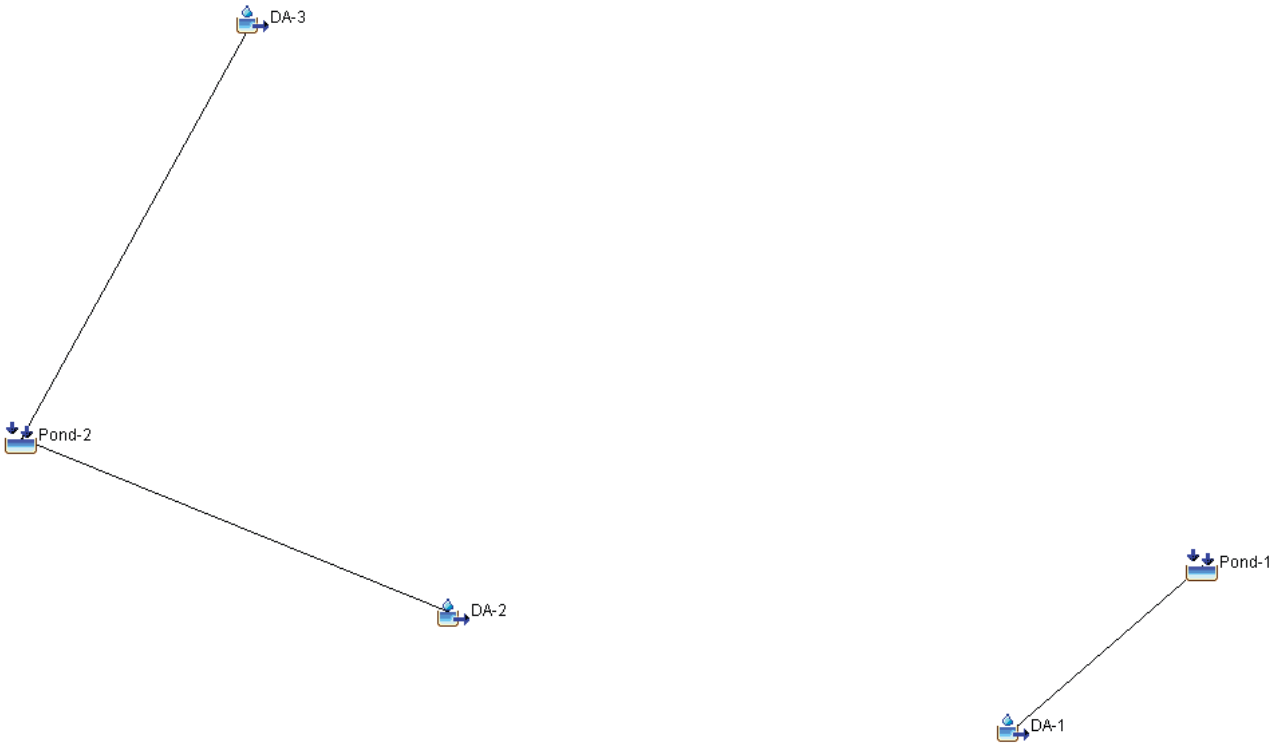
  Imperial (USCS) and SI dimensions and units terminology in fluid mechanics.
- **Grit Size vs. Surface Roughness**

  Comparing sandpaper grit size and surface roughness.
- **Manning's Formula and Gravity Flow**

  Calculate cross-sectional average velocity flow in open channels.
- **Roughness & Surface Coefficients**

  Surface coefficients that can be used to calculate friction and major pressure loss for fluid flow with surfaces like concrete, galvanized steel, corroded steel and more.

Appendix C3 - HEC HMS Output for the Existing Condition



Existing Basin Model

Project: TransMontaigne Simulation Run: Ex 2-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.41852 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:05
Precipitation Volume:	0.32375 (ACRE-FT)	Direct Runoff Volume:	0.15965 (ACRE-FT)
Loss Volume:	0.16325 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.16050 (ACRE-FT)	Discharge Volume:	0.15965 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 2-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.07227 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.05775 (ACRE-FT)	Direct Runoff Volume:	0.02652 (ACRE-FT)
Loss Volume:	0.03120 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.02656 (ACRE-FT)	Discharge Volume:	0.02652 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 2-YEAR 24-HOUR

