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DOCKET
09-AFC-4
DATE MAY 27 2010
RECD. MAY 27 2010

May 27, 2010

Ms. Felicia Miller
Project Manager
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Subject: Oakley Generating Station Project (09-AFC-4)
Contra Costa Generating Station LLC's Response to CEC Workshop Query #7

Dear Ms. Miller:

Attached are 13 hard copies and one (1) CD ROM of the Contra Costa Generating Station LLC's Response to CEC Workshop Query #7 which requested a copy of the memorandum that Radback Energy sent to the California Department of Fish and Game regarding the project's potential effects on Wetland E.

If you have any questions, please contact me at (916) 286-0278.

Sincerely,
CH2M HILL

Douglas M. Davy, Ph.D.
AFC Project Manager

Attachment
cc: POS List
Project File

**BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA**
**1516 NINTH STREET, SACRAMENTO, CA 95814**
**1-800-822-6228 – WWW.ENERGY.CA.GOV**

**APPLICATION FOR CERTIFICATION FOR THE *OAKLEY GENERATING STATION***

**Docket No. 09-AFC-4**
***PROOF OF SERVICE***
**(Revised 5/13/2010)**

**APPLICANT**

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# Contra Costa Generating Station Stormwater Management Design, Wetland E

PREPARED FOR: Liam Davis, California Department of Fish and Game
Suzanne Gilmore, California Department of Fish and Game

PREPARED BY: Jim McLucas, Radback Energy, Inc.
Paul Nelson, Black & Veatch Engineering
Douglas Davy, CH2M HILL
Debra Crowe, CH2M HILL

DATE: August 7, 2009

## Background

Contra Costa Generating Station (CCGS or project) is a combined-cycle, natural gas-fired power plant proposed by Radback Energy, Inc. (Radback) to be located on a portion of the the former DuPont Corporation (DuPont) manufacturing facility site in Oakley, Contra Costa County, California (Figure 1). The project site is located approximately 3,000 feet south of the San Joaquin River. Adjacent to and downstream of the CCGS site, and part of the project parcel, is a 1.60-acre conservation easement area that encompasses a 0.62-acre freshwater marsh wetland. This wetland has been identified as the "Wetland E Mitigation Area" in documents submitted by the DuPont to the U.S. Army Corps of Engineers (USACE). Wetland E was placed under conservation easement in January 1997 (File #97 005086) by DuPont as a mitigation measure for development elsewhere on the bank of the San Joaquin River. Because of the conservation easement for this wetland, Radback and their engineering design consultant, Black & Veatch Engineering (B&V), have designed the stormwater management system for the CCGS so that (1) the quality of stormwater draining into the wetland is not negatively affected, and (2) the CCGS will not adversely alter the flow of stormwater into the wetland. Radback believes that it may be possible to enhance the functions and values of Wetland E by careful stormwater design and is proposing enhancement measures that have the potential to improve the existing wetland and upland habitats. This memorandum describes Wetland E, the CCGS, and its drainage design, and concludes with a discussion of the preservation of Wetland E's functions and values through careful stormwater design and enhancement measures.

## Wetland E

DuPont conducted a formal delineation of wetlands at its Oakley property in June 2006. The DuPont wetland delineation report describes Wetland E as an isolated wetland approximately 2,000 feet from the nearest wetland or water, and approximately 3,000 feet from the San Joaquin River. There is no surface connection between Wetland E at the DuPont site and navigable waters (San Joaquin River). This wetland was "created to offset impacts associated with the Lauritzen Yacht Harbor property." The USACE determined Wetland E, on the basis of its lack of connectivity to other wetlands or waters, to be "intrastate isolated waters…not currently regulated by the Corps of Engineers." Figure 2 is a photograph of Wetland E. An outline of the conservation easement is presented in Attachment 1.


This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

**FIGURE 1**
**PROJECT LOCATION**
CONTRA COSTA GENERATING STATION
*OAKLEY, CALIFORNIA*

CH2MHILL

SAC\\ZION\SACGIS\PROJ\RADBACKENERGY\385962\MAPFILES\SITELOCATION.MXD MHASKELL 6/11/2009 12:39:39

FIGURE 2
Wetland E, looking south-southwest

The dominant wetland species in the open water portion of Wetland E include the common tule (*Schoenoplectus acutus*) and common cattail (*Typha latifolia*), with arroyo willow (*Salix lasiolepis*) found individually along the narrow slope between the edge of water and the top of the bank. The hydrology is supported by direct precipitation as well as surface stormwater runoff from Bridgehead Road; Pacific Gas and Electric Company's (PG&E) Antioch Terminal (natural gas transmission line yard), located south of Wetland E; and a portion of the DuPont property. Soils at the upland and wetland sample points (presented in the wetland delineation report) are composed of similar disturbed sandy soils that do not possess hydric indicators. However, based on the USACE guidance, the soils were considered hydric because of the presence of wetland hydrology and hydrophytic vegetation, as well as an abrupt change in topography. No rare plant or wildlife species were observed during biological surveys of the site for the CCGS. Table 1 presents a list of animal and plant species observed during field surveys and includes species observed in the Wetland E area.

Currently, the Wetland E easement area collects stormwater runoff from a 25-acre area located to the east and south of the easement. The CCGS will occupy the majority of the 25 acres of easement runoff area. The existing PG&E Antioch Terminal also occupies approximately 4 acres of the easement runoff area. PG&E also holds a 100-foot-wide gas pipeline easement, located directly south of Wetland E. The proposed generating station area is currently an actively farmed vineyard with loamy sandy soils. PG&E's Antioch Terminal is covered with aggregate surfacing. The easement area currently has no discharge structure or facility for release of stormwater that collects via direct rainfall or runoff from the surrounding area. Based on B&V calculation 52.5406.1003 "Stormwater Analysis for Wetland" (Attachment 2), the easement area can collect and store stormwater from a 100-year storm event without discharging stormwater (there is no surface connection to wetlands or waters).

## Project Overview and Drainage Design

Contra Costa Generating Station, LLC proposes to construct, own, and operate the CCGS. The CCGS will be a natural gas-fired, combined-cycle electrical generating facility with a nominal generating capacity of 624 megawatts. The CCGS will be located at the intersection of Bridgehead Road and Wilbur Avenue. The proposed project would connect to PG&E's existing high-pressure natural gas pipeline at the Antioch Terminal, located adjacent to the project site along Bridgehead Road. The potable water line would connect to existing potable water supply lines that served the former DuPont facilities. The sanitary sewer line would connect to an existing sewer line located along Bridgehead Road. Surrounding land uses include the former DuPont manufacturing complex to the north, vineyards adjacent to the site to the south and east, a residential subdivision further east, and mixed commercial and suburban/rural residential further south. To the west is State Route 160 on its approach to the Antioch Bridge over the Sacramento–San Joaquin River.

The CCGS stormwater design will be governed by California Regional Water Quality Control Board's C.3 requirements. Specifically, the project will be designed in accordance with Contra Costa Clean Water Program Stormwater C.3 Guidebook, September 2008, 4th Edition (Attachment 3). The C.3 requirements address both flow control and treatment of stormwater. Per page 8 of the C.3 guidebook, using the Option 2 design process detailed in Chapter 4 will allow the CCGS project to meet both treatment and flow control requirements.

Following the design process outlined by Option 2, bioswales will be used to collect all stormwater runoff from the project site. See B&V drawing 163994-SS-3001 (Attachment 4) for location and details regarding the bioswales. The B&V Calculation 52.5406.1002 "IMP Sizing for Plant Area" (Attachment 5), provides the bioswale sizing details. Drop structures DS-1 and DS-5 are located at the end of bioswales and are adjacent to the easement area. The drop structures will discharge stormwater to the easement area if a rainfall event is larger than the design event noted in the C.3 guidebook. See B&V drawing 163994-SS-3050 (Attachment 6) for a typical drop structure detail. Rainfall less than the design event will be contained in the bioswales and will infiltrate through the sandy soils or evaporate. The soils, plantings, and irrigation for the bioswales will be in accordance with Appendix B of the C.3 guidebook. To allow stormwater to reach the easement area during rainfall events less than a C.3 design event, a perforated underdrain is located under the northern bioswale. As shown in Section 1 and 1A on B&V drawing 163994-SS-3001, the underdrain is located 2 feet below the bottom of the bioswale. The stormwater will be filtered through the plant roots and a biologically active soil mix within the bioswale, removing suspended solids and other potential pollutants prior to the underdrain collecting the stormwater and discharging to the easement area.

## Preservation and Enhancement of Wetland E

Wetland E functions to collect and store stormwater, enhance water quality through infiltration to groundwater, provide natural habitat views from Bridgehead Road and Highway 4, and provide habitat to wildlife in an industrial setting. Radback proposes to enhance these functions of Wetland E, as well as increase the biological diversity of the conservation easement area as part of the CCGS project. Radback proposes to preserve and enhance the wetland habitat and retain the conservation easement as it is.

A comprehensive wetland enhancement plan will be prepared and submitted to the California Department of Fish and Game (CDFG) as part of the permitting process with the California Energy Commission (CEC). The plan will be submitted to CDFG for approval prior to submitting to the CEC, well in advance of the start of construction. Enhancement of the wetland area, as well as the associated uplands within the 1.60-acre conservation easement area, is proposed to include, but not be limited to, the following measures:

1. Reduce cover in exotic non-native plant species.
2. Increase cover in native plant species.
3. Increase native shrub and tree cover to enhance the structural diversity and wildlife habitat values.
4. Include plantings of native species that will be propagated from locally occurring species such as soil stabilizing grasses *Leymus triticoides* and *Leymus glaucus* to replace non-native annuals, and coyote brush (*Baccharis pilularis*), valley or live oak (*Quercus lobata* or *Q. agrifolia*), and Bush lupine (*Lupinus ludovicianus*) to increase structural and habitat diversity. The inclusion of specific upland host plants for special-status insects, including buckwheat (*Eriogonum* sp.) and telegraph weed (*Heterotheca grandiflora*) will increase potential habitat value for locally occurring endemic species.
5. Introduce aquatic food plants for waterfowl.
6. Install bird perches and nest boxes to increase wildlife use of the area.
7. Improve water quality by use of bioswales and underdrains.
8. Improve stormwater management with the ability to better monitor and control the amount of water discharged to the wetland.
9. Improve aesthetics by removing garbage that has collected in the area.

TABLE 1
List of Plant and Wildlife Species Observed, DuPont Oakley Site, Spring 2009
*Contra Costa Generating Station Stormwater Management Design, Wetland E*

| Scientific Name | Common Name | Present in Wetland E? |
|---|---|---|
| **Plants** | | |
| Aizoaceae | | |
| *Tetragonia tetragonioides* | New Zealand spinach | No |
| *Carpobrotus edulis* | iceplant | No |
| Amaranthaceae | | |
| *Amaranthus blitum* | purple amaranth | No |
| Anacardiaceae | | |
| *Schinus molle* | Peruvian peppertree | No |
| Apocynaceae | | |
| *Nerium oleander* | oleander | No |
| Arecaceae | | |
| *Washingtonia filifera* | California fan palm | No |
| Asteraceae | | |
| *Heterotheca grandiflora* | telegraphweed | No |
| *Carduus pycnocephalus* | Italian thistle | No |
| *Cotula coronopifolia* | common brassbuttons | No |
| *Senecio vulgaris* | old-man-in-the-spring | No |
| Boraginaceae | | |
| *Amsinckia menziesii* | common fiddleneck | No |
| Caryophyllaceae | | |
| *Stellaria media* | common chickweed | No |
| *Cerastium* sp. | chickweed | No |
| *Spergula arvensis* | corn spurry | No |
| Casuarinaceae | | |
| *Casuarina equisetifolia* | beach sheoak | No |
| Chenopodiaceae | | |
| *Salsola tragus* | prickly Russian thistle | No |
| Cucurbitaceae | | |
| *Marah fabaceus* | California manroot | No |
| Cyperaceae | | |
| *Schoenoplectus acutus* | hardstem bulrush | No |
| Fabaceae | | |
| *Lupinus bicolor* | miniature lupine | No |
| *Lotus scoparius* | common deerweed | No |
| *Medicago polymorpha* | burclover | No |
| *Sonchus asper* | spiny sowthistle | No |
| *Quercus agrifolia* | California live oak | No |
| *Quercus wislizeni* | interior live oak | No |
| Geraniaceae | | |
| *Erodium cicutarium* | redstem stork's bill | No |
| Lamiaceae | | |
| *Lamium amplexicaule* | henbit deadnettle | No |
| Lythraceae | | |
| *Lythrum hyssopifolia* | hyssop loosestrife | No |

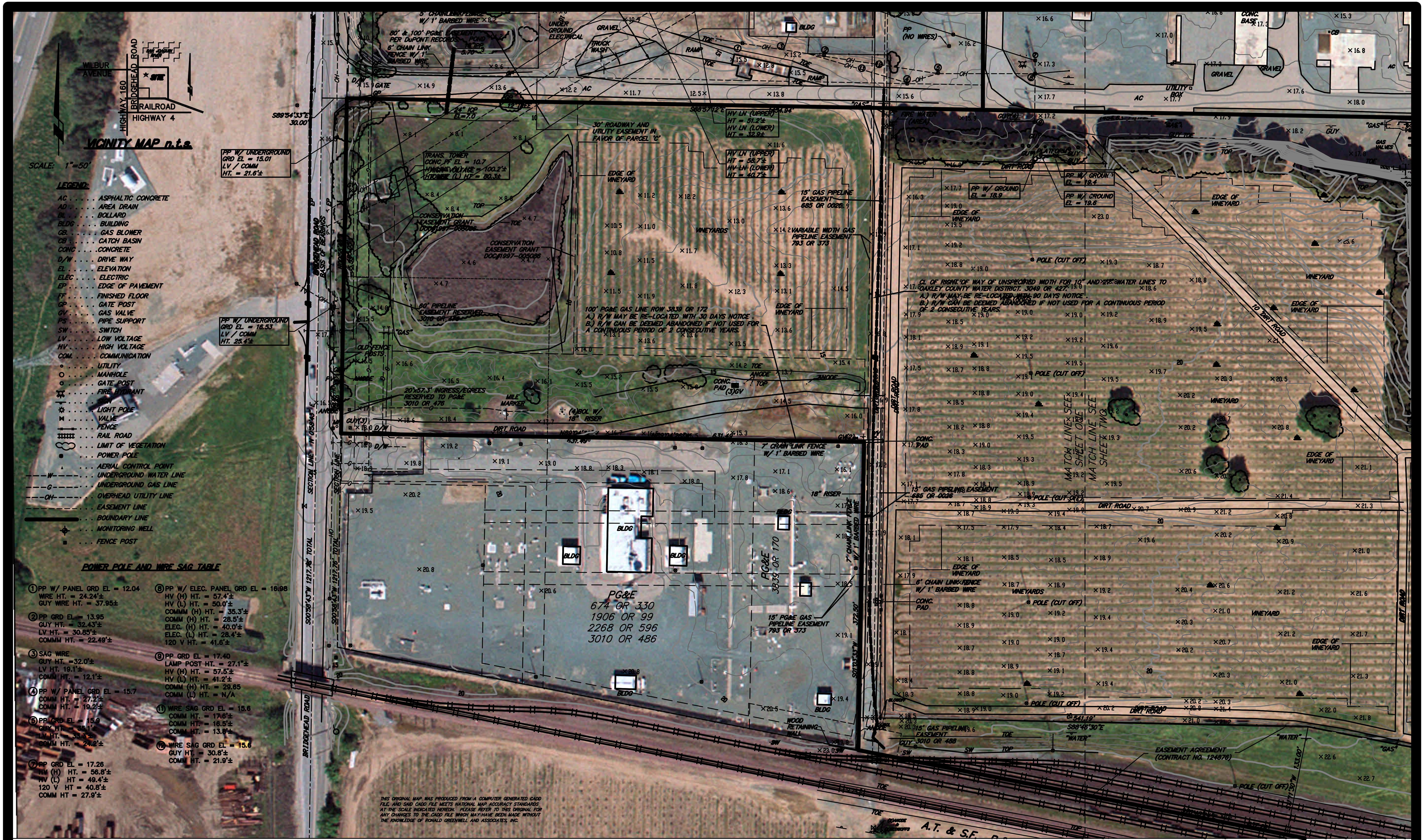
TABLE 1
List of Plant and Wildlife Species Observed, DuPont Oakley Site, Spring 2009
*Contra Costa Generating Station Stormwater Management Design, Wetland E*

| Scientific Name | Common Name | Present in Wetland E? |
|---|---|---|
| Malvaceae | | |
| *Malva parviflora* | cheeseweed mallow | No |
| Onagraceae | | |
| *Epilobium brachycarpum* | tall annual willowherb | No |
| Oxalidaceae | | |
| *Oxalis albicans* | woodsorrel | No |
| Plantaginaceae | | |
| *Plantago major* | common plantain | No |
| Poaceae | | |
| *Bromus diandrus* | ripgut brome | No |
| *Bromus rubens* | red brome | No |
| *Hordeum murinum* | mouse barley | No |
| *Vulpia myuros* | rat-tail fescue | No |
| *Distichlis spicata* | saltgrass | No |
| *Polypogon monspeliensis* | annual rabbitsfoot grass | No |
| *Cynodon dactylon* | Bermudagrass | No |
| *Lolium perenne* ssp. *multiflorum* | Italian ryegrass | No |
| Polygonaceae | | |
| *Rumex crispus* | curly dock | No |
| Portulacaceae | | |
| *Montia parvifolia* | miner's lettuce | No |
| *Calandrinia* sp. | redmaids | No |
| Rosaceae | | |
| *Prunus dulcis* | sweet almond | No |
| *Rubus ursinus* | California blackberry | Yes |
| *Malus pumila* | paradise apple | No |
| Salicaceae | | |
| *Salix gooddingii* | Goodding's willow | No |
| Simaroubaceae | | |
| *Ailanthus altissima* | tree of heaven | No |
| Typhaceae | | |
| *Typha latifolia* | broadleaf cattail | Yes |
| Viscaceae | | |
| *Phoradendron* sp. | mistletoe | No |
| **Birds** | | |
| Ciconiiformes | | |
| *Ardea herodias* | great blue heron | No |
| Falconiformes | | |
| *Buteo lineatus* | red-shouldered hawk | No |
| *Buteo jamaicensis* | red-tailed hawk | No |
| *Buteo swainsoni* | Swainson's hawk | No |
| Charadriiformes | | |
| *Charadrius vociferus* | killdeer | No |

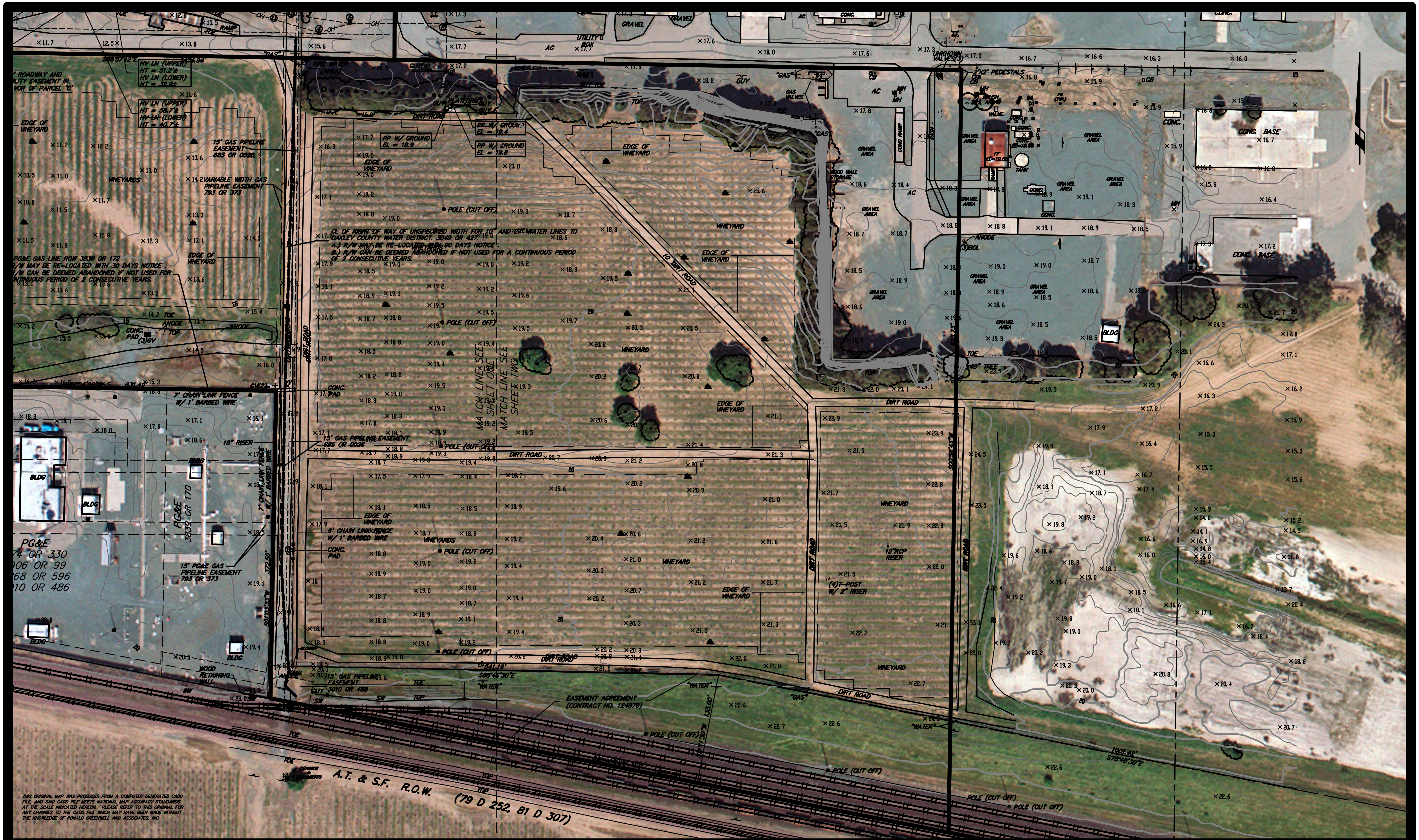
TABLE 1
List of Plant and Wildlife Species Observed, DuPont Oakley Site, Spring 2009
*Contra Costa Generating Station Stormwater Management Design, Wetland E*

| Scientific Name | Common Name | Present in Wetland E? |
|---|---|---|
| Columbiformes | | |
| *Columba livia* | rock pigeon | No |
| *Zenaida macroura* | mourning dove | Yes |
| Apodiformes | | |
| *Calypte anna* | Anna's hummingbird | Yes |
| Passeriformes | | |
| *Sayornis nigricans* | black phoebe | Yes |
| *Tyrannus verticalis* | western kingbird | No |
| *Aphelocoma californica* | western scrub-jay | No |
| *Corvus brachyrhynchos* | American crow | No |
| *Petrochelidon pyrrhonota* | cliff swallow | No |
| *Hirundo rustica* | barn swallow | No |
| *Psaltriparus minimus* | bushtit | Yes |
| *Sturnus vulgaris* | European starling | No |
| *Dendroica coronata* | yellow-rumped warbler | No |
| *Zonotrichia atricapilla* | golden-crowned sparrow | Yes |
| *Zonotrichia leucophrys* | white-crowned sparrow | No |
| *Junco hyemalis* | dark-eyed junco | No |
| *Agelaius phoeniceus* | red-winged blackbird | Yes |
| *Icterus bullockii* | Bullock's oriole | No |
| *Carpodacus mexicanus* | house finch | Yes |
| *Passer domesticus* | house sparrow | Yes |
| *Mimus polyglottos* | northern mockingbird | No |
| *Colaptes auratus* | northern flicker | No |
| *Sturnella neglecta* | meadowlark | No |
| **Reptiles** | | |
| Squamata | | |
| *Sceloporus occidentalis* | western fence lizard | No |
| **Mammals** | | |
| Rodentia | | |
| *Spermophilus beecheyi* | California ground squirrel | No |
| Lagomorpha | | |
| *Lepus californicus* | black-tailed jackrabbit | No |

# Attachment 1
# Ronald Greenwell and Associates
# “Topographic Survey”




| | | | | |
|---|---|---|---|---|
| RGA RONALD GREENWELL & ASSOCIATES, INC.<br>LAND DEVELOPMENT · SURVEYING · G.P.S<br>10 SOUTH LAKE DRIVE, SUITE 1<br>ANTIOCH, CALIFORNIA 94509<br>TEL.(925) 778-0626<br>FAX(925) 778-7160 | SCALE: 1"=50'<br>GRAPHIC SCALE<br>50' 25' 0' 50' 100'<br>W. O 1820. 00 | | TOPOGRAPHIC SURVEY<br>PROPOSED C. C GENERATION FACILITY SITE<br>AT<br>E. I du PONT de NEMOURS and COMPANY OAKLEY SITE<br>CONTRA COSTA COUNTY MARCH 4, 2009 CALIFORNIA | SHEET NO.<br>1 OF 2 |





RGA
RONALD GREENWELL & ASSOCIATES, INC.
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TEL.(925) 778-0626
FAX(925) 778-7160


SCALE: 1"=50'

GRAPHIC SCALE

50' 25' 0' 50' 100'

W.O. 1820.00

**TOPOGRAPHIC SURVEY**
**PROPOSED C.C GENERATION FACILITY SITE**
**AT**
**E. I du PONT de NEMOURS and COMPANY OAKLEY SITE**
CONTRA COSTA COUNTY MARCH 4, 2009 CALIFORNIA

SHEET NO.

2 OF 2

# Attachment 2
# B&V Calculation 52.5406 1003
# "Stormwater Analysis for Wetland"

BLACK & VEATCH

## Calculation Record

Client Name: Radback Energy



Project Name: Tenaska

Project No.: 163994

Calculation Title: Stormwater Analysis for Wetland

Calculation No./File No.: 52.5406.1003

Calculation Is: (check all that apply) ☐ Preliminary ☒ Final ☐ Nuclear Safety-Related

**Objective** To determine if the existing wetland at the Tenaska project site can retain the runoff of a 100-yr 24-hr storm without overflowing to other properties. The analysis is performed for pre-construction ground conditions at the site.

| Unverified Assumptions Requiring Subsequent Verification | | | |
|---|---|---|---|
| No. | Assumption | Verified By | Date |
| | | | |
| | | | |
| | | | |
| | | | |

See Page 2 of this calculation for additional assumptions.

**This Section Used for Computer Generated Calculations**

Program Name/Number: HEC-HMS    Version: 3.3

Evidence of or reference to computer program verification, if applicable:

Bases or reference thereto supporting application of the computer program to the physical problem:

**Review and Approval**

| Rev | Prepared By | Date | Verified By | Date | Approved By | Date |
|---|---|---|---|---|---|---|
| 0 | J Zhong Jimmy Zhong | March 5, 2009 | [signature] | 6 MAR 09 | [signature] | 6 MAR 09 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Purpose

To determine if the existing wetland at the Tenaska project site can retain the runoff of a 100-year 24-hour storm without overflowing to other properties. The analysis is performed for pre-construction ground conditions at the project site. The existing wetland has no outlet structure.

## References

1. Black & Veatch Drawings:
   - 163994-SS-3001, Rev. A, "Grading & Drainage - Site"
   - 163994-SS-3002, Rev. A, "Grading & Drainage - Site"
2. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
3. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, User's Manual, Version 3.3; September 2008.
4. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, Technical Reference Manual; March 2000.
5. US Department of Commerce; Technical Paper No. 40; Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years; May 1961.
6. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
7. Mays, L. W.; Stormwater Collection Systems Design Handbook, McGraw-Hill; 2001.

## Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)

Drainage area in acres (ac)

## Attachments

1. HEC-HMS Input
2. HEC-HMS Output
3. Reference 2 – Select Pages
4. Reference 6 – Select Pages

## Summary

Based on the HEC-HMS analysis, the maximum water elevation in the wetland is determined to be EL 9.1 feet. The lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis with current ground cover conditions, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm.

**Hydrology Modeling – HEC-HMS**

There is one drainage area that will drain to the wetland. See Page 5 for the boundary delineation of this area. This drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile$^2$). The measurements of the above areas were made by using AutoCAD.

The stormwater runoff to the wetland for a 100-year 24-hour storm event was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

Section 1.0 Determine the Time of Concentration

Time of concentration ($T_c$) can be calculated as:

$$T_c = T_{sheet} + T_{shallow} + T_{channel} \qquad \text{(Ref. 4, Eq. 6-11)}$$

Where:

$T_{sheet}$ = travel time in sheet flow;

$T_{shallow}$ = travel time in shallow concentrated flow;

$T_{channel}$ = travel time in open channels.

There is no open channel flow on this site. Thus $T_{channel} = 0$.

The flow path from the hydraulically most distant point of this drainage area to the wetland is identified as shown on Page 5.

The total flow length is measured to 1490 feet.

(1) Sheet Flow

Sheet flow travel time can be calculated as:

$$T_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{(Ref. 2, Eq. 3-3)}$$

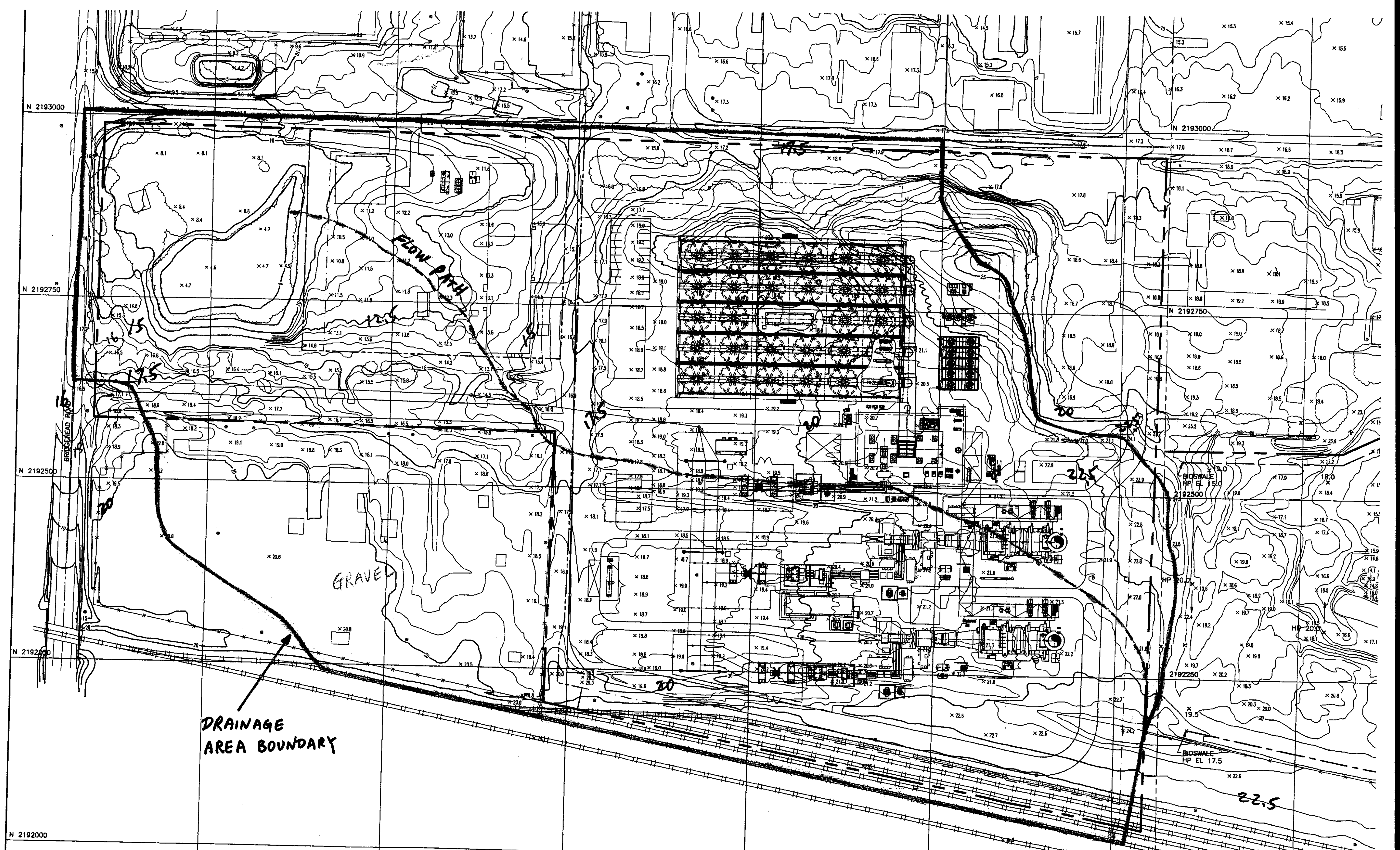
Where:

n = roughness coefficient;

L = flow length (ft);

$P_2$ = 2-year, 24-hour rainfall (in);

s = land slope (ft/ft).




Radback Tenaska project
project # 163994
52.5406.1003

stormwater Analysis
page 5 of 53

prepared by: J zhong
Date: 3/4/09
checked by: [illegible]
Date: 3/6/09

NOTE: THIS PAGE IS A PORTION OF B&V Drawing 163994-SS-3001 Rev A.

Roughness coefficient n = 0.17 for "cultivated soils, residue cover > 20%". (Ref. 2, Table 3-1)

Per Ref. 2, "After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow". Use sheet flow length L = 300 feet.

2-year, 24-hour rainfall $P_2$ = 2 inch for this site per Ref. 5 (see Page 8).

The land slope for the first 300 feet = (24.2-21.5)/300 = 0.009 ft/ft. (Refer to Page 5)

Thus, $T_{sheet} = \dfrac{0.007 \times (0.17 \times 300)^{0.8}}{2^{0.5} \times 0.009^{0.4}}$ = 0.76 hour.

(2) Shallow Concentrated Flow
The flow length for shallow concentrated flow L = 1490-300 = 1190 feet.
The average watercourse slope = (21.5-5) / 1190 = 0.014 ft/ft. (Refer to Page 5)

Based on a slope of 0.014 ft/ft, from Ref. 2, Figure 3-1, the average velocity (V) for "unpaved" surface is found to be:

V = 1.9 ft/sec.

Thus the travel time for shallow concentrated flow is calculated to be:

$$T_{shallow} = \frac{L}{3600 \times V} = \frac{1190}{3600 \times 1.9} = 0.17 \text{ hour.}$$

In summary, the time of concentration is calculated to be:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$
= 0.76 + 0.17 + 0
= 0.93 hour.

Per Ref. 4, "For ungaged watersheds, the SCS suggests that the UH (unit hydrograph) lag time may be related to the time of concentration, $T_c$, as: $T_{lag} = 0.6\, T_c$". See Page 7.

The SCS UH lag time ($T_{lag}$) is an input parameter into the HEC-HMS computer program. Thus

$T_{lag}$ = 0.6 x 0.93 = 0.56 hour = 33.6 minutes.

UH can be found from the dimensionless form, which is included in HEC-HMS, by multiplication.

