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09-AFC-4
DATE JUL 02 2010
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July 2, 2010

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

Subject: Oakley Generating Station Project (09-AFC-4)
Response to CEC Staff Workshop Queries # 3–17

Dear Ms. Miller:

Attached are three hard copies and one electronic copy on CD-ROM of the Contra Costa Generating Station LLC's responses to the California Energy Commission Staff Data Workshop Queries 3-17. The responses were requested during the Data Request Response and Issue Resolution Workshop held on April 23, 2010.

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

APPLICATION FOR CERTIFICATION

SUPPLEMENTAL FILING

Response to CEC Staff Workshop Queries 3 through 17

Oakley Generating Station

09-AFC-4

July 2010

Submitted by

RADBACK ENERGY

Submitted to

California Energy Commission

With Technical Assistance by

CH2MHILL

IS01201022315 1SAC

Supplemental Filing

Response to CEC Staff Workshop Queries 3 through 17

In support of the

Application for Certification

for the

Oakley Generating Station

Oakley, California
(09-AFC-4)

Submitted to the:
California Energy Commission

Submitted by:

With Technical Assistance by:

Sacramento, California

July 2010

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Introduction

Attached are Contra Costa Generating Station, LLC's (CCGS), responses to California Energy Commission (CEC) Staff workshop queries 3 through 17 for the Oakley Generating Station (OGS) project (09-AFC-04). The Workshop Queries are informal requests for additional information that Staff raised during the Data Request Response and Issue Resolution Workshop that was held on April 23, 2010, and for which the CCGS has agreed to provide a response or additional information to assist Staff in preparing their environmental and engineering assessment of the OGS.

The responses are grouped by individual discipline or topic area. New or revised graphics or tables are numbered in reference to the Workshop Query number. For example, the first table used in response to Workshop Query 5 would be numbered Table WSQ5-1. The first figure used in response to Workshop Query 2 would be Figure WSQ2-1, and so on.

Additional tables, figures, or documents submitted in response to a data request (supporting data, stand-alone documents such as plans, folding graphics, etc.) are found at the end of a discipline-specific section and are not sequentially page-numbered consistently with the remainder of the document, though they may have their own internal page numbering system.

Air Quality (3–4)

Data Request Responses Concordance

WSQ3. Please indicate, for the responses to Data Request #3, which table or section of the AFC was revised or superseded.

Response: Table WSQ3-1 is a concordance of the tables and discussion sections from Data Request Response #3 with the AFC, indicating which table or section was revised or superseded.

TABLE WSQ3-1
Data Request Responses with Corresponding AFC Tables and Sections

Table Number and Title or Data Request Number and Topic	AFC Table	AFC Section
Table DR3-1 Combustion Turbine/HRSG and Aux Boiler Emissions for the Project (Steady State Operation-Controlled Per Turbine)	Table 5.1-5	Section 5.1.3.3
Table DR3-2 Startup and Shutdown Emissions Per Turbine	Table 5.1-6	
Table DR3-3 Each Combustion Turbine/HRSG Emissions for the Project (Including Base Load Cold, Hot/Warm Startup and Shutdown, Whichever is Greater) for the non-commissioning year	Table 5.1-7	Section 5.1.3.3
Table DR3-4 Evaporative Fluid Cooler and Fire Pump Engine Emissions for the Project	Table 5.1-8	Section 5.1.3.3
Table DR3-5 Summary of Total Facility Emissions for the Project	Table 5.1-9	Section 5.1.3.3
DR4 – Conditions of Certification for Operating Profiles Please describe the conditions of certification that would be acceptable to OGS for agencies tracking compliance with the proposed capacity factor limitations, for example by limiting the combustion turbines in terms of daily or annual heat input rates, operating hours, or energy output.		Section 5.1.3, Subsections 5.1.3.1 through 5.1.3.3
DR5 – Achievable PM10 and PM2.5 Emission Rate Please identify how the OGS project would be affected if the proposed combustion turbines were required by reviewing agencies to achieve a PM10 and PM2.5 emission rate of 3.14 lb/hr as identified in AFC Table 5.1-18.		Section 5.1.3.3
DR6 – Maximum Allowable PM10 and PM2.5 Emission Rate Please clearly identify the proposed maximum allowable PM10 and PM2.5 emission rates for the combustion turbines.		Section 5.1.3.3

TABLE WSQ3-1
Data Request Responses with Corresponding AFC Tables and Sections

Table Number and Title or Data Request Number and Topic	AFC Table	AFC Section
DR7 -Citations for Class II Significance Levels Please provide the citations for the Class II Significance Levels shown in Table 5.1-19, especially for PM2.5 and nitrogen dioxide (NO2).	Section 5.1.5.8	Table 5.1-19
DR8 – Class II Significance Levels Please summarize the applicable requirements, including increment consumption analyses (identified in AFC Appendix 5.1C), that appear to be triggered by potentially exceeding the PM2.5 Class II Significance Levels, assuming turbine PM10 and PM2.5 emissions of 7.5 lb/hr per turbine, and by NO2 exceeding the significance levels in Table 5.1-19.		Sections 5.1.5.6, 5.1.5.7, and 5.1.5.8
Table DR8-1 BAAQMD Attainment Status	Table 5.1-15	
Table DR8-2 Air Quality Impact Results for Refined Modeling Analysis of Project	Table 5.1-19	
DR9- Updated Impact Analysis Please update the impact analysis to reflect PM10 and PM2.5 impacts using the proposed maximum allowable PM10 and PM2.5 emission rate per turbine as identified in response to Data Request 6.	Table 5.1-19	Section 5.1.5.8
DR10 – Federal Nonattainment NSR Requirements Please describe the applicability of the federal nonattainment NSR requirements of Title 40, Code of Federal Register Part 51 (40 CFR 51, Appendix S) for PM2.5.	Table 5.1-15	Sections 5.1.5.6 and 5.1.5.8
DR11 – Evaluation of GHG Emissions Please describe whether the proposed OGS would be subject to the BAAQMD's evaluation of GHG emissions.		Section 5.1.3.3.1
DR13 – Auxiliary Boiler Design Please clarify whether the proposed auxiliary boiler would include an oxidation catalyst and whether the emission reductions due to that catalyst have been taken into account in the Expected Auxiliary Boiler Emissions of AFC Appendix Table 5.1A-8.		Section 5.1.2.1 and Appendix 5.1F
DR14 – Cooling System Emissions Please provide substantiating evidence or copies of technical reports supporting the assumption that only 60 percent of the cooling tower PM10 would qualify as PM2.5.	Table 5.1-8	Section 5.1.3.3
DR15 – Drift Eliminators Please describe whether drift eliminators achieving 0.0005 percent would be feasible for the evaporative fluid coolers.		Section 5.1.4.2.1 and Appendix 5.1F

TABLE WSQ3-1
Data Request Responses with Corresponding AFC Tables and Sections

Table Number and Title or Data Request Number and Topic	AFC Table	AFC Section
DR16 – Emission Offsets Please provide a tabulated list showing expected emissions and emission offset accounting indicating the proposed quantity of offsets, including the locations of emission reductions, in a quantity sufficient to fully offset the projects emissions, including appropriate offset ratios. Please show the current updated ERC certificate number and former certificate numbers for certificates that have been recently split and/or re-issued in the name of the project.	Table 5.1-3	Appendix 5.1G, Section 5.1.3.1
DR17 – Mitigation for Particulate Matter Please identify and quantify a complete package of proposed mitigation, especially for PM10 and PM2.5. For example, proposed strategies to reduce emissions in the San Joaquin Valley and the effectiveness of such strategies would need to be explicitly identified by OGS and preferably developed in consultation with Energy Commission staff before staff makes the information available in the staff assessment.		Appendix 5.1G
DR18 – Mitigation for SOx Emissions Please identify and quantify a mitigation strategy for proposed SOx emissions to ensure that OGS avoids contributing to additional PM10 and PM2.5 violations of ambient air quality standards		Appendix 5.1G
DR20 – Maximum NOx and NO2 Impacts Please confirm that the maximum NOx and NO2 impacts have been considered given that the 120 lb/hr NOx commissioning emission rate would exceed the highest NOx emission rate in the analyses shown on CD-ROM with the AFC, and if not, update the impact analysis to reflect the maximum emission rates.	Table 5.1-19	Section 5.1.5.8
DR21 – Stack Conditions Please provide the expected stack conditions (exit velocity and temperature) for the various commissioning scenarios and confirm that the commissioning-phase dispersion modeling submitted with the AFC reflects the worst-case combination of stack conditions and emission rates.	Table 5.1-18	Section 5.1.5.7
DR22 – Fire Pump Engine and Startup Emissions Please describe the operating limitations that would be acceptable for ensuring that fire pump engine testing would not occur during a turbine startup.		Section 5.1.5.7
DR24 – Sources in Neighboring Air Districts Please describe whether reasonably foreseeable sources in the neighboring air districts, such as Sacramento Metropolitan and San Joaquin Valley, have been identified for analysis and how they would be considered in the analysis.		Appendix 5.1H
DR25 – Cumulative Impacts Sources Please provide the list of sources to be considered in the cumulative air quality impact analysis.		Appendix 5.1H

TABLE WSQ3-1
Data Request Responses with Corresponding AFC Tables and Sections

Table Number and Title or Data Request Number and Topic	AFC Table	AFC Section
DR26 – Cumulative Modeling Analysis Please describe the progress for the cumulative air quality impact analysis following the protocol proposed in the AFC.		Appendix 5.1H
DR27 – GHG Emissions Sources Please provide a clear description of all sources of GHG emissions, including the fuel heat input rates and power output rates, along with the totals of those emissions for each project-related source.	Table 5.1-1	Section 5.1.2.2, Subsections 5.1.2.2.1 through 5.1.2.2.5, Section 5.1.3.3.1, Appendix 5.1A
DR28 – Incidental GHG Sources Please provide a list of all sources other than the turbines, auxiliary boiler, and the fire pump that contribute to operational GHG emissions. This information should include the total emission estimates from these sources, i.e. leaking electrical equipment (sulfur hexafluoride), worker commutes, and material deliveries using trucks.		Appendix 5.1A
DR29 – Construction PM10 Please identify the phases of construction that would be most likely to cause PM10 24- hour concentrations over the California Ambient Air Quality Standard.		Appendix 5.1E
DR30 – Construction PM10 Control Measures Please describe what additional emission control measures could be implemented to mitigate this impact to a level below the standard. One example would be fence-line monitoring of ambient concentrations, with the results being used to trigger various corrective actions.		Section 5.1.3.5 and Appendix 5.1E
DR31 – Construction Phase GHG Please provide a clarifying table summarizing the sources and assumptions for developing the GHG emission estimates and the totals of those emissions from each source.		Appendix 5.1E
DR32 – Construction Vehicle Miles Please describe the vehicle miles of travel assumed and if the assumptions include onsite activities as well as offsite activities, such as material deliveries and construction worker commutes.		Appendix 5.1E
DR33 – Locomotive Emissions Please ensure that construction emission estimates include locomotive emissions from proposed deliveries by rail, if railroad traffic would be generated by the project. This emission estimate would focus on trips generated by the project and emissions in the Bay Area air basin.		Appendix 5.1E

Construction Phase Greenhouse Gas Emissions Calculation

WSQ4. Please provide the greenhouse gas emissions calculation results for construction

Response: Attachment WSQ4-1 is a spreadsheet that shows the calculation of construction greenhouse gases.

Attachment WSQ4-1
Construction Greenhouse Gas Emissions

CO2e Emissions Estimates

Total CO2 emisisons from diesel combustion:	10034.6	tons/period
Total CO2 emissions from gasoline combustion:	1489.4	tons/period
Approximate methane fraction of CO2 for diesel combustion:	0.000051	
Approximate N2O fraction of CO2 for diesel combustion:	0.000032	
Approximate methane fraction of CO2 for gasoline combustion:	0.000213	
Approximate N2O fraction of CO2 for gasoline combustion:	0.000113	
Estimated methane from diesel combustion:	0.511765	tons/period
Estimated N2O from diesel combustion:	0.321107	tons/period
Estimated methane from gasoline combustion:	0.317242	tons/period
Estimated N2O from diesel combustion:	0.168302	tons/period
Estimated methane CO2e from diesel combustion:	10.74706	tons/period
Estimated N2O CO2e from diesel combustion:	99.54323	tons/period
Estimated methane CO2e from gasoline combustion:	6.662086	tons/period
Estimated N2O CO2e from gasoline combustion:	52.17368	tons/period

Total CO2e emissions from construction: 11693 tons/period

10524 metric tons/period

CCAR General Protocol, Jan 2009, Version 3.1.
IPCC SAR values for methane and N2O.

Transmission System Engineering (5)

Existing and New Transmission System

WSQ5. Please provide maps that show the existing transmission system in the Oakley and Antioch area and the system with the Oakley Generating Station in place.

Response: Section 3 of the Application for Certification (AFC) for the Oakley Generating Station (OGS) project described both a double–circuit and a single-circuit option. In both cases, the 230 kV generator tie-line from the OGS to the Contra Costa Substation would be single-circuit. The two options had to do with whether the existing Contra-Costa DuPont 60 kV line would be supported from the same towers as the OGS generator tie-line. Figure WSQ5-1 schematically depicts the existing 60 kV transmission system in the vicinity of the OGS. Figure WSQ5-2 depicts the same information geographically. Presently, a 60 kV line runs from the Contra Costa Substation to the DuPont substation, which is located immediately north of the OGS site. A generation tie-line from GWF's Wilbur Avenue East power plant taps into this line just east of the OGS site. A second 60 kV line runs from the Contra Costa Substation to the Balfour Substation, which is located in Brentwood, east of Oakley. The DuPont Substation has a second outgoing 60 kV line which taps the Contra Costa-Balfour 60 kV line at the intersection of Bridgehead Road and Main Street.

The OGS-Contra Costa 230 kV generator tie line is proposed to follow the route of the existing Contra Costa-DuPont 60 kV line. For the portion of this line that is south of Main Street (which becomes 18th Avenue on the Antioch side of Highway 160), double-circuit tubular steel pole towers were proposed to replace the existing single-circuit lattice towers (see Figure 3.2-3a of the AFC). The Contra Costa-DuPont 60 kV line would be on one side of the towers and the new OGS-Contra Costa 230 kV generation tie-line would be on the other side. PG&E has since determined that, because of the decrease in demand associated with the closure and demolition of DuPont's manufacturing facilities, the existing Contra Costa-DuPont 60 kV line can be removed. Thus, the portion of the OGS-Contra Costa 230 kV line that is south of Main Street will instead use a single-circuit tower (see Figure 3.2-3b of the AFC). Figure WSQ5-3 schematically depicts the removal of the Contra Costa-DuPont 60 kV line. Figure WSQ5-4 schematically depicts the post-project configuration with the installation of the 230 kV generation tie-line. Figure WSQ5-5 depicts the same information geographically.

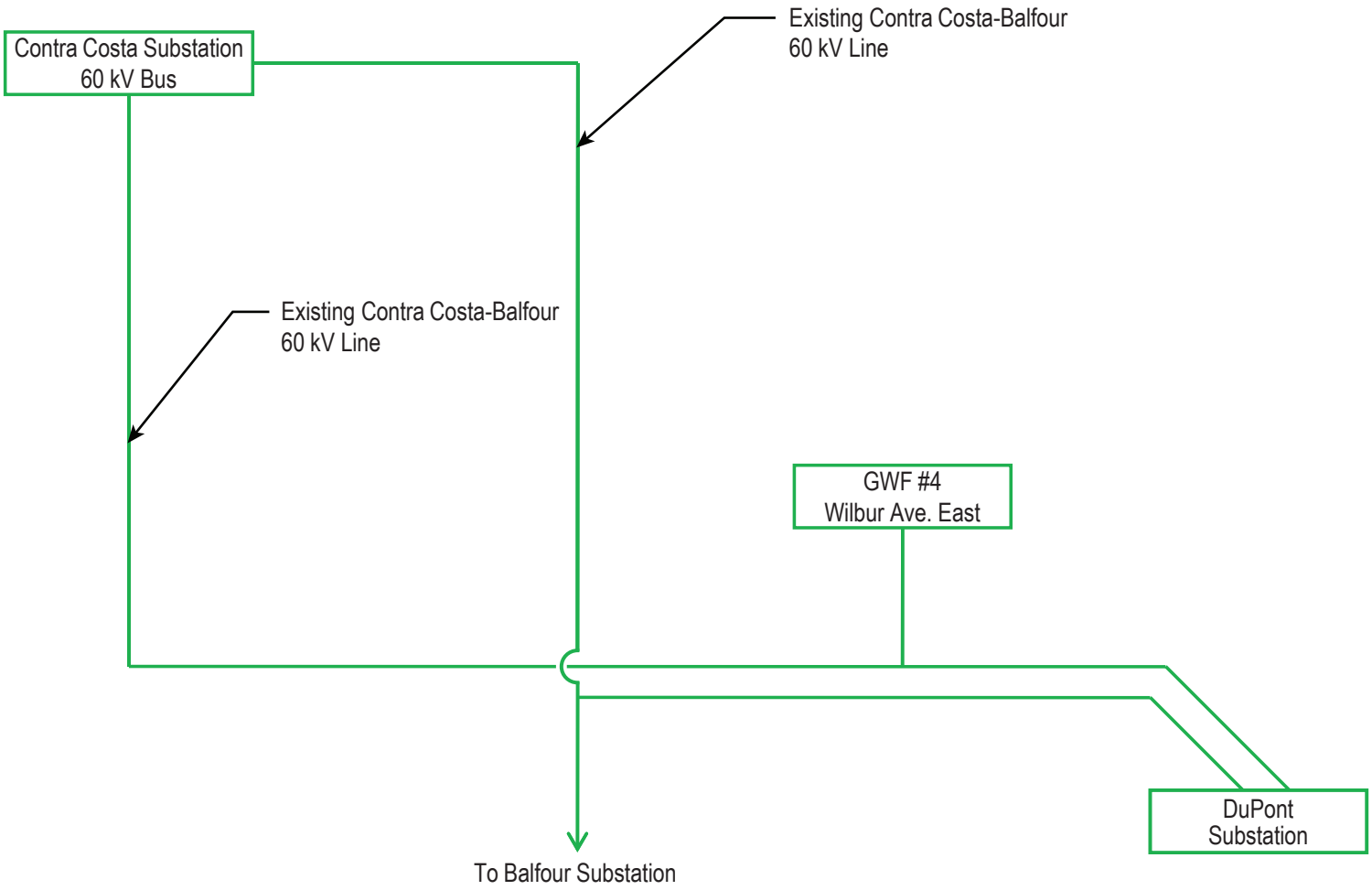
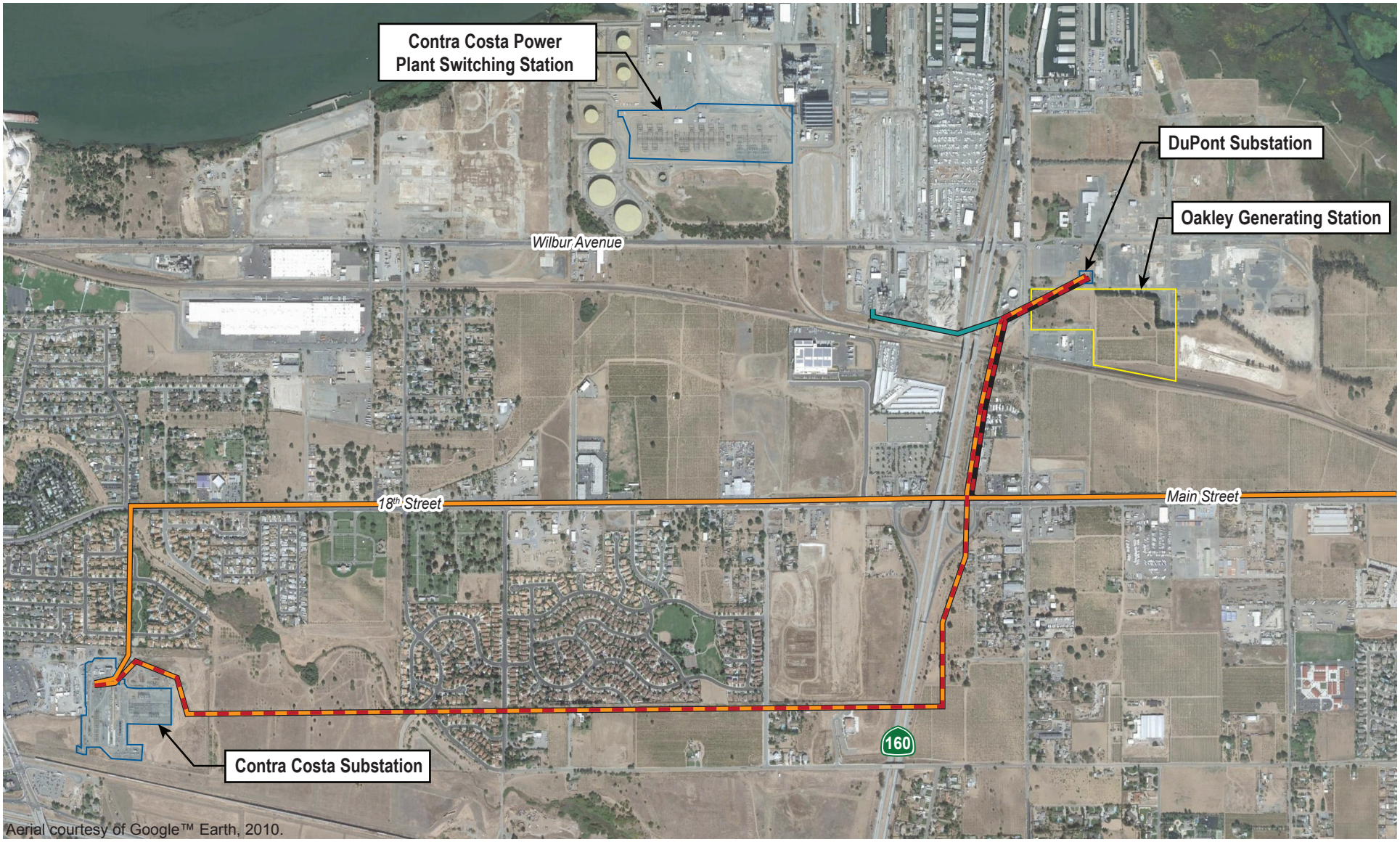


FIGURE WSQ5-1
EXISTING 60 KV IN VICINITY OF OAKLEY GENERATING STATION
OAKLEY GENERATING STATION
OAKLEY, CALIFORNIA



LEGEND

- GWF #4 Tap 60 kV
- Contra Costa-Balfour 60 kV
- Contra Costa-DuPont 60 kV
- Contra Costa-DuPont 60 kV and DuPont Tap 60 kV