Subbasin: DA-3

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.87666 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.40775 (ACRE-FT)	Direct Runoff Volume:	0.28209 (ACRE-FT)
Loss Volume:	0.12550 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.28225 (ACRE-FT)	Discharge Volume:	0.28209 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 50-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.53248 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.73074 (ACRE-FT)	Direct Runoff Volume:	0.52396 (ACRE-FT)
Loss Volume:	0.20455 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.52620 (ACRE-FT)	Discharge Volume:	0.52396 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 50-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.27796 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.13035 (ACRE-FT)	Direct Runoff Volume:	0.09031 (ACRE-FT)
Loss Volume:	0.03994 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.09041 (ACRE-FT)	Discharge Volume:	0.09031 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 50-YEAR 24-HOUR

Subbasin: DA-3

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	2.43412 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.92034 (ACRE-FT)	Direct Runoff Volume:	0.77664 (ACRE-FT)
Loss Volume:	0.14333 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.77702 (ACRE-FT)	Discharge Volume:	0.77664 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 100-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.80800 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.82633 (ACRE-FT)	Direct Runoff Volume:	0.61441 (ACRE-FT)
Loss Volume:	0.20936 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.61697 (ACRE-FT)	Discharge Volume:	0.61441 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 100-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.32948 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.14740 (ACRE-FT)	Direct Runoff Volume:	0.10630 (ACRE-FT)
Loss Volume:	0.04098 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.10642 (ACRE-FT)	Discharge Volume:	0.10630 (ACRE-FT)

Project: TransMontaigne Simulation Run: Ex 100-YEAR 24-HOUR

Subbasin: DA-3

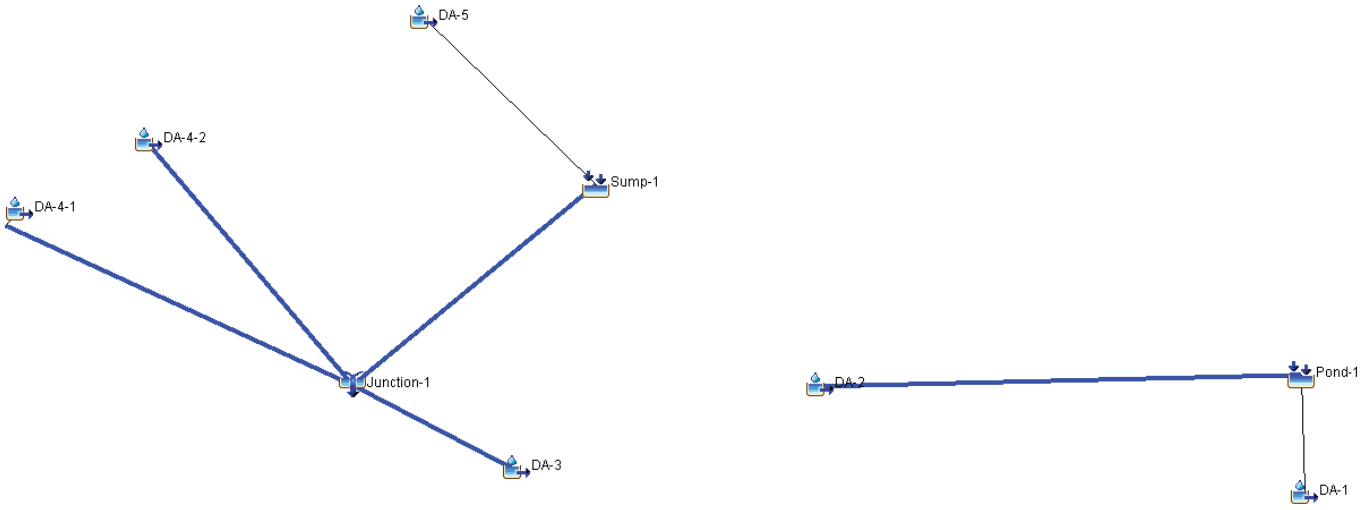
Start of Run:	01Jan2024, 00:00	Basin Model:	Existing
End of Run:	02Jan2024, 00:05	Meteorologic Model:	Ex 100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	2.79671 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	1.04073 (ACRE-FT)	Direct Runoff Volume:	0.89509 (ACRE-FT)
Loss Volume:	0.14521 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.89551 (ACRE-FT)	Discharge Volume:	0.89509 (ACRE-FT)

Appendix C4 - HEC HMS Output for the Proposed Condition



Proposed Basin Model

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.13181 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.07350 (ACRE-FT)	Direct Runoff Volume:	0.04377 (ACRE-FT)
Loss Volume:	0.02970 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.04380 (ACRE-FT)	Discharge Volume:	0.04377 (ACRE-FT)

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.35729 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.24849 (ACRE-FT)	Direct Runoff Volume:	0.12738 (ACRE-FT)
Loss Volume:	0.12080 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.12769 (ACRE-FT)	Discharge Volume:	0.12738 (ACRE-FT)