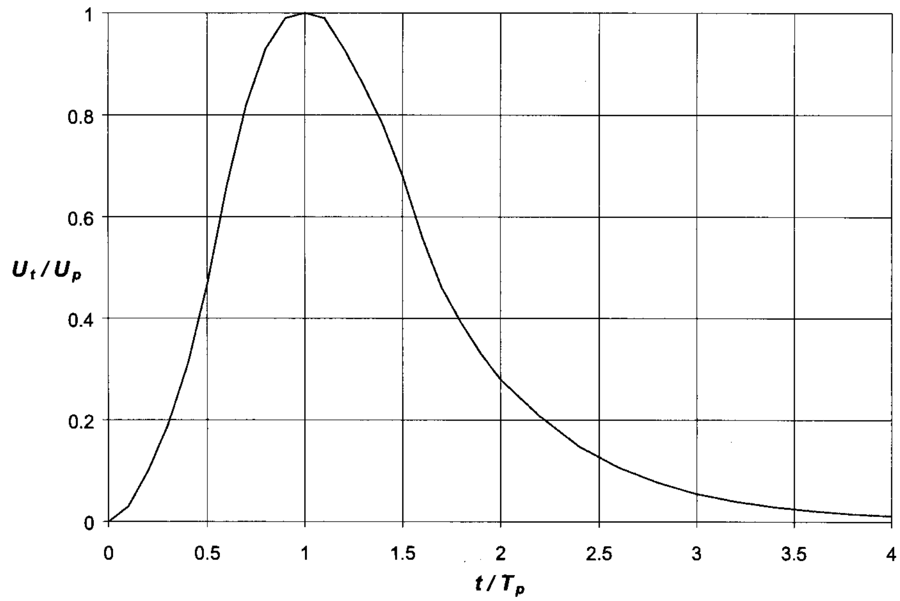



*Figure 6-2. SCS unit hydrograph*

## Estimating the SCS UH Model Parameters

The SCS UH lag can be estimated via calibration, using procedures described in Chapter 9, for gaged headwater subwatersheds.

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, $t_c$, as:

$$t_{lag} = 0.6\, t_c \qquad (6\text{-}10)$$

Time of concentration is a quasi-physically based parameter that can be estimated as

$$t_c = t_{sheet} + t_{shallow} + t_{channel} \qquad (6\text{-}11)$$

where $t_{sheet}$ = sum of travel time in sheet flow segments over the watershed land surface; $t_{shallow}$ = sum of travel time in shallow flow segments, down streets, in gutters, or in shallow rills and rivulets; and $t_{channel}$ = sum of travel time in channel segments.

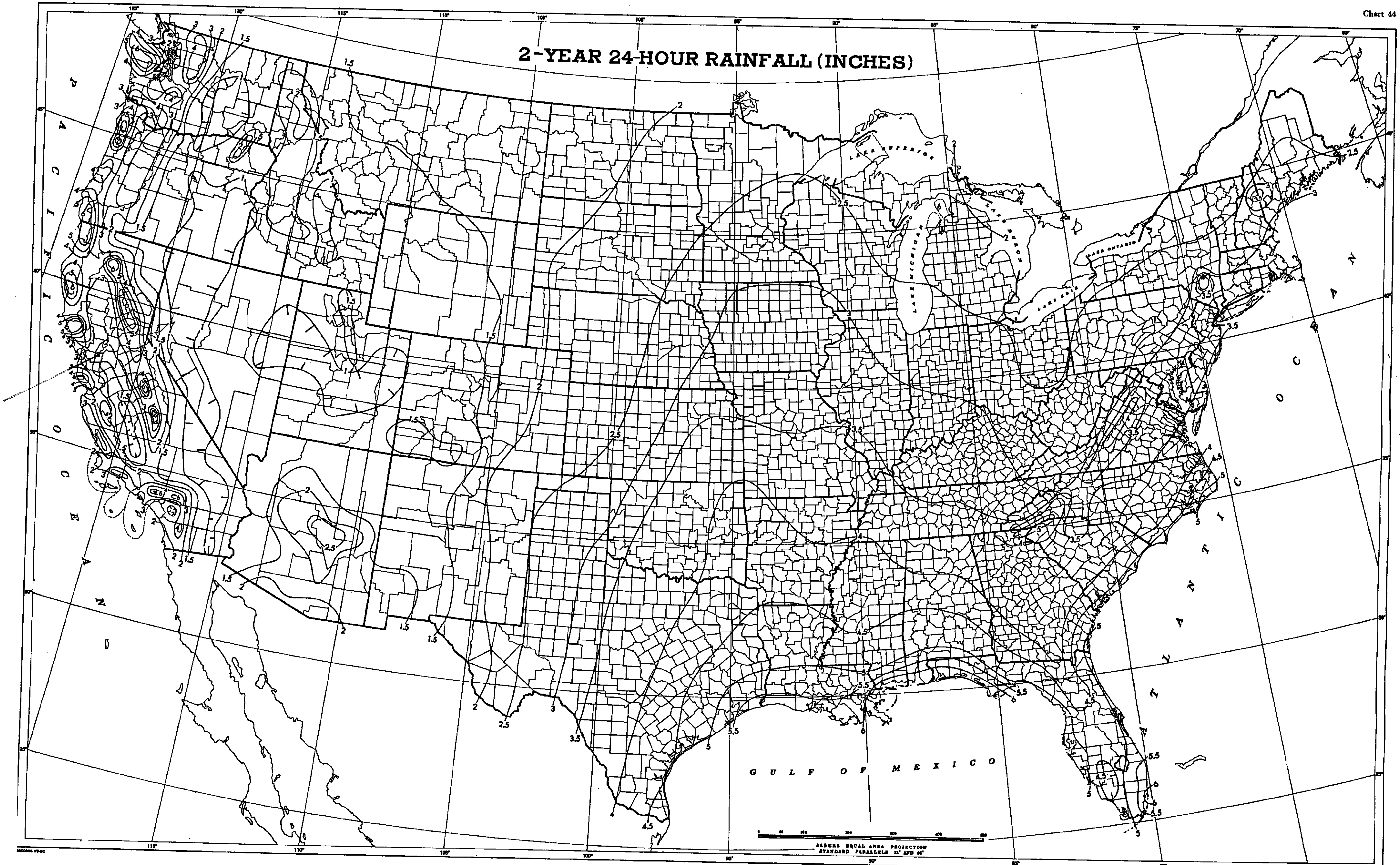
NOTE: THIS PAGE IS FROM REF. 4.

Identify open channels where cross section information is available. Obtain cross sections from field surveys, maps, or aerial photographs. For these channels, estimate velocity by Manning's equation:

$$V = \frac{CR^{2/3}S^{1/2}}{n} \qquad (6\text{-}12)$$

where $V$ = average velocity; $R$ = the hydraulic radius (defined as the ratio of channel cross-section area to wetted perimeter); $S$ = slope of the energy grade

SITE
2"

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NOTE: THIS PAGE IS
FROM REF. 5.

Section 2.0 Rainfall Distribution

From Ref. 2, Figure B-2, the rainfall distribution for the site in Contra Costa County, California should be Type I distribution.

From Ref. 5, the 100-year 24-hour rainfall amount for the site is 4 inches. (See Page 10)

Section 3.0 Determine the Composite SCS Curve Number

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area.

The drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile$^2$). The measurements of the above areas were made by using AutoCAD.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

Per Ref. 2, Table 2-2b, the curve number (CN) for "Row Crops, straight row (SR) with crop residue cover (CR)" for Group A soil is between 64 (good condition) and 71 (poor condition). Use the average curve number 68 for the vineyard area.

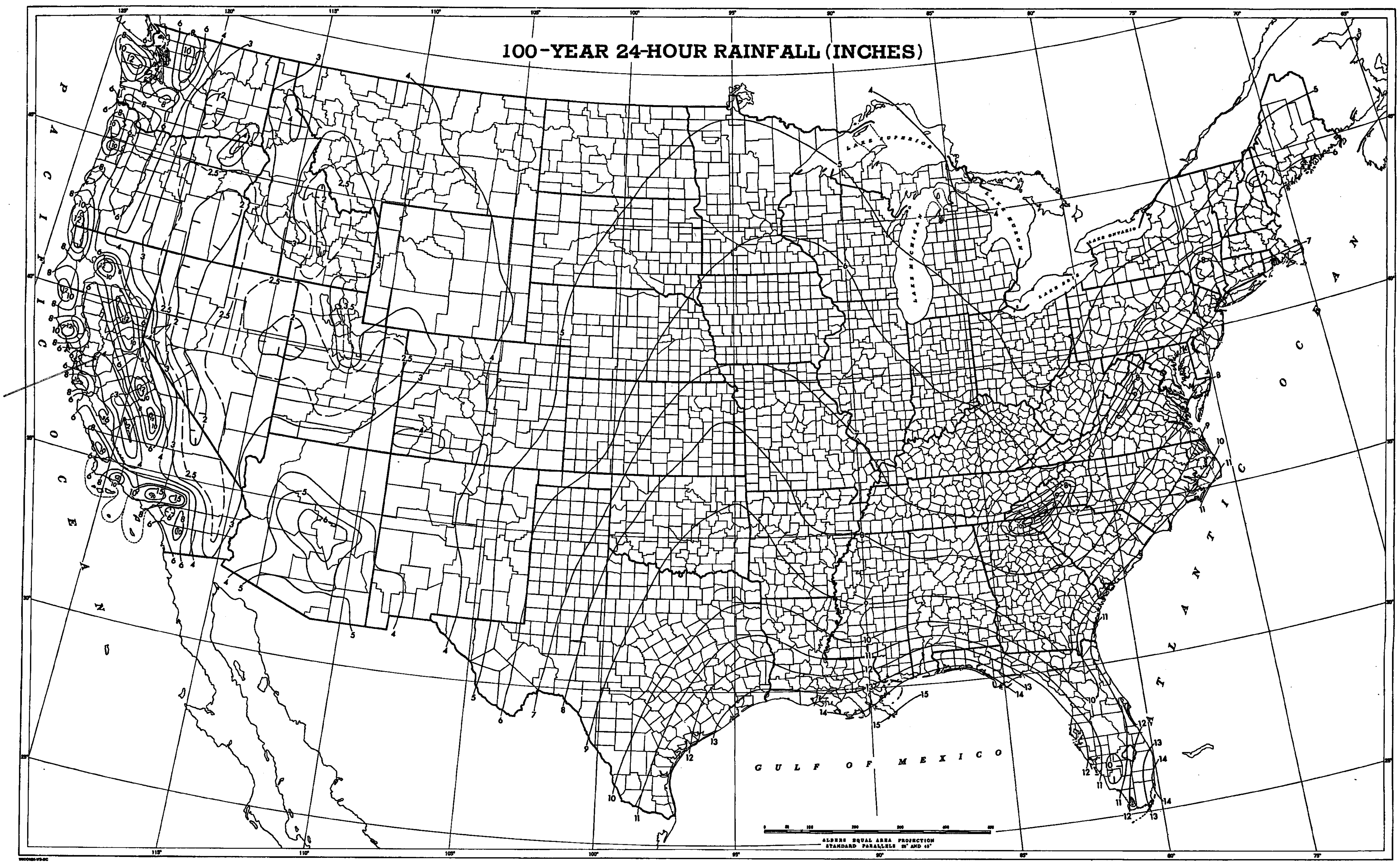
Per Ref. 2, Table 2-2a, the curve number for gravel area for Group A soil is 76. The ground cover in railroad yard is similar to the gravel area. Use the same curve number (76) for the railroad yard.

Treat the wetland as an impervious area since it may have standing water in it. Per Ref. 2, Table 2-2a, a curve number of 98 can be used for this area.

Thus the composite curve number (CN) for the drainage area is calculated as:

$$CN = (19.85 \times 68 + 3.96 \times 76 + 0.94 \times 76 + 0.40 \times 98) / 25.15 = 70.$$

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It




SITE
4"



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NOTE: THIS PAGE IS FROM REF. 5.

includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction ($I_a$) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2)

Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 70, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/70 - 10) = 0.857$ inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. The impervious area consists of the roofs of a few small buildings in the southwest portion of the drainage area. By using AutoCAD, the total roof area is measured to be 0.17 acre. Thus,

% impervious = 0.17 / 25.15 = 0.68%, say 1%.

Section 4.0 Wetland Area versus Elevation

The bottom of the wetland is at an approximate elevation of 5 feet. See B&V Drawing SS-3001 (Page 5). The relationship of Area versus Elevation for the wetland area was presented in the table below. The wetland area was measured by using AutoCAD. It should be noted that a small portion of the wetland at the east side within the project property will be filled at a later time. This area will be graded at a 4 (H) to 1 (V) slope towards the wetland. The area in the table below at Elevation 10 (1.44 acres) has already had the future fill area been deducted to accurately model the wetland storage capacity.

| Elevation (ft) | Wetland Area (acre) |
|---|---|
| 5.0 | 0.40 |
| 7.5 | 0.62 |
| 10.0 | 1.44 |

Section 5.0 HEC-HMS Output

The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at

EL 5 assuming that standing water in the wetland is not higher than EL 5 before the 100-year 24-hour storm begins.

The maximum water elevation in the wetland was calculated by running the HEC-HMS program.

The output results are included in Attachment 2 and are summarized below.

| | |
|---|---|
| Peak Inflow: | 9.0 $ft^3$/sec. |
| Peak Storage: | 2.8 acre-feet |
| Peak Elevation: | 9.1 feet. |

**Conclusion:**

Based on the HEC-HMS analysis, the existing wetland will be able to contain all the runoff from its drainage area at current ground cover conditions for a 100-year 24-hour storm.

From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm.

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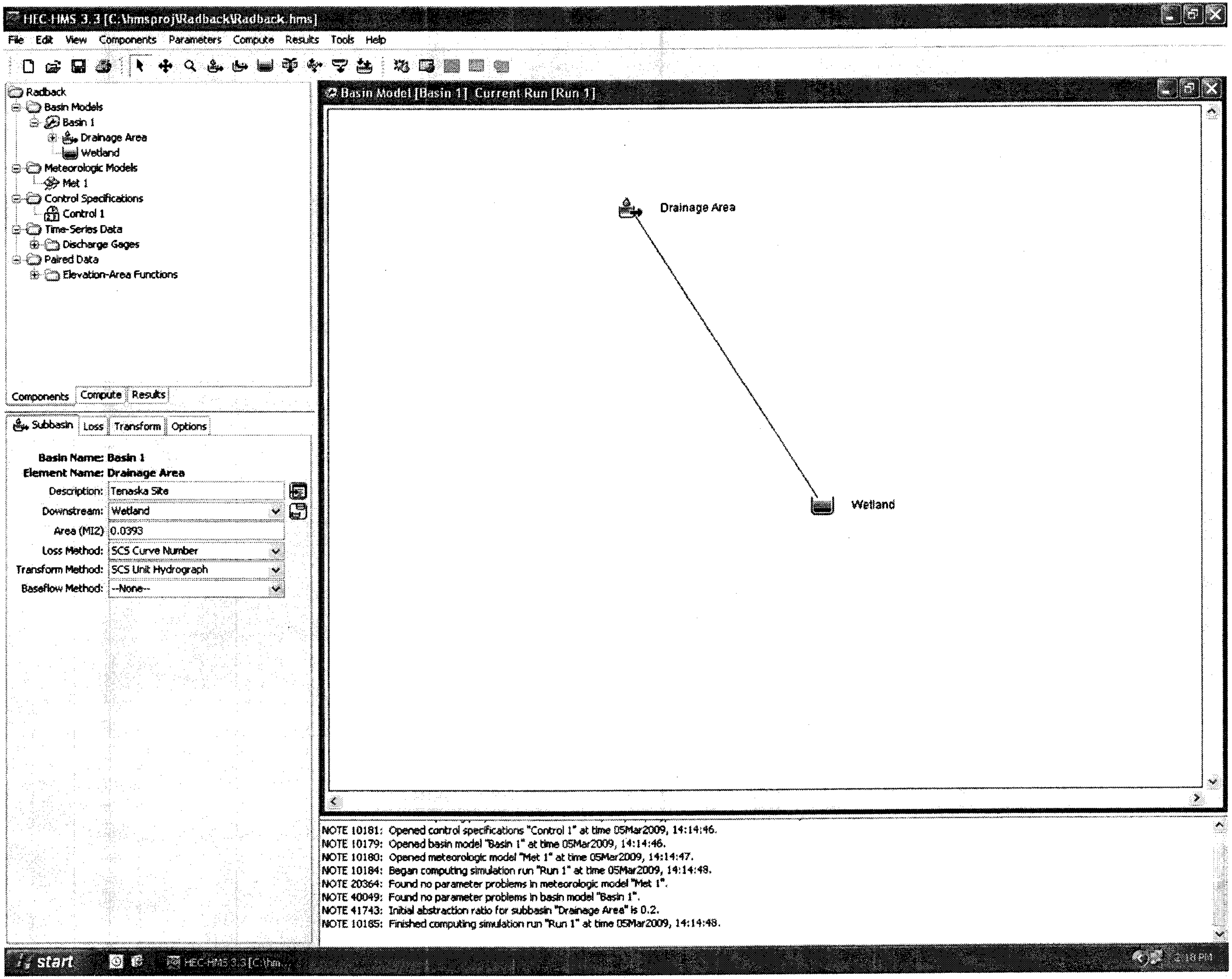
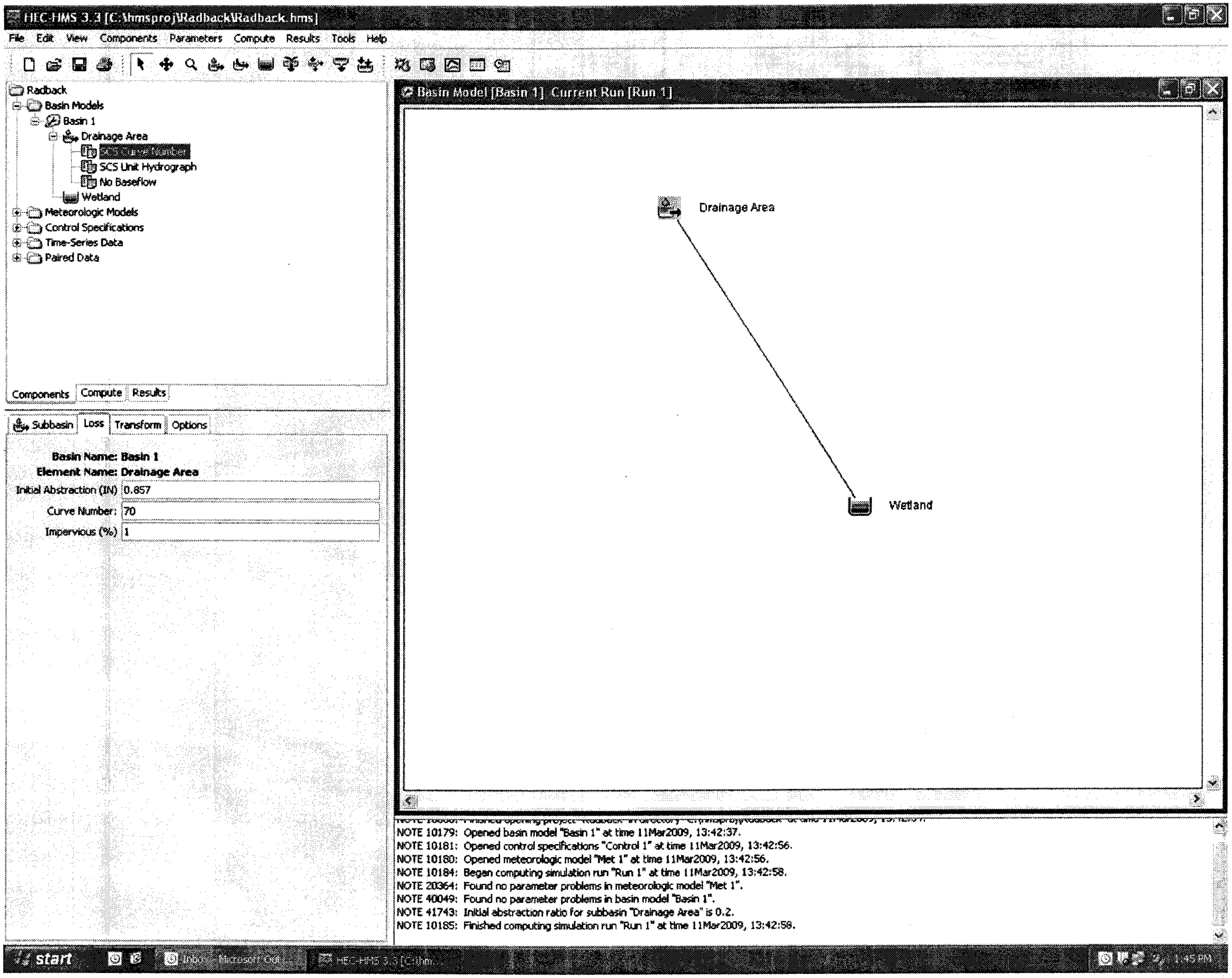
# Attachment 1

## HEC-HMS Input


HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1
Element Name: Drainage Area
Description: Tenaska Site
Downstream: Wetland
Area (MI2) 0.0393
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Baseflow Method: --None--
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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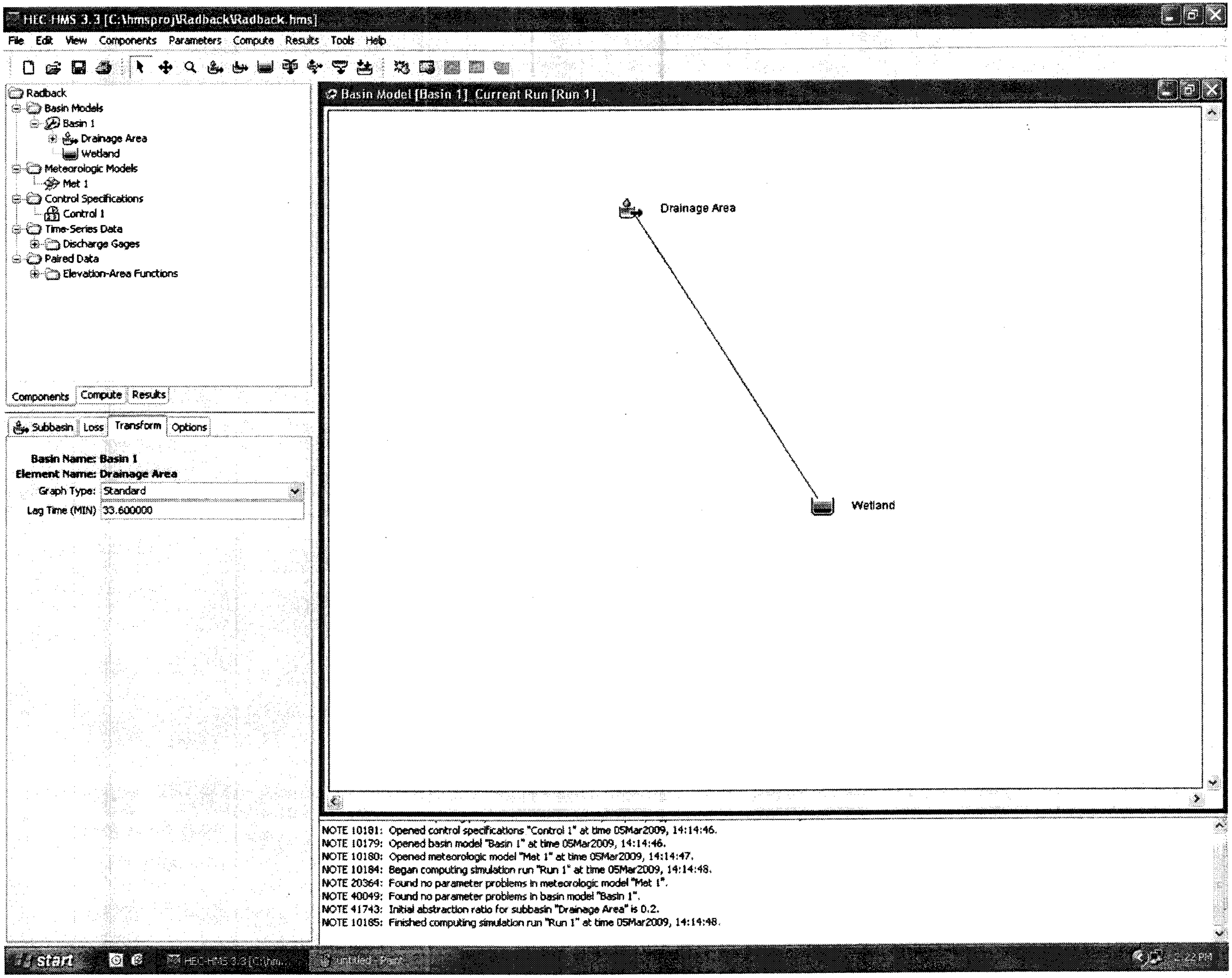
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1
Element Name: Drainage Area
Initial Abstraction (IN) 0.857
Curve Number: 70
Impervious (%) 1
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10179: Opened basin model "Basin 1" at time 11Mar2009, 13:42:37.
NOTE 10181: Opened control specifications "Control 1" at time 11Mar2009, 13:42:56.
NOTE 10180: Opened meteorologic model "Met 1" at time 11Mar2009, 13:42:56.
NOTE 10184: Began computing simulation run "Run 1" at time 11Mar2009, 13:42:58.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 11Mar2009, 13:42:58.
start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File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1
Element Name: Drainage Area
Graph Type: Standard
Lag Time (MIN) 33.600000
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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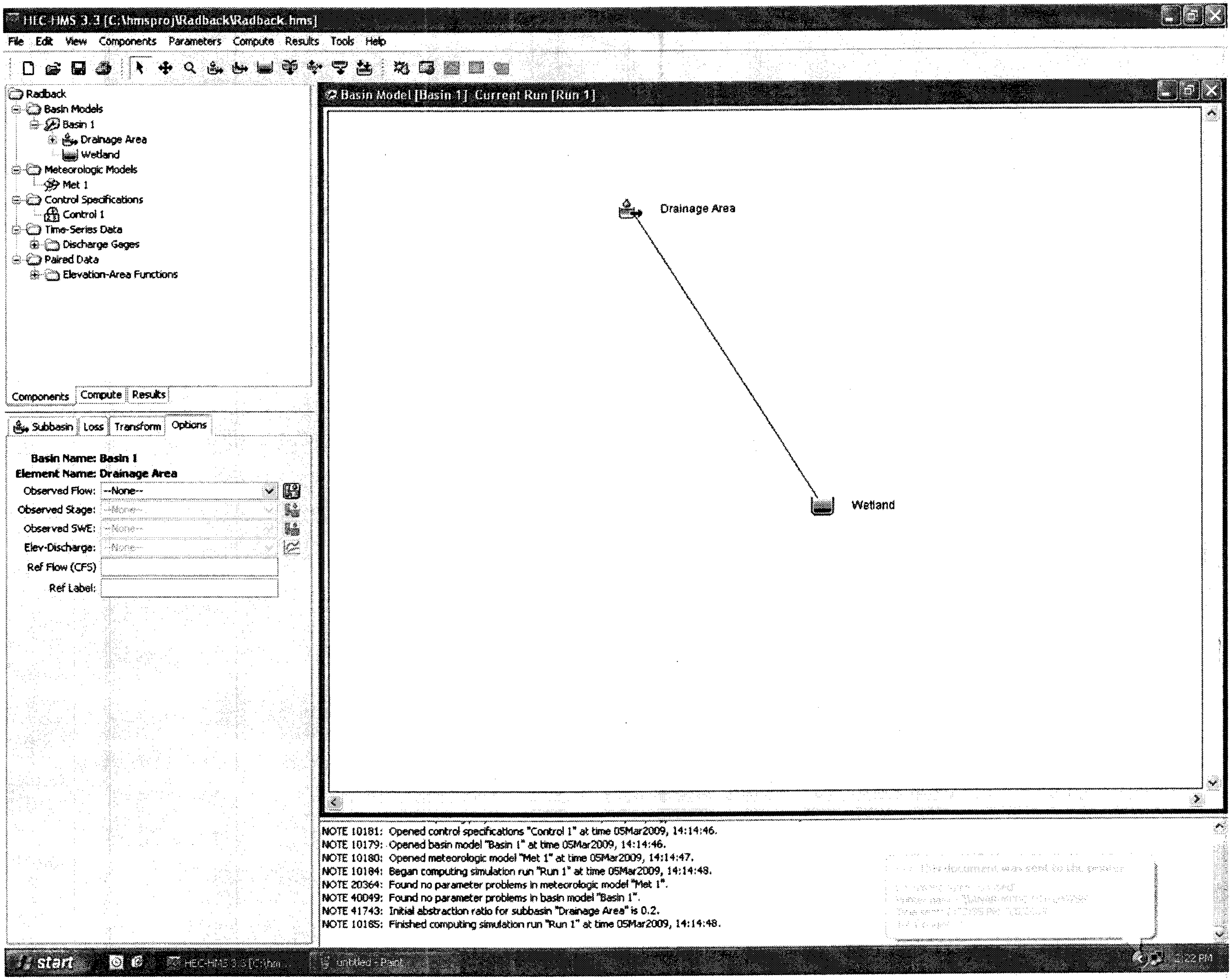
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1
Element Name: Drainage Area
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge:
Ref Flow (CFS)
Ref Label:
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
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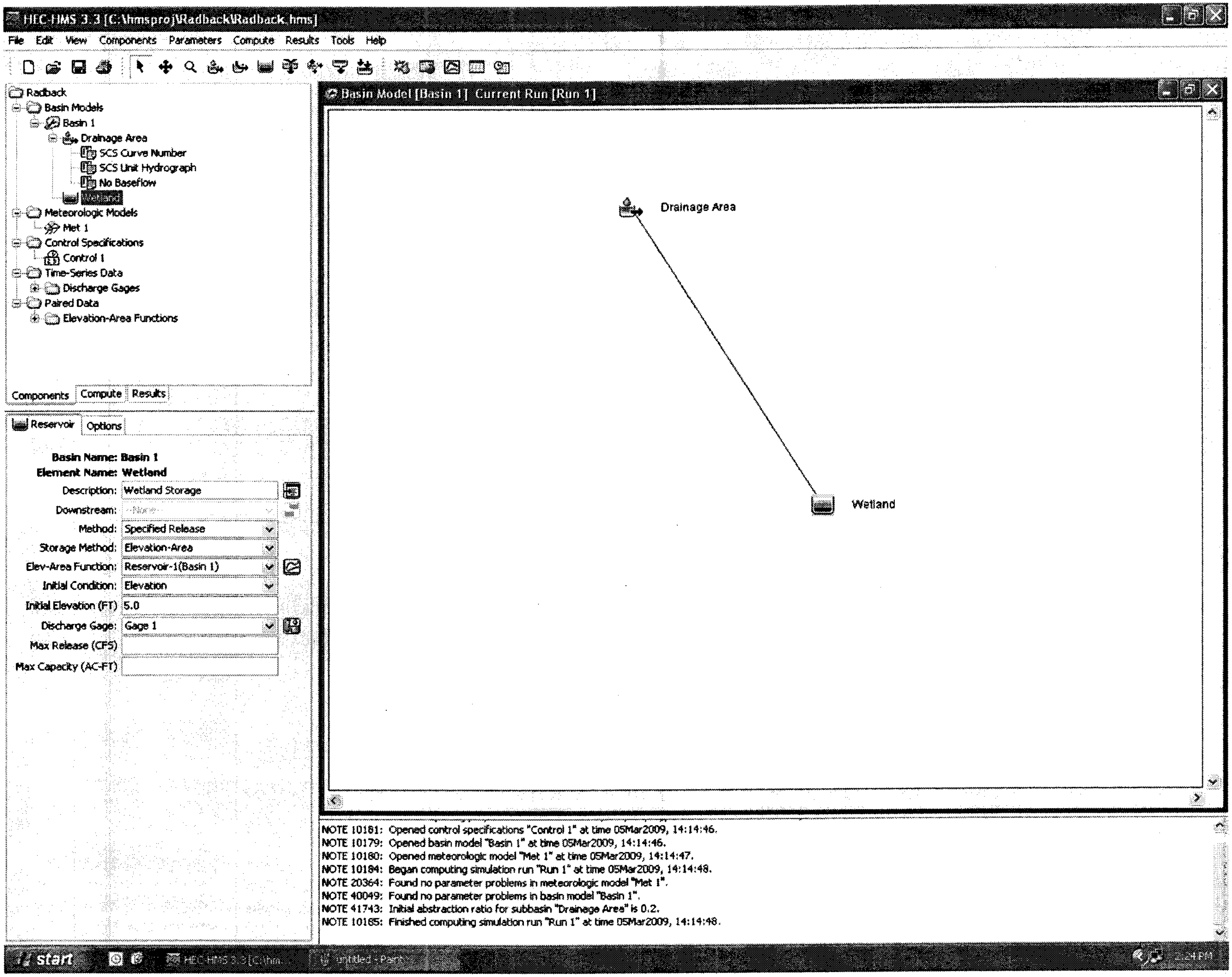
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Reservoir Options
Basin Name: Basin 1
Element Name: Wetland
Description: Wetland Storage
Downstream: --None--
Method: Specified Release
Storage Method: Elevation-Area
Elev-Area Function: Reservoir-1(Basin 1)
Initial Condition: Elevation
Initial Elevation (FT) 5.0
Discharge Gage: Gage 1
Max Release (CFS)
Max Capacity (AC-FT)
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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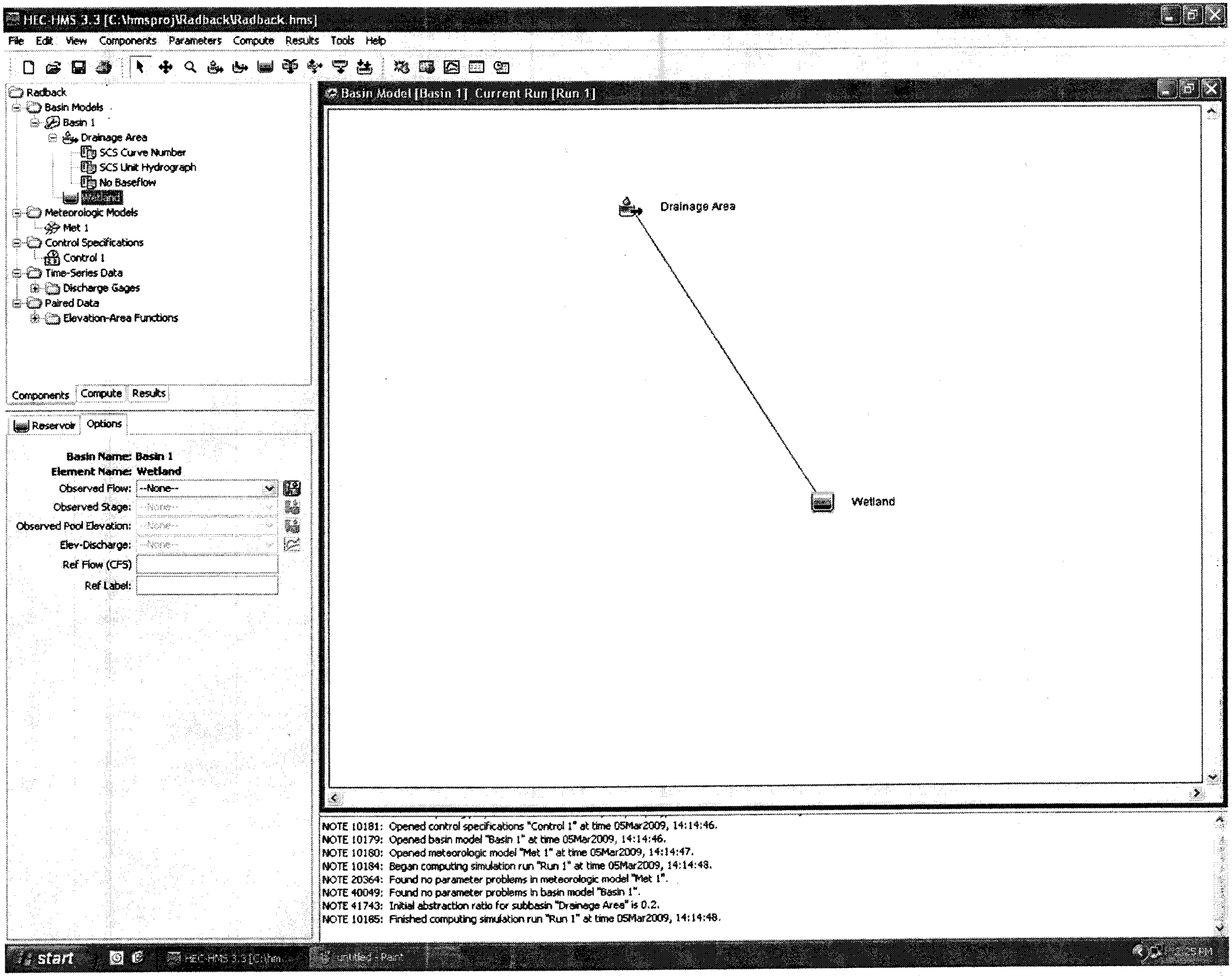
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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File Edit View Components Parameters Compute Results Tools Help
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Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Reservoir Options
Basin Name: Basin 1
Element Name: Wetland
Observed Flow: --None--
Observed Stage: --None--
Observed Pool Elevation: --None--
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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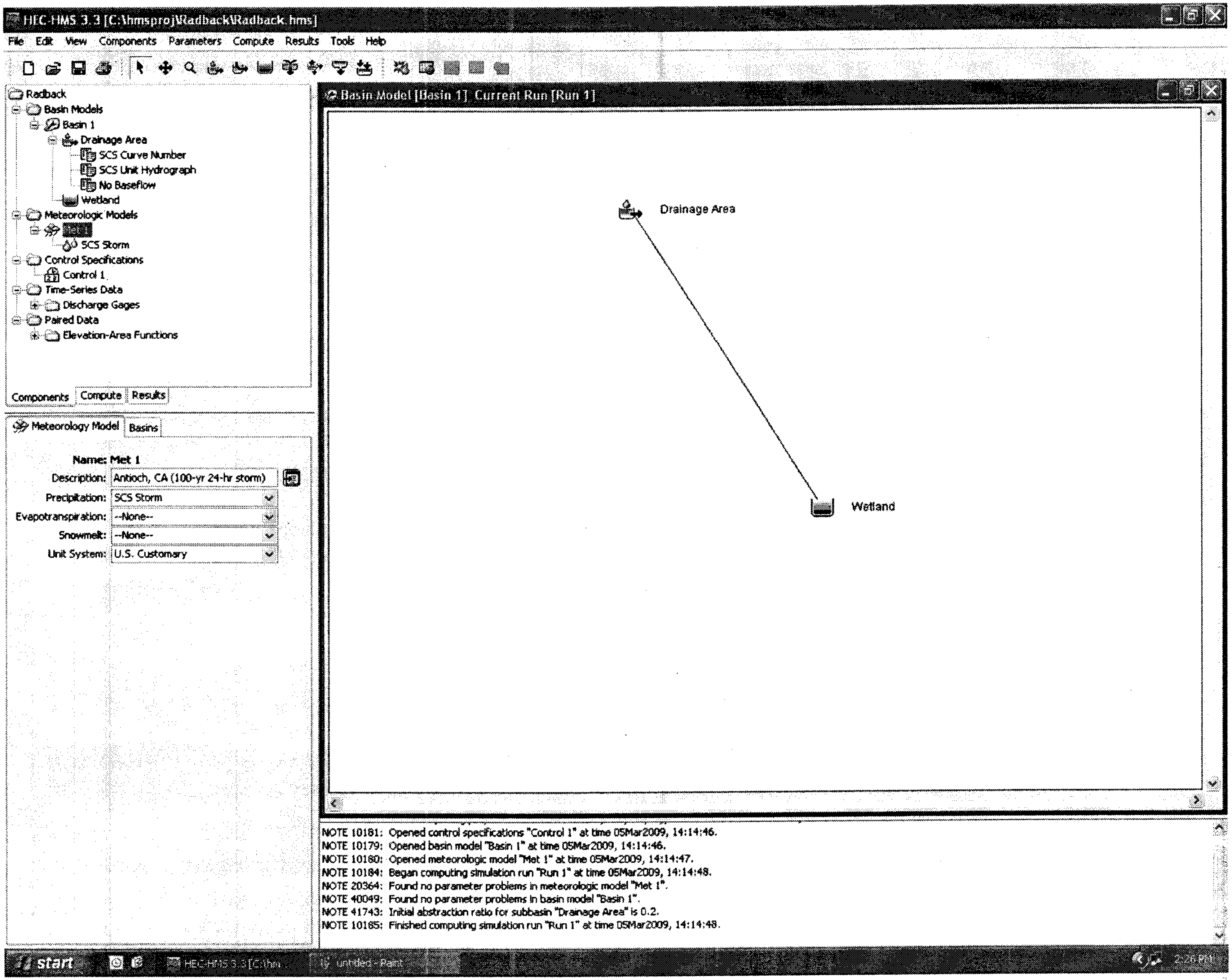
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start
untitled - Paint


HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Meteorology Model Basins
Name: Met 1
Description: Antioch, CA (100-yr 24-hr storm)
Precipitation: SCS Storm
Evapotranspiration: --None--
Snowmelt: --None--
Unit System: U.S. Customary
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
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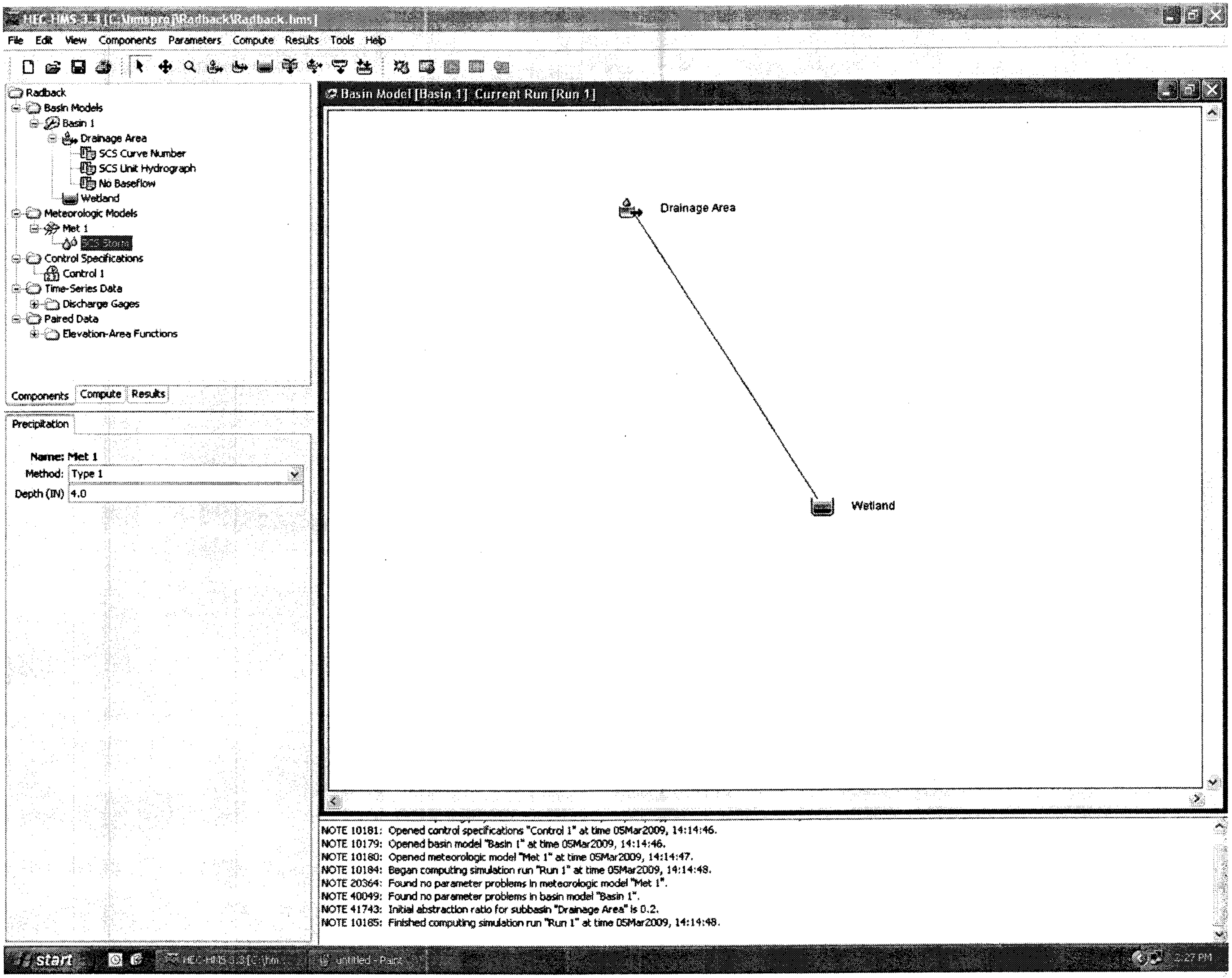
start
untitled - Paint


File Edit View Components Parameters Compute Results Tools Help
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Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components
Compute
Results
Precipitation
Name: Met 1
Method: Type 1
Depth (IN) 4.0
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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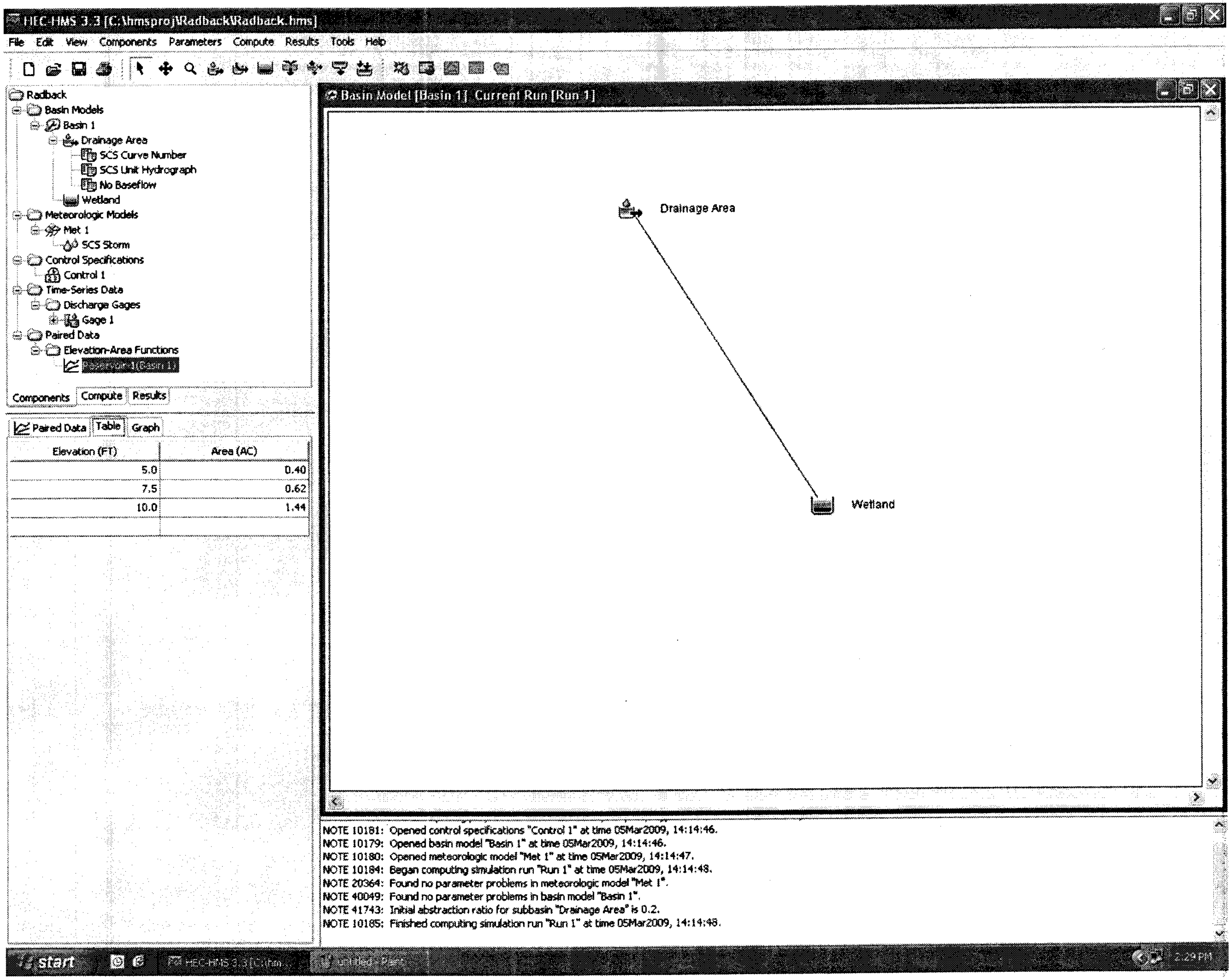
start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File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Gage 1
Paired Data
Elevation-Area Functions
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
5.0 0.40
7.5 0.62
10.0 1.44
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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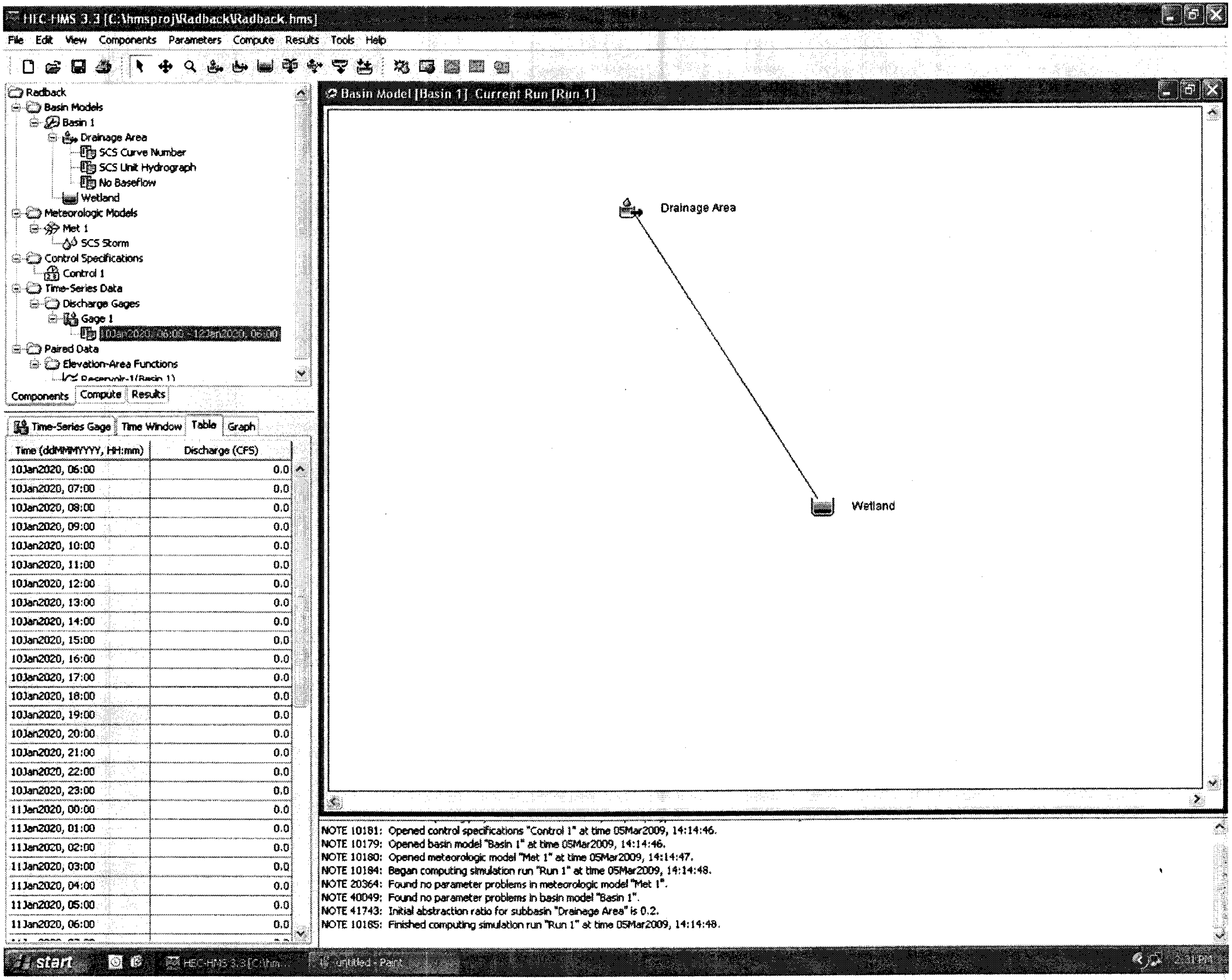
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start


HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Gage 1
10Jan2020, 06:00 - 12Jan2020, 06:00
Paired Data
Elevation-Area Functions
Components Compute Results
Time-Series Gage Time Window Table Graph
Time (ddMMMYYYY, HH:mm) Discharge (CFS)
10Jan2020, 06:00 0.0
10Jan2020, 07:00 0.0
10Jan2020, 08:00 0.0
10Jan2020, 09:00 0.0
10Jan2020, 10:00 0.0
10Jan2020, 11:00 0.0
10Jan2020, 12:00 0.0
10Jan2020, 13:00 0.0
10Jan2020, 14:00 0.0
10Jan2020, 15:00 0.0
10Jan2020, 16:00 0.0
10Jan2020, 17:00 0.0
10Jan2020, 18:00 0.0
10Jan2020, 19:00 0.0
10Jan2020, 20:00 0.0
10Jan2020, 21:00 0.0
10Jan2020, 22:00 0.0
10Jan2020, 23:00 0.0
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11Jan2020, 02:00 0.0
11Jan2020, 03:00 0.0
11Jan2020, 04:00 0.0
11Jan2020, 05:00 0.0
11Jan2020, 06:00 0.0
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
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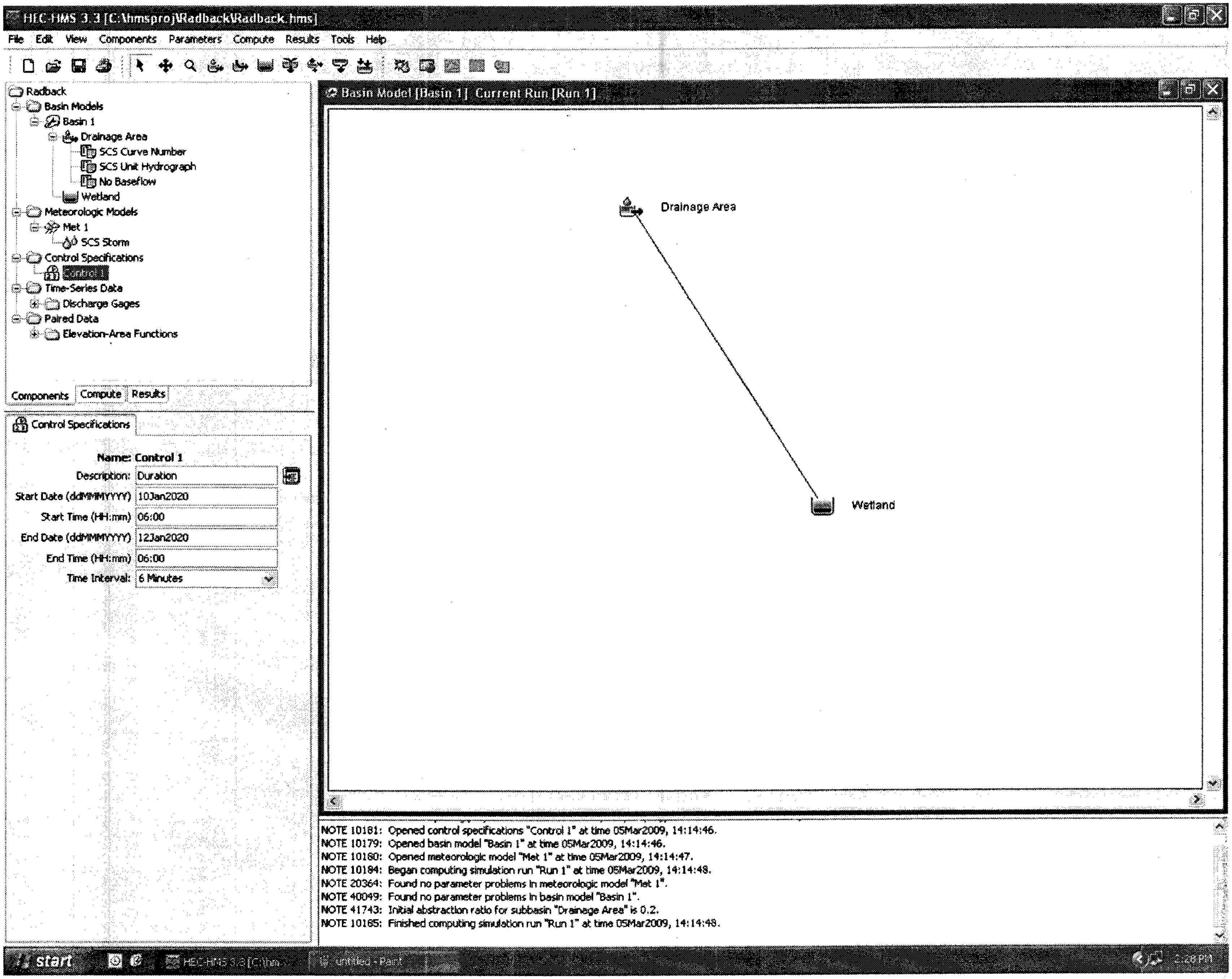
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start
untitled - Paint


HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Control Specifications
Name: Control 1
Description: Duration
Start Date (ddMMMYYYY) 10Jan2020
Start Time (HH:mm) 06:00
End Date (ddMMMYYYY) 12Jan2020
End Time (HH:mm) 06:00
Time Interval: 6 Minutes
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start
untitled - Paint

Radback Tenaska Project stormwater Analysis JZ 3/4/09

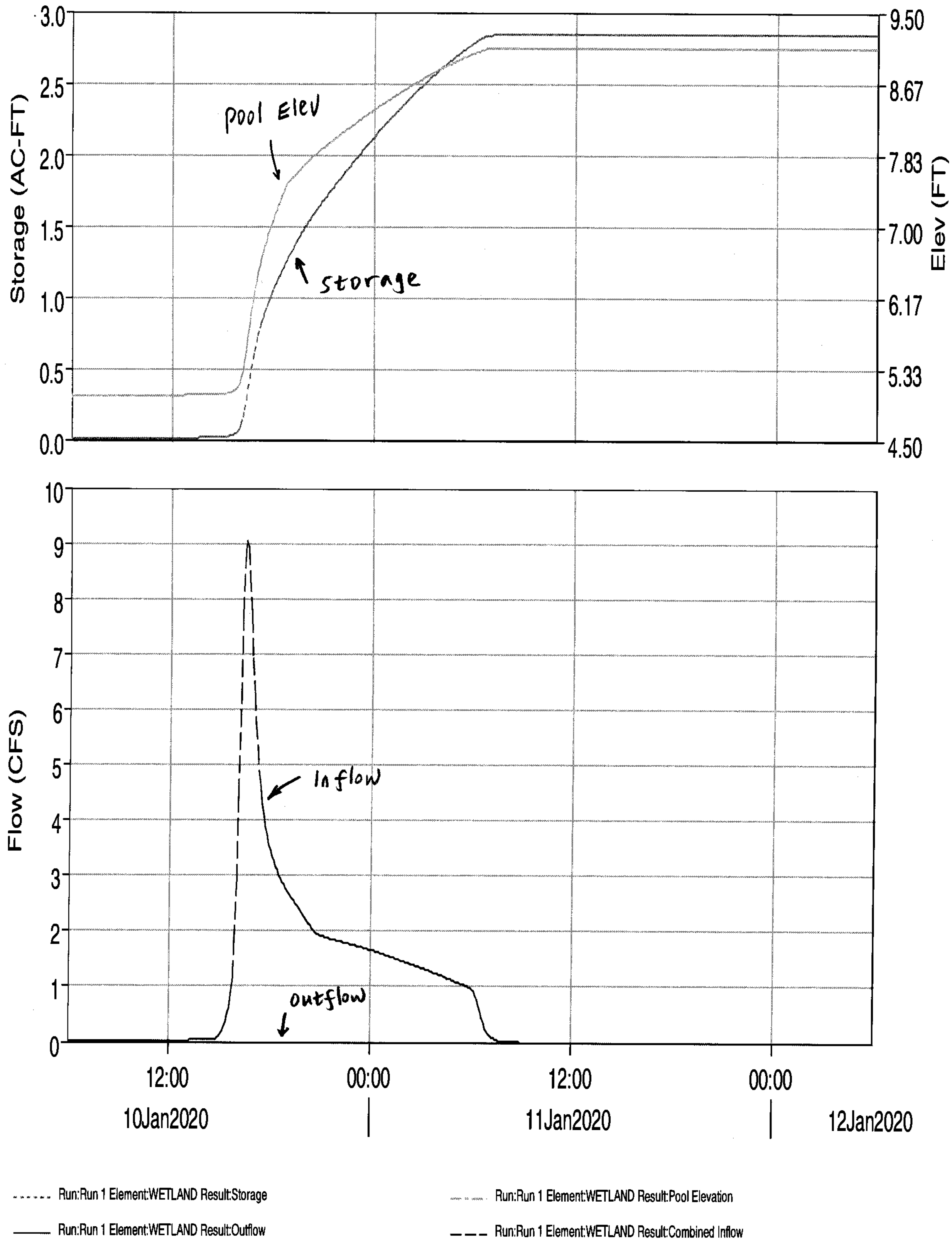
project # 163994 # of pages: 15

52, 5406, 1003

# Attachment 2

# HEC-HMS Output

Reservoir "Wetland" Results for Run "Run 1"



Project: Radback
Simulation Run: Run 1 Reservo

Start of Run: 10Jan2020, 06:00 Basin
End of Run: 12Jan2020, 06:00 M
Compute Time: 11Mar2009, 13:42:58

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 06:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 06:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 07:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:24 | 0.0 | 0.0 | 5.0 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 08:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 08:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 09:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 10:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:30 | 0.0 | 0.0 | 5.0 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 11:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 11:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 12:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:36 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:42 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:48 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 13:54 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:00 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:06 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:12 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:18 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:24 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:30 | 0.0 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:36 | 0.0 | 0.0 | 5.0 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 14:42 | 0.1 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:48 | 0.1 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 14:54 | 0.1 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 15:00 | 0.1 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 15:06 | 0.2 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 15:12 | 0.2 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 15:18 | 0.3 | 0.0 | 5.0 | 0.0 |
| 10Jan2020 | 15:24 | 0.4 | 0.0 | 5.1 | 0.0 |
| 10Jan2020 | 15:30 | 0.5 | 0.0 | 5.1 | 0.0 |
| 10Jan2020 | 15:36 | 0.6 | 0.0 | 5.1 | 0.0 |
| 10Jan2020 | 15:42 | 0.8 | 0.0 | 5.1 | 0.0 |
| 10Jan2020 | 15:48 | 1.1 | 0.0 | 5.1 | 0.0 |
| 10Jan2020 | 15:54 | 1.8 | 0.1 | 5.1 | 0.0 |
| 10Jan2020 | 16:00 | 2.9 | 0.1 | 5.2 | 0.0 |
| 10Jan2020 | 16:06 | 4.4 | 0.1 | 5.2 | 0.0 |
| 10Jan2020 | 16:12 | 6.2 | 0.2 | 5.3 | 0.0 |
| 10Jan2020 | 16:18 | 7.7 | 0.2 | 5.4 | 0.0 |
| 10Jan2020 | 16:24 | 8.7 | 0.3 | 5.6 | 0.0 |
| 10Jan2020 | 16:30 | 9.0 | 0.4 | 5.7 | 0.0 |
| 10Jan2020 | 16:36 | 8.9 | 0.4 | 5.8 | 0.0 |
| 10Jan2020 | 16:42 | 8.4 | 0.5 | 6.0 | 0.0 |
| 10Jan2020 | 16:48 | 7.7 | 0.6 | 6.1 | 0.0 |
| 10Jan2020 | 16:54 | 6.9 | 0.6 | 6.2 | 0.0 |
| 10Jan2020 | 17:00 | 6.3 | 0.7 | 6.3 | 0.0 |
| 10Jan2020 | 17:06 | 5.8 | 0.7 | 6.4 | 0.0 |
| 10Jan2020 | 17:12 | 5.3 | 0.8 | 6.5 | 0.0 |
| 10Jan2020 | 17:18 | 4.9 | 0.8 | 6.6 | 0.0 |
| 10Jan2020 | 17:24 | 4.6 | 0.9 | 6.7 | 0.0 |
| 10Jan2020 | 17:30 | 4.3 | 0.9 | 6.8 | 0.0 |
| 10Jan2020 | 17:36 | 4.1 | 0.9 | 6.8 | 0.0 |
| 10Jan2020 | 17:42 | 3.9 | 1.0 | 6.9 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 17:48 | 3.7 | 1.0 | 7.0 | 0.0 |
| 10Jan2020 | 17:54 | 3.6 | 1.0 | 7.0 | 0.0 |
| 10Jan2020 | 18:00 | 3.5 | 1.1 | 7.1 | 0.0 |
| 10Jan2020 | 18:06 | 3.3 | 1.1 | 7.1 | 0.0 |
| 10Jan2020 | 18:12 | 3.3 | 1.1 | 7.2 | 0.0 |
| 10Jan2020 | 18:18 | 3.2 | 1.1 | 7.2 | 0.0 |
| 10Jan2020 | 18:24 | 3.1 | 1.2 | 7.3 | 0.0 |
| 10Jan2020 | 18:30 | 3.0 | 1.2 | 7.3 | 0.0 |
| 10Jan2020 | 18:36 | 3.0 | 1.2 | 7.4 | 0.0 |
| 10Jan2020 | 18:42 | 2.9 | 1.2 | 7.4 | 0.0 |
| 10Jan2020 | 18:48 | 2.8 | 1.3 | 7.5 | 0.0 |
| 10Jan2020 | 18:54 | 2.8 | 1.3 | 7.5 | 0.0 |
| 10Jan2020 | 19:00 | 2.7 | 1.3 | 7.5 | 0.0 |
| 10Jan2020 | 19:06 | 2.7 | 1.3 | 7.6 | 0.0 |
| 10Jan2020 | 19:12 | 2.6 | 1.3 | 7.6 | 0.0 |
| 10Jan2020 | 19:18 | 2.6 | 1.4 | 7.6 | 0.0 |
| 10Jan2020 | 19:24 | 2.5 | 1.4 | 7.6 | 0.0 |
| 10Jan2020 | 19:30 | 2.5 | 1.4 | 7.6 | 0.0 |
| 10Jan2020 | 19:36 | 2.5 | 1.4 | 7.7 | 0.0 |
| 10Jan2020 | 19:42 | 2.4 | 1.5 | 7.7 | 0.0 |
| 10Jan2020 | 19:48 | 2.4 | 1.5 | 7.7 | 0.0 |
| 10Jan2020 | 19:54 | 2.3 | 1.5 | 7.7 | 0.0 |
| 10Jan2020 | 20:00 | 2.3 | 1.5 | 7.7 | 0.0 |
| 10Jan2020 | 20:06 | 2.2 | 1.5 | 7.8 | 0.0 |
| 10Jan2020 | 20:12 | 2.2 | 1.5 | 7.8 | 0.0 |
| 10Jan2020 | 20:18 | 2.1 | 1.6 | 7.8 | 0.0 |
| 10Jan2020 | 20:24 | 2.1 | 1.6 | 7.8 | 0.0 |
| 10Jan2020 | 20:30 | 2.1 | 1.6 | 7.8 | 0.0 |
| 10Jan2020 | 20:36 | 2.0 | 1.6 | 7.8 | 0.0 |
| 10Jan2020 | 20:42 | 2.0 | 1.6 | 7.9 | 0.0 |
| 10Jan2020 | 20:48 | 2.0 | 1.6 | 7.9 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 10Jan2020 | 20:54 | 1.9 | 1.7 | 7.9 | 0.0 |
| 10Jan2020 | 21:00 | 1.9 | 1.7 | 7.9 | 0.0 |
| 10Jan2020 | 21:06 | 1.9 | 1.7 | 7.9 | 0.0 |
| 10Jan2020 | 21:12 | 1.9 | 1.7 | 7.9 | 0.0 |
| 10Jan2020 | 21:18 | 1.9 | 1.7 | 8.0 | 0.0 |
| 10Jan2020 | 21:24 | 1.9 | 1.7 | 8.0 | 0.0 |
| 10Jan2020 | 21:30 | 1.9 | 1.8 | 8.0 | 0.0 |
| 10Jan2020 | 21:36 | 1.9 | 1.8 | 8.0 | 0.0 |
| 10Jan2020 | 21:42 | 1.9 | 1.8 | 8.0 | 0.0 |
| 10Jan2020 | 21:48 | 1.8 | 1.8 | 8.0 | 0.0 |
| 10Jan2020 | 21:54 | 1.8 | 1.8 | 8.1 | 0.0 |
| 10Jan2020 | 22:00 | 1.8 | 1.8 | 8.1 | 0.0 |
| 10Jan2020 | 22:06 | 1.8 | 1.8 | 8.1 | 0.0 |
| 10Jan2020 | 22:12 | 1.8 | 1.9 | 8.1 | 0.0 |
| 10Jan2020 | 22:18 | 1.8 | 1.9 | 8.1 | 0.0 |
| 10Jan2020 | 22:24 | 1.8 | 1.9 | 8.1 | 0.0 |
| 10Jan2020 | 22:30 | 1.8 | 1.9 | 8.1 | 0.0 |
| 10Jan2020 | 22:36 | 1.8 | 1.9 | 8.2 | 0.0 |
| 10Jan2020 | 22:42 | 1.8 | 1.9 | 8.2 | 0.0 |
| 10Jan2020 | 22:48 | 1.8 | 2.0 | 8.2 | 0.0 |
| 10Jan2020 | 22:54 | 1.8 | 2.0 | 8.2 | 0.0 |
| 10Jan2020 | 23:00 | 1.7 | 2.0 | 8.2 | 0.0 |
| 10Jan2020 | 23:06 | 1.7 | 2.0 | 8.2 | 0.0 |
| 10Jan2020 | 23:12 | 1.7 | 2.0 | 8.2 | 0.0 |
| 10Jan2020 | 23:18 | 1.7 | 2.0 | 8.3 | 0.0 |
| 10Jan2020 | 23:24 | 1.7 | 2.0 | 8.3 | 0.0 |
| 10Jan2020 | 23:30 | 1.7 | 2.1 | 8.3 | 0.0 |
| 10Jan2020 | 23:36 | 1.7 | 2.1 | 8.3 | 0.0 |
| 10Jan2020 | 23:42 | 1.7 | 2.1 | 8.3 | 0.0 |
| 10Jan2020 | 23:48 | 1.7 | 2.1 | 8.3 | 0.0 |
| 10Jan2020 | 23:54 | 1.7 | 2.1 | 8.3 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 11Jan2020 | 00:00 | 1.7 | 2.1 | 8.4 | 0.0 |
| 11Jan2020 | 00:06 | 1.6 | 2.1 | 8.4 | 0.0 |
| 11Jan2020 | 00:12 | 1.6 | 2.2 | 8.4 | 0.0 |
| 11Jan2020 | 00:18 | 1.6 | 2.2 | 8.4 | 0.0 |
| 11Jan2020 | 00:24 | 1.6 | 2.2 | 8.4 | 0.0 |
| 11Jan2020 | 00:30 | 1.6 | 2.2 | 8.4 | 0.0 |
| 11Jan2020 | 00:36 | 1.6 | 2.2 | 8.4 | 0.0 |
| 11Jan2020 | 00:42 | 1.6 | 2.2 | 8.5 | 0.0 |
| 11Jan2020 | 00:48 | 1.6 | 2.2 | 8.5 | 0.0 |
| 11Jan2020 | 00:54 | 1.6 | 2.2 | 8.5 | 0.0 |
| 11Jan2020 | 01:00 | 1.6 | 2.3 | 8.5 | 0.0 |
| 11Jan2020 | 01:06 | 1.6 | 2.3 | 8.5 | 0.0 |
| 11Jan2020 | 01:12 | 1.5 | 2.3 | 8.5 | 0.0 |
| 11Jan2020 | 01:18 | 1.5 | 2.3 | 8.5 | 0.0 |
| 11Jan2020 | 01:24 | 1.5 | 2.3 | 8.5 | 0.0 |
| 11Jan2020 | 01:30 | 1.5 | 2.3 | 8.6 | 0.0 |
| 11Jan2020 | 01:36 | 1.5 | 2.3 | 8.6 | 0.0 |
| 11Jan2020 | 01:42 | 1.5 | 2.3 | 8.6 | 0.0 |
| 11Jan2020 | 01:48 | 1.5 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 01:54 | 1.5 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 02:00 | 1.5 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 02:06 | 1.4 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 02:12 | 1.4 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 02:18 | 1.4 | 2.4 | 8.6 | 0.0 |
| 11Jan2020 | 02:24 | 1.4 | 2.4 | 8.7 | 0.0 |
| 11Jan2020 | 02:30 | 1.4 | 2.4 | 8.7 | 0.0 |
| 11Jan2020 | 02:36 | 1.4 | 2.5 | 8.7 | 0.0 |
| 11Jan2020 | 02:42 | 1.4 | 2.5 | 8.7 | 0.0 |
| 11Jan2020 | 02:48 | 1.4 | 2.5 | 8.7 | 0.0 |
| 11Jan2020 | 02:54 | 1.4 | 2.5 | 8.7 | 0.0 |
| 11Jan2020 | 03:00 | 1.3 | 2.5 | 8.7 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 11Jan2020 | 03:06 | 1.3 | 2.5 | 8.7 | 0.0 |
| 11Jan2020 | 03:12 | 1.3 | 2.5 | 8.8 | 0.0 |
| 11Jan2020 | 03:18 | 1.3 | 2.5 | 8.8 | 0.0 |
| 11Jan2020 | 03:24 | 1.3 | 2.5 | 8.8 | 0.0 |
| 11Jan2020 | 03:30 | 1.3 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 03:36 | 1.3 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 03:42 | 1.3 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 03:48 | 1.2 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 03:54 | 1.2 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 04:00 | 1.2 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 04:06 | 1.2 | 2.6 | 8.8 | 0.0 |
| 11Jan2020 | 04:12 | 1.2 | 2.6 | 8.9 | 0.0 |
| 11Jan2020 | 04:18 | 1.2 | 2.6 | 8.9 | 0.0 |
| 11Jan2020 | 04:24 | 1.2 | 2.6 | 8.9 | 0.0 |
| 11Jan2020 | 04:30 | 1.2 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 04:36 | 1.2 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 04:42 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 04:48 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 04:54 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 05:00 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 05:06 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 05:12 | 1.1 | 2.7 | 8.9 | 0.0 |
| 11Jan2020 | 05:18 | 1.1 | 2.7 | 9.0 | 0.0 |
| 11Jan2020 | 05:24 | 1.1 | 2.7 | 9.0 | 0.0 |
| 11Jan2020 | 05:30 | 1.0 | 2.7 | 9.0 | 0.0 |
| 11Jan2020 | 05:36 | 1.0 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 05:42 | 1.0 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 05:48 | 1.0 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 05:54 | 1.0 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 06:00 | 1.0 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 06:06 | 1.0 | 2.8 | 9.0 | 0.0 |

| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
|---|---|---|---|---|---|
| 11Jan2020 | 06:12 | 0.9 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 06:18 | 0.9 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 06:24 | 0.8 | 2.8 | 9.0 | 0.0 |
| 11Jan2020 | 06:30 | 0.7 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 06:36 | 0.5 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 06:42 | 0.4 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 06:48 | 0.3 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 06:54 | 0.2 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:00 | 0.2 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:06 | 0.1 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:12 | 0.1 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:18 | 0.1 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:24 | 0.1 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:30 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:36 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:42 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:48 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 07:54 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:00 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:06 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:12 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:18 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:24 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:30 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:36 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:42 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:48 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 08:54 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 09:00 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 09:06 | 0.0 | 2.8 | 9.1 | 0.0 |
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| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
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| Date | Time | Inflow (CFS) | Storage (AC-FT) | Elevation (FT) | Outflow (CFS) |
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| 11Jan2020 | 18:54 | 0.0 | 2.8 | 9.1 | 0.0 |
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| 11Jan2020 | 19:36 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 19:42 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 19:48 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 19:54 | 0.0 | 2.8 | 9.1 | 0.0 |
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| 11Jan2020 | 20:06 | 0.0 | 2.8 | 9.1 | 0.0 |
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| 11Jan2020 | 20:48 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 20:54 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 21:00 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 21:06 | 0.0 | 2.8 | 9.1 | 0.0 |
| 11Jan2020 | 21:12 | 0.0 | 2.8 | 9.1 | 0.0 |
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| 11Jan2020 | 21:24 | 0.0 | 2.8 | 9.1 | 0.0 |
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# Attachment 3

Reference 2

Select pages

# Chapter 2 Estimating Runoff

## SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{\left(P - I_a\right)^2}{\left(P - I_a\right) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
$I_a$ = initial abstraction (in)

Initial abstraction ($I_a$) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. $I_a$ is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, $I_a$ was found to be approximated by the following empirical equation:

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

By removing $I_a$ as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{\left(P - 0.2S\right)^2}{\left(P + 0.8S\right)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

## Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

### Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

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

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type and hydrologic condition | Average percent impervious area [2] | A | B | C | D |
| *Fully developed urban areas (vegetation established)* | | | | | |
| Open space (lawns, parks, golf courses, cemeteries, etc.) [3]: | | | | | |
| 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: | | | | | |
| 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 |
| 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 |
| 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.

**Table 2-2b** Runoff curve numbers for cultivated agricultural lands [1]

| Cover description | | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|---|
| Cover type | Treatment [2] | Hydrologic condition [3] | A | B | C | D |
| Fallow | Bare soil | — | 77 | 86 | 91 | 94 |
| | Crop residue cover (CR) | Poor | 76 | 85 | 90 | 93 |
| | | Good | 74 | 83 | 88 | 90 |
| Row crops | Straight row (SR) | Poor | 72 | 81 | 88 | 91 |
| | | Good | 67 | 78 | 85 | 89 |
| | SR + CR | Poor | 71 | 80 | 87 | 90 |
| | | Good | 64 | 75 | 82 | 85 |
| | Contoured (C) | Poor | 70 | 79 | 84 | 88 |
| | | Good | 65 | 75 | 82 | 86 |
| | C + CR | Poor | 69 | 78 | 83 | 87 |
| | | Good | 64 | 74 | 81 | 85 |
| | Contoured & terraced (C&T) | Poor | 66 | 74 | 80 | 82 |
| | | Good | 62 | 71 | 78 | 81 |
| | C&T+ CR | Poor | 65 | 73 | 79 | 81 |
| | | Good | 61 | 70 | 77 | 80 |
| Small grain | SR | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | SR + CR | Poor | 64 | 75 | 83 | 86 |
| | | Good | 60 | 72 | 80 | 84 |
| | C | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | C + CR | Poor | 62 | 73 | 81 | 84 |
| | | Good | 60 | 72 | 80 | 83 |
| | C&T | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| | C&T+ CR | Poor | 60 | 71 | 78 | 81 |
| | | Good | 58 | 69 | 77 | 80 |
| Close-seeded or broadcast legumes or rotation meadow | SR | Poor | 66 | 77 | 85 | 89 |
| | | Good | 58 | 72 | 81 | 85 |
| | C | Poor | 64 | 75 | 83 | 85 |
| | | Good | 55 | 69 | 78 | 83 |
| | C&T | Poor | 63 | 73 | 80 | 83 |
| | | Good | 51 | 67 | 76 | 80 |

1 Average runoff condition, and $I_a$=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

## 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 bank-full elevation.

# 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:

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

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

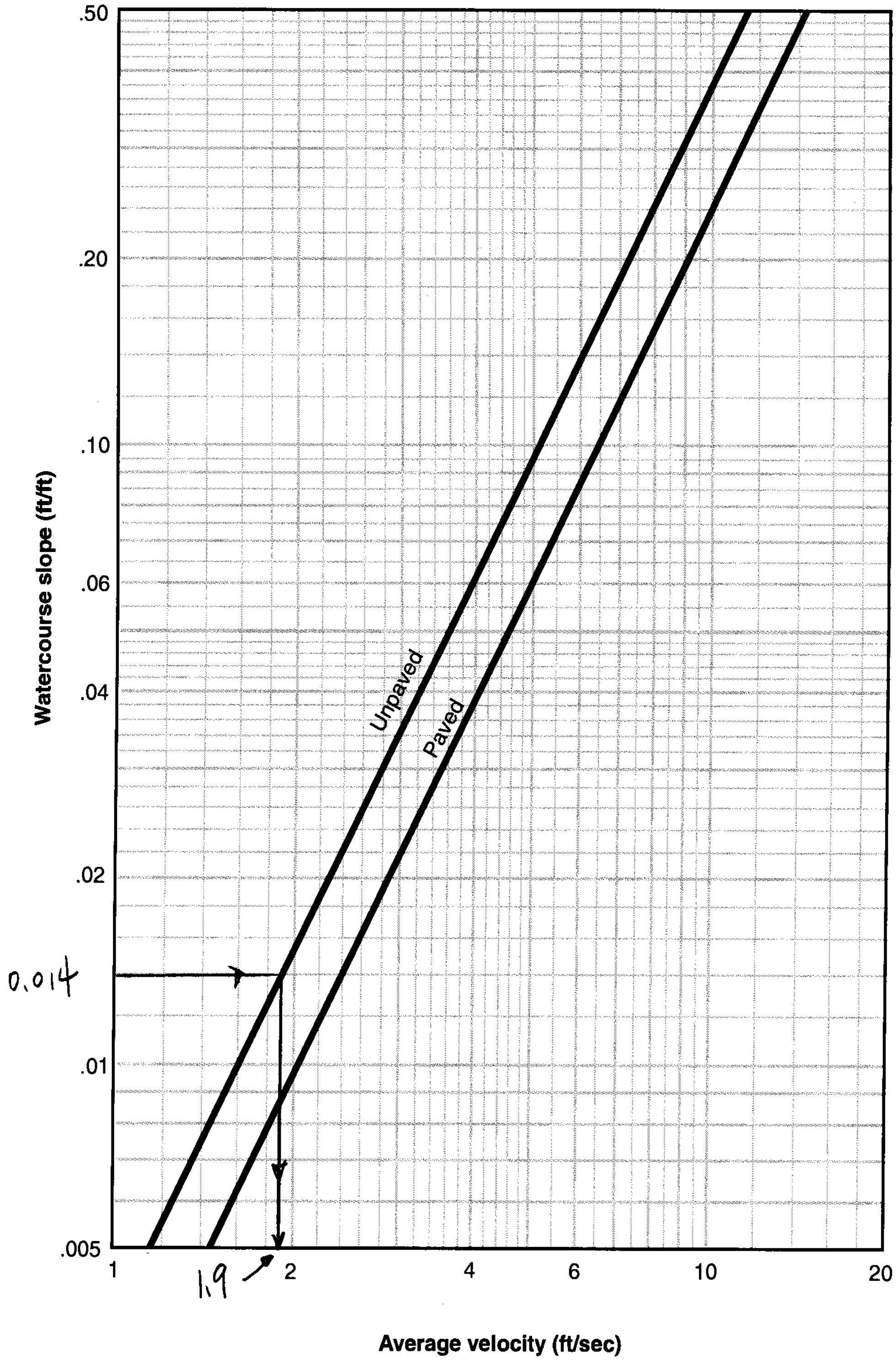
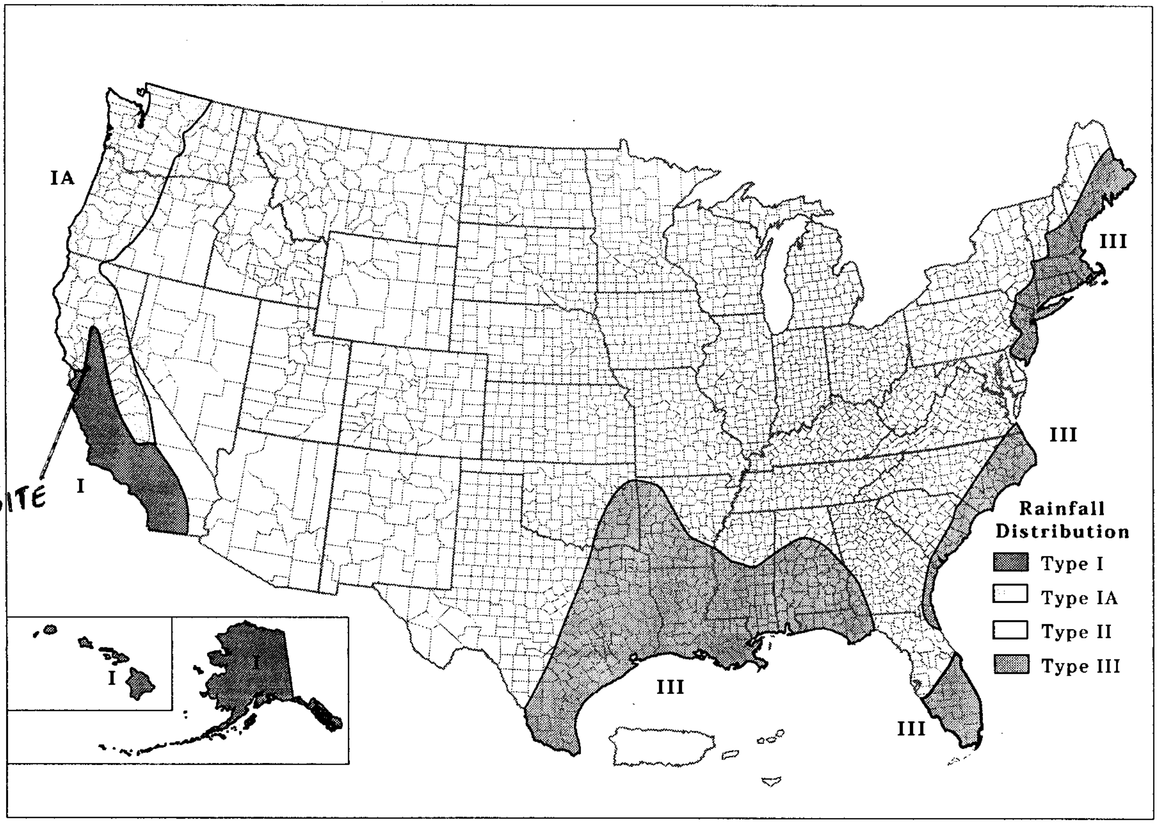


**Figure B-2** Approximate geographic boundaries for NRCS (SCS) rainfall distributions




## 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 A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

**Group A**soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

**Group B**soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

**Group C**soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

**Group D**soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

## Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

| *HSG* | *Soil textures* |
|---|---|
| A | Sand, loamy sand, or sandy loam |
| B | Silt loam or loam |
| C | Sandy clay loam |
| D | Clay loam, silty clay loam, sandy clay, silty clay, or clay |

## Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Radback Tenaska project          Stormwater Analysis          JT 3/4/09

project # 163994

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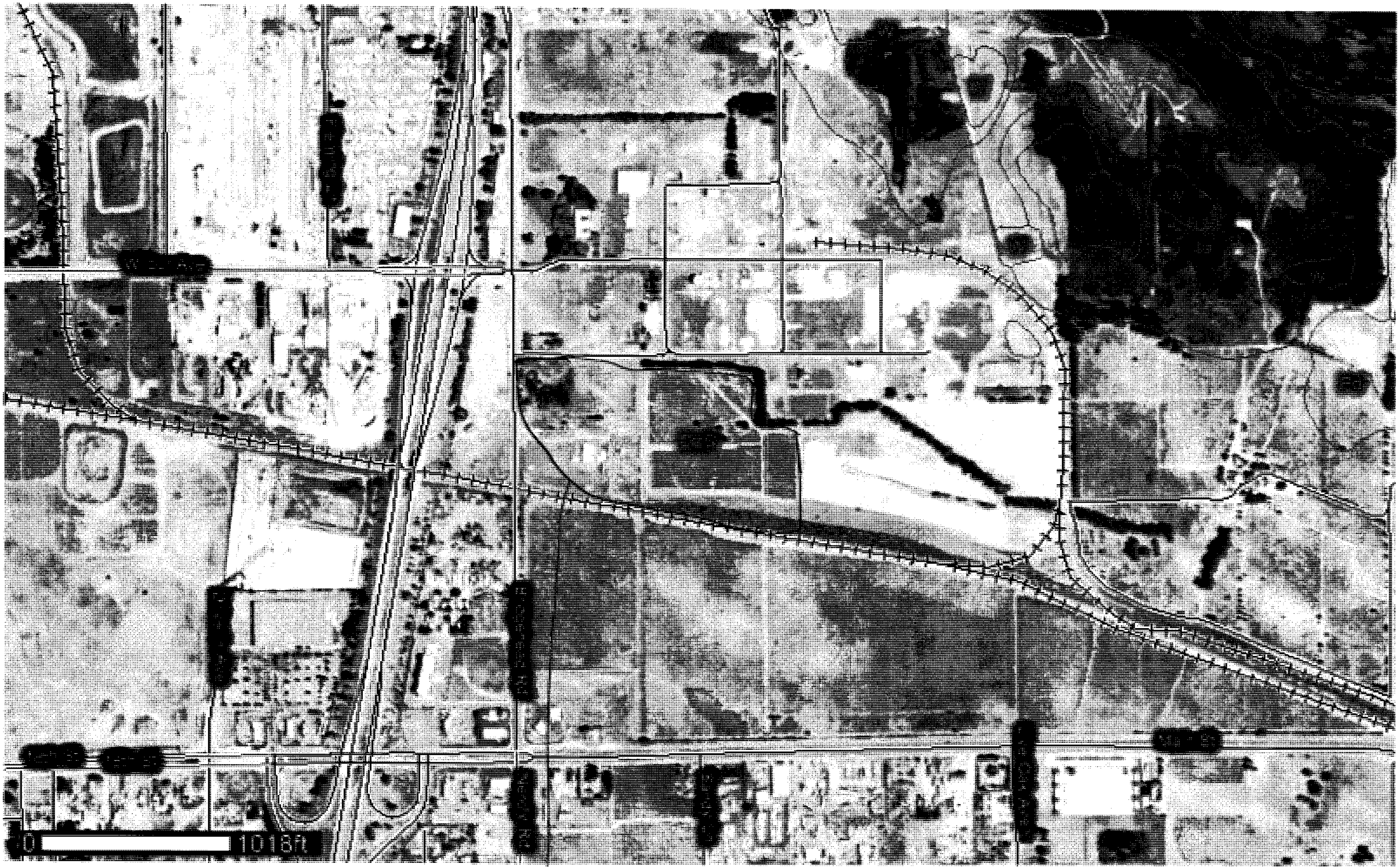
# Attachment 4

Reference 6

Select pages

( printed out from the Online Web soil survey )




Project site

# Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

# Contra Costa County, California

## DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

### Map Unit Setting

*Elevation:* 10 to 150 feet
*Mean annual precipitation:* 12 to 14 inches
*Mean annual air temperature:* 59 degrees F
*Frost-free period:* 260 to 300 days

### Map Unit Composition

*Delhi and similar soils:* 85 percent
*Minor components:* 15 percent

### Description of Delhi

#### Setting

*Landform:* Flood plains, terraces, alluvial fans
*Landform position (three-dimensional):* Tread, talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Eolian deposits derived from igneous and sedimentary rock

#### Properties and qualities

*Slope:* 2 to 9 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Somewhat excessively drained
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (5.95 to 19.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Low (about 4.2 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3s
*Land capability (nonirrigated):* 6e

#### Typical profile

*0 to 5 inches:* Sand
*5 to 60 inches:* Sand

### Minor Components

#### Unnamed

*Percent of map unit:* 12 percent

#### Laugenour

*Percent of map unit:* 3 percent

## Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

# Attachment 3
# Contra Costa Clean Water Program
# Stormwater C.3 Guidebook

Appendix

# B

# Soils, Plantings, and Irrigation for Bioretention Facilities

*Additional guidance for design and construction of bioretention facilities and flow-through planters*

Bioretention facility owners are responsible for ensuring the following standards of performance are achieved throughout the life of the facility:

- Runoff must percolate through the imported bioretention soil mix at a minimum rate of 5" per hour.
- Plantings must be maintained in a healthy condition without use of conventional fertilizers or pesticides.
- Irrigation systems must minimize water use and be controlled to prevent overwatering and underdrain flow during dry weather.

As described in Chapter 5, municipalities will periodically verify these standards continue to be achieved. Operation and maintenance verification is required by the municipalities' stormwater NPDES permit issued by the Regional Water Quality Control Board.

The design criteria and checklists and other guidance in Chapter 4—including the design sheets on pp. 63-78—aim to ensure new bioretention facilities and planter boxes can reliably meet these standards of performance.

The additional guidance in this Appendix will assist applicants and

Appendix B Contents

their designers as they proceed from initial planning through design and construction.

Responsibility for design, construction, maintenance, and performance of stormwater treatment and flow-control facilities and their components rests with the applicant or property owner.

## Soils

Soils for bioretention areas must meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

ICON KEY

- Helpful Tip
- Submittal Requirement
- Terms to Look Up
- References & Resources

Some native loamy sands may be suitable for both objectives; however, such soils are rare in Contra Costa and are not generally available from suppliers.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

The Contra Costa Clean Water Program has developed specifications for two bioretention soil mixes. Local soil products suppliers have expressed interest in developing "brand-name" mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a "brand-name" mix from a soil supplier. A list of suppliers who have submitted test results and certification to the Program is on the Program website. Updated soil and compost test results may be required; tests must be within 120 days prior to the delivery date of the bioretention soil to the project site.

Credit
This Appendix was prepared based on recommendations by WRA Environmental Consultants, Inc.
www.wra-ca.com

Typically, batch-specific test results and certification will be required for projects installing more that 100 cubic yards of bioretention soil.

► SOIL SPECIFICATION

Bioretention soils should meet the following criteria.

1. General Requirements
   Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth.

Bioretention Soil shall be a mixture of topsoil or fine sand, and compost, measured on a volume basis.

Mix A – Topsoil Blend
10%-20% Topsoil
50%-60% Fine Sand
30%-40% Compost

Mix B – Fine Sand Blend
60%-70% Fine Sand
30%-40% Compost

1.1. Submittals
The applicant must submit to the municipality for approval:

A. A sample of mixed bioretention soil.

B. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.

C. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.

D. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in Section 1.4.

E. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".

F. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.

G. Provide the following information about the testing laboratory(ies) name of laboratory(ies) including

1) contact person(s)

2) address(es)

3) phone contact(s)

4) e-mail address(es)

5) qualifications of laboratory(ies), and personnel including date of current certification by STA, ASTM, or approved equal

1.2. Sand for Bioretention Soil

A. General
Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be non-plastic.

B. Sand for Bioretention Soil Texture
Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

| Sieve Size | Percent Passing (by weight) | |
|---|---|---|
| | *Min* | *Max* |
| 3/8 inch | 100 | 100 |
| No. 4 | 90 | 100 |
| No. 8 | 70 | 100 |
| No. 16 | 40 | 95 |
| No. 30 | 15 | 70 |
| No. 40 | 5 | 55 |
| No. 100 | 0 | 15 |
| No. 200 | 0 | 5 |

Note all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

1.3. Topsoil for Bioretention Soil

A. General
Topsoil shall be free of wood, waste, or any other deleterious material.

B. Topsoil for Bioretention Soil Texture
The overall topsoil texture shall be loamy sand as analyzed by an accredited laboratory. The overall dry weight percentages shall be 60-90% sand, with less than 20% passing than the #200 sieve and less than 5% clay of the total weight with no gravel.

1.4. Composted Material

Compost shall be a well decomposed, stable, weed free organic matter source meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

A. Compost Quality Analysis

Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Evaluation of Composting and Compost (TMECC). The lab report shall verify:

1) Feedstock Materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues.

2) Organic Matter Content: 35% - 75% by dry wt.

3) Carbon and Nitrogen Ratio: C:N < 25:1.

4) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable. In addition any one of the following is required to indicate stability:

   a. Oxygen Test < 1.3 O2 /unit TS /hr

   b. Specific oxy. Test < 1.5 O2 / unit BVS /

   c. Respiration test < 8 C / unit VS / day

   d. Dewar test < 20 Temp. rise (°C)

   e. e. Solvita® > 5 Index value

5) Toxicity: any one of the following measures is sufficient to indicate non-toxicity.

   a. NH4- : NO3-N < 3

   b. Ammonium < 500 ppm, dry basis

   c. Seed Germination > 80 % of control

   d. Plant Trials > 80% of control

e. e. Solvita® > 5 Index value

6) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.

a. Total Nitrogen content 0.9% or above preferred.

b. Boron: Total shall be <80 ppm; Soluble shall be <2.5 ppm

7) Salinity: Must be reported; < 6.0 mmhos/cm

8) pH shall be between 6.5 and 8. May vary with plant species.

B. Particle size: 95% passing a 1/2" screen.

C. Bulk density: shall be between 500 and 1100 dry lbs/cubic yard

D. Moisture Content shall be between 30% - 55% of dry solids.

E. Inerts: compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.

F. Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

G. Select Pathogens: Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.

H. Trace Contaminants Metals (Lead, Mercury, Etc.) Product must meet US EPA, 40 CFR 503 regulations.

I. Compost Testing
The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

### ► PLACEMENT AND COMPACTION OF BIORETENTION SOILS

Place the bioretention soil in 8" to 12" lifts. Lifts are **not to be compacted** but are placed to reduce the possibility of excessive settlement. Allow time for natural compaction and settlement prior to planting. Bioretention soil may be watered to encourage compaction.

## Plantings

### ► PLANT SELECTION GUIDELINES

The plants tabulated in Attachment B-1 were selected for the following characteristics:

- Adaptation to Contra Costa's climate
- Drought tolerance
- Adaptation to well-drained soils
- Adaptation to low soil fertility
- Allow infiltration
- Are not invasive weeds
- Do not have aggressive roots

Characteristics noted in the table, including irrigation preferences and ability to tolerate heat, coastal conditions, flooding, and wind should be considered when selecting plants.

This list is not comprehensive, nor will all these species succeed at every site. Selection for a particular site should be done by experienced professionals familiar with the plants and site conditions. Avoid planting species on the California Invasive Plant Council's invasive plant inventory list.

### ► PLANT INSTALLATION

Trees and large shrubs installed in bioretention facilities are susceptible to blowing over before roots are established. They should be staked securely. Three stakes per tree are recommended at windy sites. Straps should be inspected once or twice a year and removed once trees are established to prevent girdling.

### ► FERTILIZATION

Due to the potential for conveying nutrients to storm drains, no fertilizer should be added to bioretention facilities or planter boxes. Compost tea, available from various nurseries and garden supply retailers, may be applied at a recommended rate of 5 gallons mixed with 15 gallons of water per acre.

Compost tea can be applied up to two weeks prior to planting and once per year between March and June. Application is not recommended when temperatures are below 50°F or above 90°F or when rain is forecast in the next 48 hours. Additional applications may be made as needed to correct nutrient deficiencies.

► MULCH

Mulch is not required but is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Aged mulch can be obtained through soil suppliers or directly from commercial recycling yards. Apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

Compared to bark mulch, aged mulch has somewhat less of a tendency to float into overflow inlets during intense storms. To reduce mulch entering overflow inlets, it is recommended to use atrium or beehive grates with ¼" openings over overflow inlets.

► WEED CONTROL

Weeds should be controlled primarily by manual methods and soil amendment. In response to problem areas or threatening invasions, corn gluten, white vinegar, vinegar-based products such as Burn-out, or non-selective natural herbicides such as Safer's Sharpshooter may be used.

► PEST AND DISEASE CONTROL

Synthetic pesticides should not be used on bioretention facilities. Beneficial nematodes and non-toxic controls may be used. Acceptable natural pesticides include Safer® Aphid, Whitefly, and Mealybug Killer, Safer® Tree and Shrub Insect Attach, Safer® for Evergreens, and Neem oil.

## Irrigation

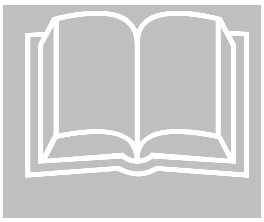
Bioretention soils have a high infiltration rate and require a different irrigation system design than what is typically used for heavy clay soils in Contra Costa County. Irrigation systems must be designed to minimize water use, avoid overwatering, and prevent the underdrain discharges during dry weather.

Bioretention facilities and planter boxes may need to be irrigated more than once a day. Irrigation controls should allow separate control of times and durations of irrigation for bioretention facilities and planter boxes vs. other landscape areas.

Smart irrigation controllers are strongly encouraged. Available controllers may access weather stations, use sensors to measure soil temperature and moisture, and allow input of soil types, plant types, root depth, light conditions, slope, and usable rainfall.

Drip emitters are strongly recommended over spray irrigation. Use multiple, lower-flow (one-half to two gallons per hour) emitters in fast-draining bioretention soils. Use two or more emitters for perennials, ground covers, and bunchgrasses. Four to six emitters may be needed for larger shrubs and trees. Some types of emitters encourage horizontal distribution of water.

Spray heads must be positioned to avoid direct spray into bioretention facility or planter box outlet structures.