North

0 1,000 2,000

Approximate scale in feet

FIGURE WSQ5-2
EXISTING 60 kV IN VICINITY OF OAKLEY GENERATING STATION

OAKLEY GENERATING STATION

OAKLEY, CALIFORNIA

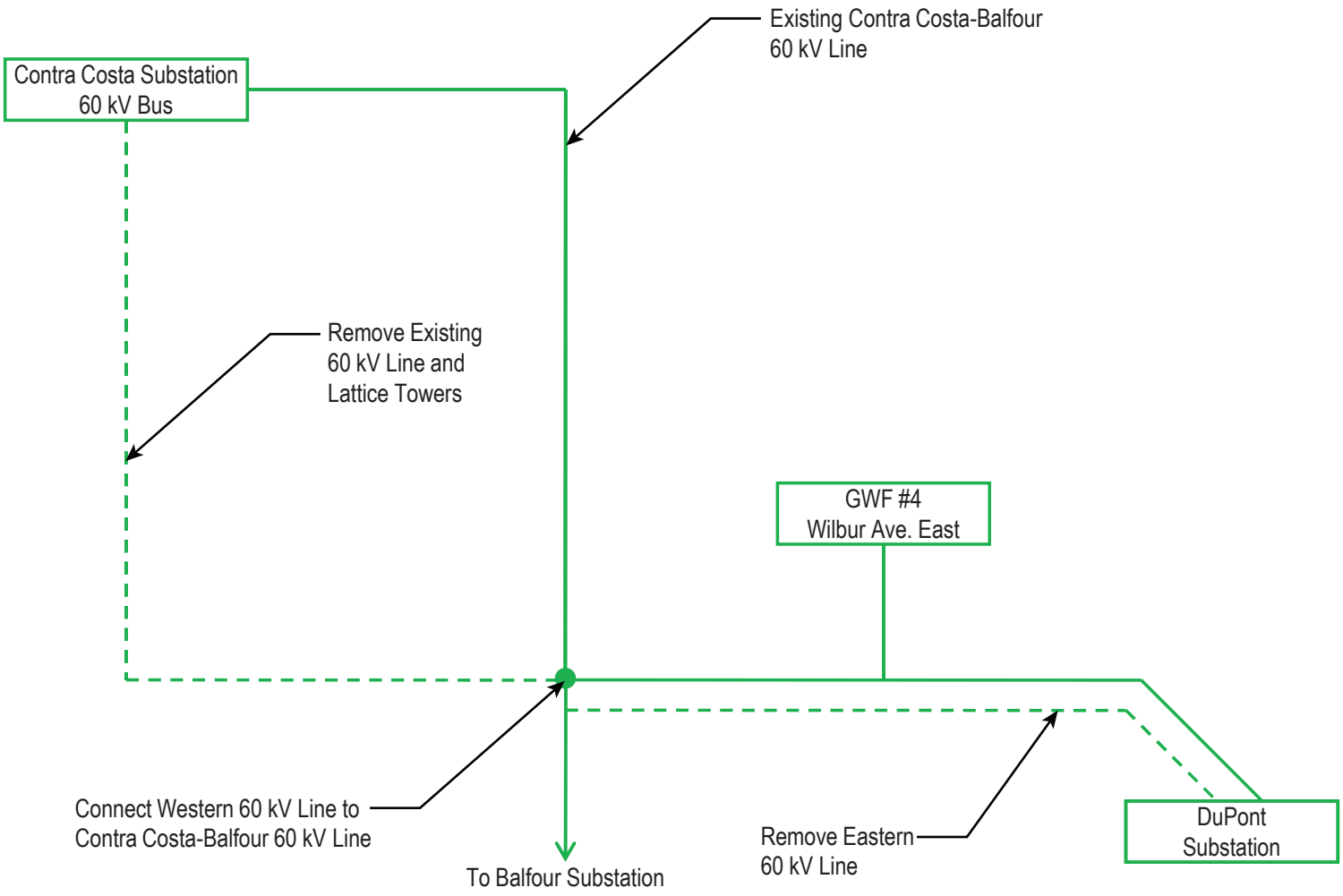


FIGURE WSQ5-3
REMOVAL OF EXISTING DUPONT-CONTRA COSTA 60 KV LINE
OAKLEY GENERATING STATION
OAKLEY, CALIFORNIA

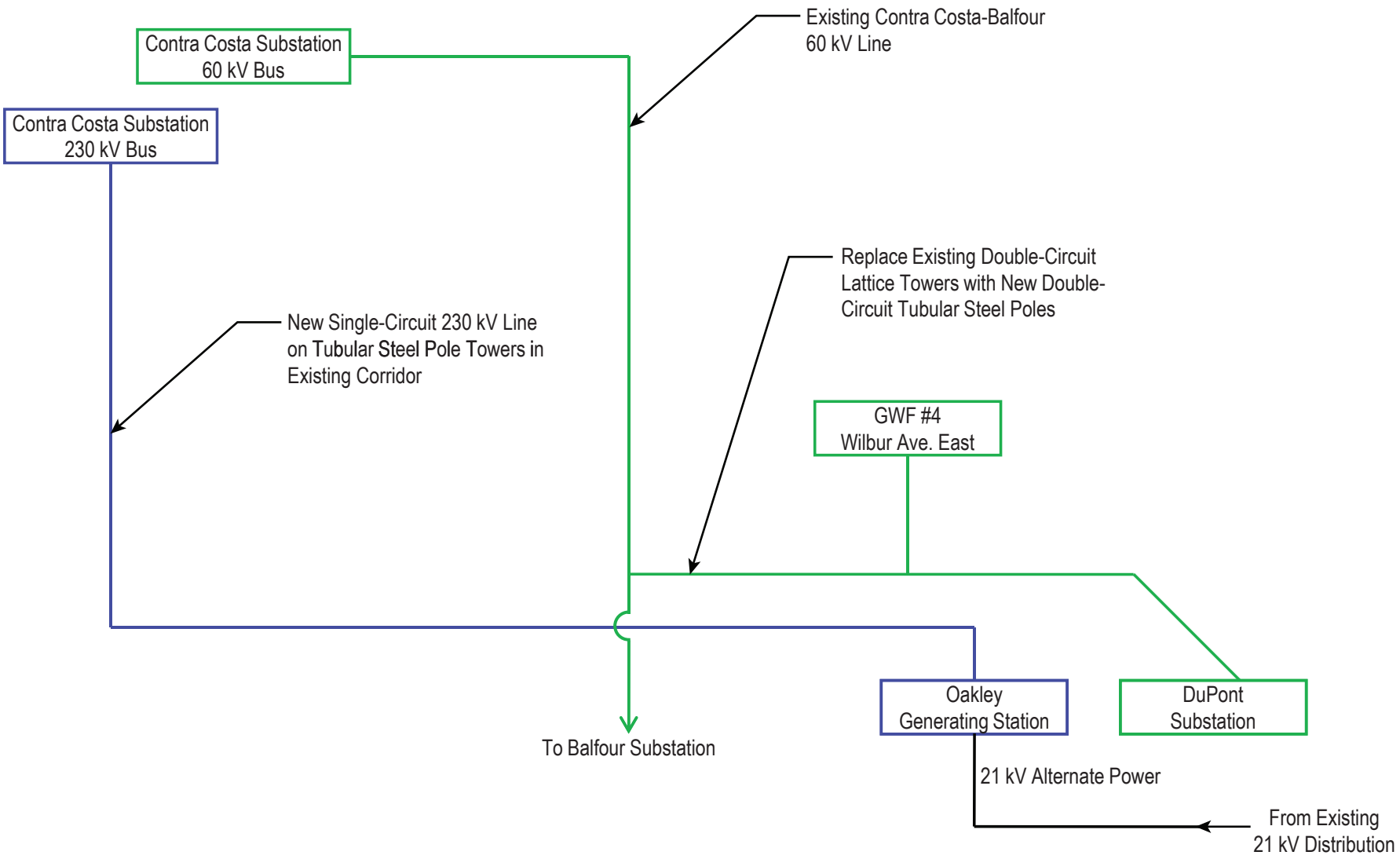
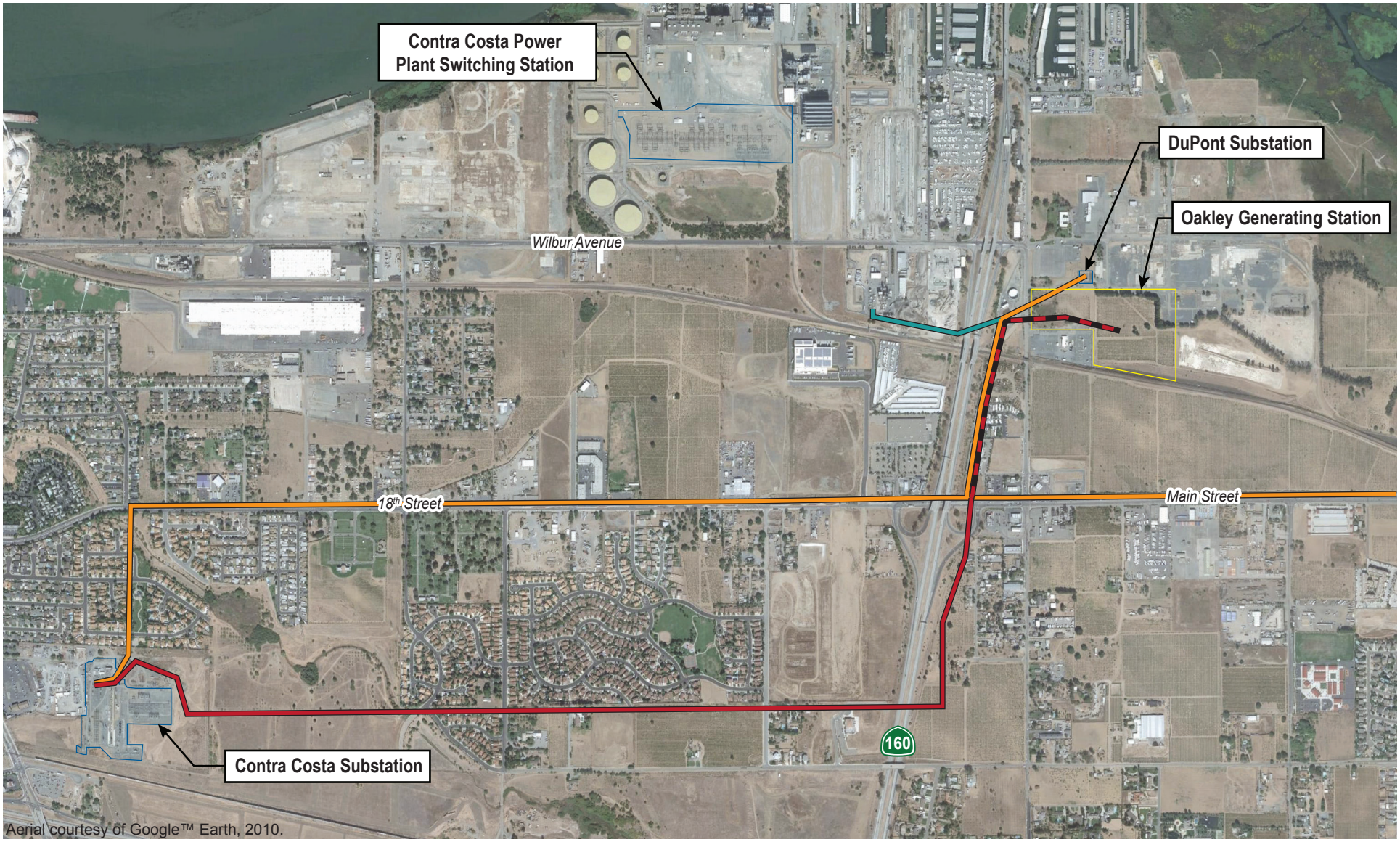


FIGURE WSQ5-4
FINAL CONFIGURATION WITH OAKLEY GENERATING STATION 230 KV LINE
OAKLEY GENERATING STATION
OAKLEY, CALIFORNIA



LEGEND

- GWF #4 Tap 60 kV
- Contra Costa-Balfour 60 kV
- OGS-Contra Costa 230 kV
- OGS-Contra Costa 230 kV and DuPont Tap 60 kV

North

0 1,000 2,000

Approximate scale in feet

FIGURE WSQ5-5
FINAL CONFIGURATION WITH OAKLEY GENERATING STATION 230 KV LINE

OAKLEY GENERATING STATION

OAKLEY, CALIFORNIA

IS012010223151SAC Figure_WSQ5-5.ai 06.21.2010 tdaus

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Water Resources (6–17)

10-year and 100-year Design Events

WSQ6. Applicant has neglected to account for increases in runoff from 10-year and 100-year design storm events. Contra Costa County C3 guidelines only apply to water quality treatment and hydromod affects. Design floods must also be controlled – See City of Oakley conditions related to Hydrology and Hydraulic Report including the 10-year and 100-year design events.

Response: See attached Calculation 52.5406.1006 (Attachment WSQ6-1) documenting that the revised stormwater design is capable of controlling 10-year and 100-year design storm events.

Technical Memorandum

WSQ7. Applicant should provide the August 2009, Technical Memo on Wetland E mentioned in Data Response 83.

Response: The August 2009 Technical Memo on Wetland E was docketed on May 27, 2010 (Docket Log No. 56917).

Stormwater Calculations

WSQ8. Existing Wetland – changes in the delivery of runoff may alter wetland hydrology. Ideally, the applicant would provide calculations for small typical storm events (0.75 to 1 inch of rainfall) and large design storms (10-year and 100-year). Calculations should be provided for existing and proposed conditions to demonstrate that runoff delivery (peak flow and volume) to the existing wetland would not be significantly altered.

Response: See attached Calculation 52.5406.1007 (Attachment WSQ8-1) documenting the peak flow and Calculation 52.5406.1006 (Attachment WSQ6-1) documenting total volume impact on the wetland for 10-year and 100-year design storm events. Attachment WSQ8-2 is a revision of Calculation 52.5406-1003 (found in Appendix 5.15A of the AFC).

Changes in Runoff

WSQ9. Increases in runoff associated with paving at least 20% of the site and using compacted gravel on another 50% of the site would increase runoff from the site. Applicant needs to demonstrate that existing wetland and proposed bioswales has adequate capacity to mitigate increase changes in runoff.

Response: See attached Calculation 52.5406.1006 (Attachment WSQ6-1) documenting that paved and aggregate covered areas are accounted for in the design. This same calculation documents that the wetland and bioswales have adequate capacity for changes in runoff.

Wetland Outlet

WSQ10. Existing wetland has no outlet or emergency spillway. What happens when 100 year storm hits and wetland is already full from previous events? Contra Costa County guidance, typically assumes that a water quality volume event has filled all C3 IMP BMPs. Accounting for an initial starting water level and a safety of factor, the wetland may need to be expanded or an outlet may need to be installed.

Response: See attached e-mail from Jorge Hernandez, Contra Costa County Flood Control (Attachment WSQ10-1) recommending use of a 100-year and then 10-year storm back to back. Also note that Mr. Hernandez indicates that allowing the wetland to discharge to the north in the same fashion as currently exists is acceptable.

Bioswale Design

WSQ11. The design and intended performance of the proposed bioswales needs to be detailed. It appears that bioswales may be undersized – (insufficient area and too deep for adequate treatment). Need to clarify if the proposed swales are to be operated as small detention ponds. Also, swales are shown in series 1>2>3 and 4>5, but calculations do not add runoff from each swale together.

Response: See Drawing 163994-SS-3001 Rev. 1 (Figure WSQ11-1) for updated routing of bioswales eliminating series flow from one bioswale to another. Drawing 163994-SS-3001 Rev. 1 replaces Figure 5.15.4 of the AFC. Drawing 163944-SS-3050 Rev. 1 (Figure WSQ11-2) provides revised details replacing the same drawing found in Appendix 5.15A of the AFC. Drawing 163944-SS-1002 Rev. 3 (Figure WSQ11-3) is a revision of Figure 2.1-1 of the AFC, which shows the location of a new stormwater pond. Updated bioswale sizing calculations are included in Calculation 52.5406.1008 (Attachment WSQ11-1). Calculation 52.5406.1008 replaces Calculation 52.5406.1002 (found in Appendix 5.15A of the AFC).

Watershed Parameters

WSQ12. Watershed parameters need to be clearly defined. Areas (including offsite areas that drain on site) shall be delineated on maps large enough to read. Pervious, impervious, and compacted gravel areas should be clearly identified. Design rainfall events should be based on Oakley, which may be different than rainfall in Sacramento.

Response: All calculations were updated to utilize rainfall events for Oakley. Final surfacing information is contained on Drawing 163994-SS-3201 in Calculation 52.5406.1008 (Attachment WSQ11-1). A larger version of Drawing 163994-SS-3201 is attached as Figure WSQ12-1. Attachment WSQ8-2 is a revision to Calculation 52.5406.1003 (found in Appendix 5.15A of the AFC) reflecting the use of the County's design rainfall data.

Water Supply / Recycled Water Use

WSQ13. Water Supply may not be adequate – Will Serve letter for 170 AFY vs. estimated demand of 240 AFY. How does Oakley propose to supply the difference?

Response: The text in Section 5.15.1.4.1 of the AFC incorrectly identified the available water supply as 170 af/yr. The will-serve letter from Diablo Water District, included in Appendix 2I of the AFC, indicates an availability of 250 af/yr. This value exceeds OGS's estimate of 240 af/yr.

Backup Supply

WSQ14. What is the proposed backup water supply?

Response: A backup water supply is not proposed for the OGS. Diablo Water District (DWD) has a robust water supply and distribution system with multiple water supplies and a looped distribution network. DWD's water supplies include treated surface water from the Randall-Bold Water Treatment Plant (WTP) and local wells. Typically, the water supplied to DWD customers is a blend of these sources. The Randall-Bold WTP, which is jointly owned by DWD and Contra Costa Water District, treats surface water from the Sacramento-San Joaquin Delta or from storage provided by Los Vaqueros Reservoir. DWD also has interconnections with neighboring cities and backup electrical generators for additional reliability. The OGS will include a service/fire water storage tank providing approximately 8 hours of operational storage and 2 hours of fire protection storage in the event of a disruption in the DWD supply.

Recycled Water Lines

WSQ15. Recycled water to the Wilber Avenue Corridor – How far will the recycled water lines be from OGS? Will OGS install recycled water supply and TDS return lines to the Wilber Avenue Corridor if ISD installs line in the vicinity of OGS? Would like to include a condition requiring use of recycled water including installation of any lateral pipelines required to link up to the Wilber Avenue Corridor.

Response: The installation of future recycled water supply and high TDS return lines is speculative at this time. In fact, as was discussed at the workshop, many of the industrial facilities and at least two power plants that the master plans were depending on as a basis for extending recycled water and the high TDS return infrastructure are no longer proposing wet cooling, and it is likely that the recycled water supply line and associated high TDS return line will not be constructed. In addition, the OGS will become the property of PG&E and CCGS is not willing to commit PG&E to install lateral pipelines to/from the Wilbur Avenue Corridor. OGS's commitment regarding the future use of recycled water remains as described in Section 2.1.8.3 of the AFC and our response to Data Request 47a. This commitment is to construct the facility in such a way as to accommodate a switch to recycled water and use of the high TDS return line if PG&E made such election in the future.

Construction Water Source

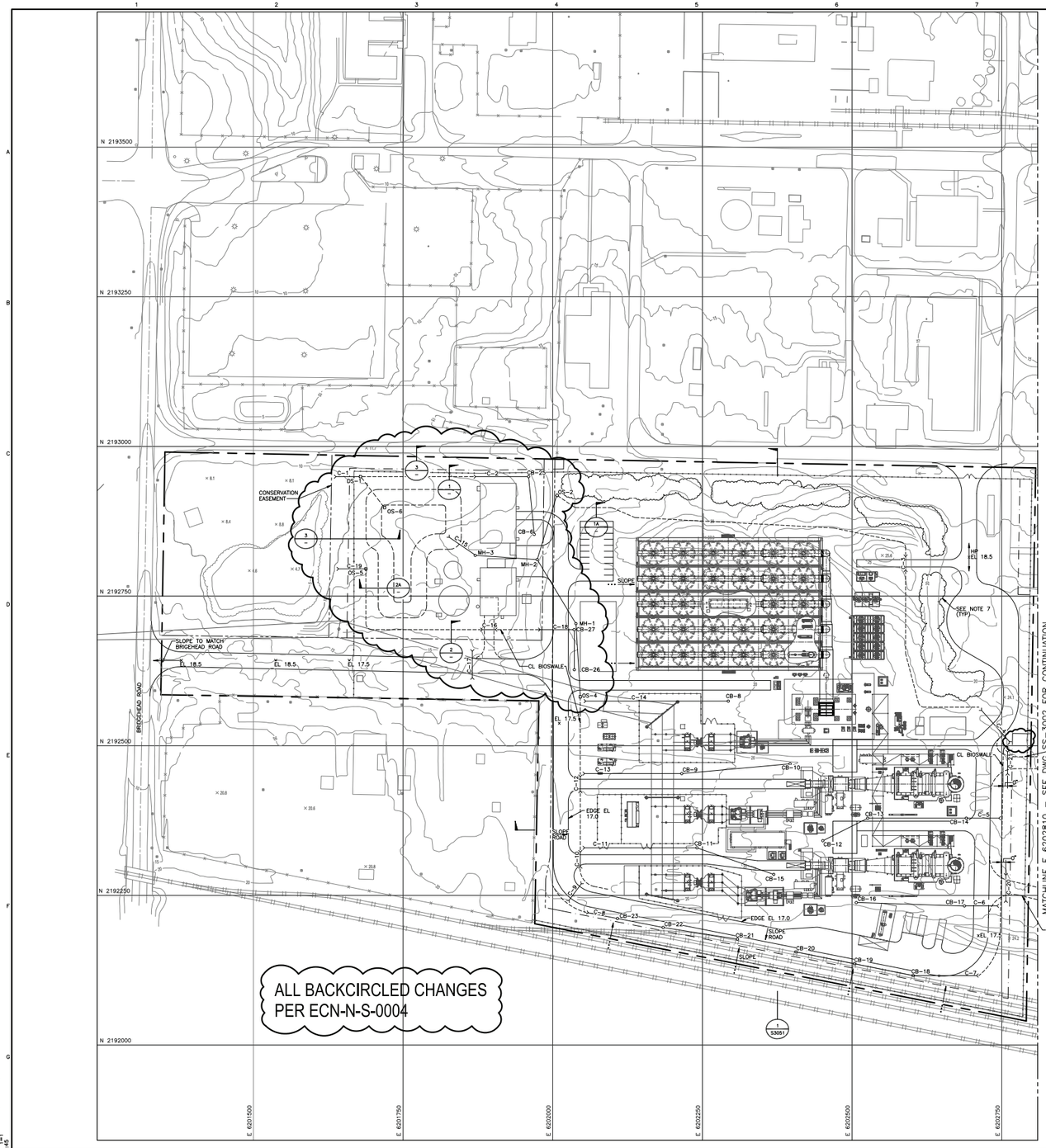
WSQ16. What is the planned source of water to be used during construction?

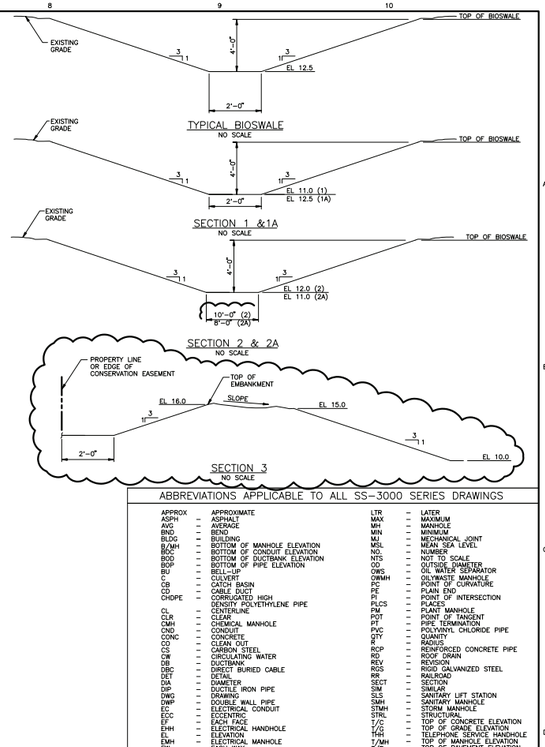
Response: The source of water to be used during construction will be the same as the permanent water supply: potable water from Diablo Water District.

Construction Water Discharge

WSQ17. Excess water may be pumped offsite from the construction laydown bioswale – where will this water be discharged?

Response: Excess water from the construction laydown bioswale will not be pumped offsite as previously indicated in Section 5.15.1.6 of the AFC, but instead will be allowed to pond in the bioswale and percolate.





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
BM/MH	–	BOTTOM OF MANHOLE ELEVATION	MSL	–	MEAN SEA LEVEL
BDC	–	BOTTOM OF CONDUIT ELEVATION	NO.	–	NUMBER
BOD	–	BOTTOM OF DUCTBANK ELEVATION	NTS	–	NOT TO SCALE
BOP	–	BOTTOM OF PIPE ELEVATION	OD	–	OUTSIDE DIAMETER
BU	–	BUILT-UP	OWS	–	OIL/WATER SEPARATOR
C	–	CELSIUS	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	REVS	–	REVISIONS
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	TEL	–	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
HOM	–	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
- CL BIOSWALE
- 1 / S3000 — SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER
- × 326.5 — FINISHED SPOT ELEVATIONS
- BM-1 — SURVEY MONUMENT/CONTROL POINT
- EXISTING FENCE
- NEW SECURITY FENCE
- TEMPORARY CONSTRUCTION FENCE
- TR-1 — EROSION CONTROL METHOD
- NEW SLIDE GATE
- NEW SWING GATE
- EXISTING POWER POLE
- CB-101 — NEW CATCH BASIN
- NEW DROP STRUCTURE
- PROPERTY LINE
- BOUNDARY LINE
- 126 — EXISTING CONTOURS
- 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 "M 543", 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, DROP AND OUTLET 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.

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
1	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
0	16/APR/09	ISSUED FOR PERMITTING	NAM	PLN		PLN	DVW

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 _____ REG NO. _____

DATE _____

BLACK & VEATCH CORPORATION

ENGINEER	PLN	DRAWN	NAM
CHECKED		DATE	

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

GRADING AND DRAINAGE – SITE PLAN – SHEET 1

PROJECT	DRAWING NUMBER	REV
163994	SS-3001	1
CODE		
AREA		

ACAD 16.1s (LMS Tech)
SCHS4101 (A1)(ISO) 01:44:45
dgn

FIGURE WSQ11-1
Bioswale Routing
Oakley Generating Station
Oakley, California

TYPICAL CONSTRUCTION LAYDOWN ROAD
NO SCALE

TYPICAL PIPE EMBEDMENT
NO SCALE

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
NO SCALE

TYPICAL OUTLET STRUCTURE DETAIL
NO SCALE

SECTION 1
NO SCALE

SECTION 2
NO SCALE

TYPICAL BIOSWALE DROP STRUCTURE DETAIL
NO SCALE

TYPICAL AGGREGATE SURFACING SECTION
NO SCALE

TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS-3201

TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
NO SCALE

CULVERT TABLE

CULVERT NO.	INLET INV ELEVATION	OUTLET INV ELEVATION	LENGTH	PIPE DIAMETER	PIPE MATERIAL	REMARKS
C-1	8.2	8.0	–	24"	–	
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	10.3	10.0	–	18"	–	
C-16	12.5	12.5	–	18"	–	
C-17	14.7	14.4	–	12"	–	
C-18	12.8	12.5	–	18"	–	
C-19	8.7	8.4	–	18"	–	
C-20	13.0	13.0	–	18"	–	
C-21	13.0	13.0	–	18"	–	

CATCH BASIN AND MAN HOLE 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	12.3	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
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"	–	–	11.8	18"	–	–	
CB-26	–	–	16.0	13.2	18"	–	–	–	–	–	–	13.2	18"	–	–	–	–	–	–	
CB-27	–	–	16.5	–	–	–	–	–	–	–	–	12.8	18"	–	–	12.8	18"	–	–	
MH-1	–	–	16.5	–	–	–	–	–	–	–	–	12.9	18"	–	–	–	–	12.9	18"	
MH-2	–	–	17.0	–	–	11.2	18"	–	–	12.3	18"	–	–	–	–	11.0	18"	–	–	
MH-3	–	–	16.5	–	–	–	–	10.3	18"	–	–	–	–	–	–	–	–	10.3	18"	

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

TYPICAL SECURITY FENCE POST DETAIL
NO SCALE

DROP (DS) AND OUTLET (OS) STRUCTURE 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	–	–	–	–	–	–	8.2	24"	–	–	–	–	–	–	8.2	24"	
OS-2	–	–	15.5	–	–	–	–	–	–	–	–	–	–	11.8	18"	–	–	–	–	
OS-3	NOT USED																			
OS-4	–	–	15.5	13.5	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-5	–	–	14.5	8.7	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-6	–	–	14.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.8	24"	

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

ALL BACKCIRCLED CHANGES
PER ECN-N-S-0004

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
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NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
1	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
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.