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-3

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.35420 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.23100 (ACRE-FT)	Direct Runoff Volume:	0.12541 (ACRE-FT)
Loss Volume:	0.10519 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.12581 (ACRE-FT)	Discharge Volume:	0.12541 (ACRE-FT)

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-4-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.14153 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.06825 (ACRE-FT)	Direct Runoff Volume:	0.04567 (ACRE-FT)
Loss Volume:	0.02256 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.04570 (ACRE-FT)	Discharge Volume:	0.04567 (ACRE-FT)

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-4-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.14153 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.06825 (ACRE-FT)	Direct Runoff Volume:	0.04567 (ACRE-FT)
Loss Volume:	0.02256 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.04570 (ACRE-FT)	Discharge Volume:	0.04567 (ACRE-FT)

Project: TransMontaigne Simulation Run: 2-YEAR 24-HOUR

Subbasin: DA-5

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	2-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.28006 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.10150 (ACRE-FT)	Direct Runoff Volume:	0.09048 (ACRE-FT)
Loss Volume:	0.01096 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.09054 (ACRE-FT)	Discharge Volume:	0.09048 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.41162 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.16590 (ACRE-FT)	Direct Runoff Volume:	0.13048 (ACRE-FT)
Loss Volume:	0.03536 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.13054 (ACRE-FT)	Discharge Volume:	0.13048 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.25420 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.56089 (ACRE-FT)	Direct Runoff Volume:	0.40949 (ACRE-FT)
Loss Volume:	0.15058 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.41031 (ACRE-FT)	Discharge Volume:	0.40949 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-3

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.19388 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.52140 (ACRE-FT)	Direct Runoff Volume:	0.39128 (ACRE-FT)
Loss Volume:	0.12911 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.39229 (ACRE-FT)	Discharge Volume:	0.39128 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-4-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.40287 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.15406 (ACRE-FT)	Direct Runoff Volume:	0.12807 (ACRE-FT)
Loss Volume:	0.02592 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.12813 (ACRE-FT)	Discharge Volume:	0.12807 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-4-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.40287 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.15406 (ACRE-FT)	Direct Runoff Volume:	0.12807 (ACRE-FT)
Loss Volume:	0.02592 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.12813 (ACRE-FT)	Discharge Volume:	0.12807 (ACRE-FT)

Project: TransMontaigne Simulation Run: 50-YEAR 24-HOUR

Subbasin: DA-5

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	50-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.65447 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.22910 (ACRE-FT)	Direct Runoff Volume:	0.21752 (ACRE-FT)
Loss Volume:	0.01144 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.21766 (ACRE-FT)	Discharge Volume:	0.21752 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.47778 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.18760 (ACRE-FT)	Direct Runoff Volume:	0.15154 (ACRE-FT)
Loss Volume:	0.03598 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.15162 (ACRE-FT)	Discharge Volume:	0.15154 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.47228 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.63425 (ACRE-FT)	Direct Runoff Volume:	0.47928 (ACRE-FT)
Loss Volume:	0.15404 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.48022 (ACRE-FT)	Discharge Volume:	0.47928 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-3

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	1.39629 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 08:00
Precipitation Volume:	0.58960 (ACRE-FT)	Direct Runoff Volume:	0.45661 (ACRE-FT)
Loss Volume:	0.13184 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.45776 (ACRE-FT)	Discharge Volume:	0.45661 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-4-1

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.46378 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.17421 (ACRE-FT)	Direct Runoff Volume:	0.14785 (ACRE-FT)
Loss Volume:	0.02628 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.14792 (ACRE-FT)	Discharge Volume:	0.14785 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-4-2

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.46378 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.17421 (ACRE-FT)	Direct Runoff Volume:	0.14785 (ACRE-FT)
Loss Volume:	0.02628 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.14792 (ACRE-FT)	Discharge Volume:	0.14785 (ACRE-FT)

Project: TransMontaigne Simulation Run: 100-YEAR 24-HOUR

Subbasin: DA-5

Start of Run:	01Jan2024, 00:00	Basin Model:	Proposed
End of Run:	02Jan2024, 00:05	Meteorologic Model:	100-year 24-hour
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control Specifications

Volume Units: ACRE-FT

Computed Results

Peak Discharge:	0.74168 (CFS)	Date/Time of Peak Discharge:	01Jan2024, 07:55
Precipitation Volume:	0.25907 (ACRE-FT)	Direct Runoff Volume:	0.24743 (ACRE-FT)
Loss Volume:	0.01148 (ACRE-FT)	Baseflow Volume:	0.00000 (ACRE-FT)
Excess Volume:	0.24759 (ACRE-FT)	Discharge Volume:	0.24743 (ACRE-FT)

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