### References and Resources


- *Recommendations for Soils Specification, Planting, and Irrigation of Bioretention Facilities*, WRA Environmental Consultants, November 5, 2008.
- US Composting Council
- ASTM International
- *Plant List and Planting Guidance for Landscape-Based Stormwater Measures.* Appendix B in the *Alameda County Clean Water Program C.3 Technical Guidance* (2006).
- *Plants and Landscapes for Summer Dry Climates.* Nora Harlow, Ed. East Bay Municipal Utility District, Oakland
- *California Native Plants for Your Garden and Wildlife*, Las Pilitas Nursery, 2008.
- *Native Treasures: Gardening with the Plants of California.* M. Nevin Smith, 2006. University of California Press.
- *The Califlora Database, 2008.*
- California Invasive Plant Council
- *A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California*, University of California Cooperative Extension and California Department of Water Resources
- Our Water Our World, website to developed to assist consumers in managing home and garden pests in a way that helps protect water.
- Bay-Friendly Landscaping for Professionals, a whole systems approach to the design, construction, and maintenance of the landscape to support the integrity of the San Francisco Bay watershed.
- University of California Statewide Integrated Pest Management (IPM) Program

## Grasses and Grass-like Plants

| *Scientific name* Common name | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA Native | Other Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | | |
| *Bromus carinatus* California brome | ✓ | | | 2 | 1 | ✓ | | | ok | ✓ | | ✓ | ✓ | ✓ | |
| *Bouteloua gracilis* blue grama | ✓ | | | 1.5 | 1 | ✓ | | | | ✓ | | ✓ | ✓ | | Tolerates no summer water, good for non-irrigated remote sites |
| *Carex densa* dense sedge | ✓ | | | 1 | 1 | | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | |
| *Carex obnupta* slough sedge | ✓ | | | 2 | 1 | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Carex praegracilis* clustered field sedge | ✓ | ✓ | | 1.5 | 1.5 | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Carex subfusca* rusty sedge | ✓ | ✓ | | 1 | 1 | | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | Great for swales |
| *Carex divulsa* Berkeley sedge | | ✓ | ✓ | 1 | 1 | | ✓ | | ok | | ✓ | ✓ | ✓ | ✓ | AKA *Carex tumulicola*,. Full sun along coast. |
| *Deschampsia cespitosa* tufted hairgrass | ✓ | | | 2 | 1 | | ✓ | | ok | | | ✓ | ✓ | ✓ | Can look weedy |
| *Distichlis spicata* salt grass | ✓ | | | 0.3 | 3 | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Looks like bermuda grass, withstands foot traffic, for soils with high salt |
| *Eleocharis palustris* creeping spikerush | ✓ | | | 1 | 1 | | ✓ | ✓ | ok | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Elymus glaucus* blue wildrye | ✓ | | | 1.5 | 2 | | ✓ | ✓ | ok | ✓ | ✓ | ✓ | ✓ | ✓ | good for grazing, difficult to mow, messy looking lawn |
| *Festuca californica* California fescue | ✓ | ✓ | ✓ | 2 | 2 | ✓ | | | ok | ✓ | ✓ | | ✓ | ✓ | |
| *Festuca idahoensis* Idaho fescue | ✓ | ✓ | | 1 | 1 | ✓ | ✓ | | ok | ✓ | ✓ | | ✓ | ✓ | Can mow. Needs light summer water at hot sites |
| *Festuca rubra* red fescue | ✓ | ✓ | | 1 | 1.5 | ✓ | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | Can mow. Lawn alternative |
| *Festuca rubra 'molate'* molate fescue | ✓ | ✓ | | 1 | 1.5 | ✓ | ✓ | | ok | ✓ | ✓ | | ✓ | c | Can mow. Lawn alternative |
| *Hordeum brachyantherum* | ✓ | ✓ | | 1.5 | 1 | | ✓ | ✓ | ok | ✓ | ✓ | | ✓ | ✓ | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| meadow barley | | | | | | | | | | | | | | | |
| *Juncus patens*<br>blue rush | ✓ | | | 2 | 1 | | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | |
| *Leymus triticoides*<br>creeping wildrye | ✓ | ✓ | | 3 | 1 | ✓ | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | Can mow. Recommended for swales. |
| *Melica californica*<br>California melica | ✓ | ✓ | | 1 | 1 | ✓ | | | | ✓ | | | ✓ | ✓ | |
| *Melica imperfect*<br>melic | ✓ | ✓ | | 1 | 1 | ✓ | | | ok | | ✓ | ✓ | | ✓ | Part shade inland, light water in Summer to keep green or goes dormant |
| *Muhlenbergia rigens*<br>deergrass | ✓ | | | 3 | 3 | ✓ | ✓ | | ok | ✓ | | ✓ | | ✓ | |
| *Nasella pulchra*<br>purple needlegrass | ✓ | ✓ | | 2 | 1 | ✓ | ✓ | | ok | ✓ | | ✓ | ✓ | ✓ | |
| *Nassella lepida*<br>foothill needlegrass | ✓ | ✓ | ✓ | 1.5 | 1 | ✓ | ✓ | | ok | ✓ | ✓ | | ✓ | ✓ | |
| *Phalaris californica*<br>California canarygrass | | ✓ | ✓ | 1.5 | 1 | | ✓ | ✓ | ok | | ✓ | ✓ | ✓ | ✓ | Can be aggressive spreader |

## Herbaceous Perennials and Groundcovers

| *Scientific name* Common name | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA Native | Other Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | | |
| *Achillea filipendulina* fernleaf yarrow | ✓ | | | 3 | 3 | ✓ | | | ✓ | ✓ | | | | | |
| *Achillea millefolium* common yarrow | ✓ | | | 1.5 | 1 | ✓ | | | ok | ✓ | | | | ✓ | Good for hot sites |
| *Achillea tomentosa* woolly yarrow | ✓ | ✓ | | 1 | 1.5 | ✓ | ✓ | | ok | ✓ | | | ✓ | | |
| *Aloe striata* coral aloe | ✓ | ✓ | | 2 | 2 | ✓ | | | ok | | | | | | Sun along coast, afternoon shade inland |
| *Arctostaphylos hookeri* Monterey manzanita | ✓ | ✓ | | 1 | 4 | ✓ | ✓ | | ok | | ✓ | | ✓ | ✓ | Better in part shade in hot sites |
| *Arctostaphylos uva-ursi* kinnick-kinnick | ✓ | ✓ | | 1 | 15 | ✓ | ✓ | | ok | | ✓ | | ✓ | ✓ | Full sun at coast, part shade inland. Cultivars to try include 'emerald carpet,' 'Point Reyes,' 'San Bruno Mountain' depending on site |
| *Ceratostigma plumbaginoides* dwarf plumbago | | ✓ | | 0.75 | 5 | ✓ | ✓ | | ✓ | ✓ | | | | | |
| *Epilobium canum* California fuchsia | ✓ | ✓ | | 1 | 4 | ✓ | | | ok | | | | | ✓ | |
| *Eriogonum fasciculatum* flattop buckwheat | ✓ | | | 3 | 4 | ✓ | | | | ✓ | | | | ✓ | |
| *Eschscholzia californica* California poppy | ✓ | | | 1 | 1 | ✓ | | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Fragaria chiloensis* beach strawberries | ✓ | ✓ | ✓ | 0.3 | 2 | ✓ | | | ok | | ✓ | | | ✓ | |
| *Gazania spp.* treasure flower | ✓ | | | 0.5 | 2 | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | |
| *Iris douglasiana* Douglas iris | ✓ | ✓ | | 1.5 | 2 | ✓ | ✓ | | ok | ✓ | ✓ | | ✓ | ✓ | Also, Iris hybrids |

| *Scientific name* | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA Native | Other Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | | |
| *Lotus scoparius*<br>deerweed | ✓ | | | 4 | 3 | ✓ | | | | ✓ | | ✓ | | ✓ | |
| *Lupinus bicolor*<br>miniature lupine | ✓ | | | 1 | 1 | ✓ | | | | | ✓ | ✓ | | ✓ | Adds nitrogen |
| *Mimulus aurantiacus*<br>common monkeyflower | ✓ | ✓ | | 3 | 3 | ✓ | | | ok | | | ✓ | | ✓ | |
| *Mimulus cardinalis*<br>scarlet monkeyflower | ✓ | ✓ | ✓ | 3 | 3 | | ✓ | ✓ | ✓ | | | ✓ | | ✓ | Aggressive seeder |
| *Polygonum capitatum*<br>pink knotweed | ✓ | ✓ | | 0.5 | 4 | ✓ | | | ✓ | ✓ | ✓ | | ✓ | | |
| *Prunella vulgaris*<br>self heal | ✓ | ✓ | | | | ✓ | ✓ | | ok | | ✓ | ✓ | ✓ | ✓ | |
| *Rudebeckia californica*<br>California coneflower | ✓ | | | 3 | 2 | ✓ | ✓ | | ok | ✓ | | ✓ | | ✓ | |
| *Salvia clevelandii*<br>Cleveland sage | | | | | | ✓ | | | | | | | | | |
| *Scaevola 'mauve clusters'*<br>fan flower | ✓ | ✓ | | 1 | 4 | ✓ | | | | ✓ | | | ✓ | | |
| *Sedum spathulifolium*<br>stone crop | ✓ | | | | | ✓ | | | ok | ✓ | | | ✓ | varies | For above the high water line |
| *Sisyrinchium bellum*<br>blue eyed grass | | | | 1 | 1 | ✓ | | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Sisyrinchium californicum*<br>yellow eyed grass | ✓ | ✓ | | 1 | 1 | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Solidago californica*<br>California goldenrod | | ✓ | | 3 | 2 | ✓ | ✓ | | ok | ✓ | | ✓ | | ✓ | |
| *Stachys byzantine*<br>lamb's ears | ✓ | ✓ | | 1 | 3 | ✓ | | | ok | ✓ | ✓ | | ✓ | | |
| *Verbena tenuisecta*<br>moss verbena | ✓ | | | 0.5 | 5 | ✓ | | | ok | ✓ | ✓ | | ✓ | | |

## Small Shrubs

| *Scientific name* | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | Native | Other Notes |
| | | | | | | | | | | | | | | | |
| *Artemisia californica*<br>California sagebrush | ✓ | | | 2-5 | 4-5 | ✓ | | | | ✓ | ✓ | | ✓ | ✓ | Will not tolerate sprinklers |
| *Baccharis pilularis 'Twin Peaks' or Pigeon Point'*<br>dwarf coyote brush | ✓ | | | 2 | 6 | ✓ | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | c | |
| *Cistus skanbergii*<br>hybrid rockrose | ✓ | | | 3 | 5 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | Best with annual shearing |
| *Correa 'Carmine Bells' or 'ivory bells'*<br>Australian fuchsia | ✓ | ✓ | | 3 | 6 | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | Ivory bells does not tolerate wind. Attracts hummingbirds. Sunset Zones 16-17 (not recommended for E. Contra Costa) |
| *Erigeron glaucus*<br>seaside daisy | ✓ | | | 1 | 1.5 | | | | ok | | ✓ | | | ✓ | |
| *Eriogonum crocatum*<br>saffron buckwheat | ✓ | | | 1.5 | 1.5 | ✓ | | | | ✓ | ✓ | | ✓ | ✓ | |
| *Eriogonum umbellatum*<br>sulfur buckwheat | ✓ | | | 0.7 | 3 | ✓ | | | ok | ✓ | | | ✓ | ✓ | |
| *Grevillea lanigera*<br>woolly grevillea | ✓ | | | 4 | 6 | ✓ | | | | ✓ | | | ✓ | | Sunset Zones 15-24 (not recommended for E. Contra Costa) |
| *Lavendula spp.*<br>lavender | ✓ | | | 1.5 | 1.5 | ✓ | | | ok | ✓ | ✓ | | | | |
| *Mahonia pinnata*<br>California holly grape | ✓ | ✓ | ✓ | 4 | 4 | ✓ | ✓ | | | ✓ | | ✓ | ✓ | ✓ | |
| *Mahonia repens*<br>creeping Oregon grape | ✓ | ✓ | | 2 | 3 | ✓ | ✓ | | ok | | ✓ | ✓ | | ✓ | |
| *Rosmarinus officinalis*<br>rosemary | ✓ | | | 2.5 | 5 | ✓ | | | ✓ | ✓ | ✓ | | ✓ | | |
| *Rubus ursinus*<br>California blackberry | | ✓ | ✓ | 3 | 5 | | ✓ | ✓ | ok | ✓ | ✓ | ✓ | ✓ | ✓ | Thorns. Harbors beneficial insects |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Symphorocarpos albus*<br>common snowberry | ✓ | ✓ | ✓ | 4 | 4 | ✓ | ✓ | ✓ | ok | ✓ | | | | ✓ | Adaptable to many conditions |
| *Westringia fruticosa*<br>coast rosemary | ✓ | | | 4 | 8 | ✓ | | | | ✓ | ✓ | | ✓ | | |
| *Whipplea modesta*<br>whipplevine | | ✓ | ✓ | 0.5 | 3 | | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | Sunset zones 16-17, 19-24 only (not recommended E. Contra Costa), best for moist shady spots |

## Large Shrubs

| *Scientific name* | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | Native | Other Notes |
| *Alyogyne huegelil*<br>blue hibiscus | ✓ | | | 6 | 5 | ✓ | | | | ✓ | | | | | Very low water after second year, Sunset zones 15-17 & 20-24 (not recommended E. Contra Costa) |
| *Arctostaphylos densiflora 'Howard Mcminn'*<br>McMinn manzanita | ✓ | ✓ | | 3 | 7 | ✓ | | | | ✓ | | | ✓ | c | |
| *Baccharis pilularis*<br>coyote brush | ✓ | | | 6 | 7 | ✓ | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | | Fast-growing, short-lived |
| *Berberis darwinii*<br>Darwin's barberry | ✓ | ✓ | | 6 | 6 | ✓ | | | | ✓ | | ✓ | ✓ | | Sprinklers will kill foliage |
| *Carpenteria californica*<br>Bush anemone | ✓ | ✓ | | 6 | 4 | ✓ | ✓ | | ✓ | ✓ | | | | ✓ | Interior climate with occasional water otherwise low water needs |
| *Ceanothus spp.*<br>Various ceanothus | ✓ | ✓ | | varies | varies | ✓ | | | | ✓ | | | ✓ | ✓ | fast-growing but short-lived |
| *Cercis occidentalis*<br>western redbud | ✓ | | | 12 | 8 | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | Prune low branches for small tree form, susceptible to disease if overwatered |
| | | | | | | | | | | | | | | | |
| *Cotinus coggygia*<br>smoke bush | ✓ | | | 15 | 15 | ✓ | | | | | | ✓ | ✓ | | No water after second year |
| *Eriogonum arborescens*<br>Santa Cruz Island buckwheat | ✓ | | | 3 | 5 | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Low water after second year |
| | | | | | | | | | | | | | | | |

## Plant Recommendations for Bioretention Facilities and Planter Boxes

| *Scientific name* / Common name | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA Native | Other Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | | |
| *Eriogonum giganteum* St. Catherines lace | ✓ | | | 5 | 6 | ✓ | | | | | ✓ | ✓ | ✓ | ✓ | best at coast, tolerant of unwatered inland garden |
| *Fremontodendron californicum* flannel bush | ✓ | | | 20 | 14 | ✓ | | | | ✓ | | ✓ | | ✓ | Fast-growing, short-lived |
| *Garrya elliptica* Coast silktassel | ✓ | ✓ | | 8 | 8 | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | 'Evie' is compact variety |
| *Heteromeles arbutifolia* toyon | ✓ | ✓ | ✓ | 7 | 5 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | Doesn't respond well to pruning low branches |
| *Juniperus chinensis 'Mint Julep"* mint julep juniper | ✓ | ✓ | | 3 | 6 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| *Lonicera hispidula* California honeysuckle | ✓ | ✓ | ✓ | 4 | 2 | | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | Climbing vine-like. Best in part shade. Attracts birds |
| *Lonicera involucrate* twinberry honeysuckle | ✓ | ✓ | ✓ | 6 | 3 | | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | Best in part shade. Attracts birds |
| *Nandina domestica* heavenly bamboo | ✓ | ✓ | | 4 | 3 | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | |
| *Philadelphus coronaries* sweet mock orange | ✓ | ✓ | | 10 | 10 | | ✓ | | ✓ | | | | ✓ | | Best with annual pruning |
| *Physocarpus capitatus* Pacific ninebark | ✓ | ✓ | | 5 | 5 | ✓ | ✓ | ✓ | ok | | ✓ | ✓ | | ✓ | Part shade and summer water required in hot locations |
| *Pittosporum eugeniodes* Pittosporum | ✓ | ✓ | | 40 | 15 | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | shear to control height |
| *Pittosporum tenuifolium* Pittosporum | ✓ | ✓ | | 40 | 15 | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | shear to control height |
| *Prunus illicifolia* holly leaf cherry | ✓ | ✓ | | 15 | 15 | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Prunus lyonii* Catalina cherry | ✓ | ✓ | | 15 | 15 | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Rhamnus californica* California coffeeberry | ✓ | ✓ | | 3-15 | 6 | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | 'Eve Case' is compact with broad foliage |
| *Rhus integrifolia* | ✓ | ✓ | | 8 | 6 | ✓ | | | ✓ | ✓ | | | ✓ | ✓ | Shear to hedge if desired |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lemonade berry | | | | | | | | | | | | | | | |
| *Ribes malvaceum*<br>chaparral currant | ✓ | ✓ | | 5 | 5 | ✓ | ✓ | | ok | ✓ | | | | ✓ | |
| *Ribes sanguineum*<br>flowering currant | | ✓ | ✓ | 5-12 | 5-12 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | Needs good air movement to avoid white fly |
| *Ribes speciosum*<br>fuchsia-flowered gooseberry | ✓ | ✓ | ✓ | 3-6 | 3-6 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| *Rosa californica*<br>California wild rose | ✓ | ✓ | | 3 | 3-6 | | ✓ | ✓ | ok | ✓ | ✓ | ✓ | ✓ | ✓ | hooked thorns not compatible with foot traffic |
| *Rosa gymnocarpa*<br>wood rose | ✓ | ✓ | | 2 | 3 | | ✓ | | ok | ✓ | ✓ | ✓ | | ✓ | |
| *Vitis californica*<br>California grape | ✓ | ✓ | | 10 | 2-10 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Climbing vine. Best in full sun. Can be aggressive in moist area. |
| *Vitis girdiana*<br>desert grape | ✓ | | | 8 | 2-11 | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | Climbing vine. May be more suited to biofilter soils than californica. |

## Small Trees

| *Scientific name* | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | Native | Other Notes |
| *Acer Negundo*<br>box elder | ✓ | ✓ | ✓ | 30 | 30 | ✓ | ✓ | | ok | ✓ | ✓ | ✓ | ✓ | ✓ | Tough shade tree, deciduous |
| *Arbetus unedo*<br>strawberry tree | ✓ | ✓ | | 15-30 | 15-30 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ‘Elfin King’ is dwarf from 6' tall |
| *Arctostaphylos manzanita*<br>common manzanita | ✓ | | | 6-15 | 8-12 | ✓ | | | | ✓ | | | ✓ | ✓ | Prune to be small tree. “Dr. Hurd” is more tolerant of summer water. |
| *Cercis occidentalis*<br>western redbud | ✓ | ✓ | | 12 | 8 | ✓ | | | | ✓ | | | ✓ | ✓ | Prune low branches for small tree form; susceptible to disease if overwatered. |
| *Eriobotrya deflexa*<br>bronze loquat | ✓ | ✓ | | 18 | 25 | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | Monthly deep watering |
| *Eriobotrya japonica*<br>Japanese loquat | ✓ | ✓ | | 25 | 20 | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | Susceptible to blight under stress |
| *Fraxinus angustfolia*<br>raywood ash | ✓ | | | 30 | 30 | | ✓ | | ✓ | ✓ | | | | | Fall color |
| *Fraxinus dipetala*<br>California ash | ✓ | ✓ | | 20 | 20 | | | | ok | ✓ | | ✓ | | ✓ | |

## Plant Recommendations for Bioretention Facilities and Planter Boxes

| *Scientific name* | Light Preference | | | Size (feet) | | Watering | | | | Tolerates | | | | CA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Sun | Part | Shade | Ht. | Width | L | M | H | Summer | Heat | Coast | Flood | Wind | Native | Other Notes |
| *Fraxinus latifolia*<br>Oregon ash | ✓ | ✓ | ✓ | 30 | 25 | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| *Fraxinus velutina*<br>velvet ash | ✓ | | | 25 | 15 | ✓ | ✓ | | ok | ✓ | | ✓ | ✓ | | |
| *Garrya elleptica*<br>coast silk tassel | ✓ | ✓ | | 20 | 20 | ✓ | ✓ | | ok | | ✓ | | | | Afternoon shade inland, responds well to pruning |
| *Laurus 'Saratoga'*<br>hybrid laurel | ✓ | ✓ | | 12-40 | 12-40 | ✓ | | | | ✓ | | ✓ | ✓ | | prune for tree form |
| *Myrica californica*<br>Pacific wax myrtle | ✓ | ✓ | ✓ | 10-30 | 10-30 | ✓ | ✓ | | | | ✓ | | | | best at coast |
| *Pinus thumbergiana*<br>Japanese black pine | ✓ | ✓ | | 25 | 20 | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | Asymmetrical, often leaning habit |
| *Pittosporum undulatum*<br>victorian box | ✓ | ✓ | | 15 | 15 | ✓ | ✓ | | ✓ | ✓ | | | | | Sunset zones 16-17, 21-24 only (not recommended E. Contra Costa. Prune low branches for tree form. |
| *Prunus ilicifolia*<br>holly leaf cherry | ✓ | ✓ | | 15 | 15 | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | |
| *Prunus lyonii*<br>Catalina cherry | ✓ | ✓ | | 15 | 15 | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | |
| *Prunus serrulata "shirofugen'*<br>cherry | ✓ | | | 25 | 25 | | ✓ | | | | ✓ | ✓ | ✓ | | Additional cultivars |

Key

| | |
|---|---|
| Water Preference-Low/Moderate/High | We have provided recommendations for irrigation. All plants should be watered with more frequency during the first two years after planting. After this establishment period, Low water use plants will only need supplemental irrigation at the hottest and driest sites. Plants with Moderate irrigation needs will be best with occasional supplemental water (once per week to once per month) and plants with High irrigation needs will be best with more frequent watering especially during periods of drought in the cooler seasons. |
| Water Preference-Summer Irrigation | Plants with a check in this column will not withstand a long period of summer drought without irrigation. Plants with an 'ok' in this column are tolerant of, but do not require, frequent summer irrigation. Plants with nothing in this column may not tolerate summer irrigation. |
| | |
| Tolerates Heat | A check in the heat column indicates that the plant will tolerate hot sites. It should not be confused with a plants preference for sun. Absence of the check indicates it should only be used in areas close to the Bay or other cool sites. |
| Tolerates Coast | The coast column indicates plants that perform well within 1,000 feet of the ocean or bay. Most of these plants tolerate some amount of salt air, fog, and wind. |
| Tolerates Wind | A check in the wind column means that the plant will tolerate winds of ten miles per hour or more. |
| | |
| CA Native - c | Cultivar of California native. Cultivars offer habitat benefits to native wildlife and are adapted to the local climate but have reduced genetic diversity. |
| | |
| Other Notes - Sunset Climate Zones | Under the Other Notes category, we have indicated appropriate Sunset Climate Zones only for plants that will not do well across all of Contra Costa County. Please refer to the *Sunset Western Garden Book* which defines climate zones in the Bay Area based on elevation, influence of the Pacific Ocean, presence of hills and other factors. |

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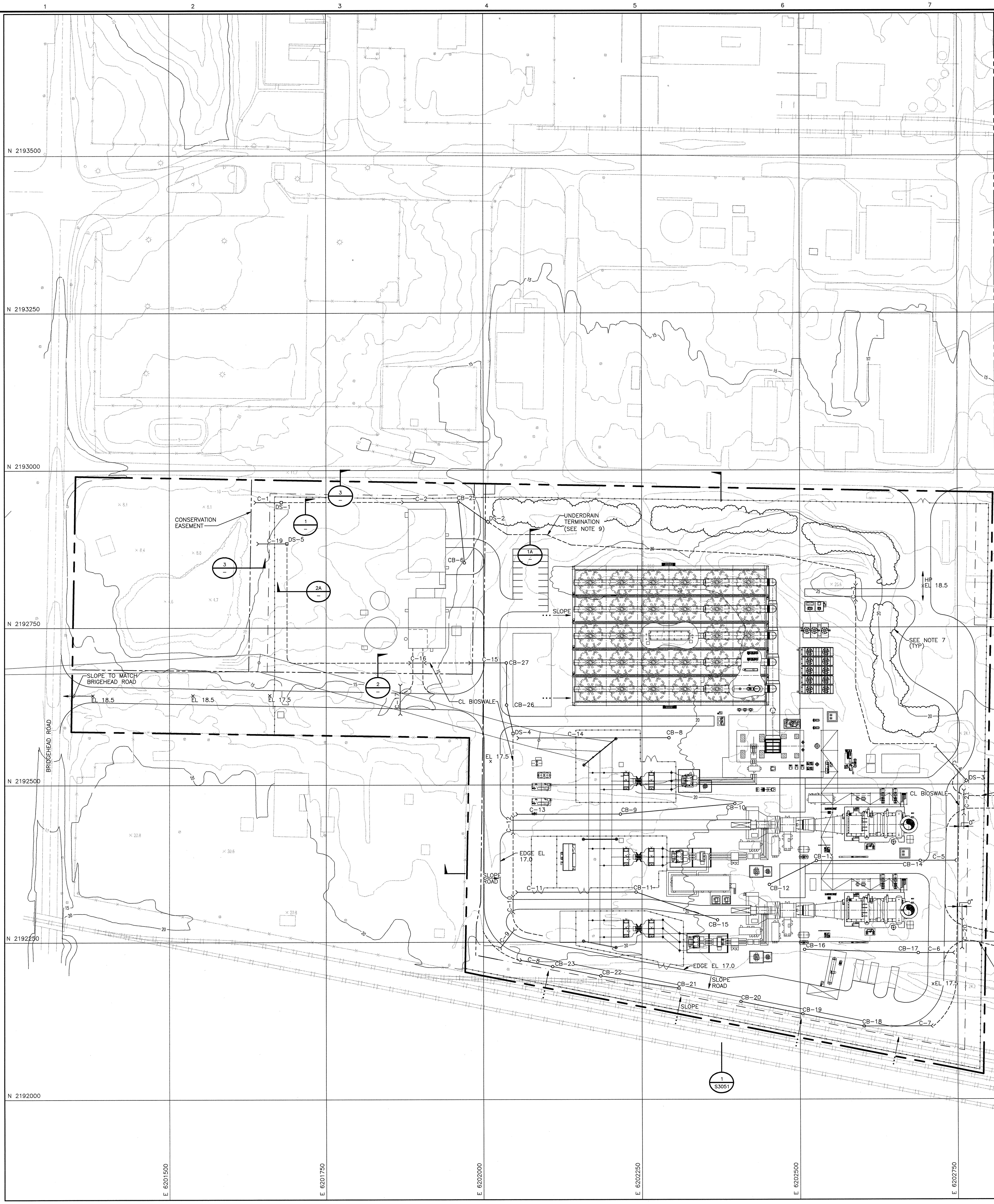
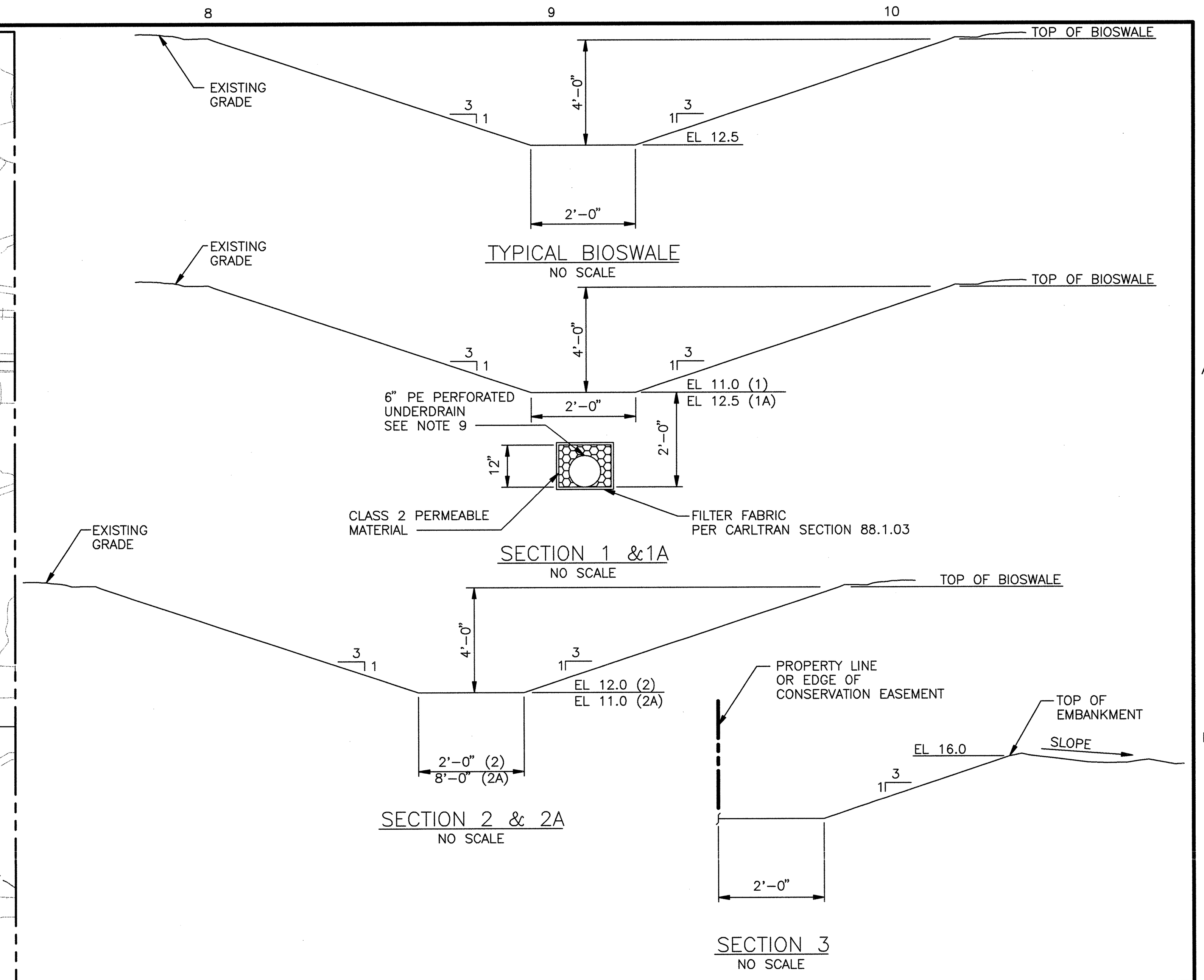
# Attachment 4
# B&V Drawing 163994-SS-3001




## ABBREVIATIONS APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

| | | | |
|---|---|---|---|
| APPROX | APPROXIMATE | LTR | LATER |
| ASPH | ASPHALT | MAX | MAXIMUM |
| AVG | AVERAGE | MH | MANHOLE |
| BND | BEND | MIN | MINIMUM |
| BLDG | BUILDING | MJ | MECHANICAL JOINT |
| B/MH | BOTTOM OF MANHOLE ELEVATION | MSL | MEAN SEA LEVEL |
| BOC | BOTTOM OF CONDUIT ELEVATION | NO. | NUMBER |
| BOD | BOTTOM OF DUCTBANK ELEVATION | NTS | NOT TO SCALE |
| BOP | BOTTOM OF PIPE ELEVATION | OD | OUTSIDE DIAMETER |
| BU | BELL-UP | OWS | OIL WATER SEPARATOR |
| C | CULVERT | OWMH | OILYWASTE MANHOLE |
| CB | CATCH BASIN | PC | POINT OF CURVATURE |
| CD | CABLE DUCT | PE | PLAIN END |
| CHDPE | CORRUGATED HIGH DENSITY POLYETHYLENE PIPE | PI | POINT OF INTERSECTION |
| CL | CENTERLINE | PLCS | PLACES |
| CLR | CLEAR | PM | PLANT MANHOLE |
| CMH | CHEMICAL MANHOLE | POT | POINT OF TANGENT |
| CND | CONDUIT | PT | PIPE TERMINATION |
| CONC | CONCRETE | PVC | POLYVINYL CHLORIDE PIPE |
| CO | CLEAN OUT | QTY | QUANITY |
| CS | CARBON STEEL | R | RADIUS |
| CW | CIRCULATING WATER | RCP | REINFORCED CONCRETE PIPE |
| DB | DUCTBANK | RD | ROOF DRAIN |
| DBC | DIRECT BURIED CABLE | REV | REVISION |
| DET | DETAIL | RGS | RIGID GALVANIZED STEEL |
| DIA | DIAMETER | RR | RAILROAD |
| DIP | DUCTILE IRON PIPE | SECT | SECTION |
| DWG | DRAWING | SIM | SIMILAR |
| DWP | DOUBLE WALL PIPE | SLS | SANITARY LIFT STATION |
| EC | ELECTRICAL CONDUIT | SMH | SANITARY MANHOLE |
| ECC | ECCENTRIC | STMH | STORM MANHOLE |
| EF | EACH FACE | STRL | STRUCTURAL |
| EHH | ELECTRICAL HANDHOLE | T/C | TOP OF CONCRETE ELEVATION |
| EL | ELEVATION | T/G | TOP OF GRADE ELEVATION |
| EMH | ELECTRICAL MANHOLE | THH | TELEPHONE SERVICE HANDHOLE |
| EW | EACH WAY | T/MH | TOP OF MANHOLE ELEVATION |
| FC | FIELD CHECK | T/P | TOP OF PAVEMENT ELEVATION |
| FDN | FOUNDATION | TP | MECH PIPE TERMINAL POINT |
| FF | FLAT FACE | TYP | TYPICAL |
| FRP | FIBERGLASS REINFORCED PIPE | UGL | UNDERGROUND LIGHTING CONDUIT |
| GR | GRADE | UNO | UNLESS NOTED OTHERWISE |
| HDM | HOT DRAIN MANHOLE | VERT | VERTICAL |
| HDPE | HIGH DENSITY POLYETHYLENE PIPE | WGT | WEIGHT |
| HP | HIGH POINT | WTR | WATER |
| HYD | HYDRANT | W/ | WITH |
| ID | INSIDE DIAMETER | W/O | WITHOUT |
| INV | INVERT | WP | WORK POINT |
| JBX | JUNCTION BOX | XFMR | TRANSFORMER |
| L | LENGTH | | |
| LP | LOW POINT | | |

## LEGEND APPLICABLE TO ALL S3000 DRAWINGS

| | |
|---|---|
| NEW CULVERT | NEW SLIDE GATE |
| CL BIOSWALE | NEW SWING GATE |
| SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER (1 / S3000) | EXISTING POWER POLE |
| FINISHED SPOT ELEVATIONS (326.5) | NEW CATCH BASIN (CB-101) |
| SURVEY MONUMENT/CONTROL POINT (BM-1) | NEW DROP STRUCTURE |
| EXISTING FENCE | PROPERTY LINE |
| NEW SECURITY FENCE | BOUNDARY LINE |
| TEMPORARY CONSTRUCTION FENCE | EXISTING CONTOURS (126) |
| EROSION CONTROL METHOD (TR-1) | GRADE TO DRAIN (DIRECTION OF ARROW) |

## NOTES APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "W 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE, ELEVATION = 11.168 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. NEW GRADE ELEVATIONS SHOWN ON THE SITE GRADING AND DRAINAGE PLANS INDICATE FINISH GRADE UNLESS NOTED OTHERWISE.
3. ALL CUT AND FILL SLOPES SHALL BE 3 HORIZONTAL TO 1 VERTICAL OR FLATTER, UNLESS NOTED OTHERWISE.
4. SEE DWG SS-3050 FOR GRADING AND DRAINAGE DETAILS INCLUDING CULVERT, CATCH BASIN AND DROP STRUCTURE CHARTS.
5. TOP OF CONCRETE ELEVATIONS AND FINISH FLOOR ELEVATIONS FOR ALL EQUIPMENT AND BUILDINGS IS EL 18.0. FINISH GRADE ADJACENT TO ALL FOUNDATIONS IS EL 17.5.
6. CL OF ALL PAVED ROADS IS EL 17.5 UNO.
7. TREES TO REMAIN. GRADE TO REMAIN UNCHANGED WITHIN 20' OF TREE BASE.
8. TEMPORARY ROAD FROM LAYDOWN AREA. ROAD AND CULVERT UNDER ROAD TO BE REMOVED AT END OF CONSTRUCTION.
9. UNDERDRAIN CONTINUOUS UNDER BIOSWALE FROM UNDERDRAIN TERMINATION TO CONSERVATION EASEMENT. UTILIZE UNPERFORATED PIPE BETWEEN DS-2 TO C-2 OUTLET AND DS-1 TO C-1 OUTLET.

# NOT TO BE USED FOR CONSTRUCTION



| NO | DATE | REVISIONS AND RECORD OF ISSUE | DRN | DES | CHK | PDE | APP |
|---|---|---|---|---|---|---|---|
| 0 | 16/APR/09 | ISSUED FOR PERMITTING | NAW | PLN | | PLN | DVW |

SCALE: 1"=60' (60' 30' 0 60' 120')

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED ____________

DATE ________ REG NO. ________

BLACK & VEATCH CORPORATION

ENGINEER PLN | DRAWN NAW | CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

GRADING AND DRAINAGE – SITE PLAN – SHEET 1

PROJECT / DRAWING NUMBER: 163994-SS-3001 | REV 0

CODE | AREA

SPU37162 A1APL017 04/15/09 E1 13:57:19 ACAD 16.1s (LMS Tech) 1=1

# Attachment 5
# B&V Calculation 52.5406.1002
# “IMP Sizing for Plant Area”

**BLACK & VEATCH**

# Calculation Record

Client Name: Radback Energy — Page 1 of 43

Project Name: Tenaska — Project No.: 163994

Calculation Title: IMP Sizing for Plant Area

Calculation No./File No.: 52.5406.1002

Calculation Is: (check all that apply) ☐ Preliminary ☒ Final ☐ Nuclear Safety-Related

**Objective** To determine the minimum required size of bioswales to satisfy Stormwater C.3 requirements for treatment and flow control for the plant area for the proposed Tenaska Project.