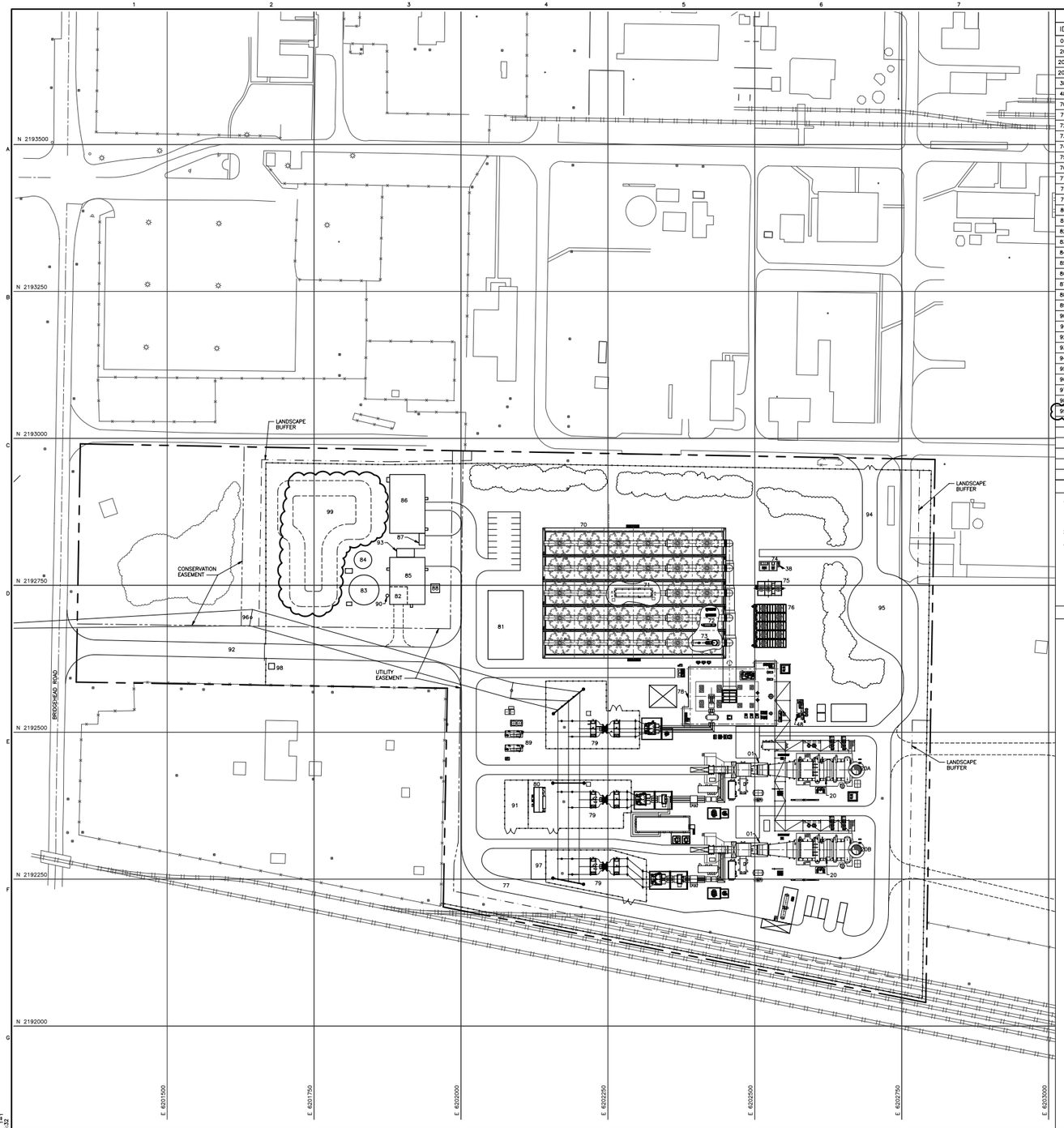
BLACK & VEATCH CORPORATION
ENGINEER PLN DRAWN NAW
CHECKED DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
SITE
SECTIONS AND DETAILS
PROJECT DRAWING NUMBER 163994-SS-3050 REV 1
CODE
AREA

SCH54101 ACAD 16.1s (LMS Tech)
A1APL017 E1 1=1
06/18/10 07:44:58

FIGURE WSQ11-2
Bioswale Design Details
Oakley Generating Station
Oakley, California

CH2MHILL



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	–	–	–	–
98	GUARD HOUSE	–	–	–	–
99	STORM WATER POND	–	–	–	–

FACILITIES LEGEND

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

ALL BACKCIRCLED CHANGES PER ECN-N-S-0004

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
3	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
2	16/APR/09	ISSUED PER ECN-N-S-0003	NAM	PLN		PLN	DVW
1	30/MAR/09	ISSUED PER ECN-N-S-0001	NAM	PLN		PLN	DVW
0	13/MAR/09	ISSUED FOR PERMITTING	NAM	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 _____ REG NO. _____
DATE _____

BLACK & VEATCH CORPORATION

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
GENERAL ARRANGEMENT SITE

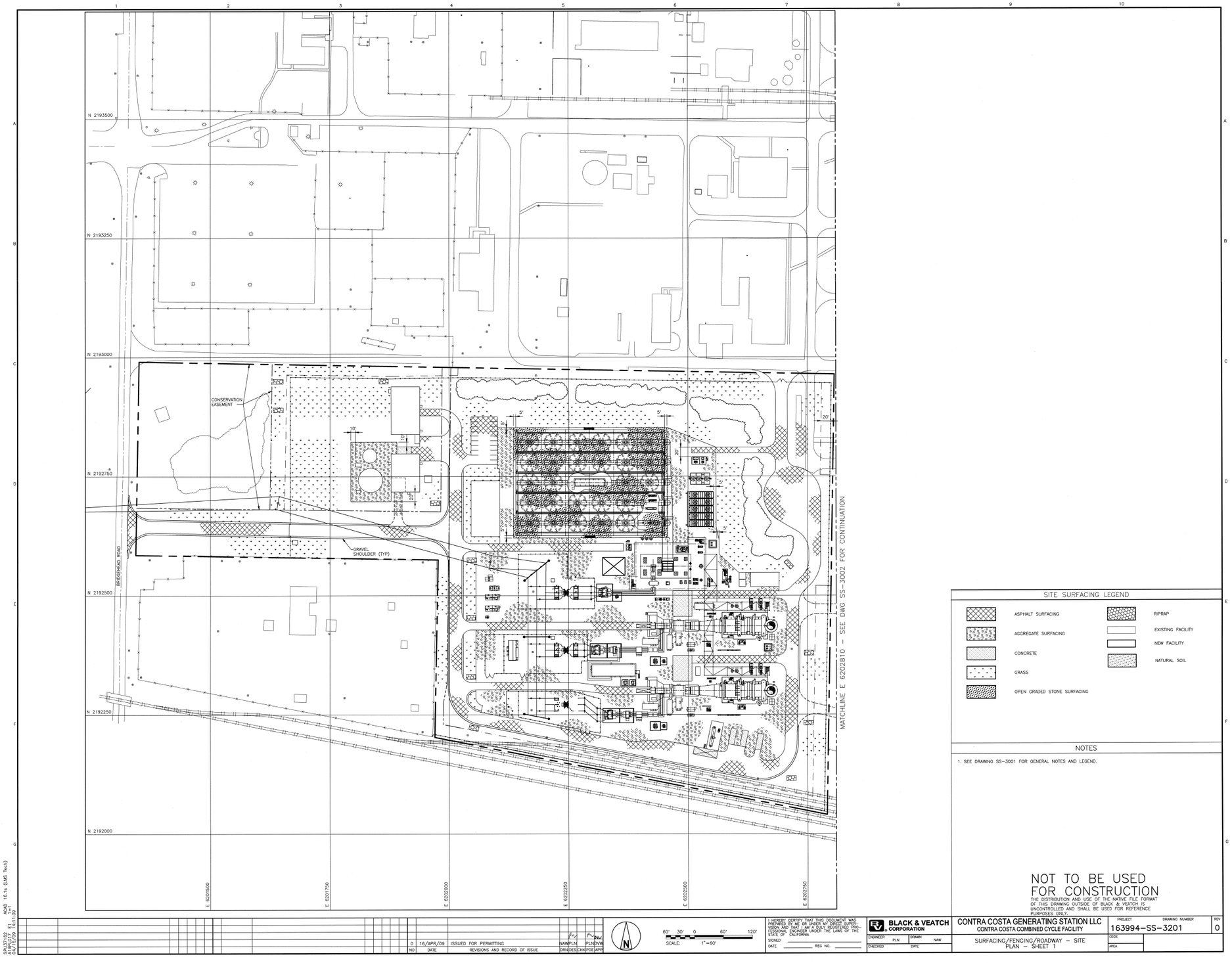
ENGINEER PLN | DRAWN NAM | CHECKED | DATE

PROJECT 163994 | DRAWING NUMBER SS-1002 | REV 3
CODE | AREA

ACAD 16.1s (LMS Tech)
SCH54101
DATE/TIME 01:44:32
DWG

FIGURE WSQ11-3
Facility Layout
Oakley Generating Station
Oakley, California

CH2MHILL



SITE SURFACING LEGEND

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

NOTES

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

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	NAM	PLN	PLN
0	16/APR/09	ISSUED FOR PERMITTING	DRN	DES	CHK	POE	APP	DVR

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 _____ REG NO. _____
DATE _____

BLACK & VEATCH CORPORATION

ENGINEER PLN | DRAWN NAW
CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SURFACING/FENCING/ROADWAY – SITE PLAN – SHEET 1

PROJECT 163994 | DRAWING NUMBER SS-3201 | REV 0
CODE
AREA

SPL01165
ACAD 15.1s (LMS Tech)
04/10/09 14:11:39

FIGURE WSQ12-1
Site Surfacing Information

Oakley Generating Station
Oakley, California

Attachment WSQ6-1
Post Construction: Wetland Volume and Water Surface Elevation (Calculation 52.5406.1006)

BLACK & VEATCH
Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 21

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: Post-Construction Wetland Volume and Water Surface Elevation

Calculation No./File No.: 52.5406.1006

Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective To determine if the existing wetland at the project site can retain the runoff from various storm events without overflowing to other properties.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: HEC-HMS Version: 3.3

Standard B&V Application Used? ☒ Yes ☐ No
If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola	11 June 2010	PLNelson	14 June 2010	PLNelson	14 June 2010

Purpose

To determine the stormwater storage volume and water surface elevation for the existing wetland and the proposed pond at the Oakley project site for storm events including the 1-inch rainfall, 10-year/24-hour storm, and combined 100-year/24-hour plus 10-year/24-hour storm (100+10) events. The analyses are performed for pre-construction and post-construction ground conditions at the project site.

References

1. Black & Veatch Drawings:
   - 163994-SS-3001, Rev. A, "Grading & Drainage - Site"
   - 163994-SS-3001, Rev. 0, "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. Contra Costa County Dept. of Public Works Maps; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977; Precipitation Duration-Frequency-Depth Curves (100-yr and 10-yr); Drawing Nos. B-159 and B-162; July 1977
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.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1008 Rev 0, Same project, June 2010
9. Black & Veatch Calculation, "Stormwater Analysis", File No. 52.5406.1003 Rev 2, Same project, June 2010
10. Email Correspondence with Contra Costa County Flood Control, May 2010

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
5. Reference 8 – Select Pages
6. Reference 9 – Select Pages
7. Reference 10

Summary

Based on the HEC-HMS analyses with current and proposed design conditions, the stormwater runoff to the wetland will not overflow to other properties for any of the analyzed storm events including the 100-year 24-hour storm followed by a 10-year 24-hour storm (100+10 event). This combined event was requested to be analyzed by Contra Costa County for the wetland area since there is no outlet within the wetland area. See Reference 10 – Attachment 7.

The maximum water surface elevation (WSEL) in the wetland is EL 10.7, produced by the combined 100+10 events. This is below the overflow elevation at the adjacent roadway of EL 11.7. The comparison between the existing and proposed site conditions for other storm events are summarized in the table below.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.03	5.1	0.05	5.1
10-year	1.10	7.2	1.51	7.7
100-year	2.70	8.9	3.58	9.7
100-year + 10-year	3.80	10.0	5.42	10.7

Hydrology Modeling – HEC-HMS

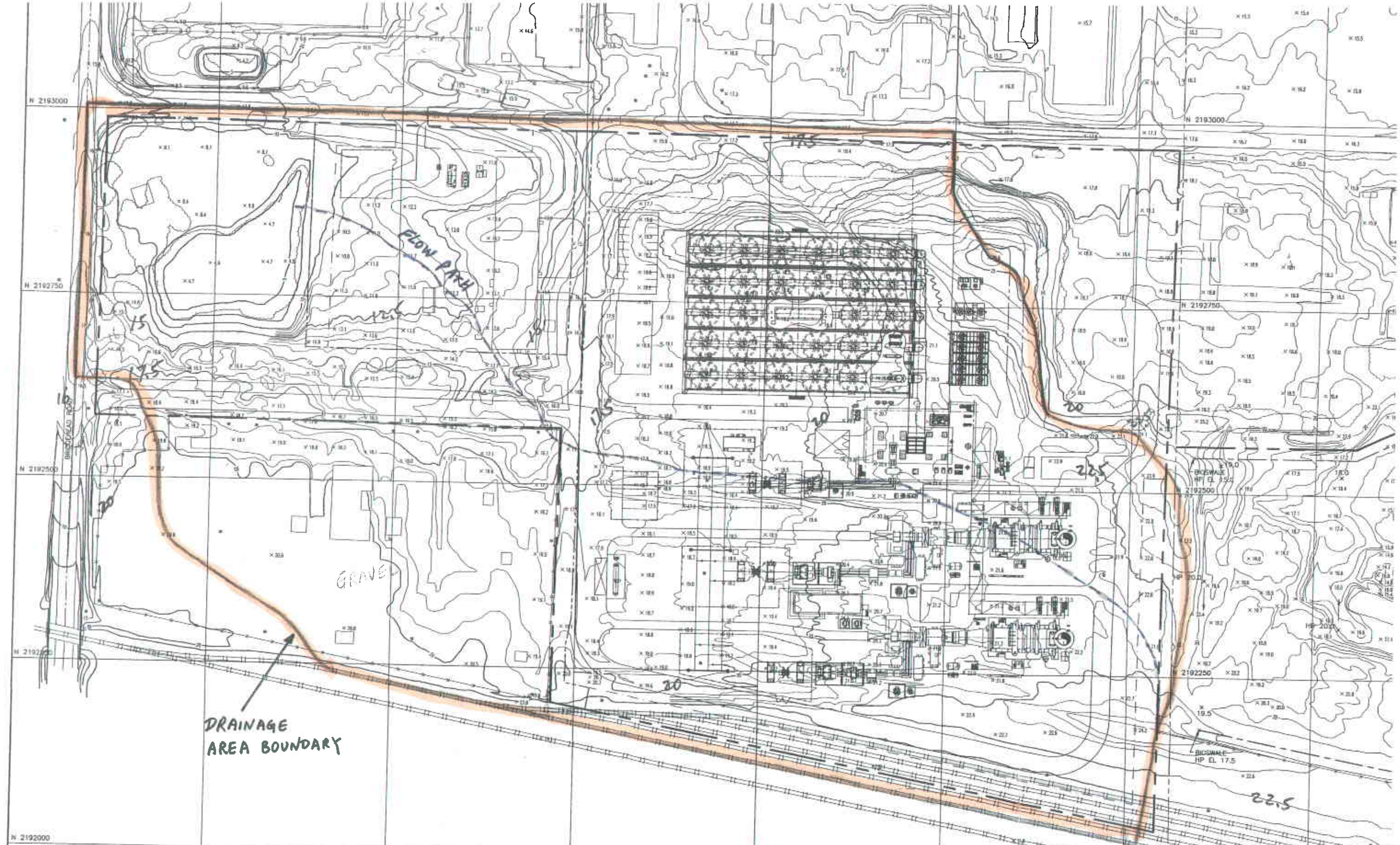
For the runoff volume and storage analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6&7 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	-	-	-	-	1.93
Gravel	3.96	2.30	-	2.51	3.35	-	-
Railroad Yard	0.94	-	-	-	0.94	-	-
Wetland	0.40	-	-	-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55	0.45	0.54	1.50	0.85	-
Impervious Surface ***	-	2.75	0.14	1.21	0.88	0.13	0.27 (ex. roads)
Transformer Contain ****	-	0.10	-	0.12	-	-	-
Open Graded Aggregate	-	1.57	-	-	-	-	-
Total Acres:	25.15	11.17	0.59	4.26	6.67	0.98	2.60
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0.0009**	**0.0067**	**0.0104**	**0.0015**	**0.0041**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).



Radback Tenaska project
project # 163994
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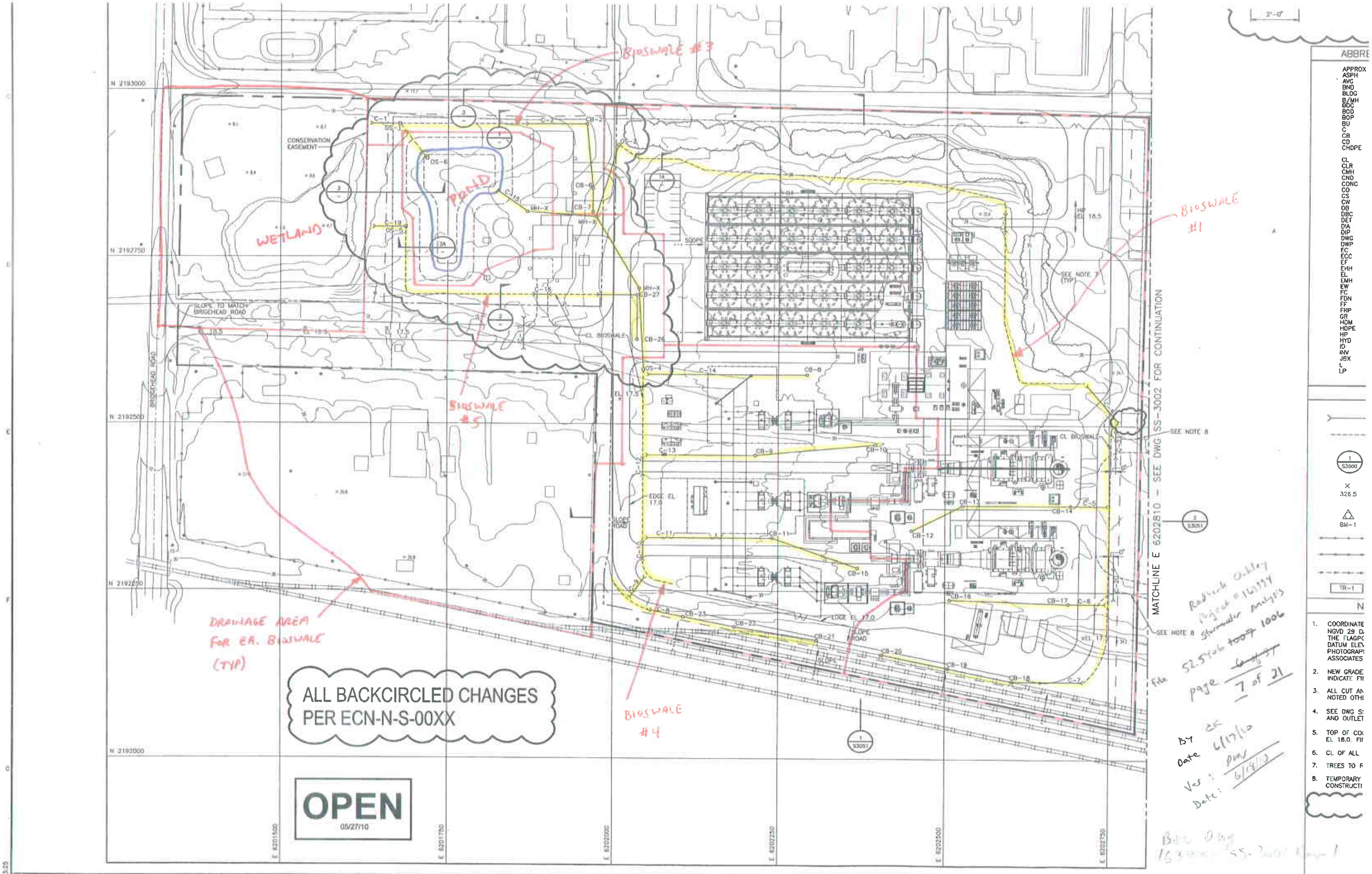
stormwater Analysis
page ~~5~~ of ~~53~~
6 of 21

prepared by: J zhong
Date 3/4/09
checked by: Pw
Date: 3/6/09

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



BIOSWALE #3
BIOSWALE #1
BIOSWALE #5
BIOSWALE #4
POND
WETLAND
CONSERVATION EASEMENT
SLOPE TO MATCH BRIDGEHEAD ROAD
BRIDGEHEAD ROAD
CL BIOSWALE
SLOPE ROAD
EDGE EL 17.0
SEE NOTE 7 (TYP)
SEE NOTE 8
MATCHLINE E 6202810 - SEE DWG SS-3002 FOR CONTINUATION
DRAINAGE AREA FOR EA. BIOSWALE (TYP)
ALL BACKCIRCLED CHANGES PER ECN-N-S-00XX
OPEN
05/27/10
N 2193000
N 2192750
N 2192500
N 2192250
N 2192000
E 6201500
E 6201750
E 6202000
E 6202250
E 6202500
E 6202750
ABBRE
APPROX
ASPH
AVG
BND
BLDG
B/MH
BDC
BOD
BOP
BU
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Redrock Oakley
Project # 163394
Stormwater Analysis
File 52.5406 ~~1007~~ 1006
page ~~6 of 37~~ 7 of 21
By CK
Date 6/17/10
Ver: PMS
Date: 6/18/10

Section 1.0 – Determine the Time of Concentration (Tc) and Lag Time

This calculation is a volumetric analysis only. Lag time (which is a function of the time of concentration) is used by HEC-HMS to compute peak flow rates only and does not affect the runoff volume computations. Therefore for simplicity, lag times of 6.0 min and 3.6 min were used for the post-construction condition. These values do not impact the volume of runoff computed within HEC-HMS. Refer to BV Calculation 52.5406.1007.

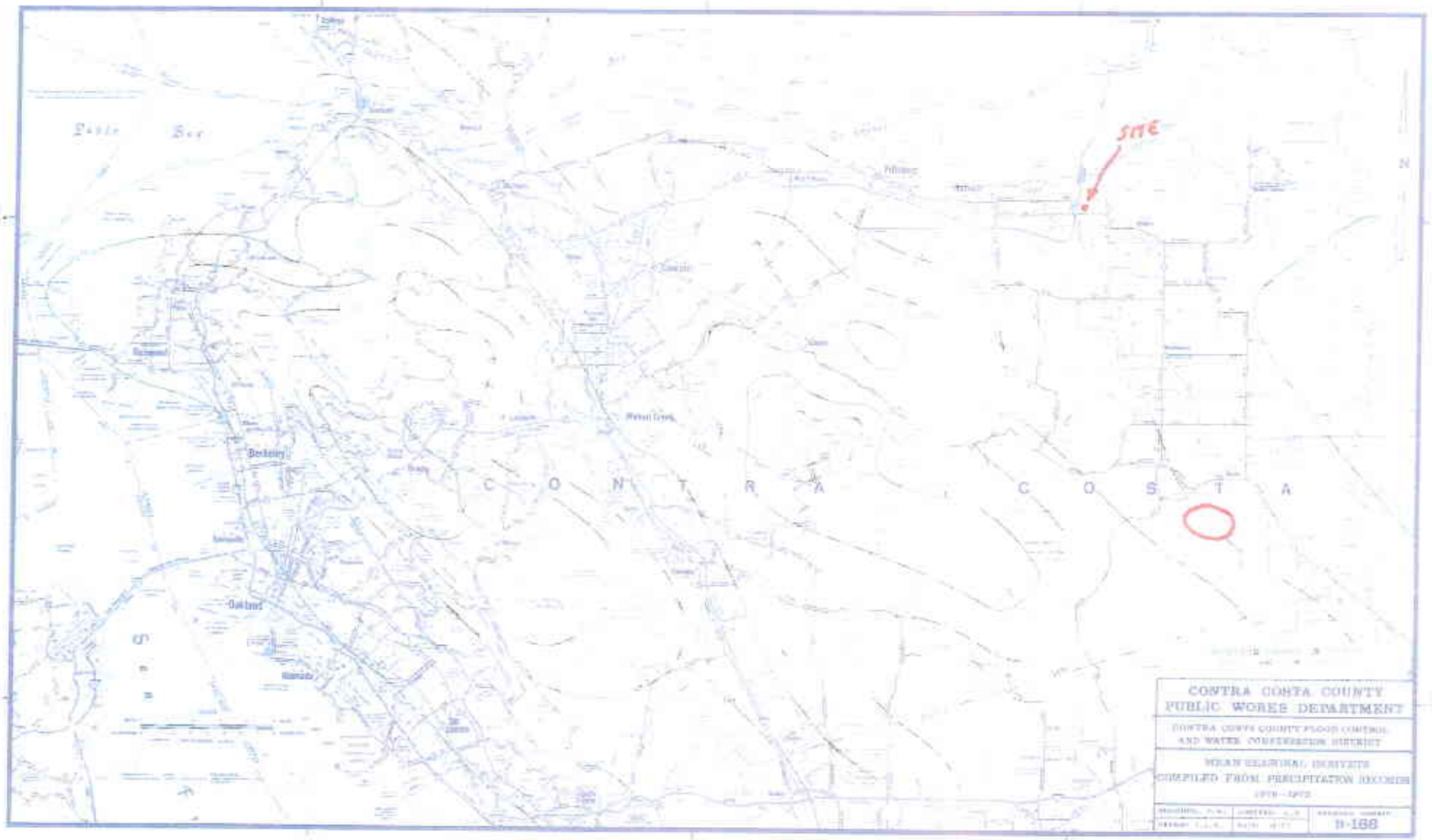
Section 2.0 – Rainfall Distribution

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 24-hour rainfall amounts for the site are: (See Pages 9 & 10)

Storm Event	100-year	10-year	Small event*
Rainfall	3.9 in.	2.6 in.	1.0 in.

* A smaller "typical" rain event of 0.75-1.0 inch was requested to be modeled by CEC



5

Redback Oakley Project #163994 (FROM REF. #4)

52.5406.~~1007~~
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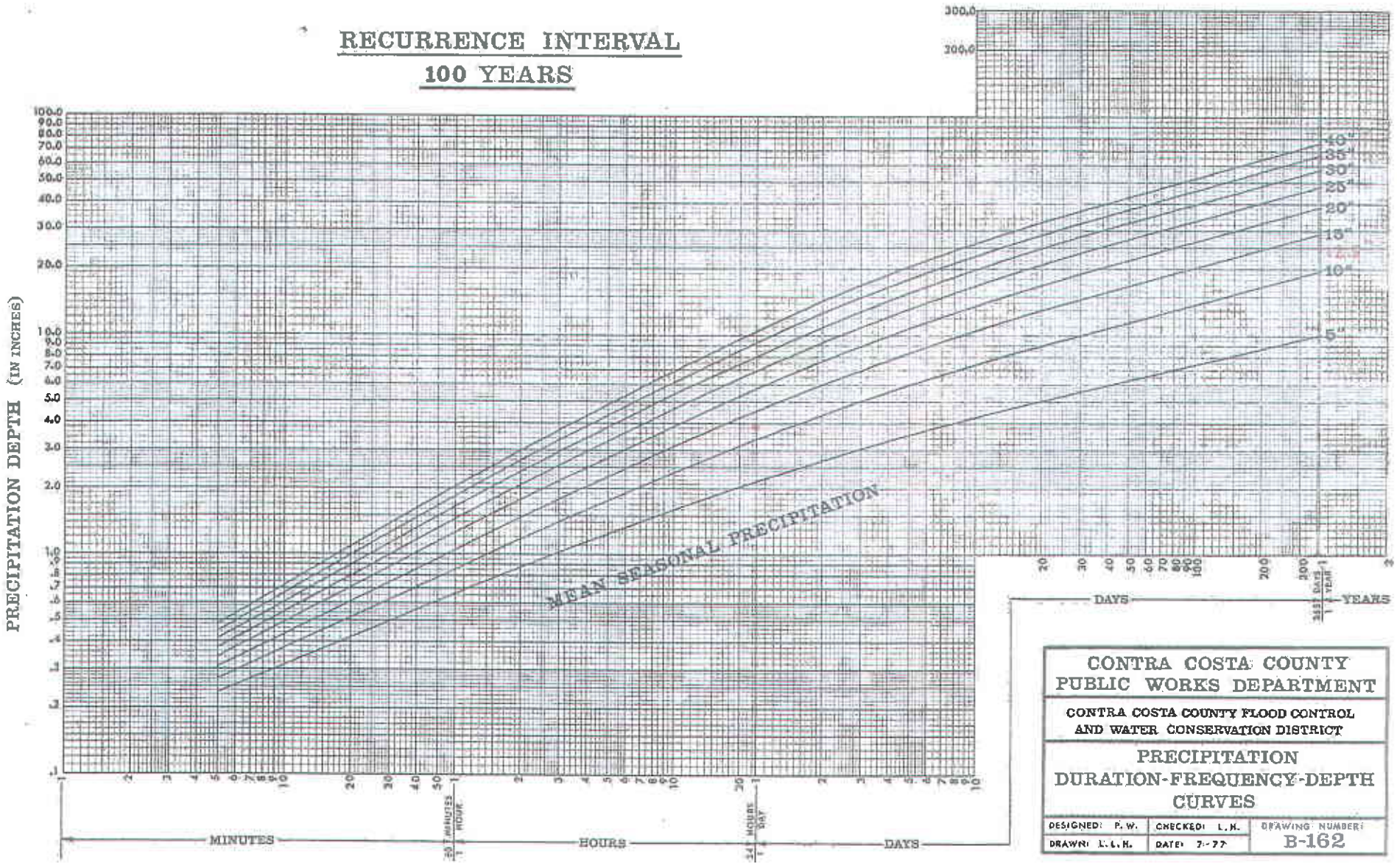
MSP = 12.5"

RECURRENCE INTERVAL
100 YEARS



CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT

CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

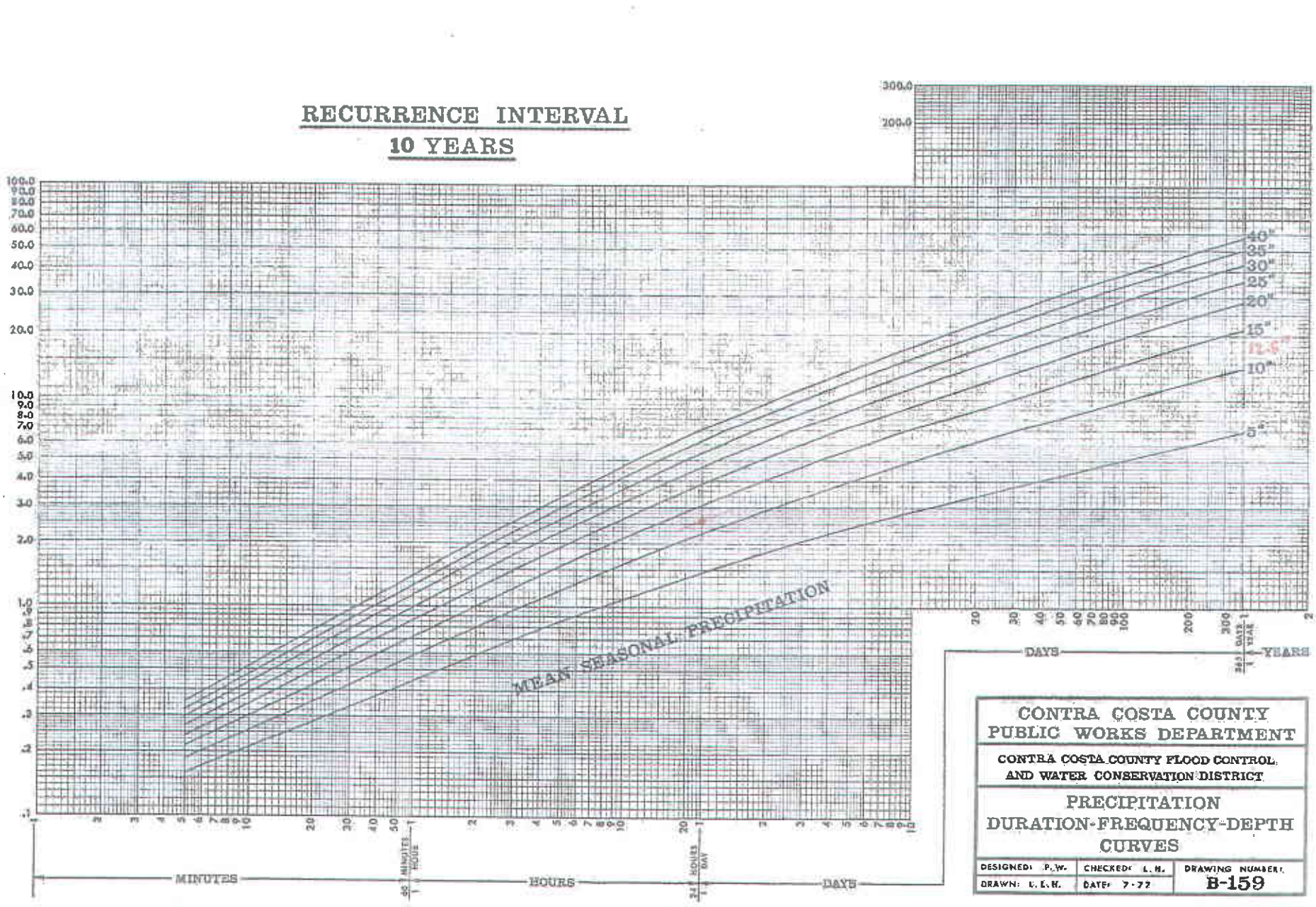
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES

DESIGNED: P.W.	CHECKED: L.H.	DRAWING NUMBER: B-162
DRAWN: L.L.H.	DATE: 7-77	

MSP = 12.5" (DWG B-166)

24-HR = 3.9" (ABOVE)

RECURRENCE INTERVAL
10 YEARS



CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT

CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES

DESIGNED: P.W.	CHECKED: L.H.	DRAWING NUMBER: B-159
DRAWN: L.L.H.	DATE: 7-77	

RADBACK OAKLEY PROJECT # 163994

52.5406.~~1007~~ .1006 Page ~~16 of 31~~ 10 of 21

(FROM REF. M) 5

MSP = 12.5" (DWG B-166)

24-HR = 2.6" (ABOVE)

Section 3.0 – Determine Composite SCS Curve Number, Initial Abstraction & Impervious %

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area. The SCS Curve Number (CN), Initial Abstraction (Ia) and Impervious % for the pre-construction site were determined in Reference 9 – see attachment 6.

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.

The proposed site drainage areas as determined earlier are summarized below, with individual CN values assigned to each type of ground cover (for Group A soils). CN values are based on Reference 2, Tables 2-2a and 2-2b.

For the pre-construction condition, the SCS Curve Number (CN = 70), Initial Abstraction (Ia = 0.857) and Impervious (% = 1) were determined in Reference 9 – see Attachment 6.

A summary of the pre- and post-construction basin parameter values determined in the following pages, and input into the HEC-HMS model are included in the table below:

Condition	Area (sq. mi.)	Composite CN	Initial Abstraction (in)	Impervious %	Lag Time (min)
Pre-Construction					
Entire Site	0.0393	70	0.857	1	19.4
Post-Construction					
Bioswale 1-2	0.0175	77	0.597	1	6.0
Bioswale 3	0.0009	75	0.667	1	6.0
Bioswale 4	0.0067	81	0.469	1	6.0
Bioswale 5	0.0104	77	0.597	1	6.0
Direct to Pond	0.0015	72	0.778	1	3.6
Direct to Wetland	0.0041	76	0.632	1	3.6

Bioswale 1+2 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface	98	2.75 ac.	269.5
Open Graded Aggregate	68	1.57 ac.	106.76
Total		11.17 ac.	860.46
Composite CN = 860.46 / 11.17 = 77			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 3 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.45 ac.	30.6
Impervious Surface	98	0.14 ac.	13.7
Total		0.59 ac.	44.3
Composite CN = 44.3 / 0.59 = 75			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = 0.667 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 4 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface	98	1.21 ac.	118.6
Total		4.26 ac.	346.1
Composite CN = 346.1 / 4.26 = 81			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/81 - 10)$ = 0.469 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 5 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	3.35 ac.	254.6
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	1.50 ac.	102
Impervious Surface	98	0.88 ac.	86.2
Total		6.67 ac.	514.2
Composite CN = 514.2 / 6.67 = 77			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Direct to Pond (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.85 ac.	57.8
Impervious Surface	98	0.13 ac.	12.74
Total		0.98 ac.	70.54
Composite CN = 514.2 / 6.67 = 72			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/72 - 10)$ = 0.778 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Direct to Wetland (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.27 ac.	26.5
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Total		2.6 ac.	196.9
Composite CN = 196.9 / 2.6 = 76			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10)$ = 0.632 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Section 4.0 – Storage Capacity versus Elevation for Wetland Area and Pond

The bottom of the wetland is at an approximate elevation of 5 feet (It is actually slightly lower than EL 5). See B&V Drawing SS-3001 (Page 6). The relationship of Area versus Elevation for the wetland area is 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 the future fill area deducted to accurately model the wetland storage capacity.

Incremental storage at each water surface elevation is calculated using the average end-area method below:

$$\text{Incremental Storage Volume} = \left(\frac{AreaHi + AreaLo}{2} \times (ElevHi - ElevLo)\right)$$

For the volume between elevations 5.0 and 7.5:

$$\text{Incremental Storage Volume} = \left(\frac{0.62 + 0.40}{2} \times (7.5 - 5.0)\right) = 1.28 \text{ ac-ft}$$

Wetland Elevation – Area – Storage Summary (See Ref. 9, Pg 11)

Elevation (ft)	Wetland Area (acre)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-
7.5	0.62	1.28	1.28
10.0	1.44	2.57	3.85
11.5	1.6	2.28	6.13

There is an outlet control structure proposed between the pond and wetland that will allow water to flow from the pond into the wetland when the water level in the pond is above elevation 10.0. The volume retained in the pond below elevation 10.0 prior to allowing discharge into the wetland is determined by calculating the total incremental storage provided below elevation 10.0 as shown in the table on the following page.

Retained Volume to Elevation 10.0 = 0.10 ac-ft + 0.23 ac-ft = 0.33 ac-ft

This storage volume reduces the runoff that reaches the wetland. The wetland water-surface elevation in the post-construction site condition takes this into account.

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Area versus Elevation for the proposed pond (areas measured using AutoCAD). Also included are columns summarizing the incremental and cumulative storage volumes provided in the pond at each elevation interval.

Pond Elevation – Area – Storage Summary

Elevation (ft)	Pond Area (acres)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
8.5	0.18	-	-
9.0	0.21	0.10	0.10
10.0	0.26	0.23	0.33
11.0	0.31	0.29	0.62
12.0	0.37	0.34	0.96
13.0	0.43	0.40	1.36
14.0	0.50	0.46	1.82
15.0	0.56	0.53	2.35

For larger storm events, the water surface elevation in the wetland will exceed the outlet control elevation in the pond, resulting in an equalized water surface elevation between the wetland and pond. Below is a table summarizing the elevation and storage volume within the wetland and pond system for larger runoff volumes.

Equalized Wetland + Pond Elevation – Area – Storage Summary

Elevation (ft)	Wetland Area (acres)	Pond Area (acres)	Incremental Wetland Storage (ac-ft)	Incremental Pond Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-	-	-
7.5	0.62	-	1.28	-	1.28
8.5	0.95 *	0.18	0.78	-	2.06
9.0	1.11 *	0.21	0.52	0.10	2.68
10.0	1.44	0.26	1.28	0.23	4.19
11.0	1.55	0.31	1.50	0.29	5.98
11.5	1.6	0.34 *	0.79	0.16	6.93

* Denotes interpolated value

Section 5.0 HEC-HMS Output

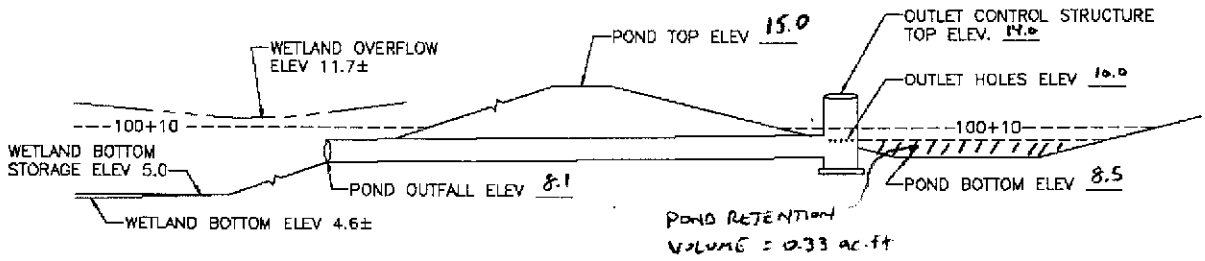
The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at EL 5 assuming that standing water in the wetland is not higher than EL 5 when the modeled rainfall events begin. Normal water level is approximately EL 4.6 as shown on Page 6.

The total runoff volume for each storm event was calculated by running the HEC-HMS program. The table below summarizes the runoff volume produced in the pre-construction and post-construction site conditions for each storm event. The output results are included in Attachment 2.

Rainfall Event	Pre-Construction Runoff Volume	Post-Construction Runoff Volume
1-inch	0.03 ac-ft	0.14 ac-ft
10-year	1.10 ac-ft	1.84 ac-ft
100-year	2.70 ac-ft	3.91 ac-ft
100-year + 10-year	3.80 ac-ft	5.75 ac-ft

Section 6.0 – Determine WSEL within Wetland Area

The results from Sections 4.0 and 5.0 were used to determine the resulting WSEL within the wetland area for each storm event. The WSEL in the wetland is determined based on the amount of runoff that is conveyed to the wetland area. As calculated in Section 4.0, the proposed pond retains a volume of 0.33 ac-ft, therefore the amount of runoff that reaches the wetland in the post-construction condition can be reduced by 0.33 ac-ft to determine the resulting wetland WSEL. Below is a general diagram of the pond and wetland configuration, showing the retained volume in the pond below elevation 10.0.



By comparing the proposed runoff volumes discharged to the wetland against the interpolated storage capacity volumes by elevation (summarized in Section 4.0), the WSEL in the wetland is determined.

Determine WSEL10 (Wetland WSEL for 10-year/24-hr storm for post-construction site)

Wetland Elevation / Volume Data (from Section 4.0)

Wetland Elevation (ft)	Cumulative Wetland Storage (ac-ft)
7.5	1.28
Interpolate WSEL10	*1.51 (10-yr post- runoff to wetland)*
10.0	3.85

Interpolating for WSEL10 = $\frac{(1.51-1.28)(10.0-7.5)}{(3.85-1.28)}+7.5$ = 7.7 ft.

Using the above method for the other storm events, the resulting post-construction WSELs in the wetland are summarized in the table below. Since the pond provides 0.33 ac-ft of retention storage, up to 0.33 ac-ft of runoff volume to the pond is deducted from the total runoff volume to wetland. For example, in the 1-inch storm, a total of 0.09 ac-ft flows to the pond – see Attachment 2. Since this is less than the 0.33 ac-ft pond retention volume, this 0.09 ac-ft is retained in the pond and deducted from total runoff (0.14 ac-ft) to yield the post-construction runoff volume of 0.05 ac-ft to the wetland.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.03	5.1	0.05	5.1
10-year	1.10	7.2	1.51	7.7
100-year	2.70	8.9	3.58	9.7
100-year + 10-year	3.80	10.0	5.42	10.7

Conclusion:

Based on the HEC-HMS analysis and the storage analysis of the existing wetland and proposed pond, the varying runoff volumes for each storm event will be contained on site without overflowing to adjacent properties. From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.7 feet, while the maximum elevation for the 100+10 storm events is EL 10.7. This analysis does not account for storage within the bioswale system, nor infiltration that would be expected to occur which would reduce the volume of runoff that would be expected to actually reach the wetland area. Therefore this analysis can be considered conservative, relating to the overall flood storage capacity for the site.

Railback Tenaska Project — Stormwater Analysis

Project # 163994

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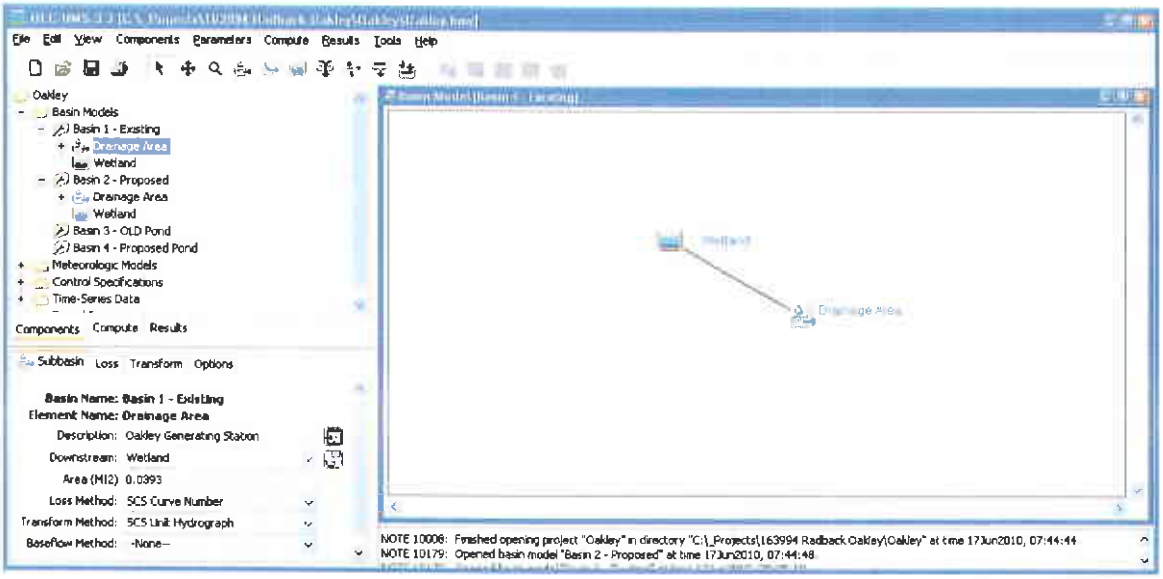
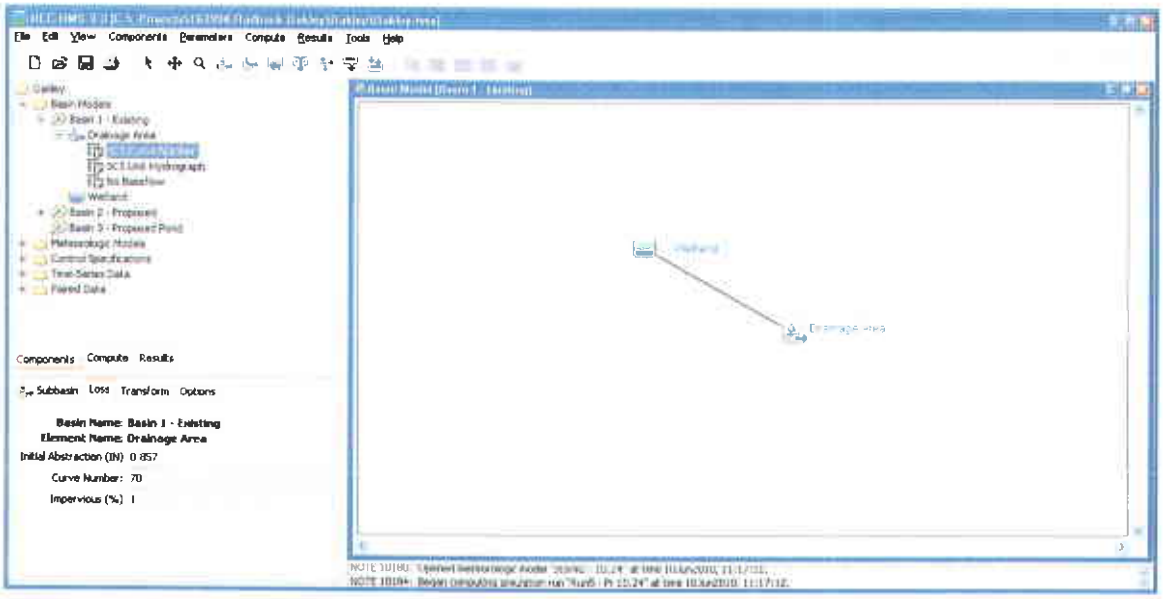
52.5406.1006

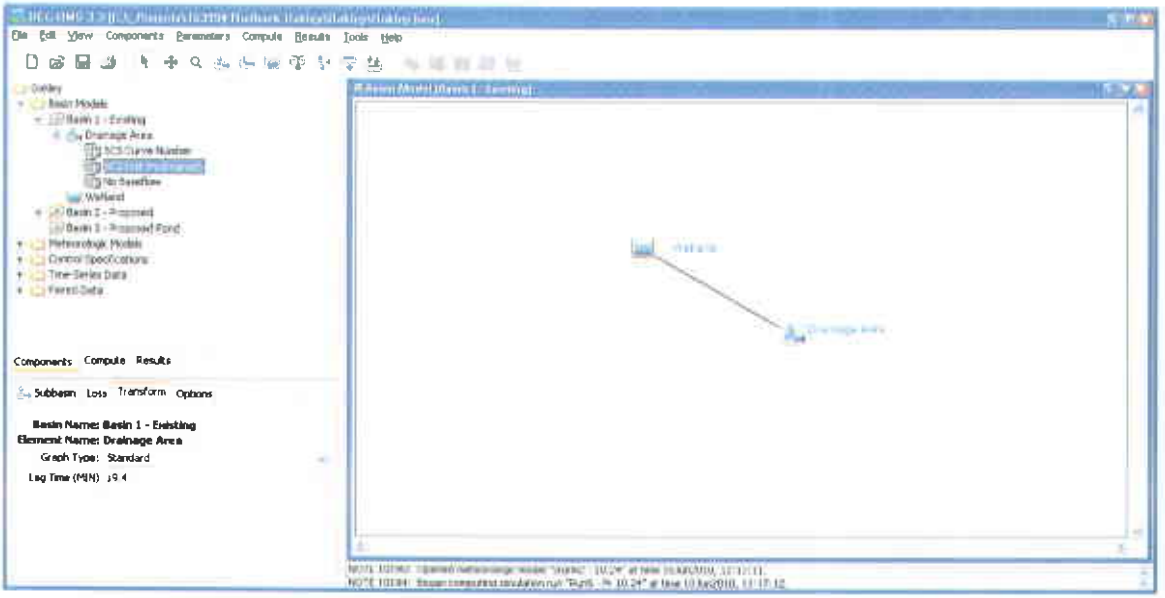
Attachment 1

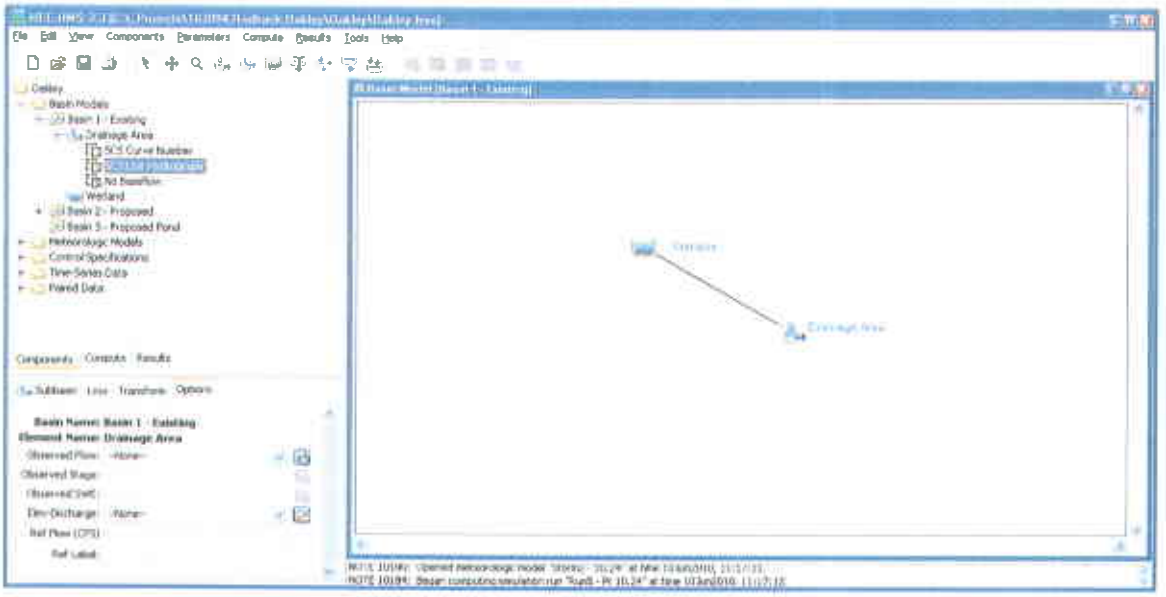
HEC-HMS Input

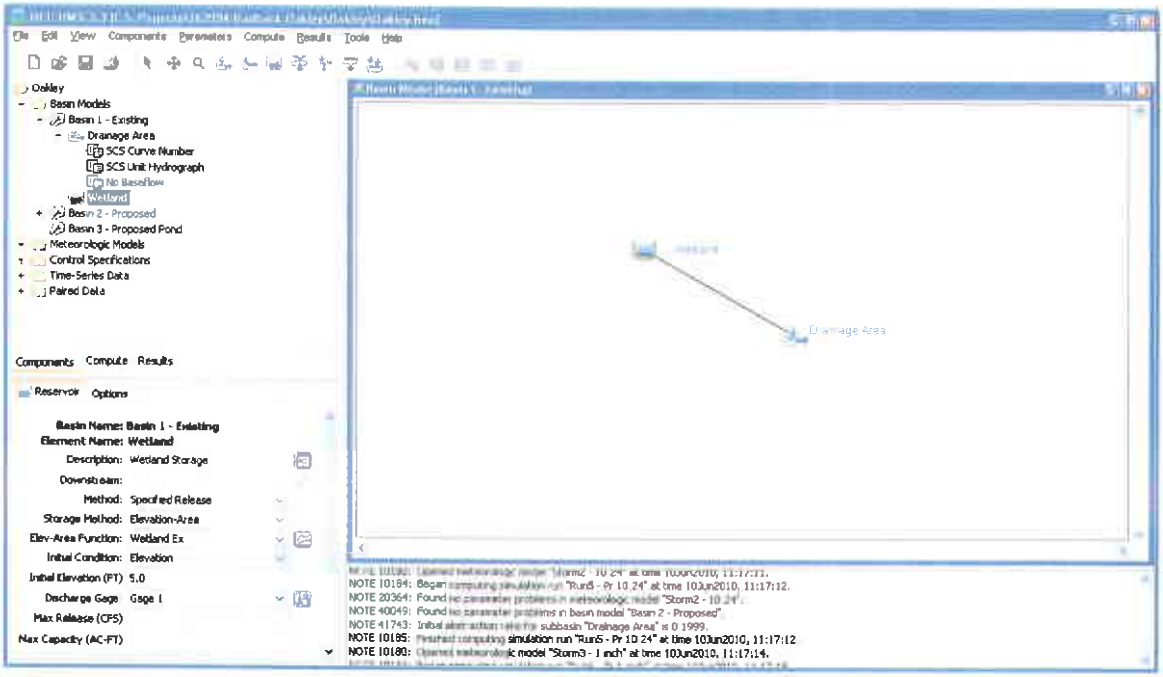
HEC-HMS Input – Basin Model 1 – Existing (Pre-Construction Condition)