**Unverified Assumptions Requiring Subsequent Verification**

| No. | Assumption | Verified By | Date |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

See Page 2 of this calculation for additional assumptions.

**This Section Used for Computer Generated Calculations**

Program Name/Number: ________ Version: ________

Evidence of or reference to computer program verification, if applicable:

Bases or reference thereto supporting application of the computer program to the physical problem:

**Review and Approval**

| Rev | Prepared By | Date | Verified By | Date | Approved By | Date |
|---|---|---|---|---|---|---|
| 0 | J Zhong *Jimmy Zhong* | March 31, 2009 | *P Nelson* | 15 APR 09 | *P Nelson* | 15 APR 09 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Purpose

To determine the minimum required size of bioswales to satisfy Stormwater C.3 requirements for treatment and flow control for the plant area for proposed Tenaska Project.

## References

1. Black & Veatch Drawing:
   - 163994-SS-3001, Rev. A, "Grading & Drainage - Site Plan - Sheet 1"
   - 163994-SS-3201, Rev. A, "Surfacing/Fencing/Roadway - Site Plan - Sheet 1"
   - 163994-SS-3050, Rev. A, "Site Sections and Details"
   - 163994-SS-1002, Rev. 1, "General Arrangement – Site"
2. Contra Costa Clean Water Program; Stormwater C.3 Guidebook; Stormwater Quality Requirements for Development Applications; Fourth Edition; September 10, 2008.
3. Contra Costa County Public Works Department; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977.
4. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
5. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
6. Email Communications between Black & Veatch and Contra Costa Clean Water Program; March 2009.

## Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)

Drainage area in acres (ac)

## Attachments

1. Black & Veatch Drawings SS1002, SS-3001, SS-3201 and SS-3050
2. Reference 2 – Select Pages
3. Reference 3 – Drawing No. B-166
4. Reference 4 – Select Pages
5. Reference 5 – Select Pages
6. Email Communications

**Summary:**

Five bioswales will be constructed within the plant area to collect and infiltrate stormwater.
Based on the Stormwater C.3 requirements, the required bioswale surface area and volume for each bioswale are listed in the following table.
The design bioswale length, shape, design surface area and volume are presented in the following table. The design bioswales in the plant area have sufficient surface areas and volume to satisfy the Stormwater C.3 requirements.

| IMP ID | Shape | Length (feet) | Side Slope | Bottom Width (feet) | Design Surface Area ($ft^2$) | Design Volume ($ft^3$) | Required Surface Area ($ft^2$) | Required Volume ($ft^3$) |
|---|---|---|---|---|---|---|---|---|
| Bioswale #1 | Trapezoidal | 390 | 3 (h) to 1 (v) | 2 | 7,800 | 12,870 | 5,406 | 4,479 |
| Bioswale #2 | Trapezoidal | 933 | 3 (h) to 1 (v) | 2 | 18,660 | 30,789 | 7,635 | 6,326 |
| Bioswale #3 | Trapezoidal | 187 | 3 (h) to 1 (v) | 2 | 2,618 | 2,992 | 740 | 613 |
| Bioswale #4 | Trapezoidal | 391 | 3 (h) to 1 (v) | 2 | 7,820 | 12,903 | 7,598 | 6,296 |
| Bioswale #5 | Trapezoidal | 465 | 3 (h) to 1 (v) | 2 ft for first 265 ft long section; 8 ft for remaining 200 ft long section | 10,305 | 19,244 | 10,274 | 8,512 |

**IMP Sizing for Plant Area**

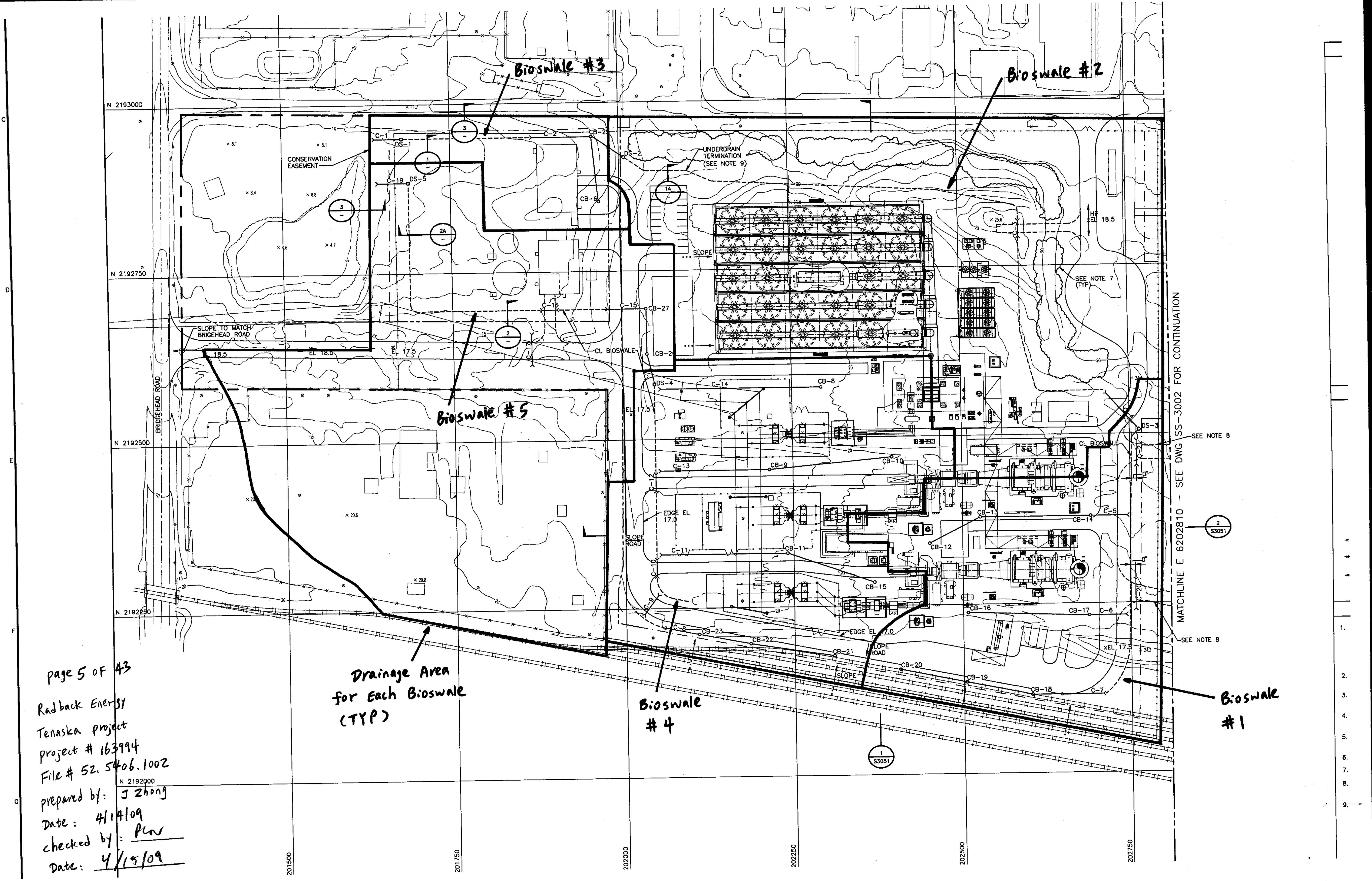
The generation area primarily consists of two combustion turbines, two heat recovery steam generators (HRSG), one air cooled condenser (ACC), three switchyards, one water treatment building, one warehouse building, two water storage tanks, one administration building, and other miscellaneous equipment/facilities. See B&V Drawing SS-1002 for plant general arrangement (Attachment 1). Plant loop road and major equipment access roads will be constructed within the plant. The areas adjacent to the buildings and equipment will have gravel surfacing. Other areas will be covered with vegetated grass. See B&V Drawing SS-3001 for proposed site surfacing of the plant (Attachment 1). The existing trees on this project site will be preserved.

Five bioswales will be constructed within the plant site to collect and infiltrate stormwater. See Page 5 for the locations of bioswales and delineated drainage area for each bioswale. Drop structures will be installed at the end of each bioswale such that sufficient depth (volume) of stormwater has to be collected in the bioswale before downstream discharge can occur.

An existing natural gas distribution facility is located west of the project and is outside the project limits. This area is generally covered by gravel surfacing. From the topography, most of the natural gas facility drains towards the wetland. After constructing the plant access road from Bridgehead Road, this area will continue to drain towards the wetland via a culvert being installed underneath the access road. The natural gas facility will be included in the IMP sizing for bioswale #5 since the stormwater from this area will flow to and accumulate in this bioswale.

<u>NRCS Soil Group</u>

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the project site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". Per Ref. 5, this type of soil can be classified as Hydrologic Soil Group A soil.




page 5 of 43
Radback Energy
Tenaska project
project # 163994
File # 52.5406.1002
prepared by: J Zhong
Date: 4/14/09
checked by: Plw
Date: 4/15/09

## IMP Sizing for Bioswale #1

Refer to Page 5, the total drainage area for bioswale #1 is measured to be: 153,520 ft$^2$ (3.52 ac). The bioswale #1 is measured to be 390 feet long.

Five drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; and (5) Transformer Containment.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

| DMA Name | Post-Project Surface Type | DMA Area (ft$^2$) |
|---|---|---|
| DMA-1 | Equipment/Roofs | 20,871 |
| DMA-2 | Asphalt Pavement | 27,640 |
| DMA-3 | Gravel Surfacing | 54,230 |
| DMA-4 | Grass/Landscape | 46,694 |
| DMA-5 | Transformer Containment | 4,085 |

Runoff Coefficients

Dense-graded aggregate (Caltran Class 2 aggregate) will be utilized as the materials for aggregate surfacing. After being compacted, the dense-graded aggregate is estimated to have a runoff coefficient of 0.5 to 0.7. See communications with Contra Costa County Clean Water Program (Attachment 6). Use 0.6 in this calculation.

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Consequently,

$$\sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} = (20,871\text{x}1.0+27,640\text{x}1.0+54,230\text{x}0.6+46,694\text{x}0.1+4,085\text{x}0)$$

$$= 85,718 \text{ ft}^2.$$

IMP Sizing Factors

Since the project site is covered by hydrologic group A soil, the subsurface reservoir volume ($V_2$) is not needed per Stormwater C.3 Guidebook. From this guidebook, for "treatment and flow control", the IMP sizing factor for the area (A) of bioswale is 0.07. The IMP sizing factor for the surface reservoir volume ($V_1$) of bioswale is 0.058. (Ref. 2, Table 4-6).

Rain Adjustment Factor

Per the Isohyetal Map by Contra Costa County Public Works, Figure B-166 (Ref. 3), the mean annual precipitation (MAP) at the project site is 12.5 inches. Consequently, for group A soils,

$$\text{Rain Adjustment Factor} = \frac{0.0009\times(MAP-20.2)+0.07}{0.07} \qquad \text{(Ref. 2, Equation 4-3)}$$

$$= \frac{0.0009\times(12.5-20.2)+0.07}{0.07}$$

$$= 0.901.$$

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum\begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix}\times\begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix}\times\begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 85{,}718 \times 0.07 \times 0.901 = 5{,}406 \text{ ft}^2.$$

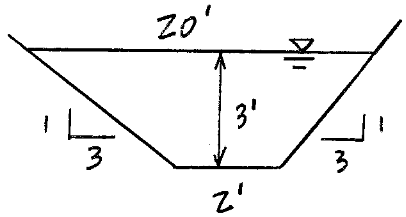
The required minimum surface reservoir volume ($V_1$) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum\begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix}\times\begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix}\times\begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 85{,}718 \times 0.058 \times 0.901 = 4{,}479 \text{ ft}^3.$$

The proposed bioswale #1 is 390 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Drop structure DS-3 will be installed at the end of bioswale #1. See B&V Drawing SS-3001

(Attachment 1). The top of grate elevation of DS-3 will be at EL 15.5 (see Drawing SS-3050). The effective depth of the bioswale is: 15.5 – 12.5 = 3 feet.




The surface area of bioswale #1 is:

$20 \times 390 = 7{,}800\ ft^2 > 5{,}406\ ft^2$, OK.

The volume of bioswale #1 is:

$$\frac{2+20}{2} \times 3 \times 390 = 12{,}870\ ft^3 > 4{,}479\ ft^3,\ \underline{OK}.$$

Conclusion: The proposed size of bioswale #1 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

| BLACK & VEATCH | | | | |
|---|---|---|---|---|
| OWNER | Radback Energy | | COMP'D BY | J. Zhong |
| PLANT | Tenaska | Unit No. | DATE | 20-Mar-2009 |
| PROJECT NO. | 163994 | File No. 52.5406.1002 | CKD BY | PCW |
| TITLE | IMP Sizing | | DATE | 4/15/09 |
| | | | PAGE | 9 OF 43 |

| Soil Type | IMP Name |
|---|---|
| A | Bioswale #1 |

| DMA Name | DMA Area ($ft^2$) | Post-Project Surface Type | DMA Runoff Factor | DMA Area x Runoff Factor |
|---|---|---|---|---|
| DMA-1 | 20,871 | Equipment/Roofs | 1.00 | 20,871 |
| DMA-2 | 27,640 | Asphalt Pavement | 1.00 | 27,640 |
| DMA-3 | 54,230 | Gravel Surfacing | 0.60 | 32,538 |
| DMA-4 | 46,694 | Landscape, Group A Soil | 0.10 | 4,669 |
| DMA-5 | 4,085 | Transformer Containment | 0.00 | 0 |
| | | | Total: | 85,718 |

| IMP Sizing Factor | Rain Adjustment Factor | Minimum Area or Volume | Proposed Area or Volume | |
|---|---|---|---|---|
| 0.070 | 0.901 | 5,406 | 7,800 | IMP Area ($ft^2$) |
| 0.058 | 0.901 | 4,479 | 12,870 | $V_1$ ($ft^3$) |
| NA | 0.901 | NA | NA | $V_2$ ($ft^3$) |
| | | | Orifice Size: | NA |

**IMP Sizing for Bioswale #2**

Refer to Page 5, the total drainage area for bioswale #2 is measured to be: 337,648 ft$^2$ (7.75 ac). The bioswale #2 is measured to be 933 feet long.

Six drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; (5) Transformer Containment; and (6) Open Graded Aggregates (ACC Area).

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

| DMA Name | Post-Project Surface Type | DMA Area (ft$^2$) |
|---|---|---|
| DMA-1 | Equipment/Roofs | 34,029 |
| DMA-2 | Asphalt Pavement | 37,473 |
| DMA-3 | Gravel Surfacing | 45,970 |
| DMA-4 | Grass/Landscape | 151,570 |
| DMA-5 | Transformer Containment | 406 |
| DMA-6 | Open Graded Aggregates | 68,200 |

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Open Graded Aggregates" will have a runoff coefficient of 0.1. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} = (34{,}029\text{x}1.0+37{,}473\text{x}1.0+45{,}970\text{x}0.6+151{,}570\text{x}0.1+406\text{x}0+68{,}200\text{x}0.1) = 121{,}061 \text{ ft}^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume ($V_1$). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

<u>Minimum Area and Minimum Volume of IMP</u>

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

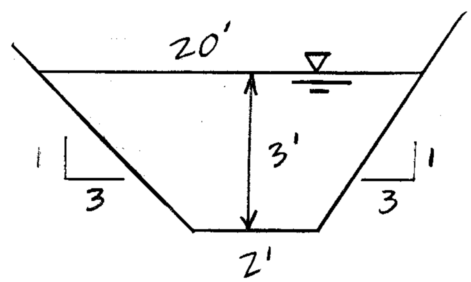
$$= 121{,}061 \times 0.07 \times 0.901 = 7{,}635 \text{ ft}^2.$$

The required minimum surface reservoir volume ($V_1$) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 121{,}061 \times 0.058 \times 0.901 = 6{,}326 \text{ ft}^3.$$

The proposed bioswale #2 is 933 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Drop structure DS-2 will be installed at the end of bioswale #2. See B&V Drawing SS-3001. The top of grate elevation of DS-2 will be at EL 15.5 (see Drawing SS-3050). The effective depth of the bioswale is: 15.5 – 12.5 = 3 feet.




The surface area of bioswale #2 is:

$20 \times 933 = 18{,}660 \text{ ft}^2 > 7{,}635 \text{ ft}^2$, <u>OK</u>.

The volume of bioswale #2 is:

$\frac{2+20}{2} \times 3 \times 933 = 30{,}789 \text{ ft}^3 > 6{,}326 \text{ ft}^3$, <u>OK</u>.

<u>Conclusion</u>: The proposed size of bioswale #2 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

| BLACK & VEATCH | OWNER | Radback Energy | | COMP'D BY | J. Zhong | | |
|---|---|---|---|---|---|---|---|
| | PLANT | Tenaska | Unit No. | DATE | 20-Mar-2009 | | |
| | PROJECT NO. | 163994 | File No. 52.5406.1002 | CKD BY | Pm | | |
| | TITLE | IMP Sizing | | DATE | 4/15/09 | | |
| | | | | PAGE | 12 | OF | 43 |

| Soil Type | IMP Name |
|---|---|
| A | Bioswale #2 |

| DMA Name | DMA Area ($ft^2$) | Post-Project Surface Type | DMA Runoff Factor | DMA Area x Runoff Factor | IMP Sizing Factor | Rain Adjustment Factor | Minimum Area or Volume | Proposed Area or Volume | |
|---|---|---|---|---|---|---|---|---|---|
| DMA-1 | 34,029 | Equipment / Roofs | 1.00 | 34,029 | | | | | |
| DMA-2 | 37,473 | Asphalt Pavement | 1.00 | 37,473 | | | | | |
| DMA-3 | 45,970 | Gravel Surfacing | 0.60 | 27,582 | | | | | |
| DMA-4 | 151,570 | Landscape, Group A Soil | 0.10 | 15,157 | | | | | |
| DMA-5 | 406 | Transformer Containment | 0.00 | 0 | | | | | |
| DMA-6 | 68,200 | Open Graded Aggregates | 0.10 | 6,820 | | | | | |
| | | | Total: | 121,061 | 0.070 | 0.901 | 7,635 | 18,660 | IMP Area ($ft^2$) |
| | | | | | 0.058 | 0.901 | 6,326 | 30,789 | $V_1$ ($ft^3$) |
| | | | | | NA | 0.901 | NA | NA | $V_2$ ($ft^3$) |
| | | | | | | | | Orifice Size: | NA |

**IMP Sizing for Bioswale #3**

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 40,711 ft$^2$ (0.93 ac). The bioswale #3 is measured to be 187 feet long.

Three drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; and (3) Grass/Landscape.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

| DMA Name | Post-Project Surface Type | DMA Area (ft$^2$) |
|---|---|---|
| DMA-1 | Equipment/Roofs | 6,423 |
| DMA-2 | Asphalt Pavement | 2,086 |
| DMA-3 | Grass/Landscape | 32,202 |

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Consequently,

$$\sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} = (6{,}423 \mathrm{x} 1.0 + 2{,}086 \mathrm{x} 1.0 + 32{,}202 \mathrm{x} 0.1)$$

$$= 11{,}729 \text{ ft}^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume ($V_1$). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 11{,}729 \times 0.07 \times 0.901 = 740 \text{ ft}^2.$$

The required minimum surface reservoir volume ($V_1$) of the bioswale is:

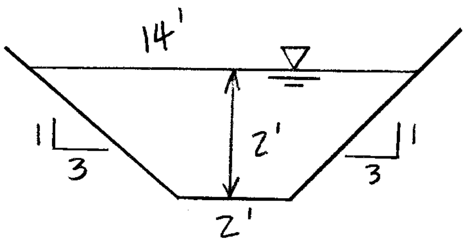
$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 11{,}729 \times 0.058 \times 0.901 = 613 \text{ ft}^3.$$

The proposed bioswale #3 is 187 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 11.0. Drop structure DS-1 will be installed at the end of bioswale #3. See B&V Drawing SS-3001. The top of grate elevation of DS-1 will be at EL 13.0 (see Drawing SS-3050). The effective depth of the bioswale is: 13.0 – 11.0 = 2 feet.

The surface area of bioswale #3 is:

$14 \times 187 = 2{,}618 \text{ ft}^2 > 740 \text{ ft}^2$, OK.




The volume of bioswale #3 is:

$\frac{2+14}{2} \times 2 \times 187 = 2992 \text{ ft}^3 > 613 \text{ ft}^3$, OK.

A 6" perforated underdrain will be installed in bioswale #3 and a portion of bioswale #2 to discharge stormwater runoff from less intensive storm events to the wetland to allow the wetland to continue to have water. See Dwg SS-3001 (Attachment 1).

Conclusion: The proposed size of bioswale #3 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

| BLACK & VEATCH | OWNER | Radback Energy | | COMP'D BY | J. Zhong | |
|---|---|---|---|---|---|---|
| | PLANT | Tenaska | Unit No. | DATE | 20-Mar-2009 | |
| | PROJECT NO. | 163994 | File No. 52.5406.1002 | CKD BY | PLN | |
| | TITLE | IMP Sizing | | DATE | 4/25/09 | |
| | | | | PAGE | 15 | OF 43 |

| Soil Type | IMP Name |
|---|---|
| A | Bioswale #3 |

| DMA Name | DMA Area ($ft^2$) | Post-Project Surface Type | DMA Runoff Factor | DMA Area x Runoff Factor |
|---|---|---|---|---|
| DMA-1 | 6,423 | Equipment / Roofs | 1.00 | 6,423 |
| DMA-2 | 2,086 | Asphalt Pavement | 1.00 | 2,086 |
| DMA-3 | 32,202 | Landscape, Group A Soil | 0.10 | 3,220 |
| | | | | |
| | | | | |
| | | | Total: | 11,729 |

| IMP Sizing Factor | Rain Adjustment Factor | Minimum Area or Volume | Proposed Area or Volume | |
|---|---|---|---|---|
| 0.070 | 0.901 | 740 | 2,618 | IMP Area ($ft^2$) |
| 0.058 | 0.901 | 613 | 2,992 | $V_1$ ($ft^3$) |
| NA | 0.901 | NA | NA | $V_2$ ($ft^3$) |
| | | | Orifice Size: | NA |

**IMP Sizing for Bioswale #4**

Refer to Page 5, the total drainage area for bioswale #4 is measured to be: 190,955 $ft^2$ (4.38 ac). The bioswale #4 is measured to be 391 feet long.

Five drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; and (5) Transformer Containment.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

| DMA Name | Post-Project Surface Type | DMA Area ($ft^2$) |
|---|---|---|
| DMA-1 | Equipment/Roofs | 19,314 |
| DMA-2 | Asphalt Pavement | 33,262 |
| DMA-3 | Gravel Surfacing | 109,208 |
| DMA-4 | Grass/Landscape | 23,692 |
| DMA-5 | Transformer Containment | 5,479 |

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} = (19{,}314 \text{x} 1.0 + 33{,}262 \text{x} 1.0 + 109{,}208 \text{x} 0.6 + 23{,}692 \text{x} 0.1 + 5{,}479 \text{x} 0)$$

$$= 120{,}470 \text{ ft}^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume ($V_1$). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

**Owner**: Radback Energy **Computed By**: J. Zhong
**Plant**: Tenaska **Unit**: **Date**: March 30, 2009
**Project No.**: 163994 **File No.** 52.5406.1002 **Verified By**: Prw
**Title**: IMP Sizing for Plant Area **Date**: 4/15/09


Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

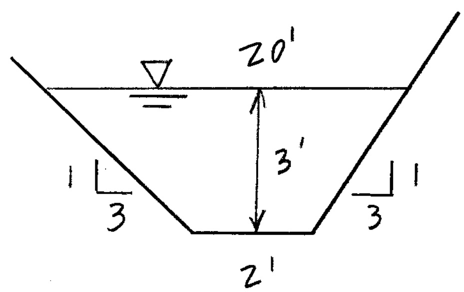
$$= 120{,}470 \times 0.07 \times 0.901 = 7{,}598 \text{ ft}^2.$$

The required minimum surface reservoir volume ($V_1$) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 120{,}470 \times 0.058 \times 0.901 = 6{,}296 \text{ ft}^3.$$

The proposed bioswale #4 is 391 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Drop structure DS-4 will be installed at the end of bioswale #4. See B&V Drawing SS-3001. The top of grate elevation of DS-4 will be at EL 15.5 (see Drawing SS-3050). The effective depth of the bioswale is: 15.5 – 12.5 = 3 feet.




The surface area of bioswale #4 is:

$20 \times 391 = 7{,}820 \text{ ft}^2 > 7{,}598 \text{ ft}^2$, <u>OK</u>.

The volume of bioswale #4 is:

$\frac{2+20}{2} \times 3 \times 391 = 12{,}903 \text{ ft}^3 > 6{,}296 \text{ ft}^3$, <u>OK</u>.

<u>Conclusion</u>: The proposed size of bioswale #4 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

| BLACK & VEATCH | | | | |
|---|---|---|---|---|
| OWNER | Radback Energy | | COMP'D BY | J. Zhong |
| PLANT | Tenaska | Unit No. | DATE | 20-Mar-2009 |
| PROJECT NO. | 163994 | File No. 52.5406.1002 | CKD BY | PLN |
| TITLE | IMP Sizing | | DATE | 4/15/09 |
| | | | PAGE | 18 OF 43 |

| Soil Type | IMP Name |
|---|---|
| A | Bioswale #4 |

| DMA Name | DMA Area ($ft^2$) | Post-Project Surface Type | DMA Runoff Factor | DMA Area x Runoff Factor |
|---|---|---|---|---|
| DMA-1 | 19,314 | Equipment / Roofs | 1.00 | 19,314 |
| DMA-2 | 33,262 | Asphalt Pavement | 1.00 | 33,262 |
| DMA-3 | 109,208 | Gravel Surfacing | 0.60 | 65,525 |
| DMA-4 | 23,692 | Landscape, Group A Soil | 0.10 | 2,369 |
| DMA-5 | 5,479 | Transformer Containment | 0.00 | 0 |
| | | | | |
| | | | **Total:** | 120,470 |

| IMP Sizing Factor | Rain Adjustment Factor | Minimum Area or Volume | Proposed Area or Volume | |
|---|---|---|---|---|
| 0.070 | 0.901 | 7,598 | 7,820 | **IMP Area ($ft^2$)** |
| 0.058 | 0.901 | 6,296 | 12,903 | **$V_1$ ($ft^3$)** |
| NA | 0.901 | NA | NA | **$V_2$ ($ft^3$)** |
| | | | **Orifice Size:** | NA |

**IMP Sizing for Bioswale #5**

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 318,309 $ft^2$ (7.31 ac) (natural gas facility included). The bioswale #5 is measured to be 465 feet long total.

Four drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; and (4) Grass/Landscape.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

| DMA Name | Post-Project Surface Type | DMA Area ($ft^2$) |
|---|---|---|
| DMA-1 | Equipment/Roofs | 15,984 |
| DMA-2 | Asphalt Pavement | 25,905 |
| DMA-3 | Gravel Surfacing | 186,725 |
| DMA-4 | Grass/Landscape | 89,695 |

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} = (15{,}984\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 162{,}894\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume ($V_1$). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 162{,}894 \times 0.07 \times 0.901 = 10{,}274 \text{ ft}^2.$$

The required minimum surface reservoir volume ($V_1$) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 162{,}894 \times 0.058 \times 0.901 = 8{,}512 \text{ ft}^3.$$

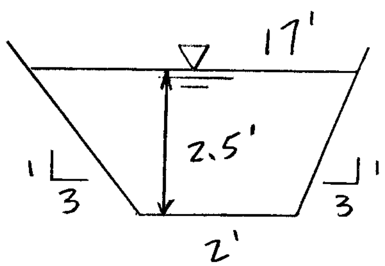
The proposed bioswale #5 is 465 feet long total. The bioswale cross section will be trapezoidal. Bottom width = 2 feet for the first 265 feet long section (Section 2 on SS-3001) and 8 feet for the remaining 200 feet long section (Section 2A on SS-3001). Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.0 for Section 2 and EL 11.0 for Section 2A. Drop structure DS-5 will be installed at the end of bioswale #5. See B&V Drawing SS-3001. The top of grate elevation of DS-5 will be at EL 15.0 (see Drawing SS-3050). The effective depth of the bioswale is: 14.5 – 11.0 = 3.5 feet for Section 2A and 14.5 – 12.0 = 2.5 feet for Section 2. See Dwg SS-3001 in Attachment 1.

The surface area of bioswale #5 is:

$17 \times 265 + 29 \times 200 = 10{,}305 \text{ ft}^2 > 10{,}274 \text{ ft}^2$, <u>OK</u>.

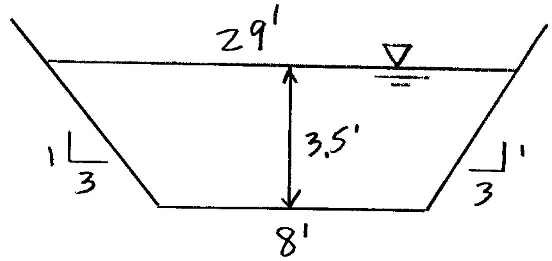
The volume of bioswale #5 is:

$$\frac{2+17}{2} \times 2.5 \times 265 + \frac{8+29}{2} \times 3.5 \times 200 = 19{,}244 \text{ ft}^3 > 8{,}512 \text{ ft}^3, \text{ OK}.$$




Section 2

DWG SS-3001




Section 2A

DWG SS-3001

Conclusion: The proposed size of bioswale #5 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

| DMA Name | DMA Area ($ft^2$) | Post-Project Surface Type | DMA Runoff Factor | DMA Area x Runoff Factor |
|---|---|---|---|---|
| DMA-1 | 15,984 | Equipment / Roofs | 1.00 | 15,984 |
| DMA-2 | 25,905 | Asphalt Pavement | 1.00 | 25,905 |
| DMA-3 | 186,725 | Gravel Surfacing | 0.60 | 112,035 |
| DMA-4 | 89,695 | Landscape, Group A Soil | 0.10 | 8,970 |
| | | | | |
| | | | Total: | 162,894 |

| Soil Type | IMP Name | | | |
|---|---|---|---|---|
| A | Bioswale #5 | | | |
| IMP Sizing Factor | Rain Adjustment Factor | Minimum Area or Volume | Proposed Area or Volume | |
| 0.070 | 0.901 | 10,274 | 10,305 | IMP Area ($ft^2$) |
| 0.058 | 0.901 | 8,512 | 19,244 | $V_1$ ($ft^3$) |
| NA | 0.901 | NA | NA | $V_2$ ($ft^3$) |
| | | | Orifice Size: | NA |

Radback Tenaska project

project # 163994  File # 52.5406.1002

Imp sizing for plant Area

prepared by: Jzhong

Date: 3/30/09

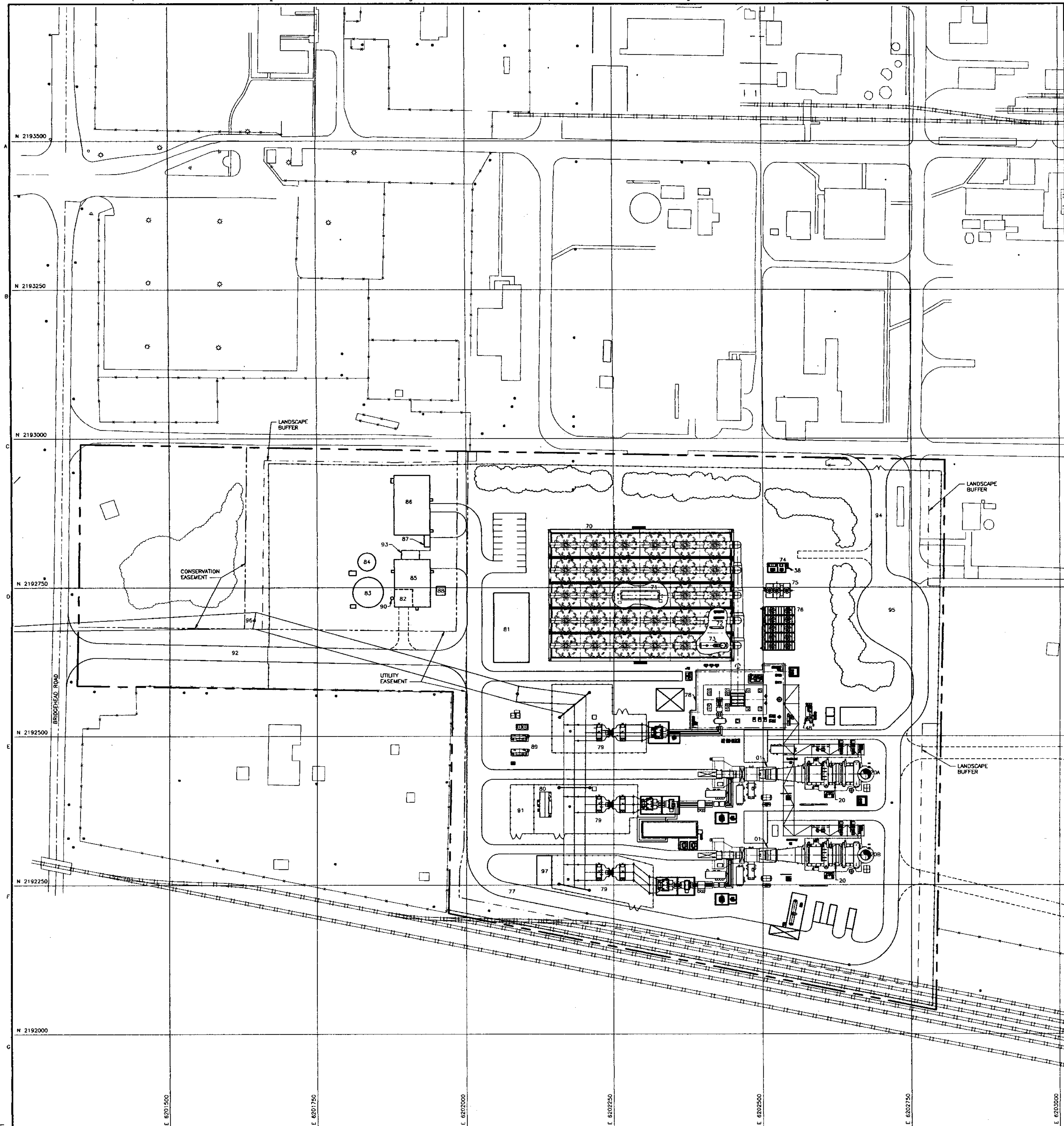
# of pages: 5

# Attachment 1

Black & Veatch Dwgs

SS-1002, SS-3001, SS-3201, SS-3050

DWG40999 31-MAR-2009 09:29:37




## FACILITIES LEGEND

| ID | FACILITY | STRUCTURE HEIGHT | TIEDOWN LOCATION NORTH | TIEDOWN LOCATION EAST | REMARKS |
|---|---|---|---|---|---|
| 01 | COMBUSTION TURBINE | 70' | – | – | – |
| 20 | HEAT RECOVERY STEAM GENERATOR (HRSG) | 103' | – | – | – |
| 20A | HRSG EXHAUST STACK A | 155' | 2192436.00 | 6202665.00 | CL EXHAUST STACK |
| 20B | HRSG EXHAUST STACK B | 155' | 2192300.00 | 6202665.00 | CL EXHAUST STACK |
| 38 | SAFETY SHOWER EYEWASH STATION | – | – | – | – |
| 48 | AUXILIARY BOILER | 50' | 2192527.61 | 6202572.26 | CL EXHAUST STACK |
| 70 | AIR COOLED CONDENSER (ACC) | 124' | – | – | – |
| 71 | ACC ELECTRICAL ENCLOSURE | 14' | – | – | – |
| 72 | CONDENSER AIR EXTRACTION SKIDS | 6' | – | – | – |
| 73 | ACC CONDENSATE COLLECTION TANK | 28' | – | – | – |
| 74 | WET SURFACE AIR COOLER CHEMICAL FEED SKIDS | 8' | – | – | – |
| 75 | WET SURFACE AIR COOLER | 23' | 2192744.67 | 6202523.00 | CL COOLER |
| 76 | CLOSED CYCLE COOLING WATER HEAT EXCHANGER | 19' | – | – | – |
| 77 | LOOP ROAD | – | – | – | – |
| 78 | STEAM TURBINE FOUNDATION | – | – | – | – |
| 79 | SWITCHYARD | 18' & 45' | – | – | – |
| 80 | SWITCHYARD CONTROL ENCLOSURE | 12' | – | – | – |
| 81 | CONTROL & ADMIN BUILDING | 14' | – | – | – |
| 82 | FIRE WATER PUMP ROOM | 20' | – | – | – |
| 83 | FIRE/SERVICE WATER STORAGE TANK | 32' | – | – | – |
| 84 | DEMIN WATER STORAGE TANK | 24' | – | – | – |
| 85 | WATER TREATMENT BUILDING | 20' | – | – | – |
| 86 | WAREHOUSE/MAINTENANCE BUILDING | 16' | – | – | – |
| 87 | LUBRICANT STORAGE SHED | 10' | – | – | – |
| 88 | WASTE WATER LIFT STATION (IF REQUIRED) | – | – | – | – |
| 89 | GAS COMPRESSORS & GAS CONDITIONING | 13' | – | – | – |
| 90 | DIESEL FIRE PUMP EXHAUST | 16' | 2192732.52 | 6201874.72 | CL EXHAUST STACK |
| 91 | GAS METERING STATION | – | – | – | – |
| 92 | ACCESS ROAD | – | – | – | – |
| 93 | LEASED MIX BED EXCHANGER CONCRETE SLAB | – | – | – | – |
| 94 | EMERGENCY ACCESS ROAD | – | – | – | – |
| 95 | CUL DA SAC (TURNAROUND) | – | – | – | – |
| 96 | 230KV POWER POLE | 106' | – | – | – |
| 97 | OUTAGE MAINTENANCE TRAILERS AREA | – | – | – | – |

## NOTES

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "W 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE, ELEVATION = 11.168 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. SEE PLANT ARRANGEMENT DRAWING SM-2001, FOR LEGEND OF MAIN POWER BLOCK.
3. PROPERTY AND EASEMENT BOUNDARY INFORMATION IS BASED UPON DRAWING EXHIBIT D, BY RONALD GREENWELL & ASSOCIATES, INC. REVISION DATED 05/FEB/09.