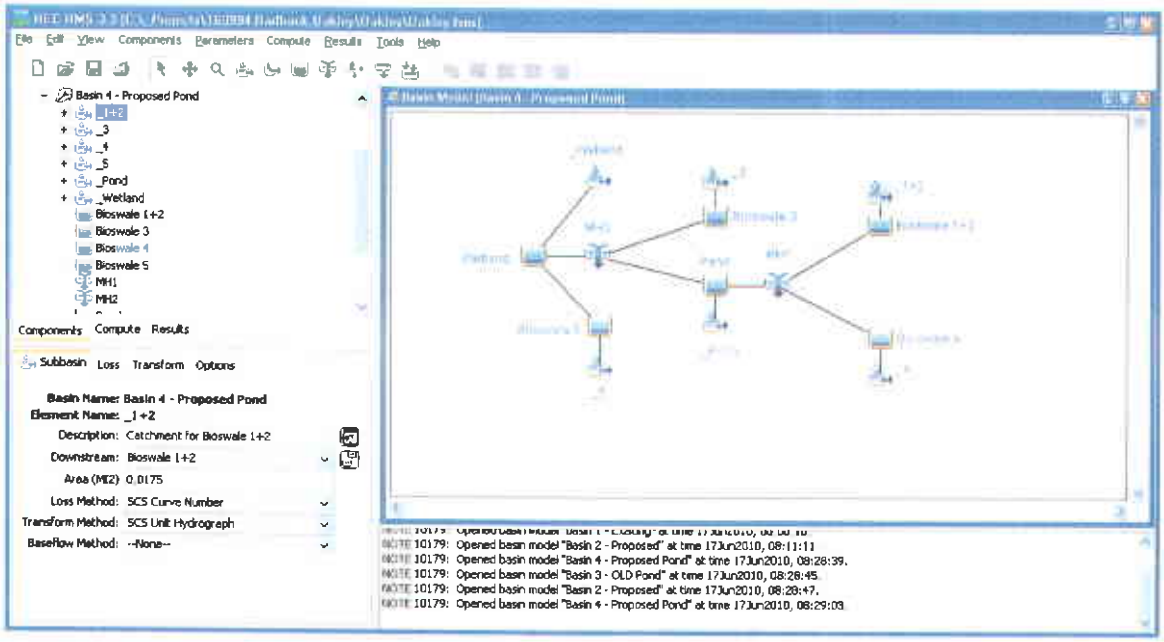

File Edit View Components Parameters Compute Results Tools Help
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1 - Existing
Element Name: Drainage Area
Graph Type: Standard
Lag Time (MIN) 19.4

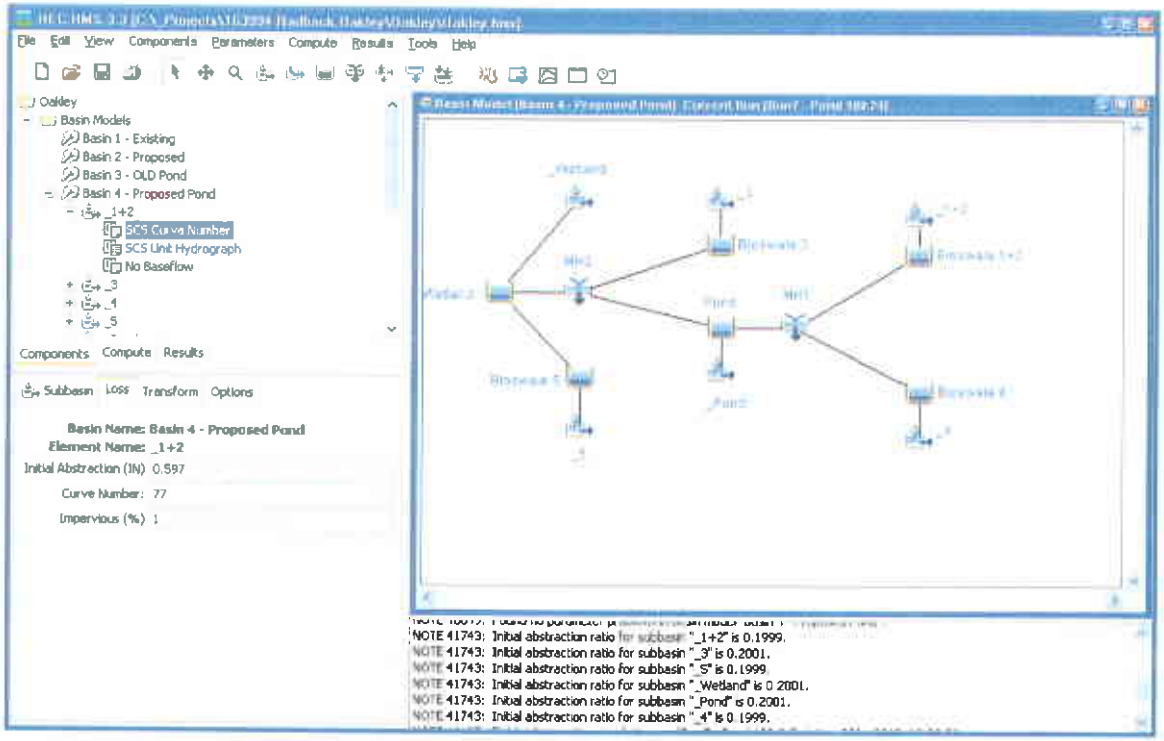

File Edit View Components Parameters Compute Results Tools Help
Basin Name: Basin 1 - Existing
Element Name: Drainage Area

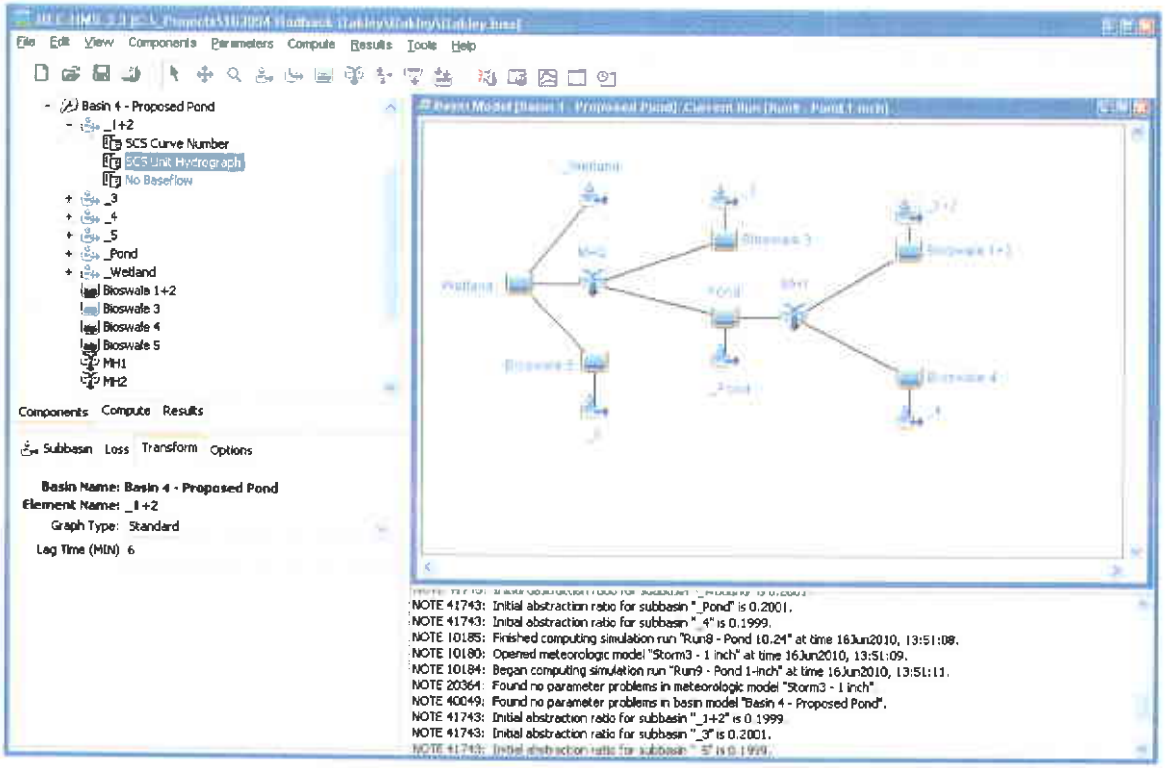

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Basin 2 - Proposed
Basin 3 - Proposed Pond
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components Compute Results
Reservoir Options
Basin Name: Basin 1 - Existing
Element Name: Wetland
Description: Wetland Storage
Downstream:
Method: Specified Release
Storage Method: Elevation-Area
Elev-Area Function: Wetland Ex
Initial Condition: Elevation
Initial Elevation (FT) 5.0
Discharge Gage Gage 1
Max Release (CFS)
Max Capacity (AC-FT)
Drainage Area
NOTE 10184: Began computing simulation run "Run5 - Pr 10 24" at time 10Jun2010, 11:17:12.
NOTE 20364: Found no parameter problems in meteorologic model "Storm2 - 10 24".
NOTE 40049: Found no parameter problems in basin model "Basin 2 - Proposed".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.1999.
NOTE 10185: Finished computing simulation run "Run5 - Pr 10 24" at time 10Jun2010, 11:17:12
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 10Jun2010, 11:17:14.

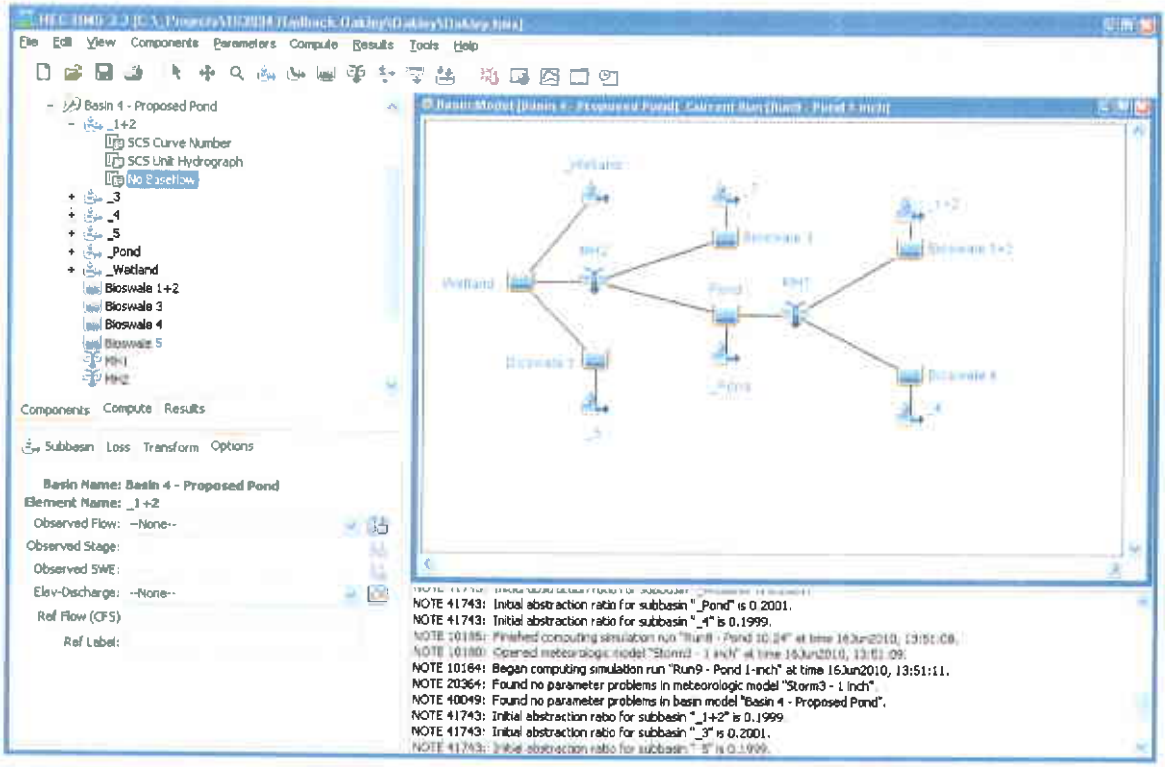
HEC-HMS Input – Basin Model 4 – Proposed (Post-Construction Condition)

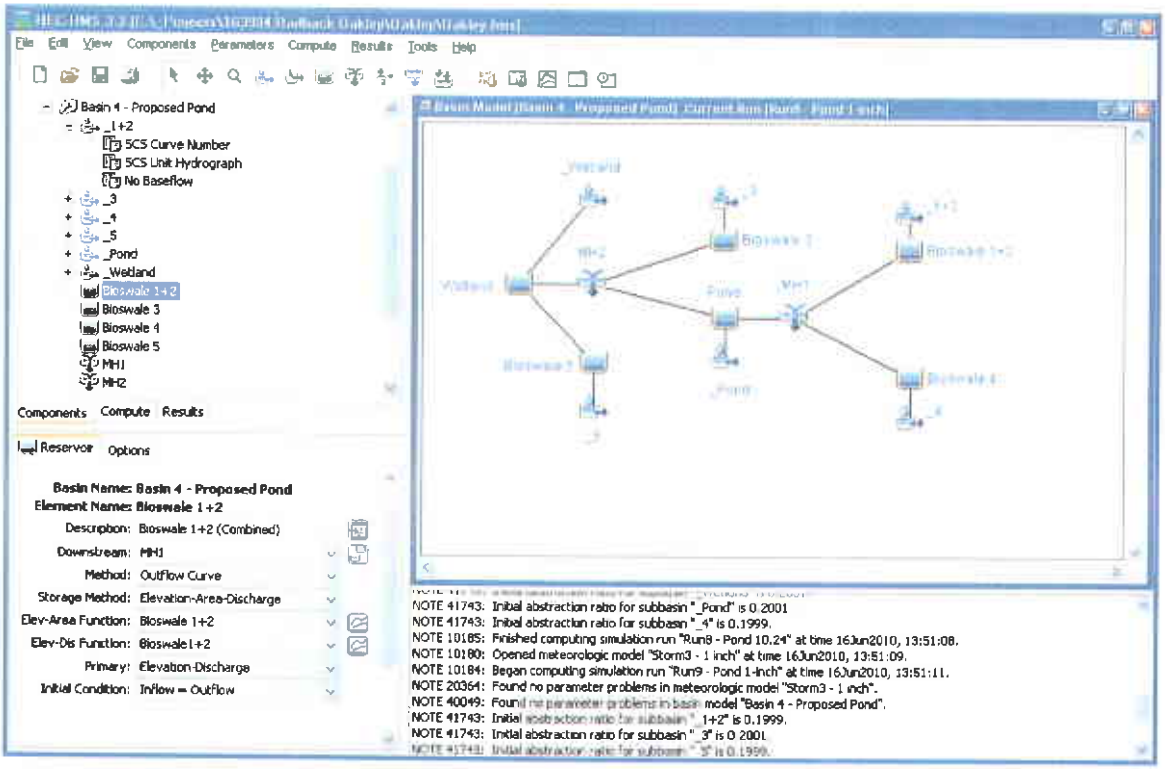
Bioswale 1+2 (Combined)

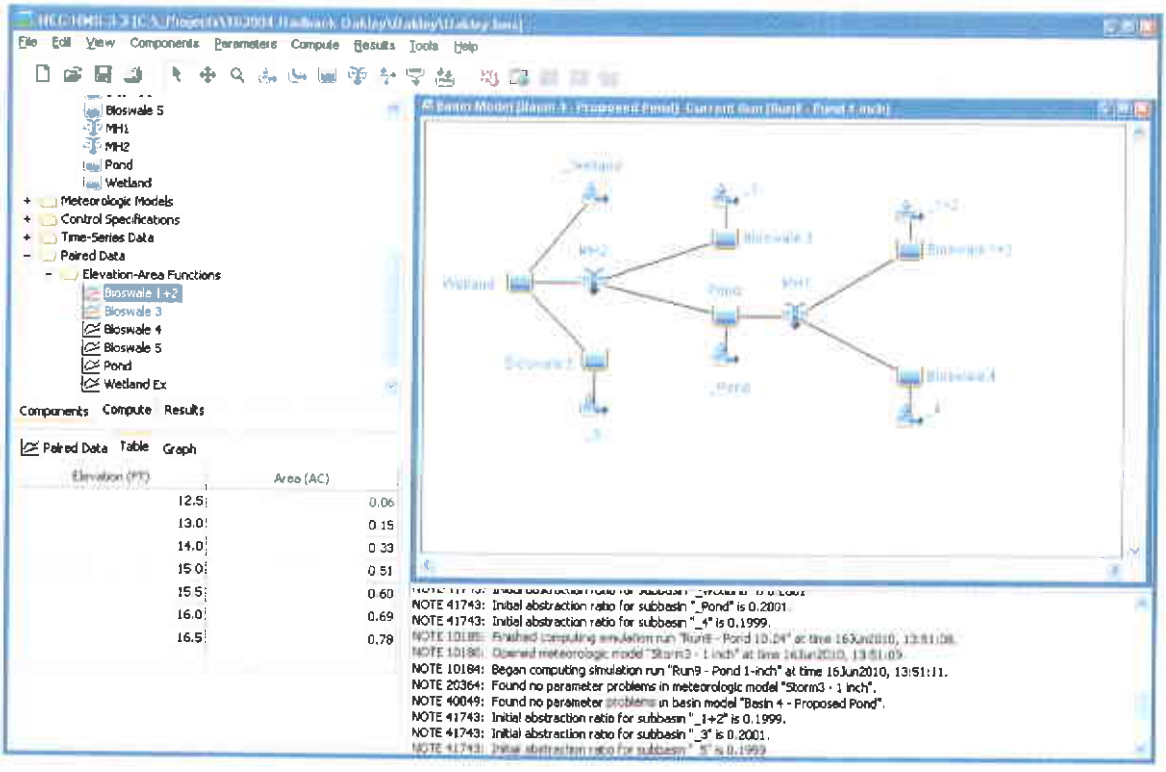


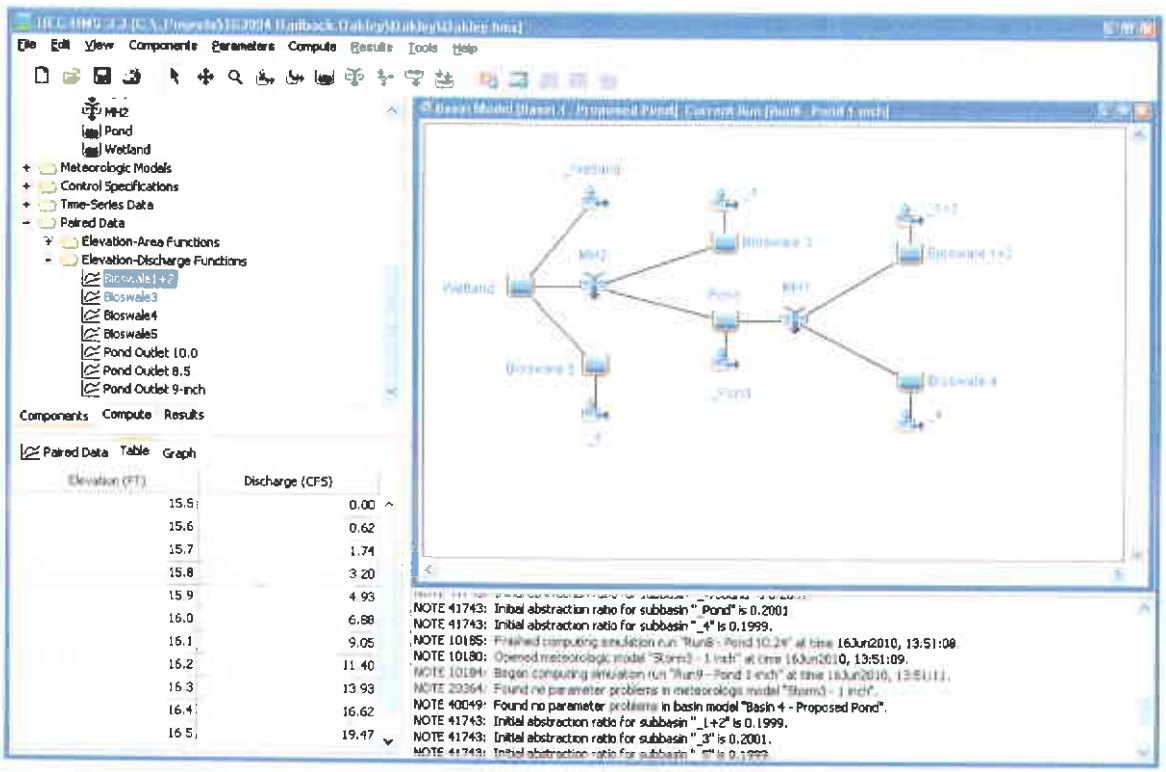



File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _1+2
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch"
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

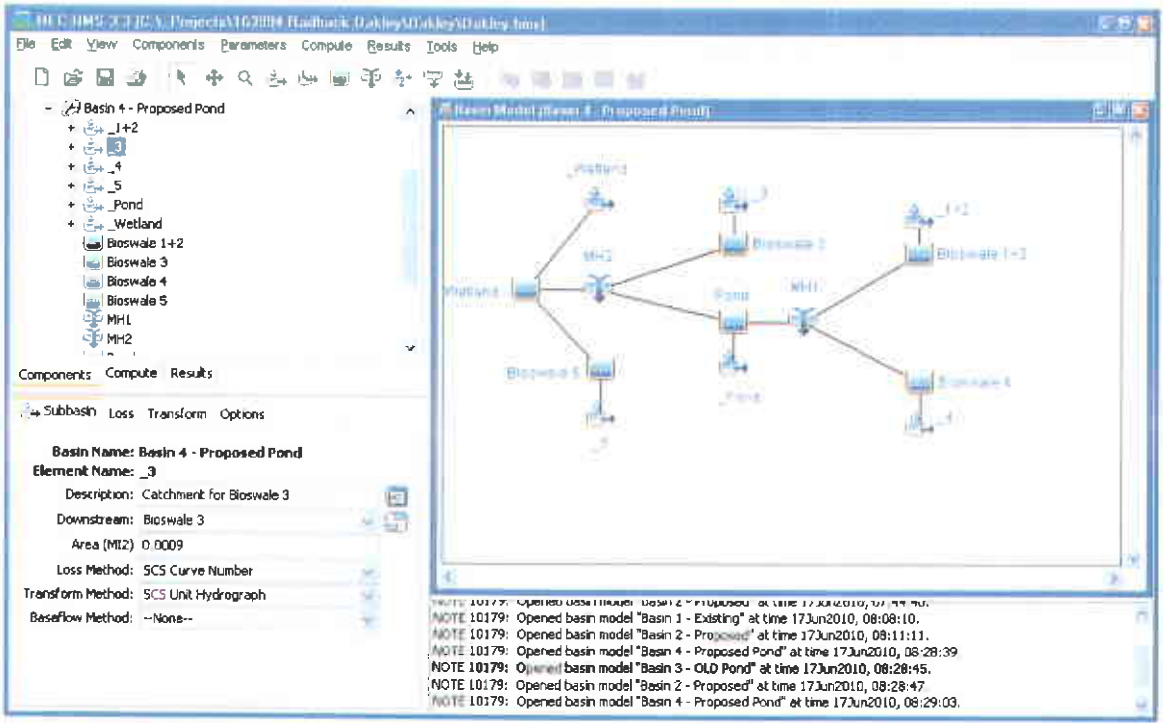

File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _1+2
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

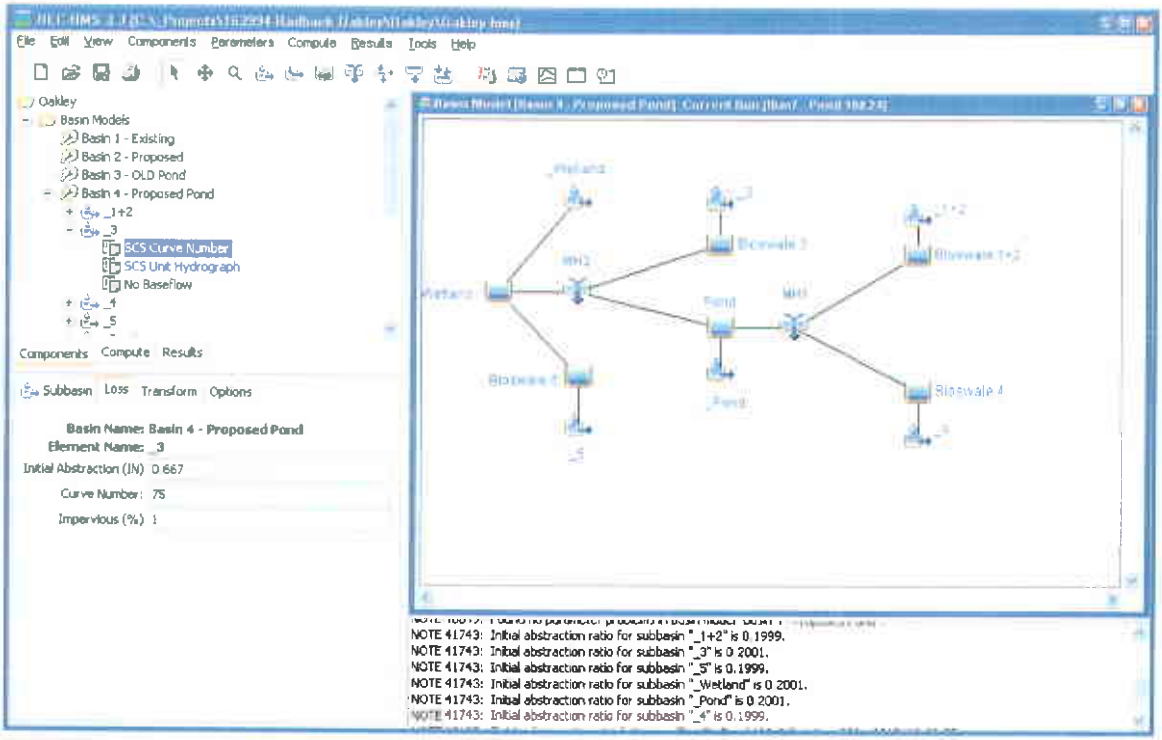

File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 1+2
Description: Bioswale 1+2 (Combined)
Downstream: MH1
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 1+2
Elev-Dis Function: Bioswale 1+2
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

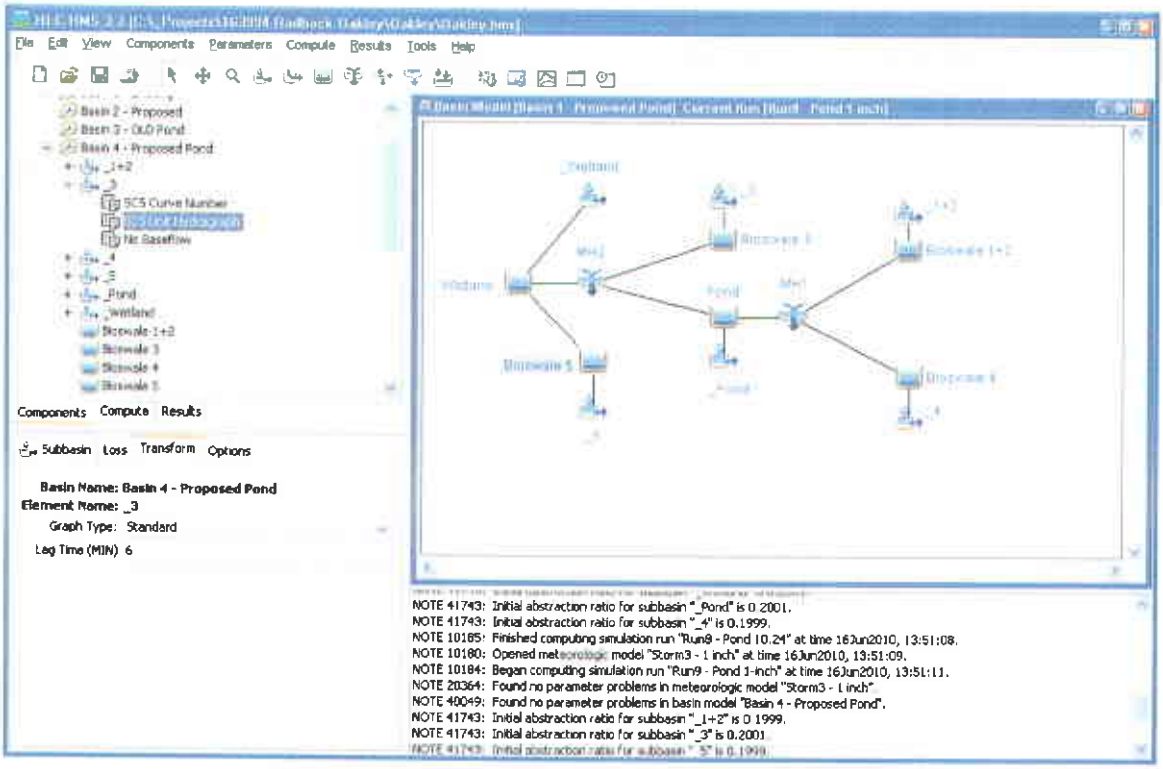

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
12.5 0.06
13.0 0.15
14.0 0.33
15.0 0.51
15.5 0.60
16.0 0.69
16.5 0.78
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

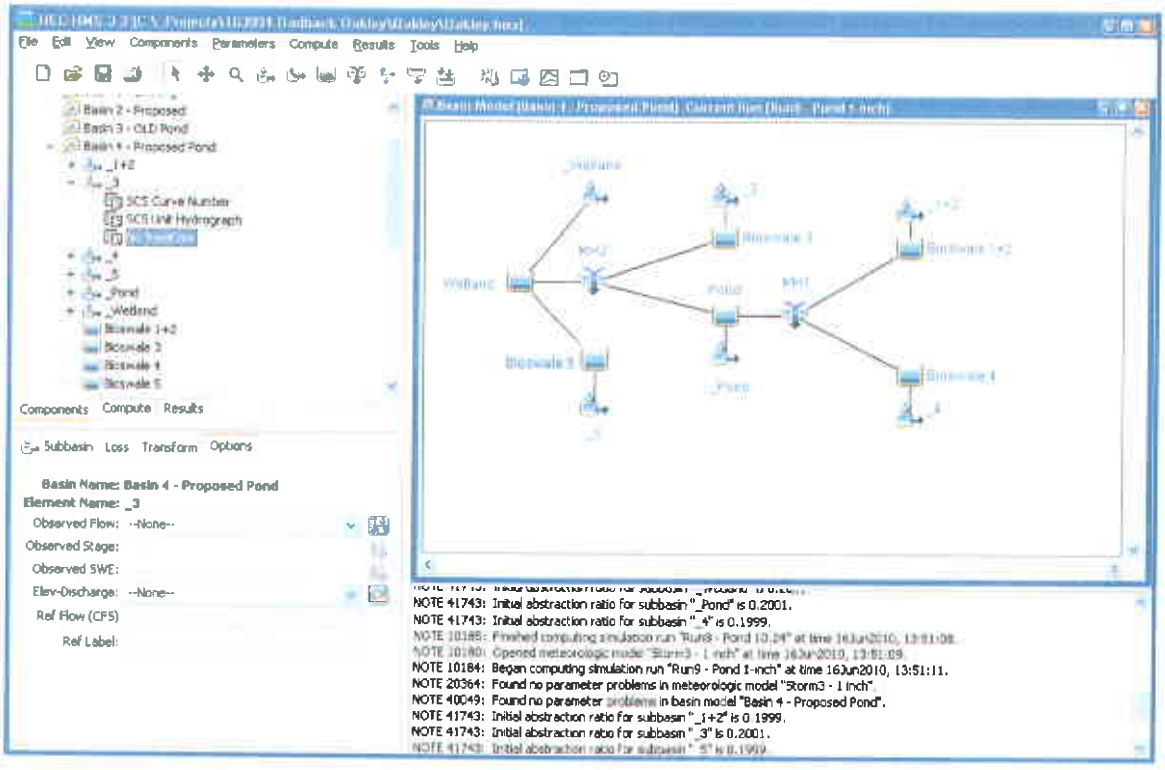

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
15.6 0.00
15.6 0.62
15.7 1.74
15.8 3.20
15.9 4.93
16.0 6.88
16.1 9.05
16.2 11.40
16.3 13.93
16.4 16.62
16.5 19.47
Wetland
MH2
Pond
MH1
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.2in" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1 inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

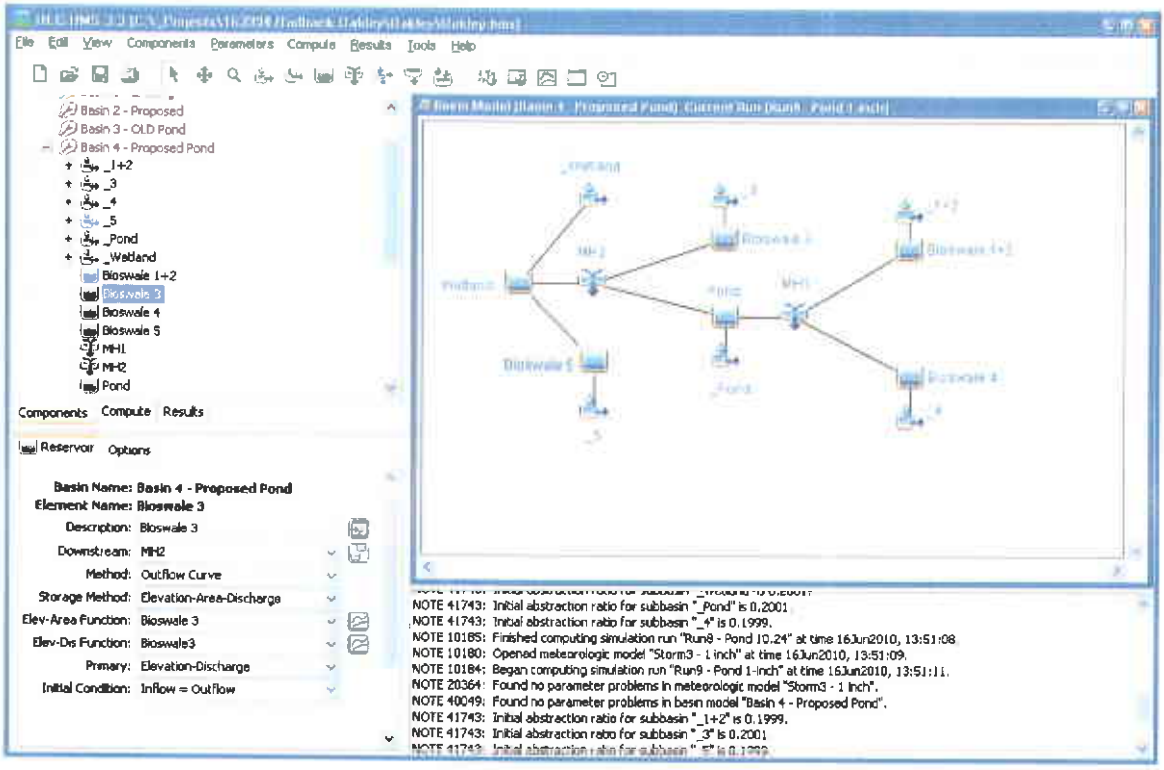
HEC-HMS Input – Bioswale 3

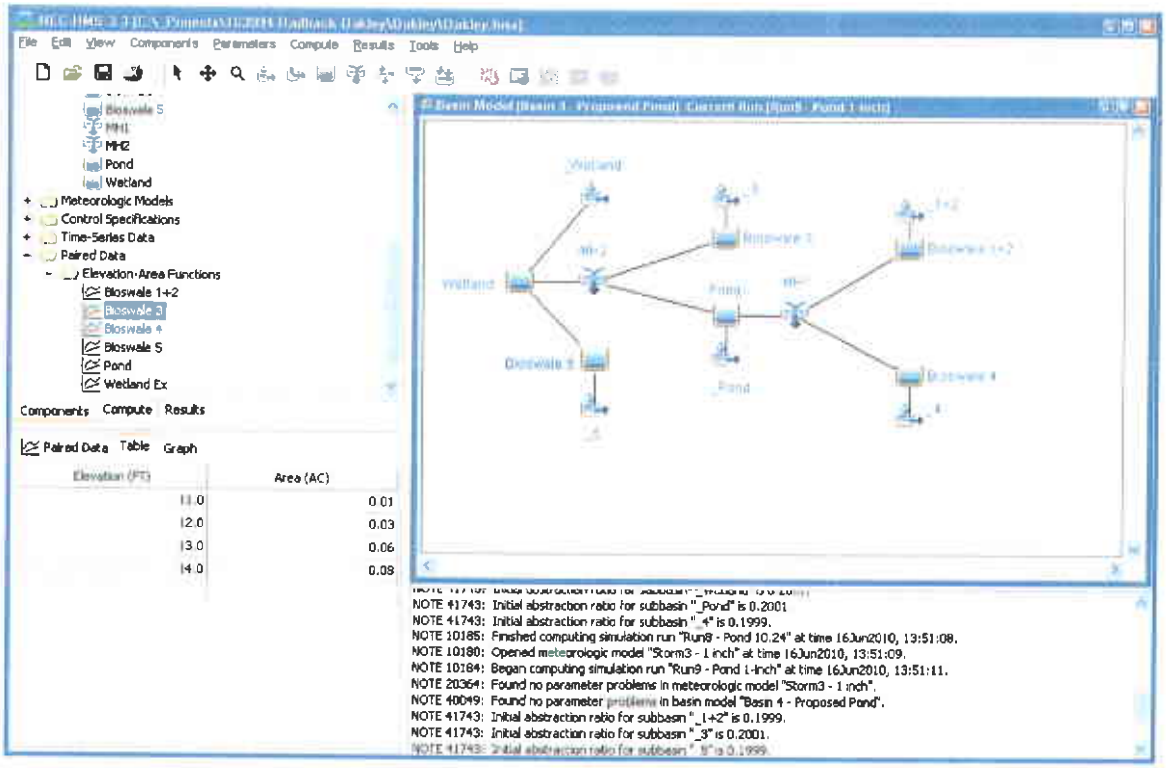


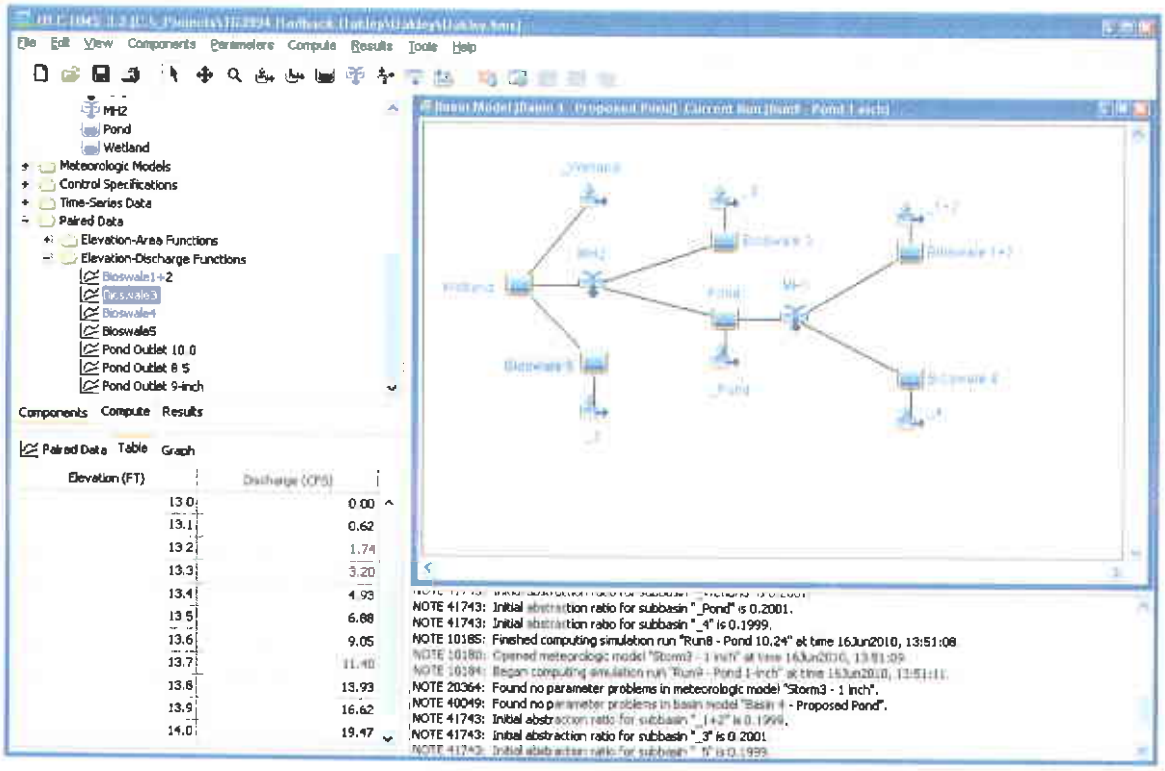



File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _3
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

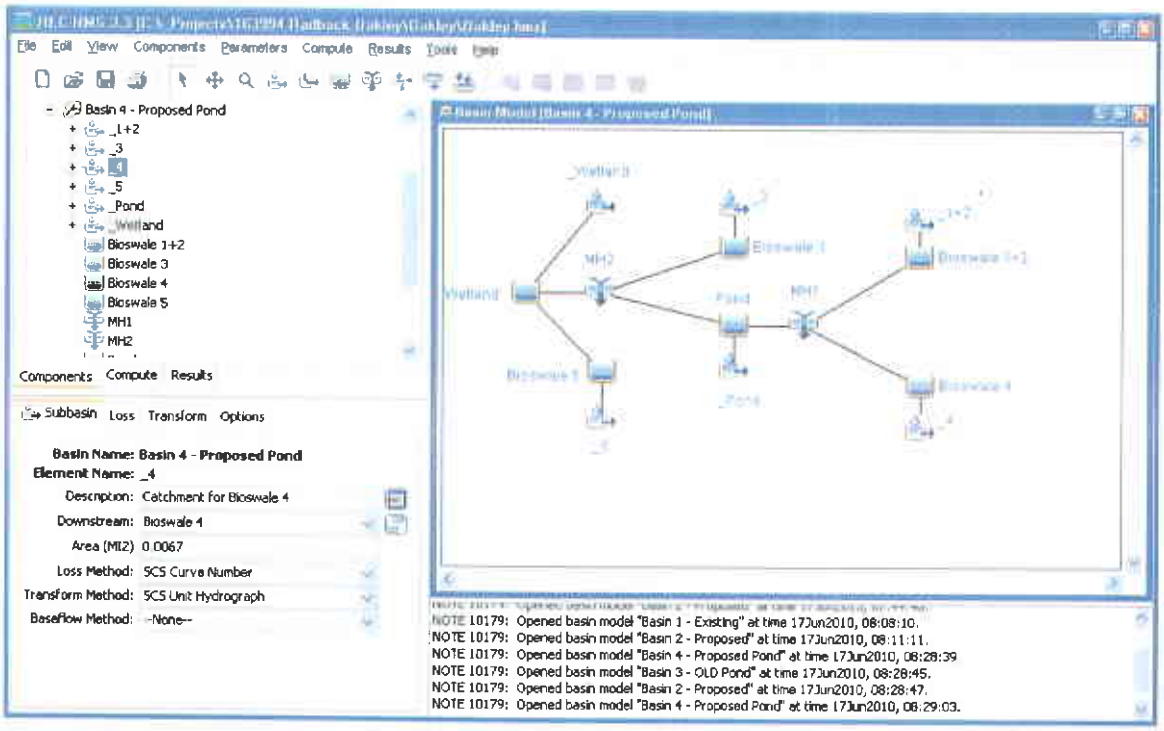

File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
SCS Curve Number
SCS Unit Hydrograph
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _3
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

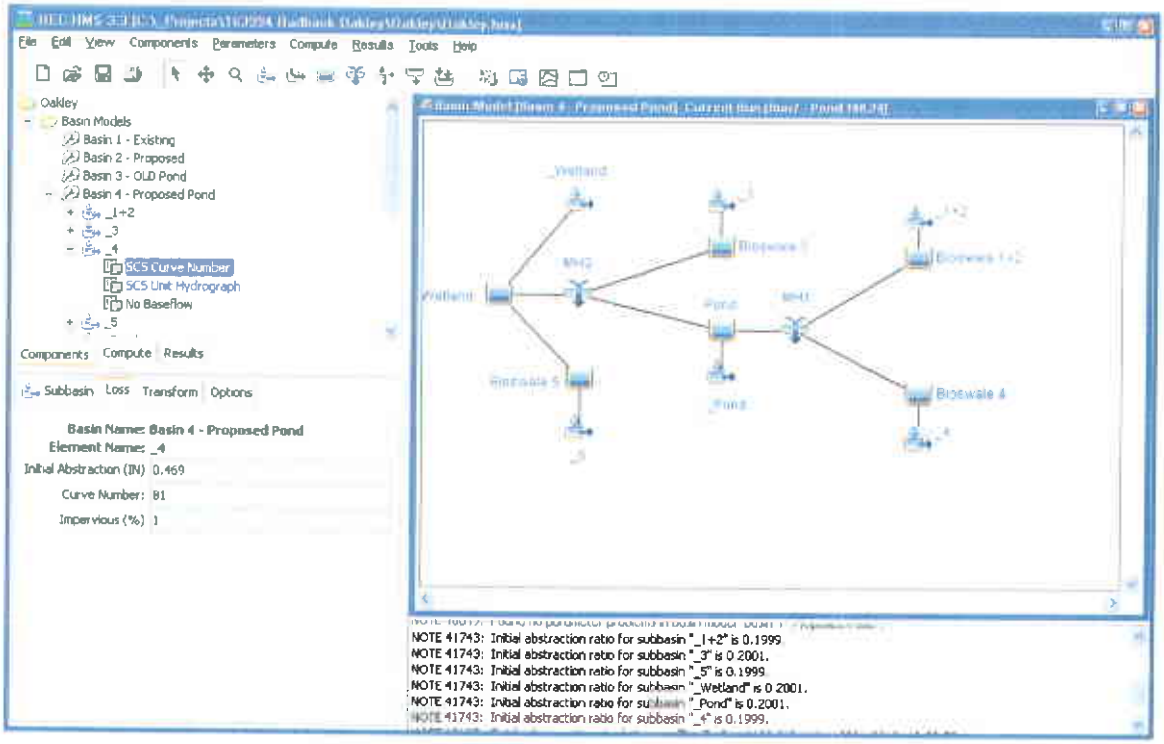

File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 3
Description: Bioswale 3
Downstream: MH2
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 3
Elev-Ds Function: Bioswale3
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

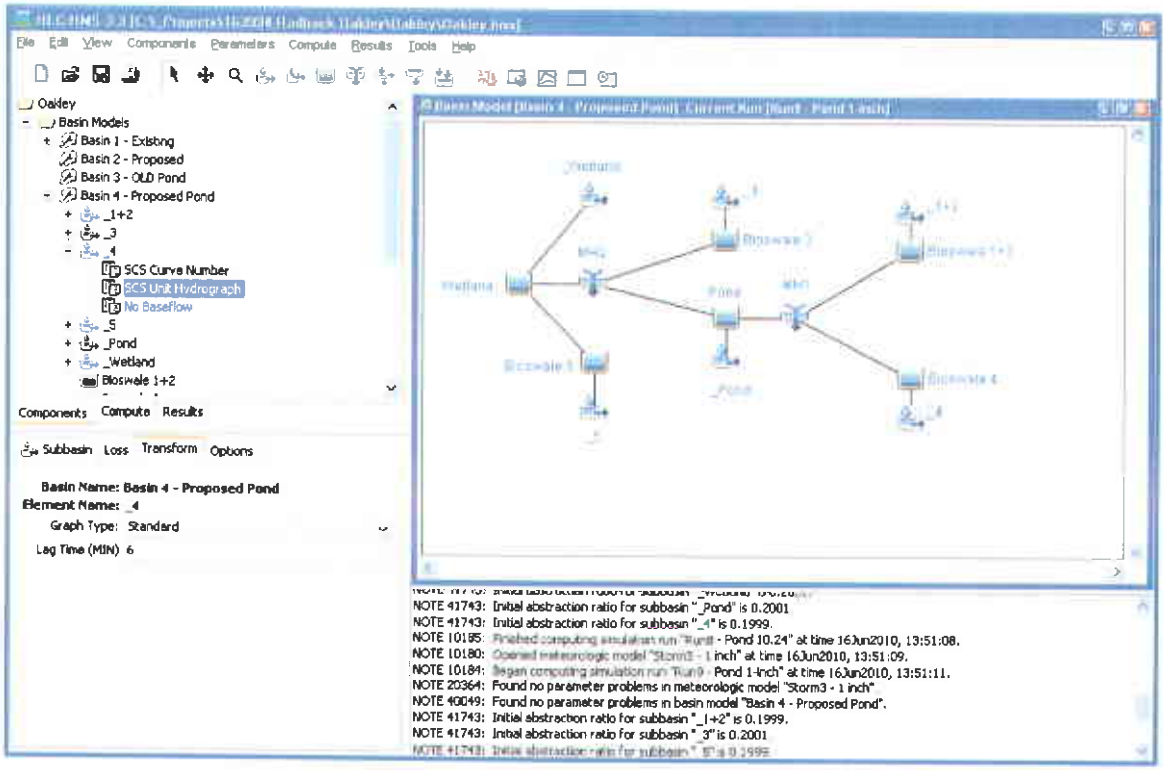

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT)
Area (AC)
11.0 0.01
12.0 0.03
13.0 0.06
14.0 0.09
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

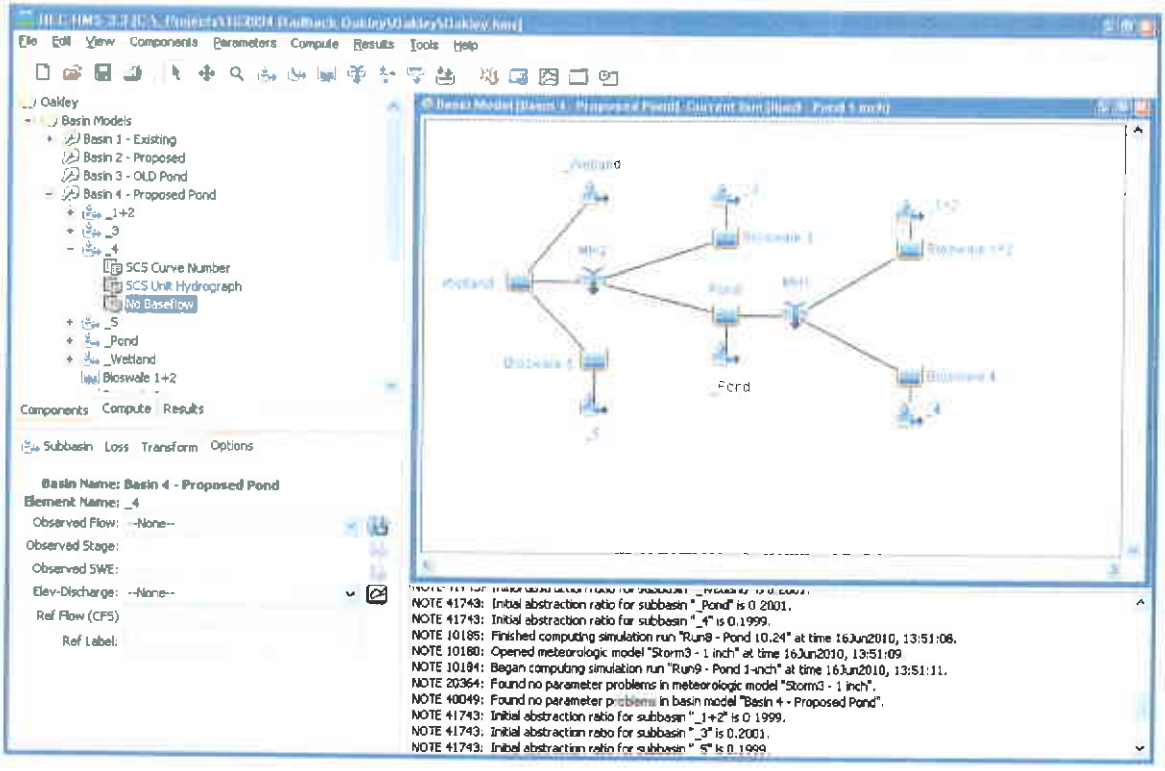

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
BioswaleS
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
13.0 0.00
13.1 0.62
13.2 1.74
13.3 3.20
13.4 4.93
13.5 6.88
13.6 9.05
13.7 11.40
13.8 13.93
13.9 16.62
14.0 19.47
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