## GENERAL LEGEND

- NEW FENCE
- EXISTING FENCE
- PROPERTY BOUNDRY (SEE NOTE 3)
- EASEMENT BOUNDARY (SEE NOTE 3)
- LANDSCAPE BUFFER

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60' 30' 0 60' 120'

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SIGNED

DATE REG NO.

BLACK & VEATCH CORPORATION

ENGINEER PLN DRAWN NAW

CHECKED DATE

CONTRA COSTA GENERATING STATION LLC

CONTRA COSTA COMBINED CYCLE FACILITY

GENERAL ARRANGEMENT SITE

PROJECT DRAWING NUMBER 163994–SS–1002

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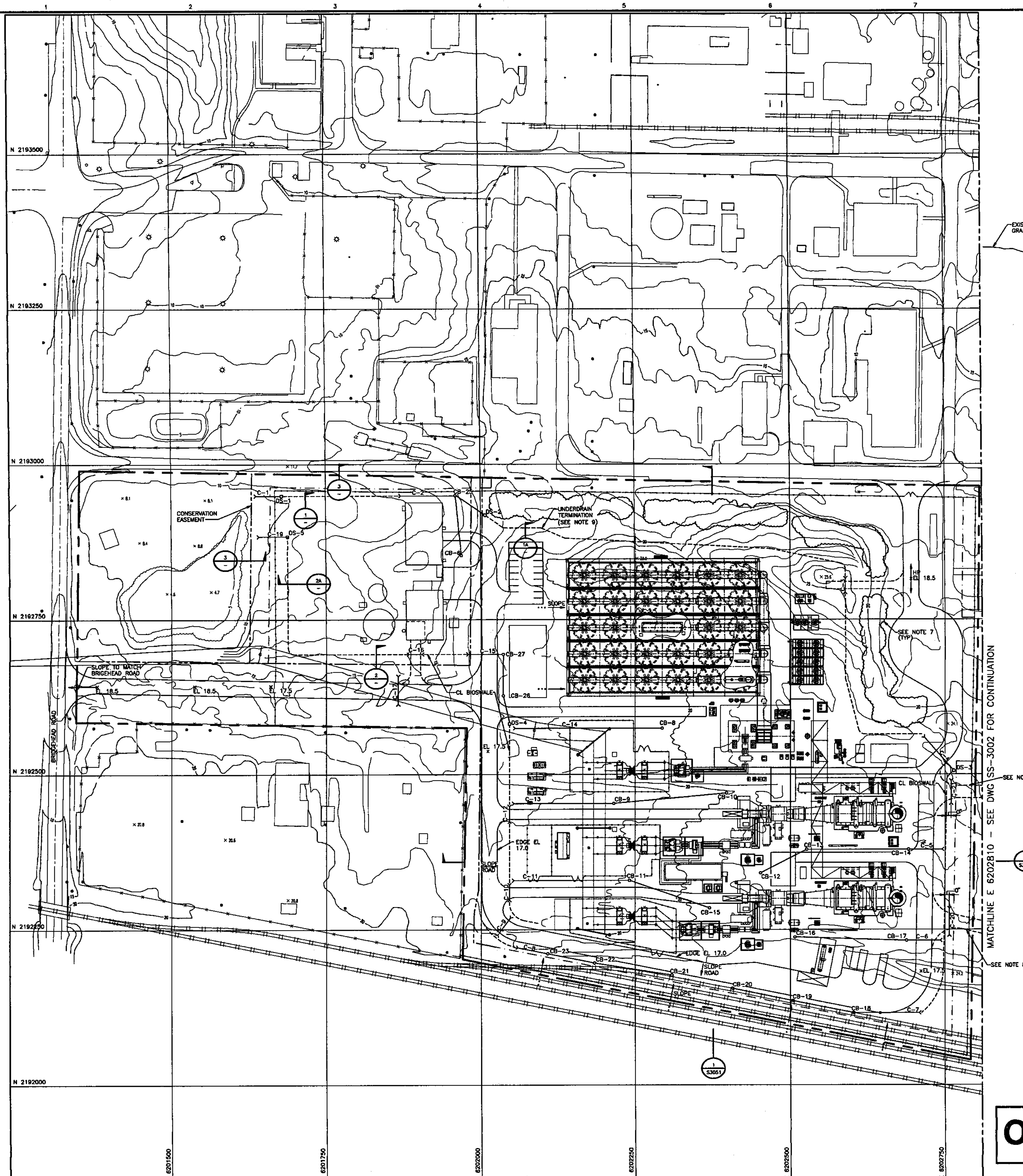


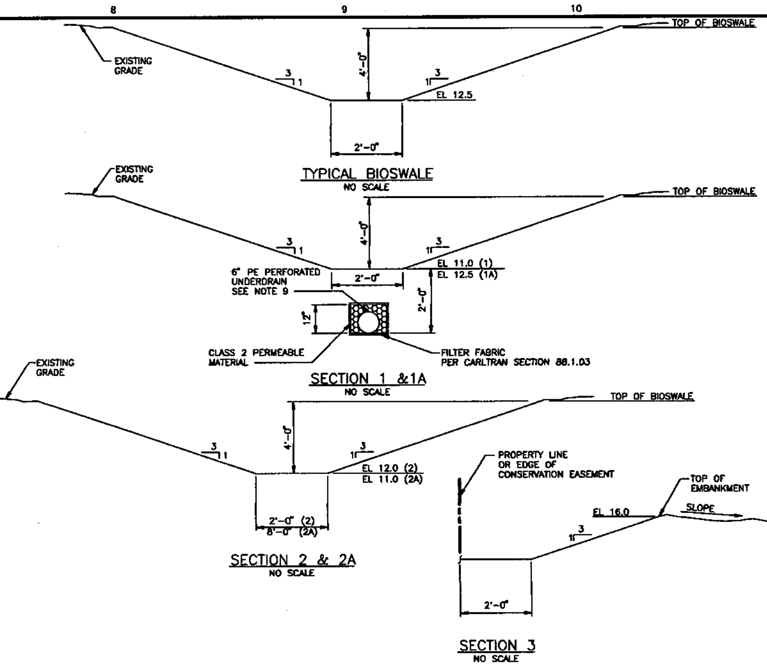


## ABBREVIATIONS APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

| | | | |
|---|---|---|---|
| APPROX | APPROXIMATE | LTR | LATER |
| ASPH | ASPHALT | MAX | MAXIMUM |
| AVG | AVERAGE | MH | MANHOLE |
| BND | BEND | MIN | MINIMUM |
| BLDG | BUILDING | MJ | MECHANICAL JOINT |
| B/MH | BOTTOM OF MANHOLE ELEVATION | MSL | MEAN SEA LEVEL |
| BOC | BOTTOM OF CONDUIT ELEVATION | NO. | NUMBER |
| BOD | BOTTOM OF DUCTBANK ELEVATION | NTS | NOT TO SCALE |
| BOP | BOTTOM OF PIPE ELEVATION | OD | OUTSIDE DIAMETER |
| BU | BELL-UP | OWS | OIL WATER SEPARATOR |
| C | CULVERT | OWMH | OILYWASTE MANHOLE |
| CB | CATCH BASIN | PC | POINT OF CURVATURE |
| CD | CABLE DUCT | PE | PLAIN END |
| CHDPE | CORRUGATED HIGH DENSITY POLYETHYLENE PIPE | PI | POINT OF INTERSECTION |
| CL | CENTERLINE | PLCS | PLACES |
| CLR | CLEAR | PM | PLANT MANHOLE |
| CMH | CHEMICAL MANHOLE | POT | POINT OF TANGENT |
| CND | CONDUIT | PT | PIPE TERMINATION |
| CONC | CONCRETE | PVC | POLYVINYL CHLORIDE PIPE |
| CO | CLEAN OUT | QTY | QUANITY |
| CS | CARBON STEEL | R | RADIUS |
| CW | CIRCULATING WATER | RCP | REINFORCED CONCRETE PIPE |
| DB | DUCTBANK | RD | ROOF DRAIN |
| DBC | DIRECT BURIED CABLE | REV | REVISION |
| DET | DETAIL | RGS | RIGID GALVANIZED STEEL |
| DIA | DIAMETER | RR | RAILROAD |
| DIP | DUCTILE IRON PIPE | SECT | SECTION |
| DWG | DRAWING | SIM | SIMILAR |
| DWP | DOUBLE WALL PIPE | SLS | SANITARY LIFT STATION |
| EC | ELECTRICAL CONDUIT | SMH | SANITARY MANHOLE |
| ECC | ECCENTRIC | STMH | STORM MANHOLE |
| EF | EACH FACE | STRL | STRUCTURAL |
| EHH | ELECTRICAL HANDHOLE | T/C | TOP OF CONCRETE ELEVATION |
| EL | ELEVATION | T/G | TOP OF GRADE ELEVATION |
| EMH | ELECTRICAL MANHOLE | THH | TELEPHONE SERVICE HANDHOLE |
| EW | EACH WAY | T/MH | TOP OF MANHOLE ELEVATION |
| FC | FIELD CHECK | T/P | TOP OF PAVEMENT ELEVATION |
| FDN | FOUNDATION | TP | MECH PIPE TERMINAL POINT |
| FF | FLAT FACE | TYP | TYPICAL |
| FRP | FIBERGLASS REINFORCED PIPE | UGL | UNDERGROUND LIGHTING CONDUIT |
| GR | GRADE | UNO | UNLESS NOTED OTHERWISE |
| HDM | HOT DRAIN MANHOLE | VERT | VERTICAL |
| HDPE | HIGH DENSITY POLYETHYLENE PIPE | WGT | WEIGHT |
| HP | HIGH POINT | WTR | WATER |
| HYD | HYDRANT | W/ | WITH |
| ID | INSIDE DIAMETER | W/O | WITHOUT |
| INV | INVERT | WP | WORK POINT |
| JBX | JUNCTION BOX | XFMR | TRANSFORMER |
| L | LENGTH | | |
| LP | LOW POINT | | |

## LEGEND APPLICABLE TO ALL S3000 DRAWINGS

| | |
|---|---|
| NEW CULVERT | NEW SLIDE GATE |
| CL BIOSWALE | NEW SWING GATE |
| 1 / S3000 — SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER | EXISTING POWER POLE |
| × 326.5 — FINISHED SPOT ELEVATIONS | CB-101 — NEW CATCH BASIN |
| BM-1 — SURVEY MONUMENT/CONTROL POINT | NEW DROP STRUCTURE |
| EXISTING FENCE | PROPERTY LINE |
| NEW SECURITY FENCE | BOUNDARY LINE |
| TEMPORARY CONSTRUCTION FENCE | 126 — EXISTING CONTOURS |
| TR-1 — EROSION CONTROL METHOD | GRADE TO DRAIN (DIRECTION OF ARROW) |

## NOTES APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "W 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE, ELEVATION = 11.168 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. NEW GRADE ELEVATIONS SHOWN ON THE SITE GRADING AND DRAINAGE PLANS INDICATE FINISH GRADE UNLESS NOTED OTHERWISE.
3. ALL CUT AND FILL SLOPES SHALL BE 3 HORIZONTAL TO 1 VERTICAL OR FLATTER, UNLESS NOTED OTHERWISE.
4. SEE DWG SS-3050 FOR GRADING AND DRAINAGE DETAILS INCLUDING CULVERT, CATCH BASIN AND DROP STRUCTURE CHARTS.
5. TOP OF CONCRETE ELEVATIONS AND FINISH FLOOR ELEVATIONS FOR ALL EQUIPMENT AND BUILDINGS IS EL 18.0. FINISH GRADE ADJACENT TO ALL FOUNDATIONS IS EL 17.5.
6. CL OF ALL PAVED ROADS IS EL 17.5 UNO.
7. TREES TO REMAIN. GRADE TO REMAIN UNCHANGED WITHIN 20' OF TREE BASE.
8. TEMPORARY ROAD FROM LAYDOWN AREA. ROAD AND CULVERT UNDER ROAD TO BE REMOVED AT END OF CONSTRUCTION.
9. UNDERDRAIN CONTINUOUS UNDER BIOSWALE FROM UNDERDRAIN TERMINATION TO CONSERVATION EASEMENT. UTILIZE UNPERFORATED PIPE BETWEEN DS-2 TO C-2 OUTLET AND DS-1 TO C-1 OUTLET.

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CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

GRADING AND DRAINAGE - SITE PLAN - SHEET 1

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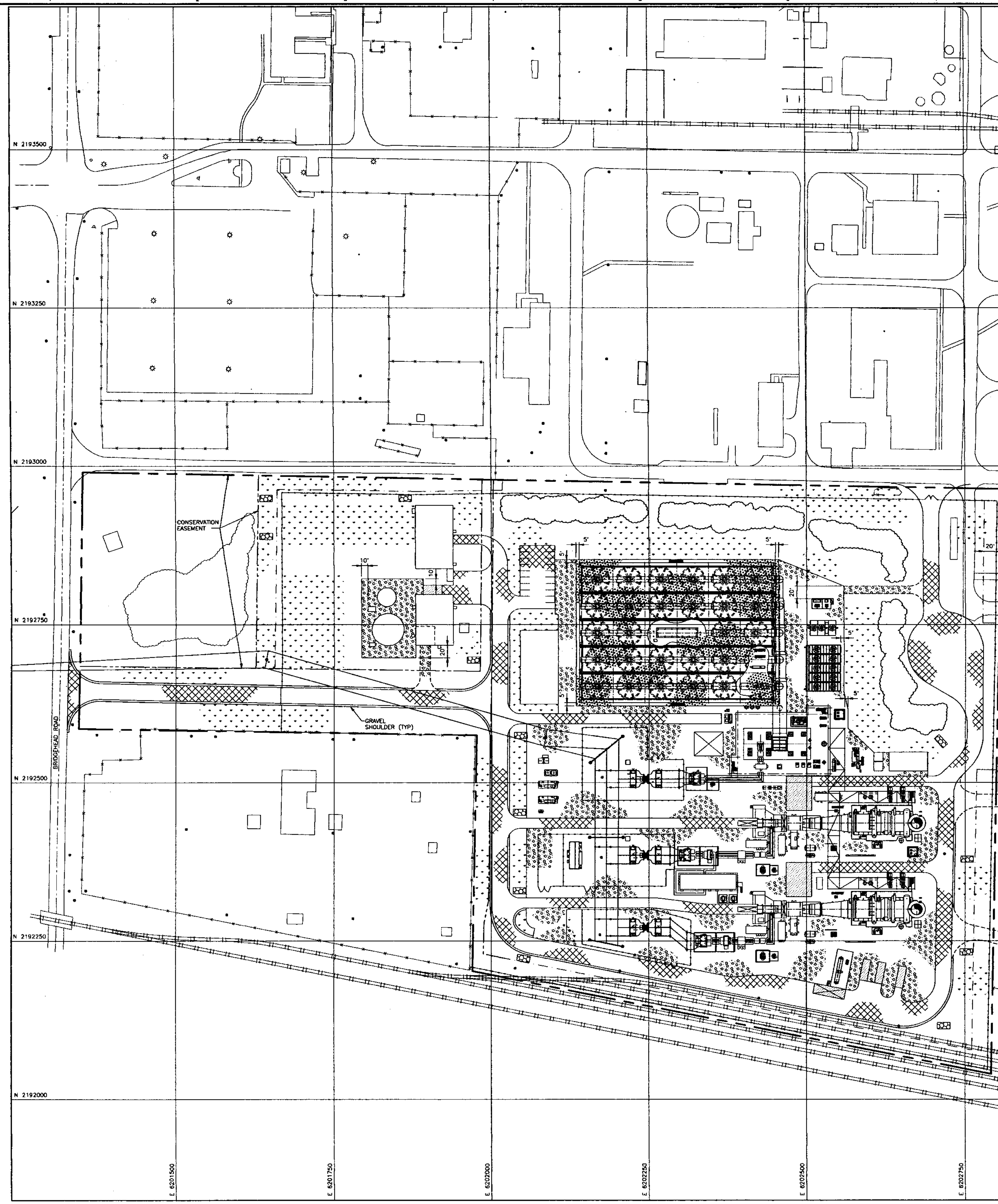
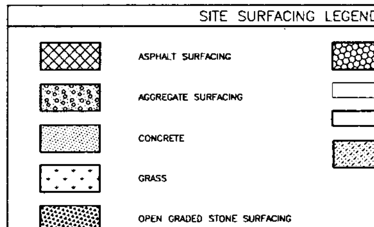



## SITE SURFACING LEGEND



| | |
|---|---|
| ASPHALT SURFACING | RIPRAP |
| AGGREGATE SURFACING | EXISTING FACILITY |
| CONCRETE | NEW FACILITY |
| GRASS | NATURAL SOIL |
| OPEN GRADED STONE SURFACING | |

## NOTES

1. SEE DRAWING SS-3001 FOR GENERAL NOTES AND LEGEND.

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AREA

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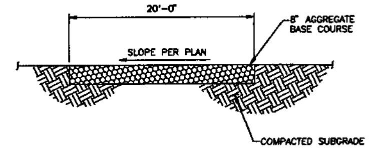
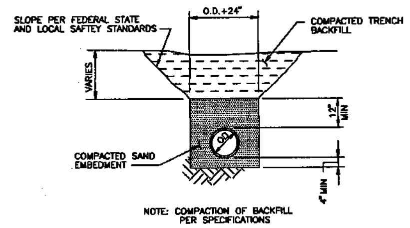
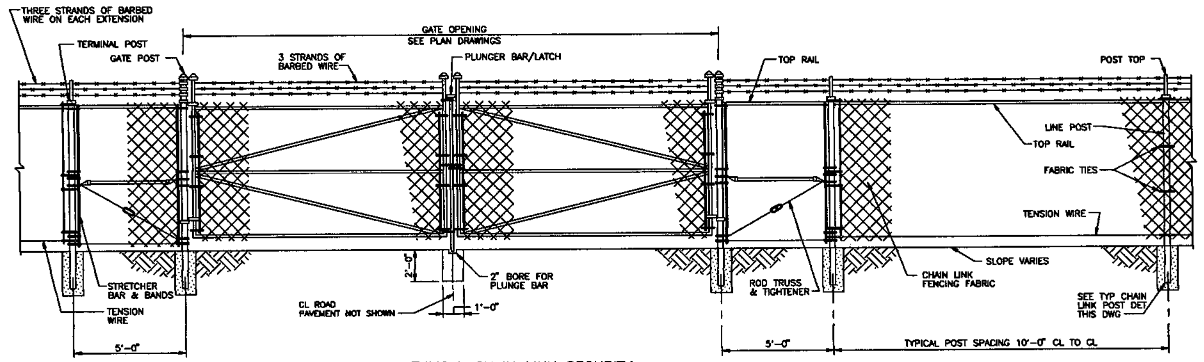


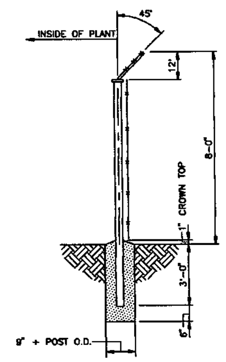

TYPICAL CONSTRUCTION LAYDOWN ROAD
NO SCALE



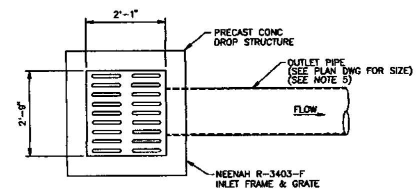

TYPICAL PIPE EMBEDMENT
NO SCALE



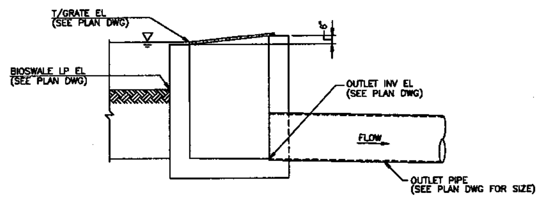

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
NO SCALE




TYPICAL SECURITY FENCE POST DETAIL
NO SCALE

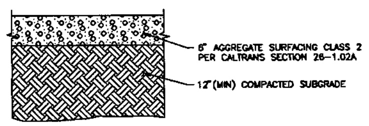



PLAN

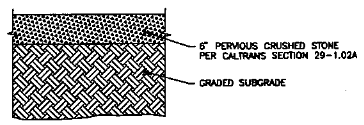



SECTION

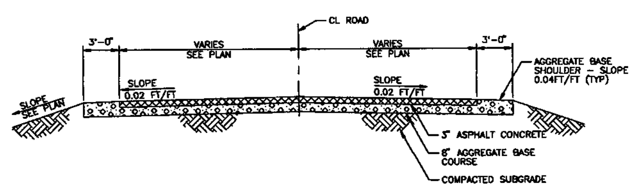
TYPICAL BIOSWALE DROP STRUCTURE DETAIL
NO SCALE




TYPICAL AGGREGATE SURFACING SECTION
NO SCALE

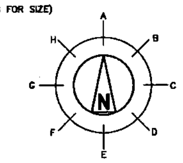



TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
NO SCALE



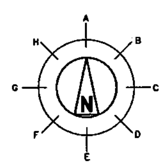

TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS-3201

| CULVERT TABLE | | | | | | |
|---|---|---|---|---|---|---|
| CULVERT NO. | INLET INV ELEVATION | OUTLET INV ELEVATION | LENGTH | PIPE DIAMETER | PIPE MATERIAL | REMARKS |
| C-1 | 8.2 | 8.0 | – | 18" | – | |
| C-2 | 11.8 | 11.5 | – | 18" | – | |
| C-3 | 13.0 | 13.0 | – | 18" | – | |
| C-4 | 13.2 | 13.0 | – | 18" | – | |
| C-5 | 13.1 | 13.0 | – | 12" | – | |
| C-6 | 13.1 | 13.0 | – | 12" | – | |
| C-7 | 13.3 | 13.0 | – | 12" | – | |
| C-8 | 13.2 | 13.0 | – | 12" | – | |
| C-9 | 13.0 | 13.0 | – | 12" | – | |
| C-10 | 13.0 | 13.0 | – | 15" | – | |
| C-11 | 13.4 | 13.0 | – | 12" | – | |
| C-12 | 13.0 | 13.0 | – | 18" | – | |
| C-13 | 13.4 | 13.0 | – | 12" | – | |
| C-14 | 13.5 | 13.0 | – | 12" | – | |
| C-15 | 12.8 | 12.5 | – | 18" | – | |
| C-16 | 12.5 | 12.5 | – | 18" | – | |
| C-17 | 14.7 | 14.4 | – | 12" | – | |
| | | | | | | |
| C-19 | 8.7 | 8.5 | – | 18" | – | |
| C-20 | – | – | – | 18" | – | |
| C-21 | – | – | – | 18" | – | |




| CATCH BASIN TABLE | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STRUCTURE NO. | CENTERLINE COORDINATES | | TOP OF GRATE ELEVATION | INLET & OUTLET PIPE INFORMATION | | | | | | | | | | | | | | | | REMARKS |
| | | | | A | | B | | C | | D | | E | | F | | G | | H | | |
| | NORTH | EAST | | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | |
| CB-6 | – | – | 16.0 | – | – | 13.2 | 12" | – | – | – | – | 13.2 | 12" | – | – | – | – | – | – | |
| CB-7 | NOT USED | | | | | | | | | | | | | | | | | | | |
| CB-8 | – | – | 17.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.5 | 12" | |
| CB-9 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB-10 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB-11 | – | – | 17.0 | – | – | – | – | – | – | 13.4 | 12" | – | – | – | – | 13.4 | 12" | – | – | |
| CB-12 | – | – | 17.0 | – | – | 13.6 | 12" | – | – | – | – | – | – | – | – | – | – | – | – | |
| CB-13 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | 13.4 | 12" | – | – | – | – | |
| CB-14 | – | – | 17.0 | – | – | – | – | 13.1 | 12" | – | – | – | – | – | – | 13.1 | 12" | – | – | |
| CB-15 | – | – | 17.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.6 | 12" | |
| CB-16 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB-17 | – | – | 17.0 | – | – | – | – | 13.1 | 12" | – | – | – | – | – | – | 13.1 | 12" | – | – | |
| CB-18 | – | – | 16.5 | – | – | 13.2 | 12" | – | – | – | – | – | – | – | – | 13.2 | 12" | – | – | |
| CB-19 | – | – | 16.5 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB-20 | – | – | 16.5 | – | – | – | – | 13.6 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB-21 | – | – | 16.5 | – | – | – | – | – | – | – | – | – | – | – | – | 13.6 | 12" | – | – | |
| CB-22 | – | – | 16.5 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB-23 | – | – | 16.5 | – | – | – | – | 13.2 | 12" | – | – | – | – | – | – | 13.2 | 12" | – | – | |
| CB-24 | NOT USED | | | | | | | | | | | | | | | | | | | |
| CB-25 | – | – | 15.0 | – | – | – | – | – | – | 11.8 | 18" | 12.3 | 12" | – | – | 11.8 | 18" | – | – | |
| CB-26 | – | – | 16.0 | 13.2 | 18" | – | – | – | – | – | – | 13.2 | 18" | – | – | – | – | – | – | |
| CB-27 | – | – | 16.5 | – | – | – | – | – | – | – | – | 12.8 | 18" | – | – | 12.8 | 18" | – | – | |

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST




| DROP STRUCTURE (DS) TABLE | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STRUCTURE NO. | CENTERLINE COORDINATES | | TOP OF GRATE ELEVATION | INLET & OUTLET PIPE INFORMATION | | | | | | | | | | | | | | | | REMARKS |
| | | | | A | | B | | C | | D | | E | | F | | G | | H | | |
| | NORTH | EAST | | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | |
| DS-1 | – | – | 13.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 12.1 | 18" | |
| DS-2 | – | – | 15.5 | – | – | – | – | – | – | – | – | – | – | – | – | 11.8 | 18" | – | – | |
| DS-3 | – | – | 15.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.2 | 18" | |
| DS-4 | – | – | 15.5 | 13.5 | 18" | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| DS-5 | – | – | 14.5 | 8.7 | 18" | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| | | | | | | | | | | | | | | | | | | | | |

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST

NOTES

1. FILTER FABRIC SHALL BE UV-STABILIZED NONWOVEN GEOTEXTILE HAVING A MINIMUM WEIGHT OF 135 $g/M^2$ PER CALTRANS SS 88-1.03.
2. SEE DWG SS-3001 FOR GENERAL NOTES AND LEGEND.

**OPEN**
04/01/09

NOT TO BE USED FOR CONSTRUCTION



| NO | DATE | REVISIONS AND RECORD OF ISSUE | DRN | DES | CHK | PDE | APP |
|---|---|---|---|---|---|---|---|
| 0 | 16/APR/09 | ISSUED FOR PERMITTING | NAW | PLN | | PLN | DVW |

60' 30' 0 60' 120'
SCALE: 1"=60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA
SIGNED
DATE REG NO.

BLACK & VEATCH CORPORATION
ENGINEER PLN DRAWN NAW
CHECKED DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SITE
SECTIONS AND DETAILS

PROJECT DRAWING NUMBER: 163994-SS-3050
REV: 0
CODE
AREA

Radback Tenaska project
project # 163994 File # 52.5406.1002
IMP sizing for Plant Area

prepared by: J zhong
Date: 3/30/09
# of pages: 5

Attachment 2

Reference 2

Select pages

(Runoff factor) x (tributary area) ≤ 2 x (self-retaining area) *Equation 4-1*

For treatment-only sites, and

(Runoff factor) x (tributary area) ≤ 1 x (self-retaining area) *Equation 4-2*

for sites subject to flow-control requirements. Use the runoff factors in Table 4-2.

Prolonged ponding is a potential problem at higher impervious/pervious ratios. In your design, ensure that the pervious area soils can handle the additional run-on and are sufficiently well-drained.

Runoff from self-treating and self-retaining areas does not require any further treatment or flow control.

TABLE 4-2. Runoff factors to be used when sizing IMPs.

| Surface | Treatment and Flow Control | Treatment only |
|---|---|---|
| Roofs | 1.0 | 1.0 |
| Concrete or Asphalt | 1.0 | 1.0 |
| Pervious Concrete | 0.1 | 0.1 |
| Porous Asphalt | 0.1 | 0.1 |
| Grouted Unit Pavers | 1.0 | 1.0 |
| Solid Unit Pavers | 0.5 | 0.2 |
| Crushed Aggregate | 0.1 | 0.1 |
| Turfblock | 0.1 | 0.1 |
| Landscape, Group A Soil | 0.1 | 0.1 |
| Landscape, Group B Soil | 0.3 | 0.1 |
| Landscape, Group C Soil | 0.5 | 0.1 |
| Landscape, Group D Soil | 0.7 | 0.1 |

**Areas draining to IMPs** are used to calculate the required size of the IMP. On most densely developed sites—such as commercial and mixed-use developments and small-lot residential subdivisions—most DMAs will drain to IMPs.

The CCCWP has developed sizing factors (ratios of IMP area to impervious DMA area). For each IMP design, factors are provided for:

TABLE 4-6. Sizing Factors

| Treatment and Flow Control | NRCS Soil Group | | | |
|---|---|---|---|---|
| **IMP** | **A** | **B** | **C** | **D** |
| Bioretention Facility | | | | |
| A | 0.07 | 0.11 | 0.06 | 0.05 |
| $V_1$ | 0.058 | 0.092 | 0.050 | 0.042 |
| $V_2$ | N/A | N/A | 0.066 | 0.055 |
| Flow-through Planter | | | | |
| A | N/A | N/A | 0.06 | 0.05 |
| $V_1$ | N/A | N/A | 0.050 | 0.042 |
| $V_2$ | N/A | N/A | 0.066 | 0.055 |
| Dry Well | | | | |
| A | 0.05 | 0.06 | N/A | N/A |
| V | 0.130 | 0.204 | N/A | N/A |
| Cistern + bioretention facility | | | | |
| A (bioretention facility) | *0.04* | *0.04* | *0.04* | *0.04* |
| V (cistern) | 0.193 | 0.228 | 0.088 | 0.060 |

* Cistern sized for flow control when used in conjunction with a treatment IMP. IMP underdrain required in B, C and D soils.

**Treatment Only**

| | | | | |
|---|---|---|---|---|
| Bioretention Facility | | | | |
| A | *0.04* | *0.04* | *0.04* | *0.04* |
| Flow-through Planter | | | | |
| A | *0.04* | *0.04* | *0.04* | *0.04* |
| Dry Well (treatment only) | | | | |
| A | 0.02 | 0.04 | N/A | N/A |
| V | 0.068 | 0.136 | N/A | N/A |

Units Notes:
A = $ft^2$ of IMP footprint per $ft^2$ of tributary impervious area (unitless)
V, $V_1$, $V_2$ = $ft^3$ per $ft^2$ of equivalent tributary impervious area (ft.)

#### STEP 5: OBTAIN SIZING AND RAIN ADJUSTMENT FACTORS FOR EACH IMP

For each of the IMPs, obtain the appropriate **area** sizing factor from Table 4-6.

Sizing factors for treatment-only IMPs (in *italics*) do not require any adjustment for differing rainfall patterns.

Both area (A) and volume ($V_1$, $V_2$) sizing factors for treatment-plus-flow-control IMPs, however, must be adjusted to account for the effects of differing rainfall patterns on pre-project and post-project runoff.