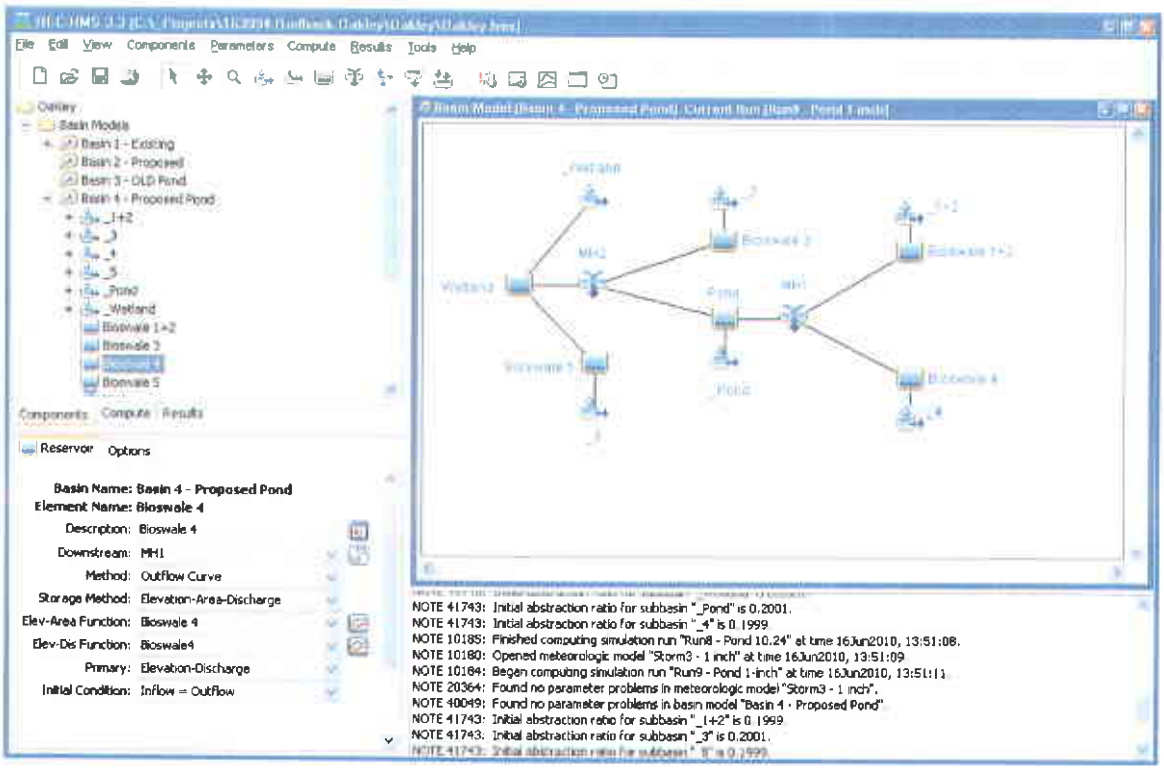
HEC-HMS Input – Bioswale 4

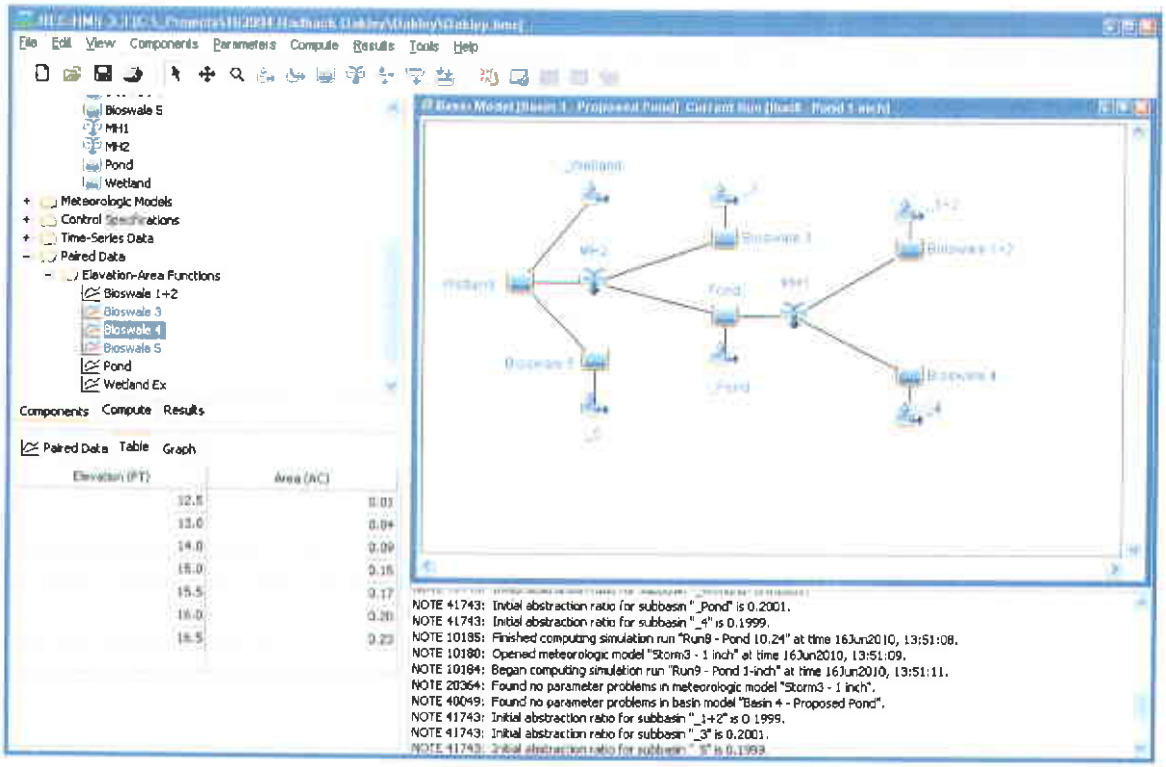


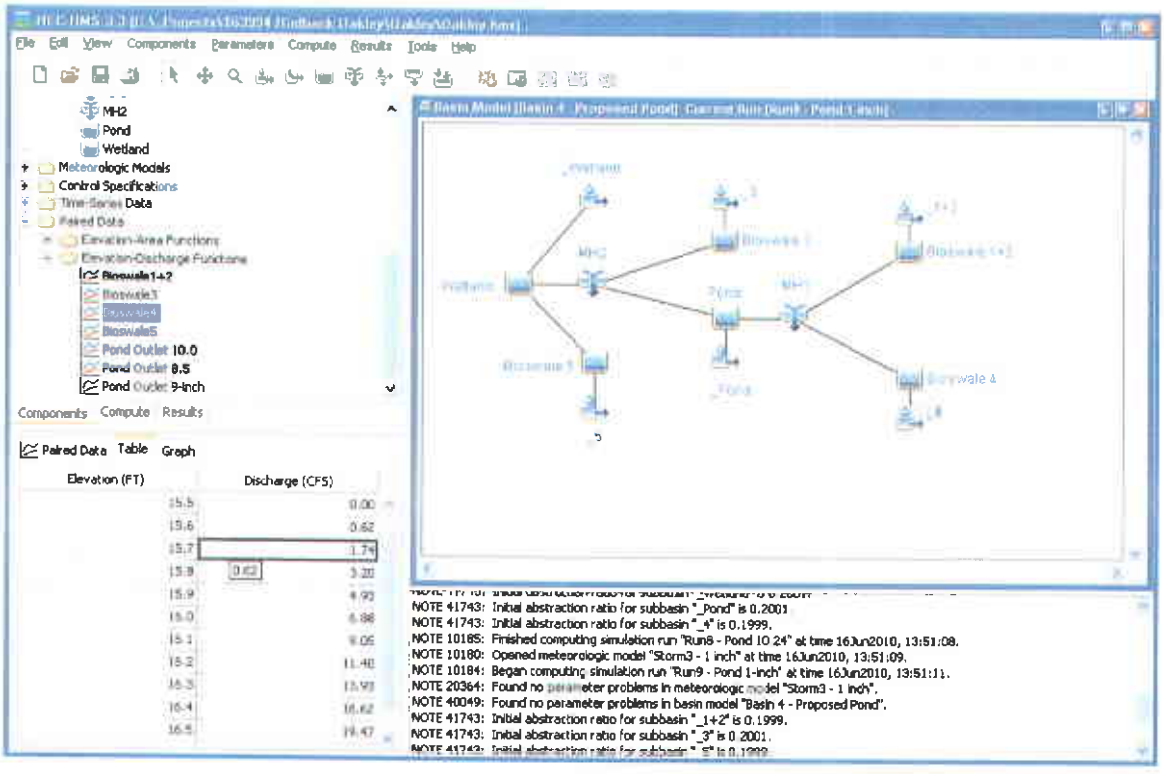



File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_5
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _4
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch"
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

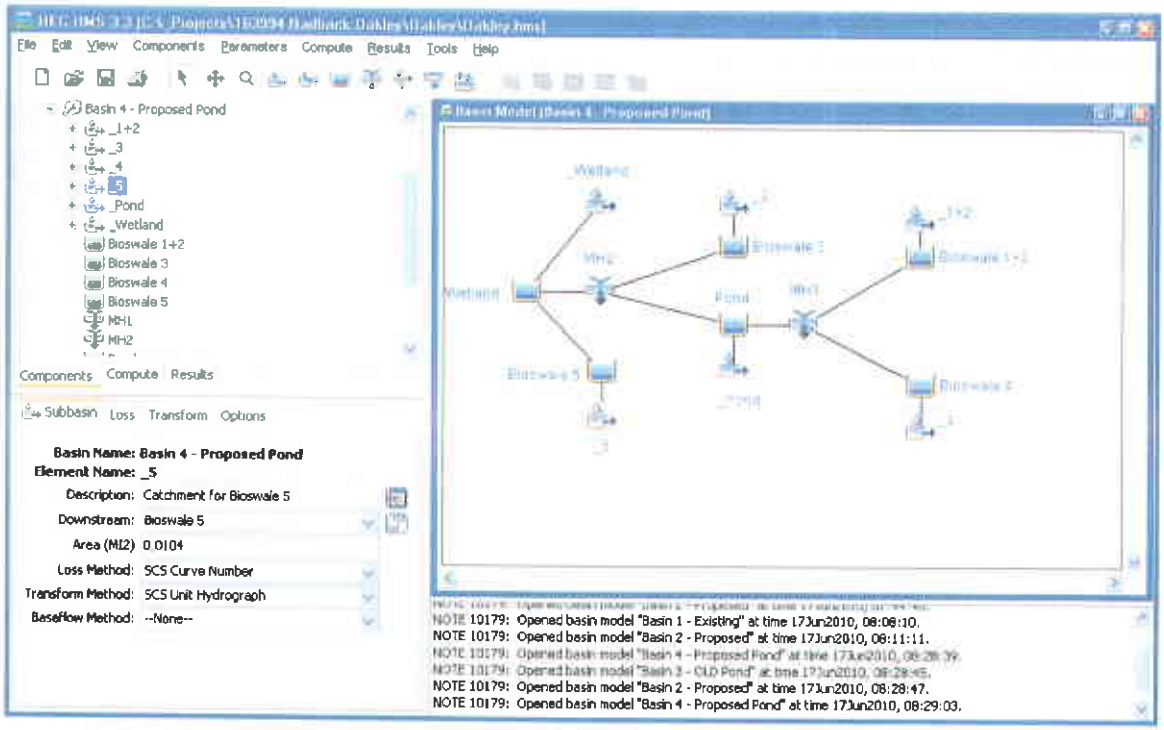

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_5
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _4
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

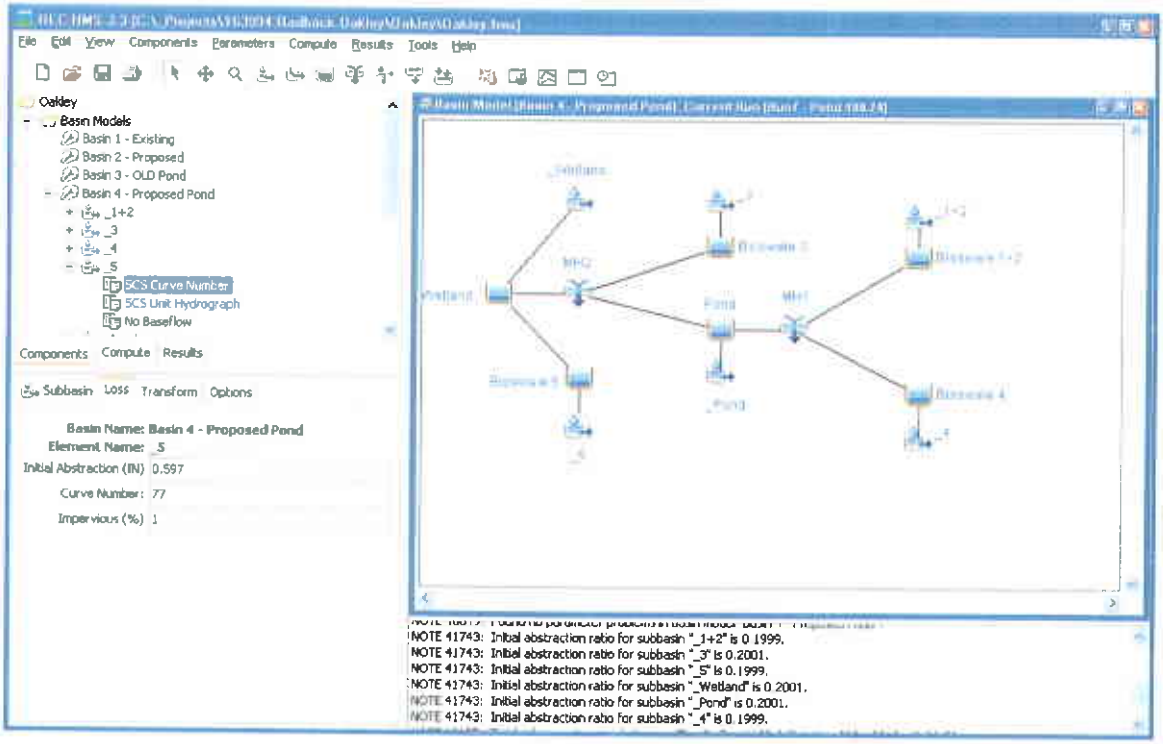

File Edit View Components Parameters Compute Results Tools Help
Overlay
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 4
Description: Bioswale 4
Downstream: MH1
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 4
Elev-Dis Function: Bioswale4
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

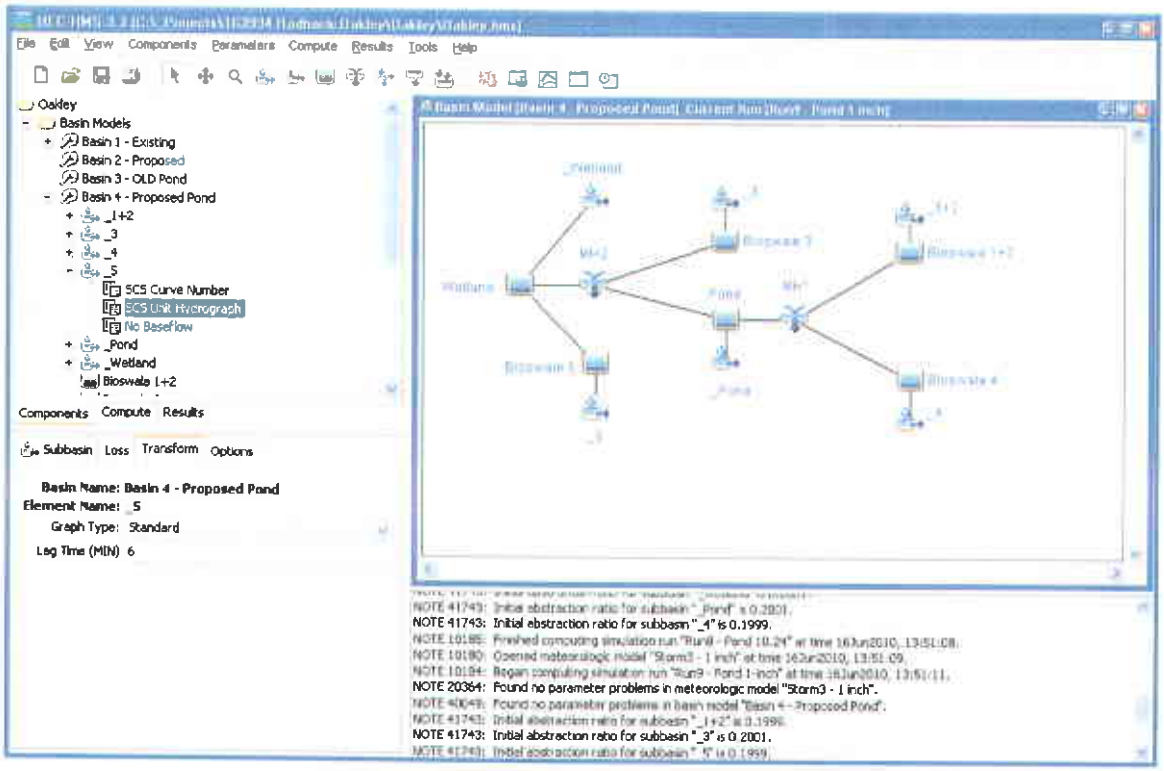

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
12.5 0.03
13.0 0.04
14.0 0.09
15.0 0.15
15.5 0.17
16.0 0.20
16.5 0.23
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

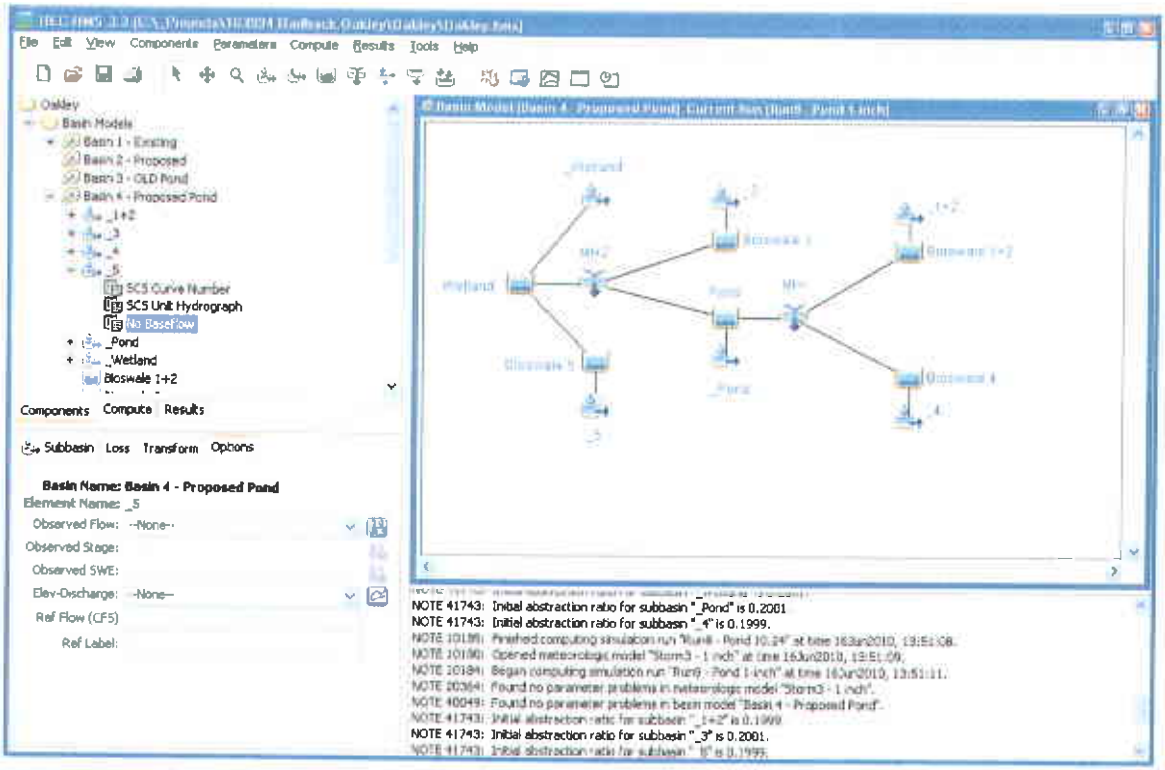

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT)
Discharge (CFS)
15.5 0.00
15.6 0.62
15.7 1.74
15.8 0.62 3.20
15.9 4.93
16.0 6.88
16.1 9.05
16.2 11.40
16.3 13.93
16.4 16.62
16.5 19.47
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10 24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

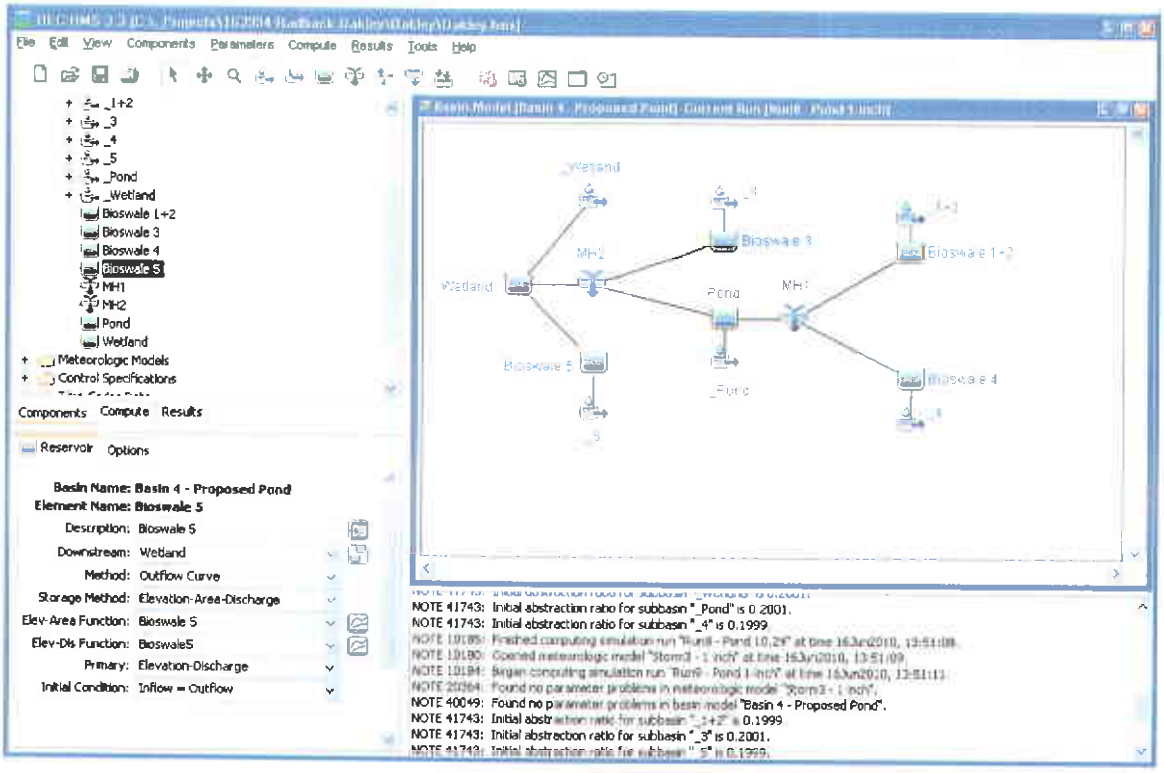
HEC-HMS Input – Bioswale 5

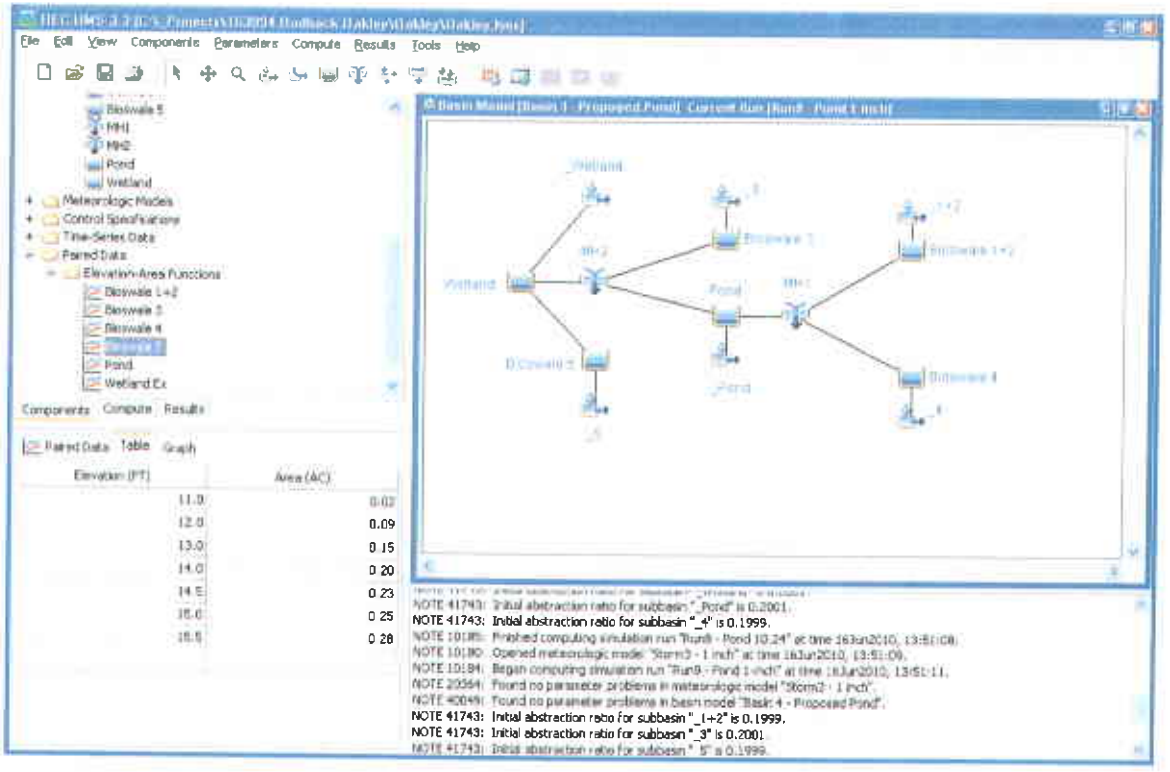


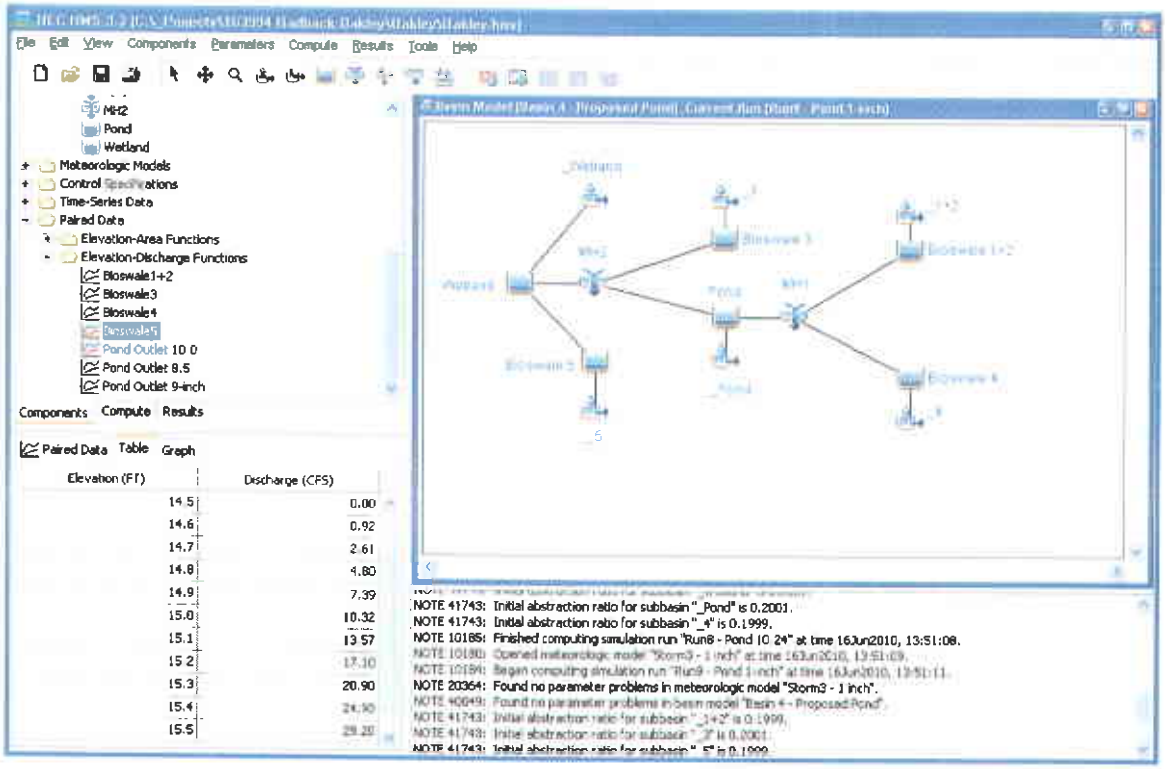



File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _5
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10186: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