Use the equations below to compute the rainfall adjustment:

*Equation 4-3*

$$\text{For Group A soils, } Rain\ Adjustment = \frac{0.0009 \times \left(MAP_{project\ site} - 20.2\right) + 0.07}{0.07}$$

*Equation 4-4*

$$\text{For Group B soils, } Rain\ Adjustment = \frac{-0.0005 \times \left(MAP_{project\ site} - 20.2\right) + 0.11}{0.11}$$

*Equation 4-5*

$$\text{For Group C soils, } Rain\ Adjustment = \frac{-0.0022 \times \left(MAP_{project\ site} - 20.2\right) + 0.06}{0.06}$$

*Equation 4-6*

$$\text{For Group D soils, } Rain\ Adjustment = \frac{-0.0022 \times \left(MAP_{project\ site} - 20.2\right) + 0.05}{0.05}$$

where *MAP* is the mean annual precipitation at the site as shown on the isohyetal map, Contra Costa County Public Works Figure B-166, available on the CCCWP C.3 web pages.

#### ▶ STEP 6: CALCULATE MINIMUM AREA AND VOLUME OF EACH IMP

The minimum area and storage volumes of each IMP are found by summing up the contributions of each tributary DMA and multiplying by the adjusted sizing factor for the IMP.

*Equation 4-7*

$$Min.\,IMP\,Area\ or\ Volume = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

Bioretention facilities and flow-through planters have two storage volumes. $V_1$ is the floodable volume above the soil layer. $V_2$ is the storage volume below the soil layer, calculated by multiplying the volume of gravel by an assumed porosity of 0.4. See Figure 4-6. Note these volumes can be configured in a variety of practical combinations of depth and area to best fit into your landscape design.

Cisterns and dry wells have a single storage volume (V).

V is calculated using Equation 4-8:

*Equation 4-8*

$$Min.V = \sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} \times \begin{pmatrix} IMP\,Volume \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

Use the format of Table 4-7 to present the calculations of the required minimum area and volumes of the receiving IMP:

TABLE 4-7. Format for presenting calculations of minimum IMP Areas and Volumes

| *DMA Name* | *DMA Area (square feet)* | *Post-project surface type* | *DMA Runoff factor* | *DMA Area × runoff factor* |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | ***Total*** | |

| *Soil Type:* | *IMP Name* | | | |
|---|---|---|---|---|
| | | | | |
| *IMP Sizing factor* | *Rain Adjust-ment Factor* | *Minimum Area or Volume* | *Proposed Area or Volume* | |
| | | | | ***IMP Area*** |
| | | | | ***V or V1*** |
| | | | | ***V2*** |
| | | | ***Orifice Size:*** | |

**► STEP 7: DETERMINE IF IMP AREA AND VOLUME ARE ADEQUATE**

Sizing and configuring IMPs may be an iterative process. After computing the minimum IMP area using Steps 1–6, review the site plan to determine if the reserved IMP area is sufficient. If so, the planned IMPs will meet the Provision C.3 sizing requirements. If not, revise the plan accordingly. Revisions may include:

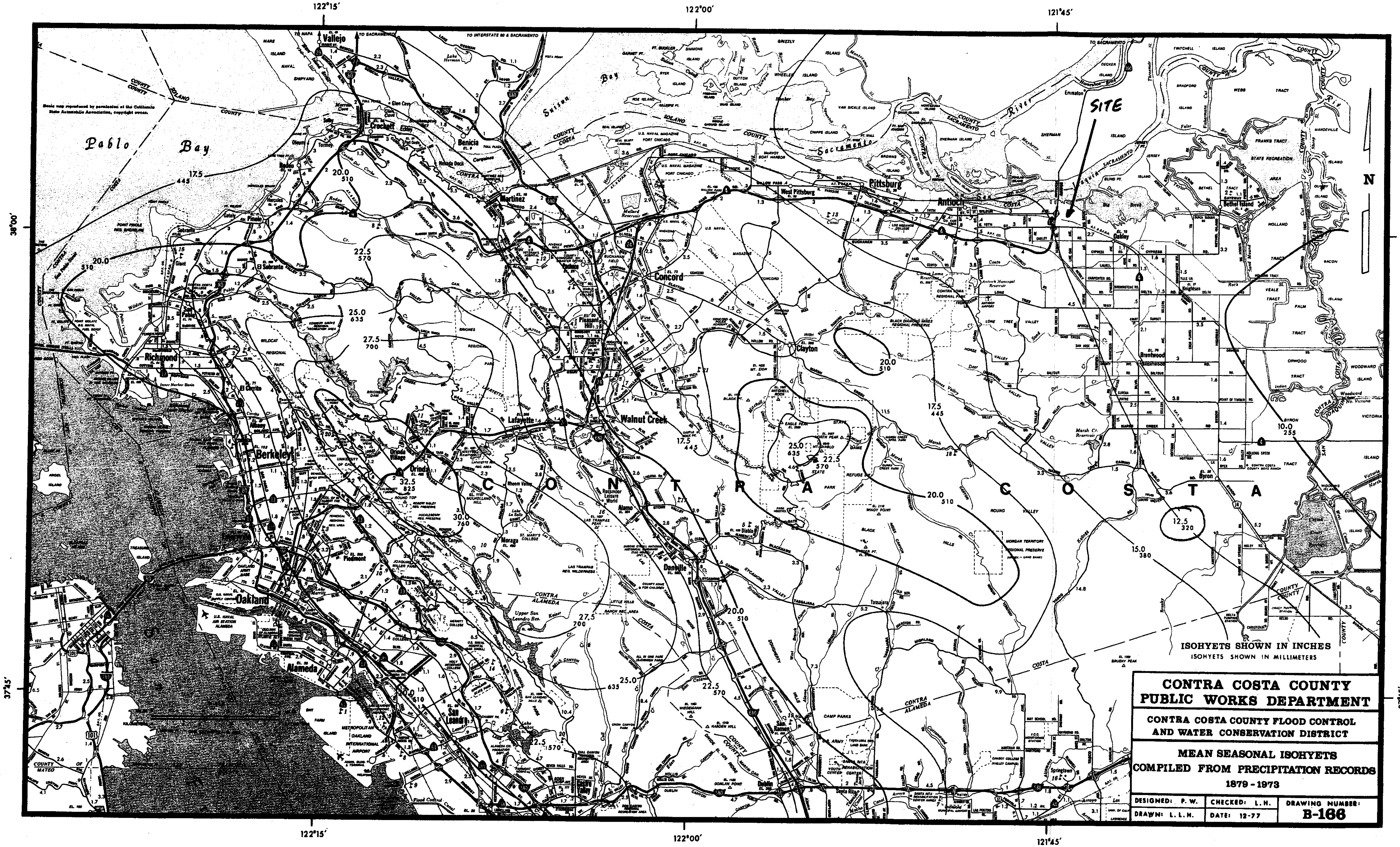
Radback Tenaska project
project # 163994 File # 52.5406.1002
IMP Sizing for ~~[illegible]~~ Plant Area

prepared by: JZhong
Date: 3/24/09
# of pages: 2

Attachment 3

Reference 3

Drawing No. B-166



CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT
CONTRA COSTA COUNTY FLOOD CONTROL
AND WATER CONSERVATION DISTRICT
MEAN SEASONAL ISOHYETS
COMPILED FROM PRECIPITATION RECORDS
1879 - 1973
DESIGNED: P. W.
CHECKED: L. H.
DRAWING NUMBER:
B-166
DRAWN: L. L. H.
DATE: 12-77
ISOHYETS SHOWN IN INCHES
ISOHYETS SHOWN IN MILLIMETERS
SITE
N
CONTRA COSTA
122°15′
122°00′
121°45′
38°00′
37°45′
Pablo Bay
Suisun Bay
Richmond
Berkeley
Oakland
Alameda
San Leandro
Piedmont
El Cerrito
Pinole
Hercules
Rodeo
Crockett
Vallejo
Benicia
Martinez
Concord
Pleasant Hill
Walnut Creek
Lafayette
Orinda
Moraga
Clayton
Danville
Alamo
Pittsburg
West Pittsburg
Antioch
Oakley
Brentwood
Byron
Dublin
Castro Valley
Springtown
17.5
445
20.0
510
22.5
570
25.0
635
27.5
700
30.0
760
32.5
825
15.0
380
12.5
320
10.0
255

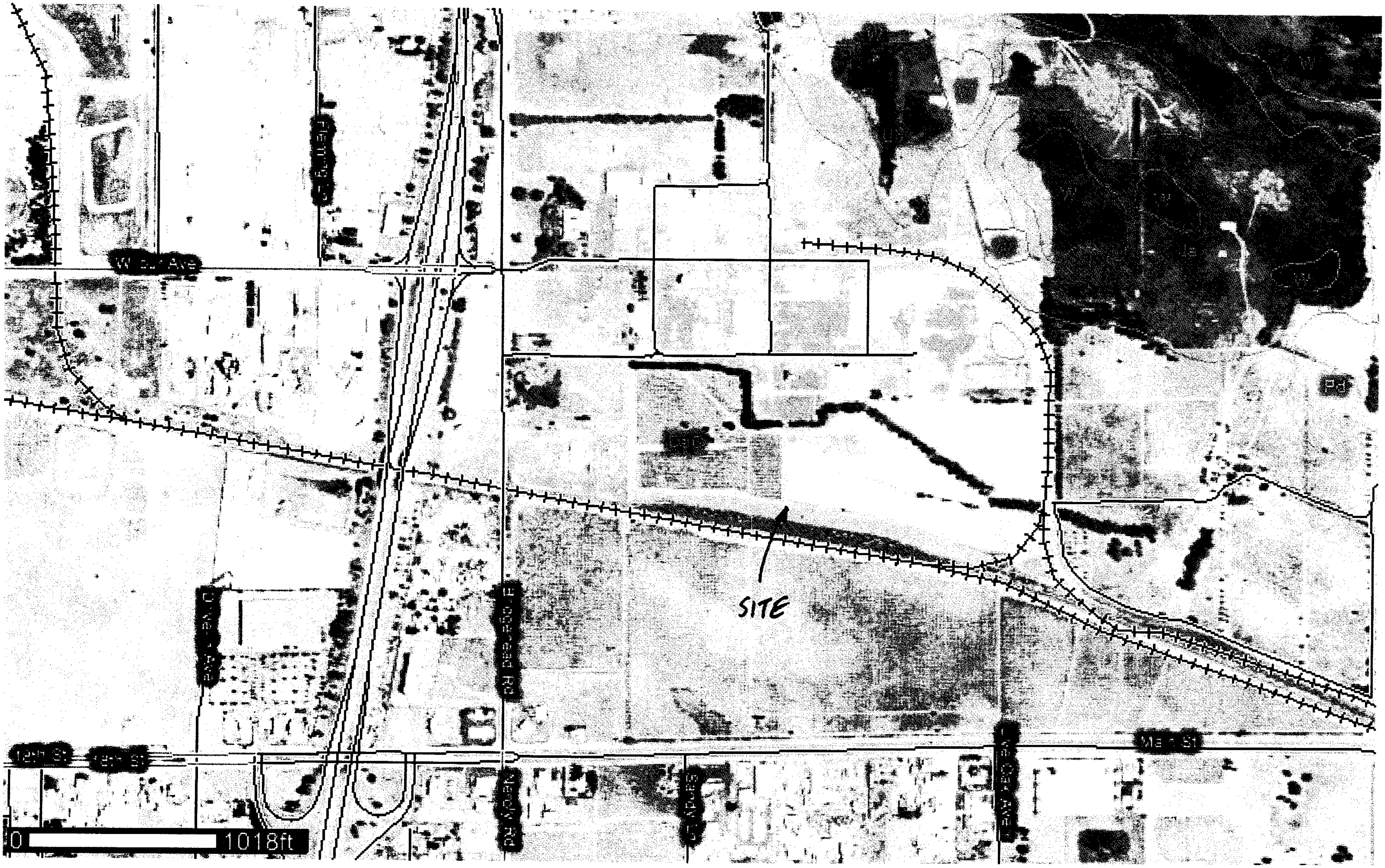
Radback Tenaska project
project # 163994 File # 52.5406.1002
IMP sizing for ~~Lagoon~~ plant Area

prepared by: J Zhang
Date: 3/24/09
# of pages: 4

Attachment 4

Reference 4

select pages


SITE
0
1018ft
12th St

# Contra Costa County, California

## DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

### Map Unit Setting

*Elevation:* 10 to 150 feet
*Mean annual precipitation:* 12 to 14 inches
*Mean annual air temperature:* 59 degrees F
*Frost-free period:* 260 to 300 days

### Map Unit Composition

*Delhi and similar soils:* 85 percent
*Minor components:* 15 percent

### Description of Delhi

#### Setting

*Landform:* Flood plains, terraces, alluvial fans
*Landform position (three-dimensional):* Tread, talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Eolian deposits derived from igneous and sedimentary rock

#### Properties and qualities

*Slope:* 2 to 9 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Somewhat excessively drained
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (5.95 to 19.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Low (about 4.2 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3s
*Land capability (nonirrigated):* 6e

#### Typical profile

*0 to 5 inches:* Sand
*5 to 60 inches:* Sand

### Minor Components

#### Unnamed

*Percent of map unit:* 12 percent

**Laugenour**

*Percent of map unit:* 3 percent

## Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

Radback Tenaska project
project # 163994 File # 52.5406.1002
IMP sizing for ~~[illegible]~~ plant Area

prepared by JZhong
Date: 3/24/09
# of pages: 2

Attachment 5

Reference 5

select page

# Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

**Group A** soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

**Group B** soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

**Group C** soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

**Group D** soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

## Disturbed soil profiles

As a result of urbanization, the soil profile may be con- siderably altered and the listed group classification ma no longer apply. In these circumstances, use the follov ing to determine HSG according to the texture of the new surface soil, provided that significant compactior has not occurred (Brakensiek and Rawls 1983).

| *HSG* | *Soil textures* |
|---|---|
| A | Sand, loamy sand, or sandy loam |
| B | Silt loam or loam |
| C | Sandy clay loam |
| D | Clay loam, silty clay loam, sandy clay, silty clay, or clay |

## Drainage and group D soils

Some soils in the list are in group D because of a higl water table that creates a drainage problem. Once th soils are effectively drained, they are placed in a diff ent group. For example, Ackerman soil is classified ε A/D. This indicates that the drained Ackerman soil is group A and the undrained soil is in group D.

Radback Tenaska project

project # 163994 File # 52.5406.1002

IMP sizing for ~~[struck]~~ Plant Area

prepared by: JZhong

Date: 3/24/09

# of pages: 3

Attachment 6

Email communications with contra costa county clean water program

## Zhong, Jimmy

**From:** Dan Cloak [dan@dancloak.com]
**Sent:** Monday, March 02, 2009 3:54 PM
**To:** 'Tom Dalziel'; Zhong, Jimmy
**Subject:** RE: Stormwater C.3 Question

Hi,

It is correct that dense-graded aggregates are not very pervious. Why not use an open-graded aggregate, such as ½ in. crushed rock? Be sure to use a rigid frame around the gravel area.

"Porous Pavements" by Bruce Ferguson is a good reference for porous pavement design.

If dense-graded aggregate is used, I would suggest a runoff coefficient of 0.5 to 0.7, depending on slope.

Dan

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**From:** Tom Dalziel [mailto:tdalz@pw.cccounty.us]
**Sent:** Monday, March 02, 2009 11:04 AM
**To:** Zhong, Jimmy; Dan@dancloak.com
**Subject:** RE: Stormwater C.3 Question

Hi Dan,

Can you review and respond, as appropriate, to Jimmy on my behalf?

Thanks.

Tom Dalziel
Assistant Program Manager
Contra Costa Clean Water Program
tdalz@pw.cccounty.us
Ph. (925) 313-2392, Fax (925) 313-2301

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**From:** Zhong, Jimmy [mailto:ZhongJ@bv.com]
**Sent:** Wednesday, February 25, 2009 1:11 PM
**To:** Tom Dalziel
**Subject:** Stormwater C.3 Question

Tom,

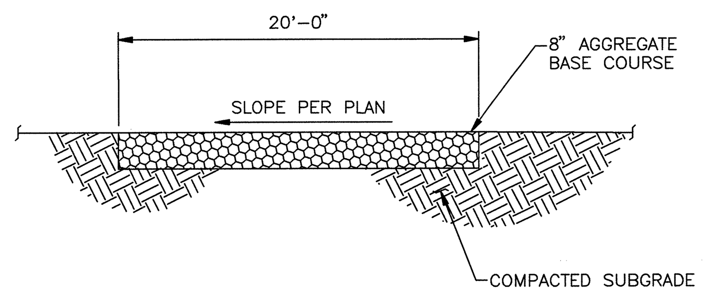
I talked to you and Dan this morning regarding runoff factor for Class 2 aggregates (Caltran Standard Specification Section 26). After our phone call, I had a discussion with my supervisor. He indicated that this type of material is **dense-graded** aggregate which is typically used as pavement base material. After being compacted, this type of material is not that pervious based on his experience. Dense-graded aggregates have much lower porosity than open-graded aggregates after compaction. As such, my supervisor thinks the runoff factor of 0.1 can apply to open-graded aggregate but may not be able to apply to dense-graded aggregate. Would you please forward this email to Dan and ask him again if a runoff factor of 0.1 can still be applied to Class 2 aggregates (compacted)? If not, what kind of runoff factor should be used?

I apologize if I did not communicate clearly this morning on the type of material we are using and for any confusions it caused.

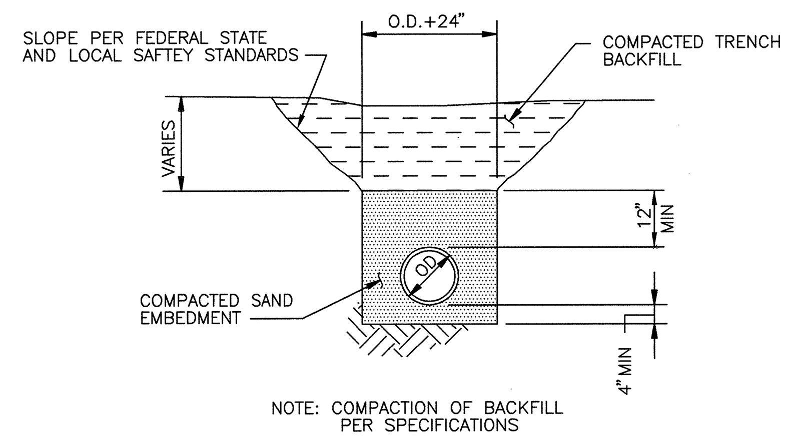
Thanks again for your help.

Jimmy Zhong, P.E.
Geotechnical/Civil Engineer
Energy Division
Black & Veatch Corporation
3550 Green Court, Ann Arbor, MI 48105
P: (734) 622-8533    F: (734) 622-8700

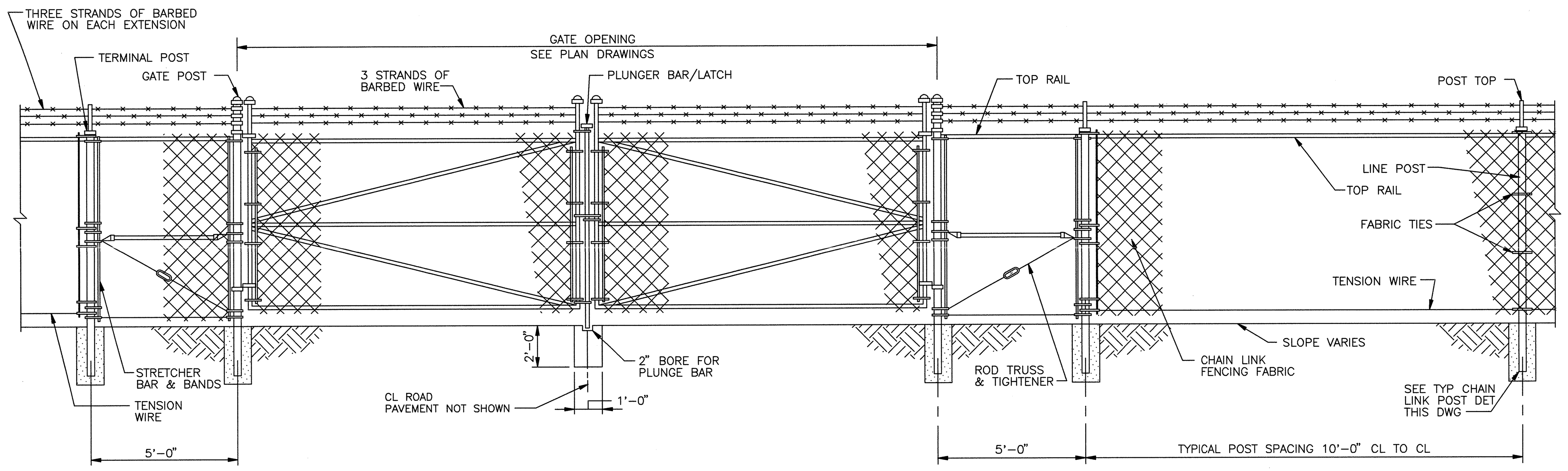
# Attachment 6
# B&V Drawing 163994-SS-3050



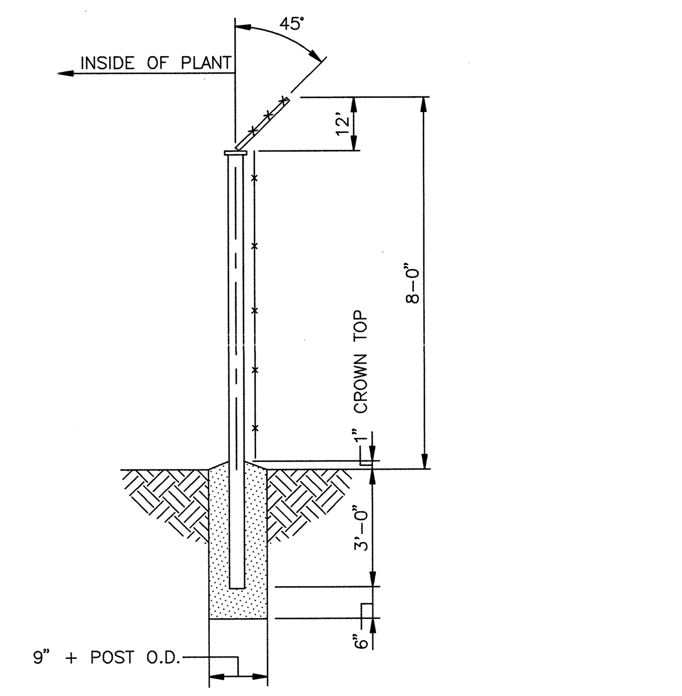

TYPICAL CONSTRUCTION LAYDOWN ROAD
NO SCALE



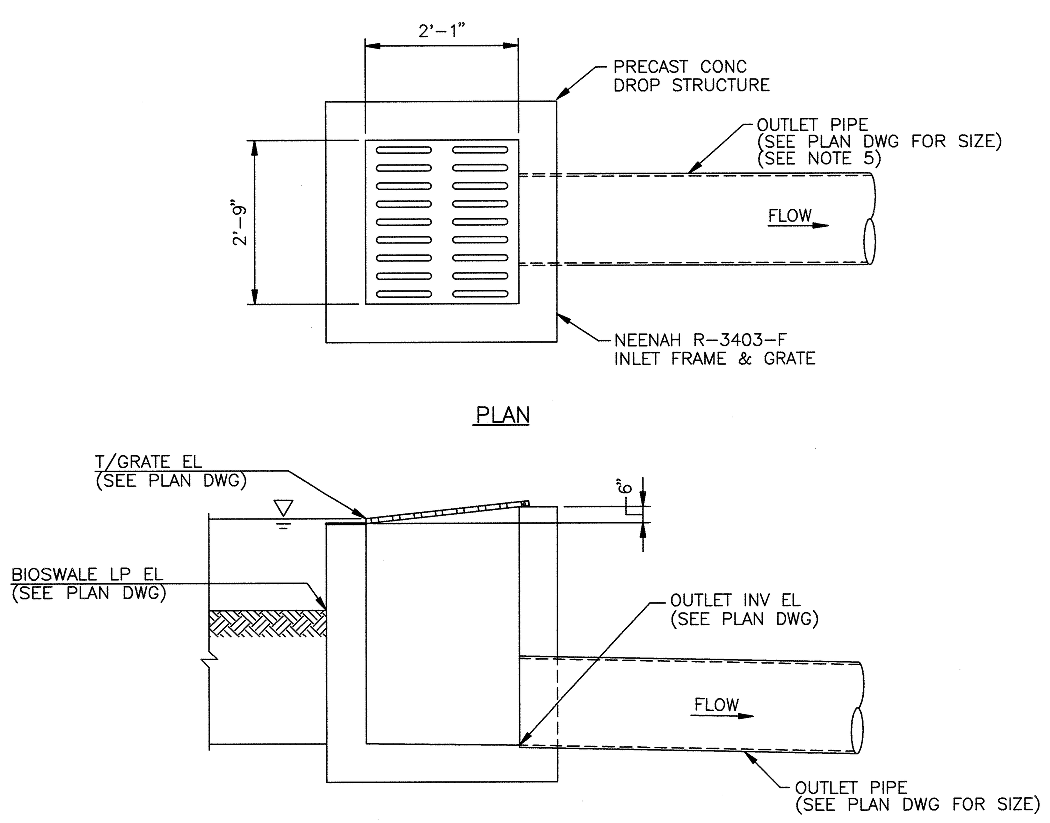

TYPICAL PIPE EMBEDMENT
NO SCALE



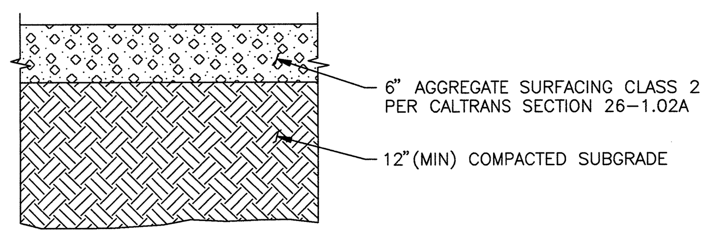

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
NO SCALE



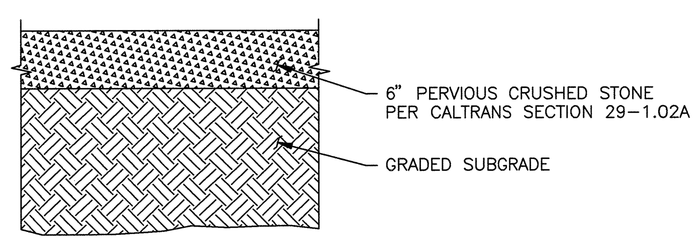

TYPICAL SECURITY FENCE POST DETAIL
NO SCALE



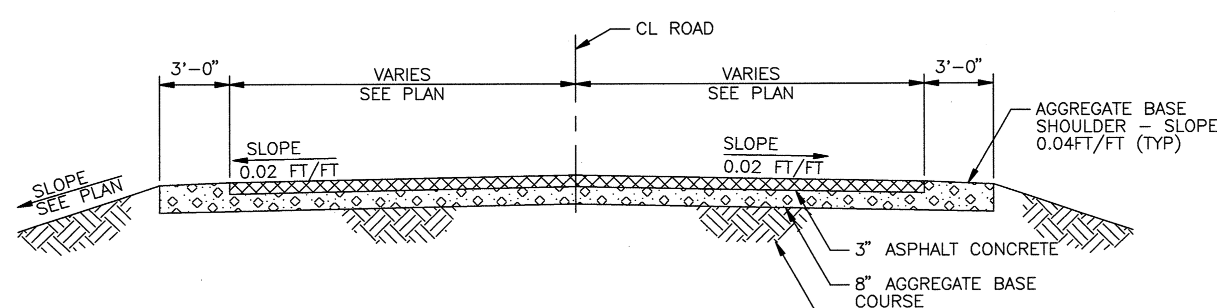

TYPICAL BIOSWALE DROP STRUCTURE DETAIL
NO SCALE




TYPICAL AGGREGATE SURFACING SECTION
NO SCALE



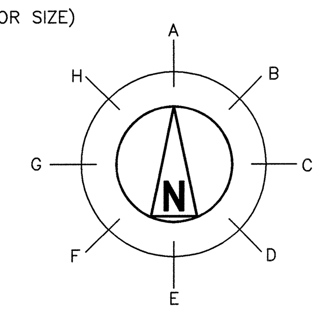

TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
NO SCALE




TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS–3201

CULVERT TABLE

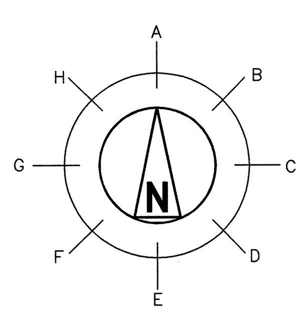
| CULVERT NO. | INLET INV ELEVATION | OUTLET INV ELEVATION | LENGTH | PIPE DIAMETER | PIPE MATERIAL | REMARKS |
|---|---|---|---|---|---|---|
| C–1 | 8.2 | 8.0 | – | 18" | – | |
| C–2 | 11.8 | 11.5 | – | 18" | – | |
| C–3 | 13.0 | 13.0 | – | 18" | – | |
| C–4 | 13.2 | 13.0 | – | 18" | – | |
| C–5 | 13.1 | 12.9 | – | 12" | – | |
| C–6 | 13.1 | 12.9 | – | 12" | – | |
| C–7 | 13.3 | 13.0 | – | 12" | – | |
| C–8 | 13.2 | 13.0 | – | 12" | – | |
| C–9 | 13.0 | 13.0 | – | 12" | – | |
| C–10 | 13.0 | 13.0 | – | 15" | – | |
| C–11 | 13.4 | 12.6 | – | 12" | – | |
| C–12 | 13.0 | 13.0 | – | 18" | – | |
| C–13 | 13.4 | 12.6 | – | 12" | – | |
| C–14 | 13.5 | 12.5 | – | 12" | – | |
| C–15 | 12.8 | 12.5 | – | 18" | – | |
| C–16 | 12.5 | 12.5 | – | 18" | – | |
| C–17 | 14.7 | 14.4 | – | 12" | – | |
| | | | | | | |
| C–19 | 8.7 | 8.4 | – | 18" | – | |
| C–20 | 13.0 | 13.0 | – | 18" | – | |
| C–21 | 13.0 | 13.0 | – | 18" | – | |




CATCH BASIN TABLE

| STRUCTURE NO. | CENTERLINE COORDINATES | | TOP OF GRATE ELEVATION | INLET & OUTLET PIPE INFORMATION | | | | | | | | | | | | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | | B | | C | | D | | E | | F | | G | | H | | |
| | NORTH | EAST | | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | |
| CB–6 | – | – | 16.0 | – | – | 13.2 | 12" | – | – | – | – | 13.2 | 12" | – | – | – | – | – | – | |
| CB–7 | NOT USED | | | | | | | | | | | | | | | | | | | |
| CB–8 | – | – | 17.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.5 | 12" | |
| CB–9 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB–10 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB–11 | – | – | 17.0 | – | – | – | – | – | – | 13.4 | 12" | – | – | – | – | 13.4 | 12" | – | – | |
| CB–12 | – | – | 17.0 | – | – | 13.6 | 12" | – | – | – | – | – | – | – | – | – | – | – | – | |
| CB–13 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | 13.4 | 12" | – | – | – | – | |
| CB–14 | – | – | 17.0 | – | – | – | – | 13.1 | 12" | – | – | – | – | – | – | 13.1 | 12" | – | – | |
| CB–15 | – | – | 17.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.6 | 12" | |
| CB–16 | – | – | 17.0 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB–17 | – | – | 17.0 | – | – | – | – | 13.1 | 12" | – | – | – | – | – | – | 13.1 | 12" | – | – | |
| CB–18 | – | – | 16.5 | – | – | 13.2 | 12" | – | – | – | – | – | – | – | – | 13.2 | 12" | – | – | |
| CB–19 | – | – | 16.5 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB–20 | – | – | 16.5 | – | – | – | – | 13.6 | 12" | – | – | – | – | – | – | – | – | – | – | |
| CB–21 | – | – | 16.5 | – | – | – | – | – | – | – | – | – | – | – | – | 13.6 | 12" | – | – | |
| CB–22 | – | – | 16.5 | – | – | – | – | 13.4 | 12" | – | – | – | – | – | – | 13.4 | 12" | – | – | |
| CB–23 | – | – | 16.5 | – | – | – | – | 13.2 | 12" | – | – | – | – | – | – | 13.2 | 12" | – | – | |
| CB–24 | NOT USED | | | | | | | | | | | | | | | | | | | |
| CB–25 | – | – | 15.0 | – | – | – | – | – | – | 11.8 | 18" | 12.3 | 12" | – | – | 11.8 | 18" | – | – | |
| CB–26 | – | – | 16.0 | 13.2 | 18" | – | – | – | – | – | – | 13.2 | 18" | – | – | – | – | – | – | |
| CB–27 | – | – | 16.5 | – | – | – | – | – | – | – | – | 12.8 | 18" | – | – | 12.8 | 18" | – | – | |

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST




DROP STRUCTURE (DS) TABLE

| STRUCTURE NO. | CENTERLINE COORDINATES | | TOP OF GRATE ELEVATION | INLET & OUTLET PIPE INFORMATION | | | | | | | | | | | | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | | B | | C | | D | | E | | F | | G | | H | | |
| | NORTH | EAST | | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | INV EL | DIA | |
| DS–1 | – | – | 13.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 12.1 | 18" | |
| DS–2 | – | – | 15.5 | – | – | – | – | – | – | – | – | – | – | – | – | 11.8 | 18" | – | – | |
| DS–3 | – | – | 15.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 13.2 | 18" | |
| DS–4 | – | – | 15.5 | 13.5 | 18" | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| DS–5 | – | – | 14.5 | 8.7 | 18" | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| | | | | | | | | | | | | | | | | | | | | |

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST

## NOTES

1. FILTER FABRIC SHALL BE UV–STABILIZED NONWOVEN GEOTEXTILE HAVING A MINIMUM WEIGHT OF 135 $g/M^2$ PER CALTRANS SS 88–1.03.
2. SEE DWG SS–3001 FOR GENERAL NOTES AND LEGEND.

NOT TO BE USED FOR CONSTRUCTION



| NO | DATE | REVISIONS AND RECORD OF ISSUE | DRN | DES | CHK | PDE | APP |
|---|---|---|---|---|---|---|---|
| 0 | 16/APR/09 | ISSUED FOR PERMITTING | NAW | PLN | | PLN | DVW |

SCALE: 1"=60' (60' 30' 0 60' 120')

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA
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DATE REG NO.

BLACK & VEATCH CORPORATION
ENGINEER PLN DRAWN NAW
CHECKED DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
SITE
SECTIONS AND DETAILS

PROJECT DRAWING NUMBER 163994–SS–3050 REV 0
CODE
AREA

SPU37162 A1MOLD7 E1 1=1 04/15/09 13:56:58 ACAD 16.1s (LMS Tech)