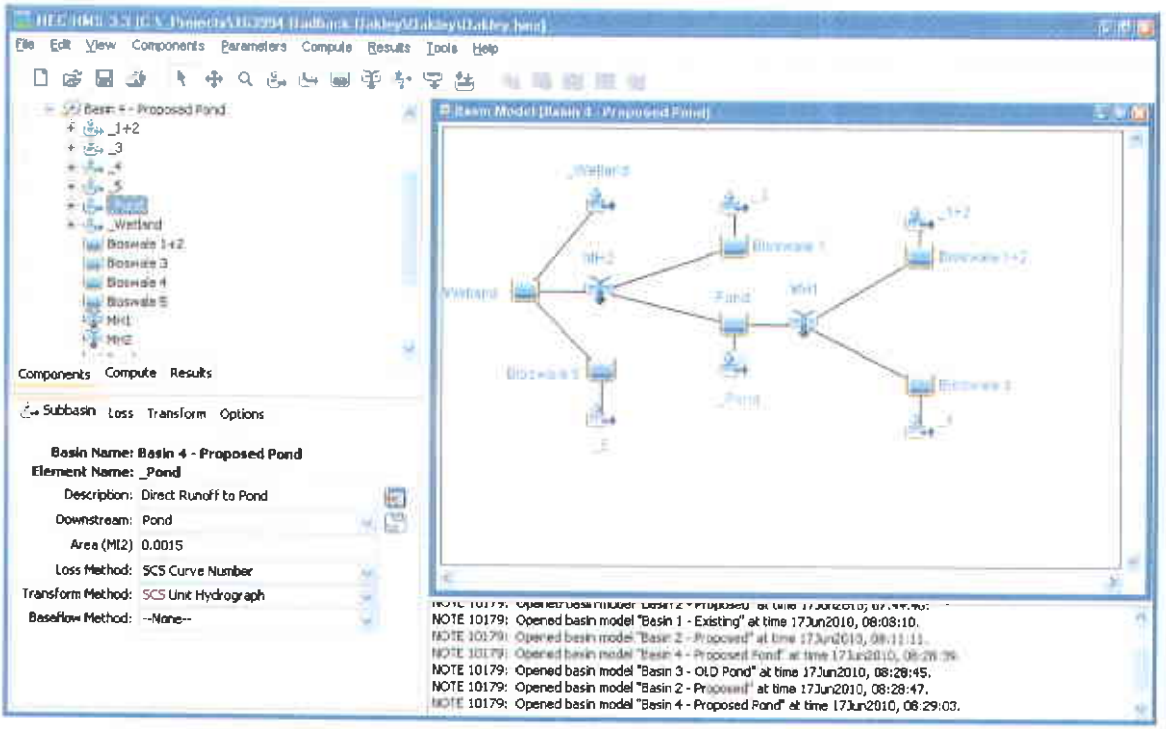

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _5
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10186: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

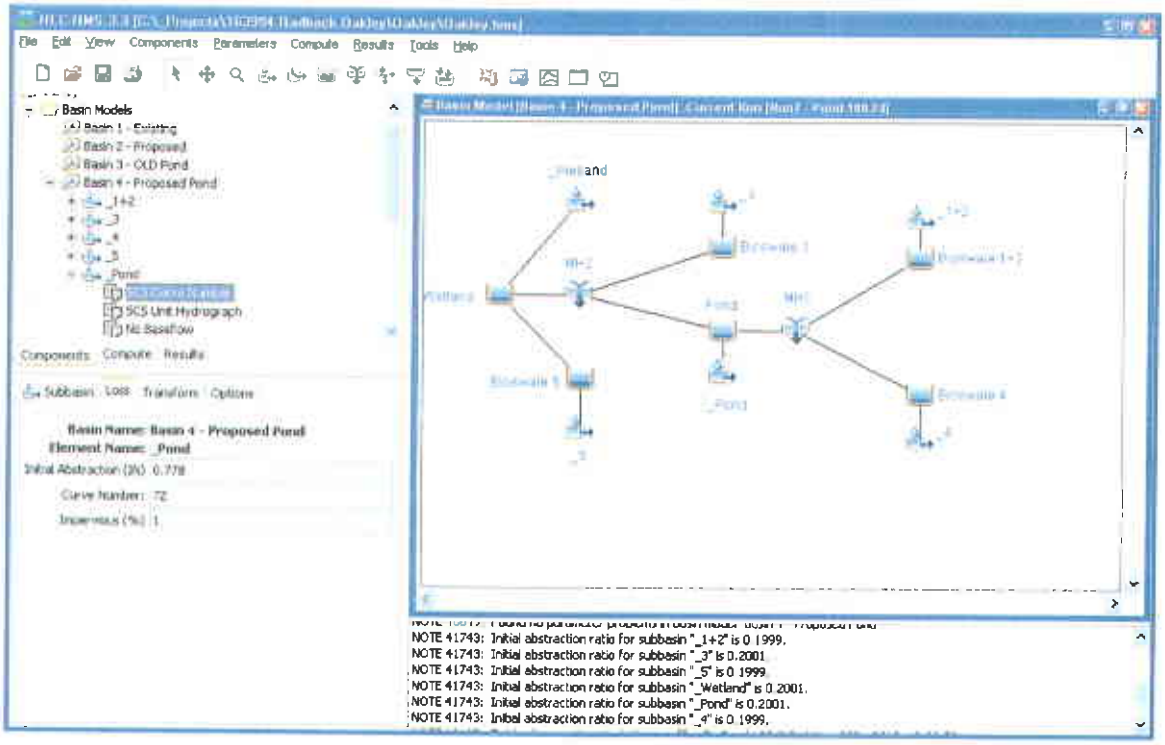

File Edit View Components Parameters Compute Results Tools Help
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 5
Description: Bioswale 5
Downstream: Wetland
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 5
Elev-Ds Function: Bioswale5
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
Wetland
MH2
Bioswale 3
Bioswale 1+2
Pond
MH1
Bioswale 5
Bioswale 4
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

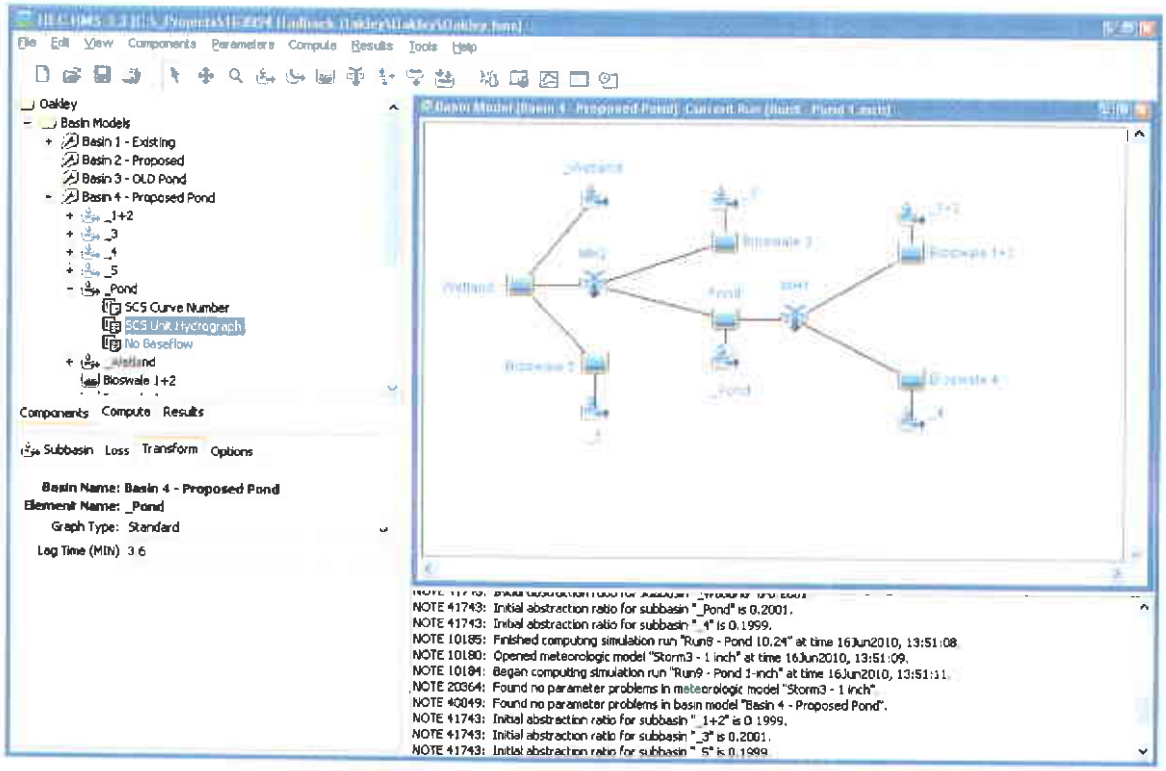

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
11.0 0.02
12.0 0.09
13.0 0.15
14.0 0.20
14.5 0.23
15.0 0.25
15.5 0.28
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

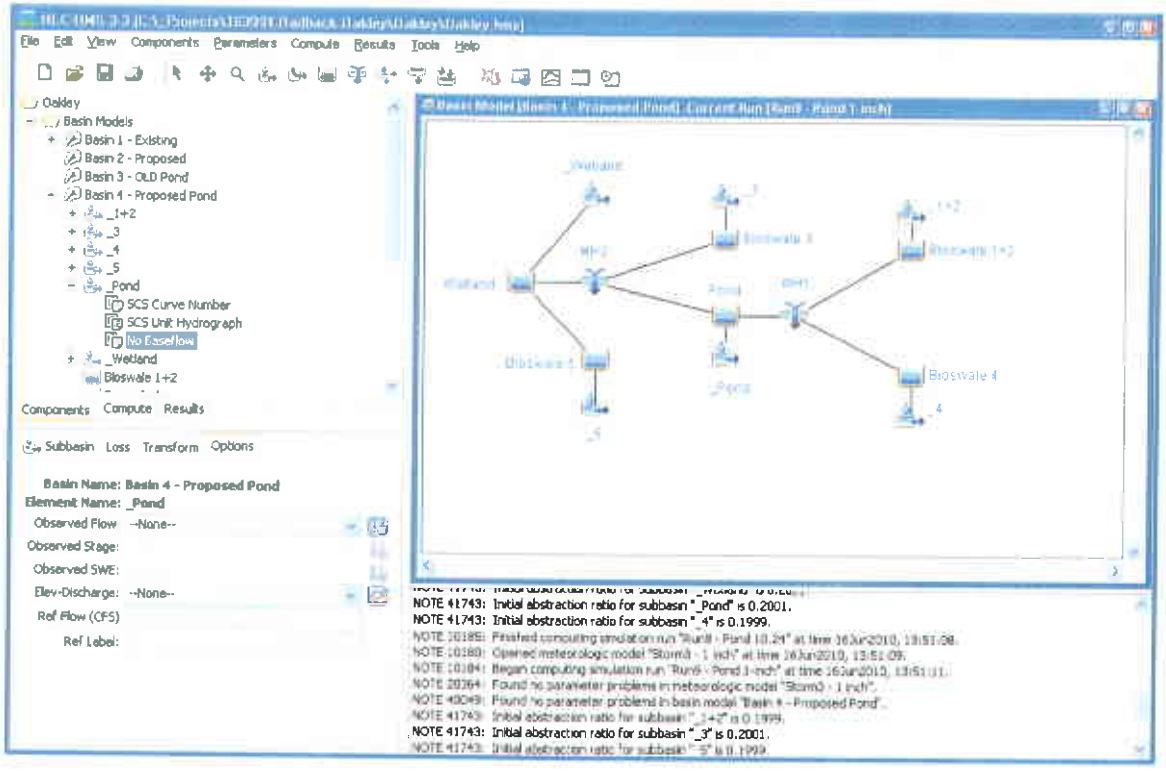

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (Ft)
Discharge (CFS)
14.5 0.00
14.6 0.92
14.7 2.61
14.8 4.80
14.9 7.39
15.0 10.32
15.1 13.57
15.2 17.10
15.3 20.90
15.4 24.90
15.5 29.20
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10 24" at time 16Jun2010, 13:51:08.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".

HEC-HMS Input – Direct Runoff to Pond

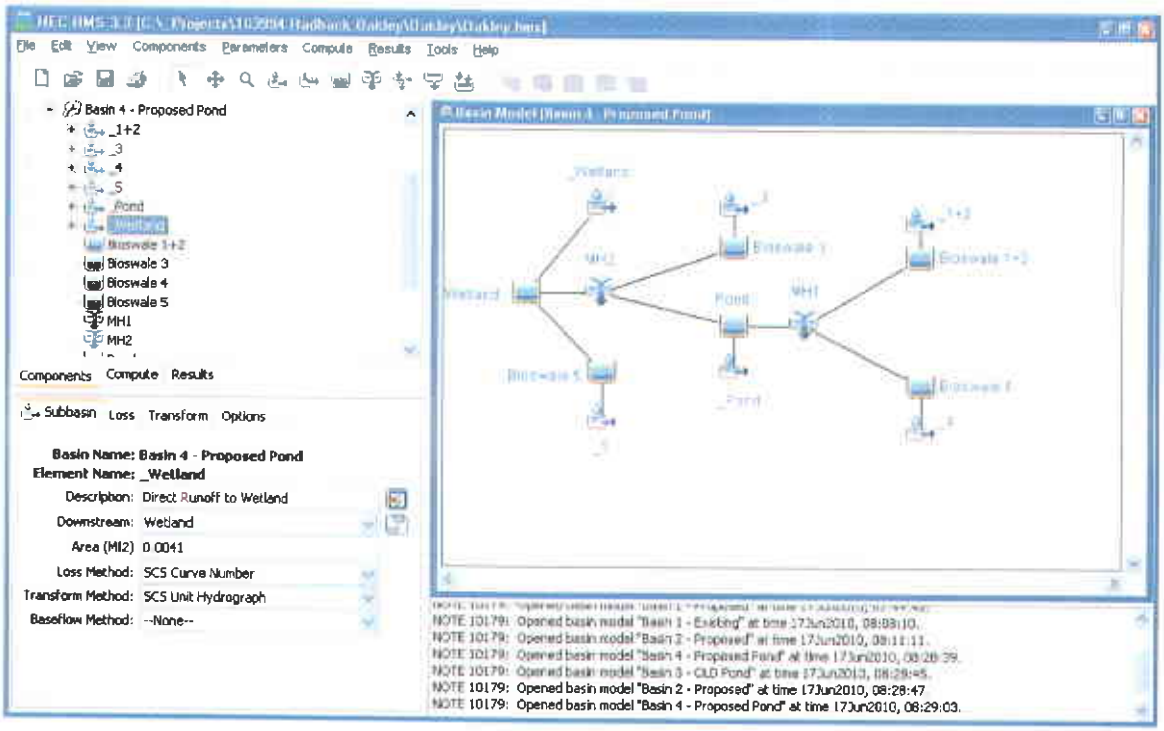


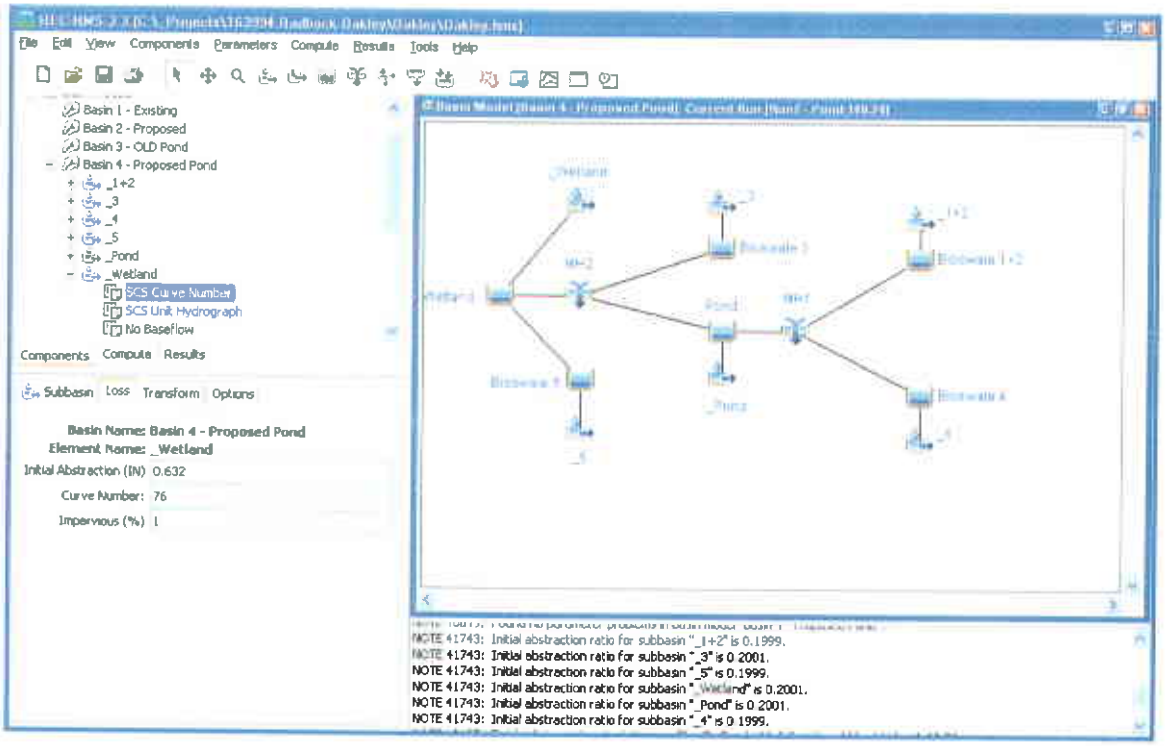


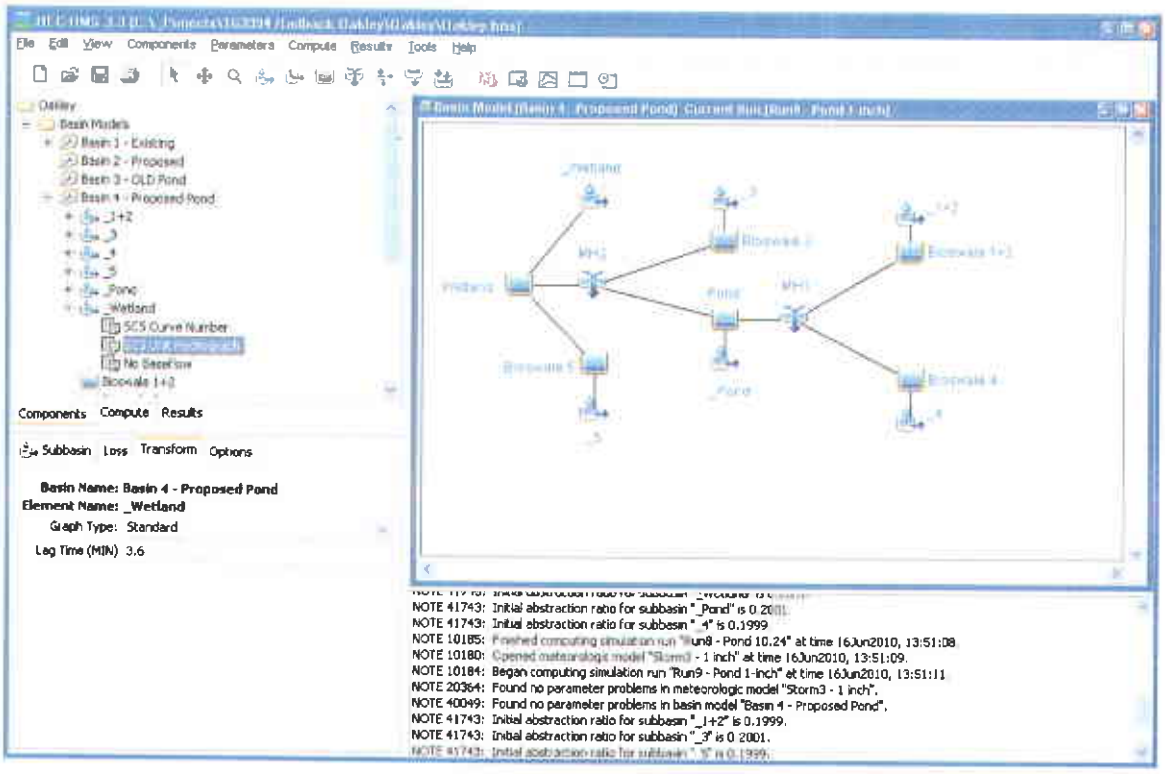

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Pond
Graph Type: Standard
Lag Time (MIN) 3.6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run9 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

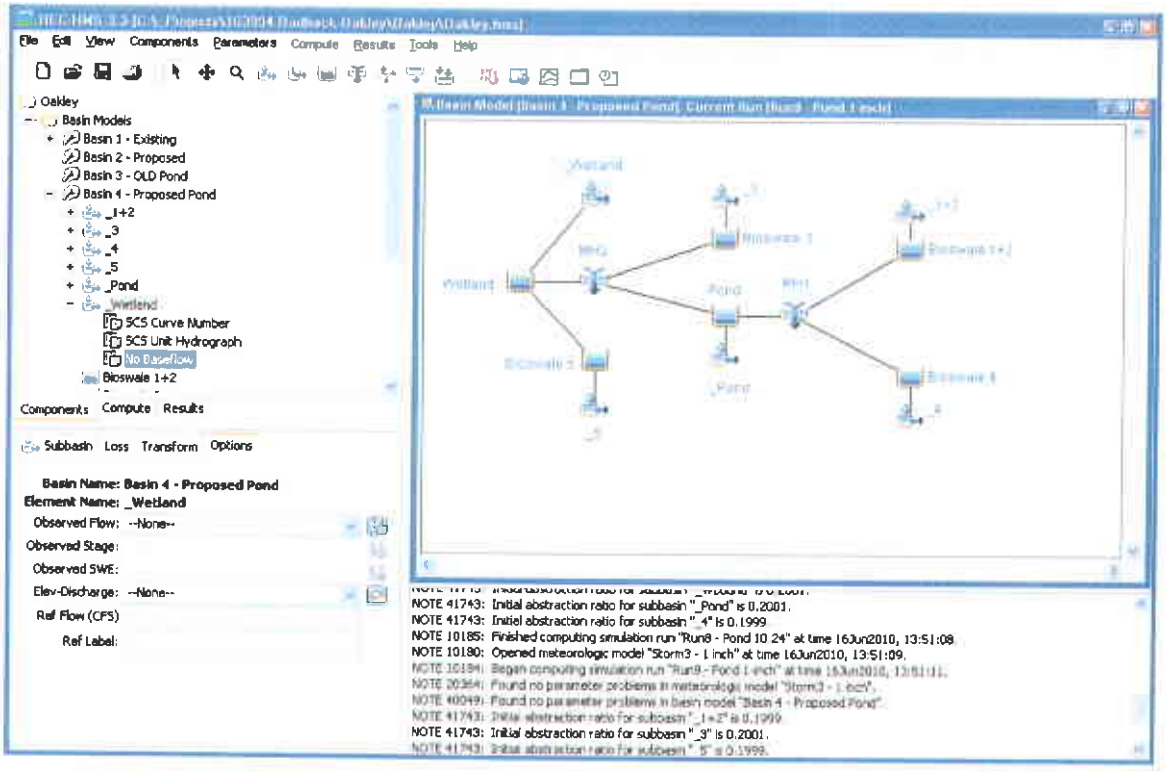

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Pond
Observed Flow --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

HEC-HMS Input – Direct Runoff to Wetland

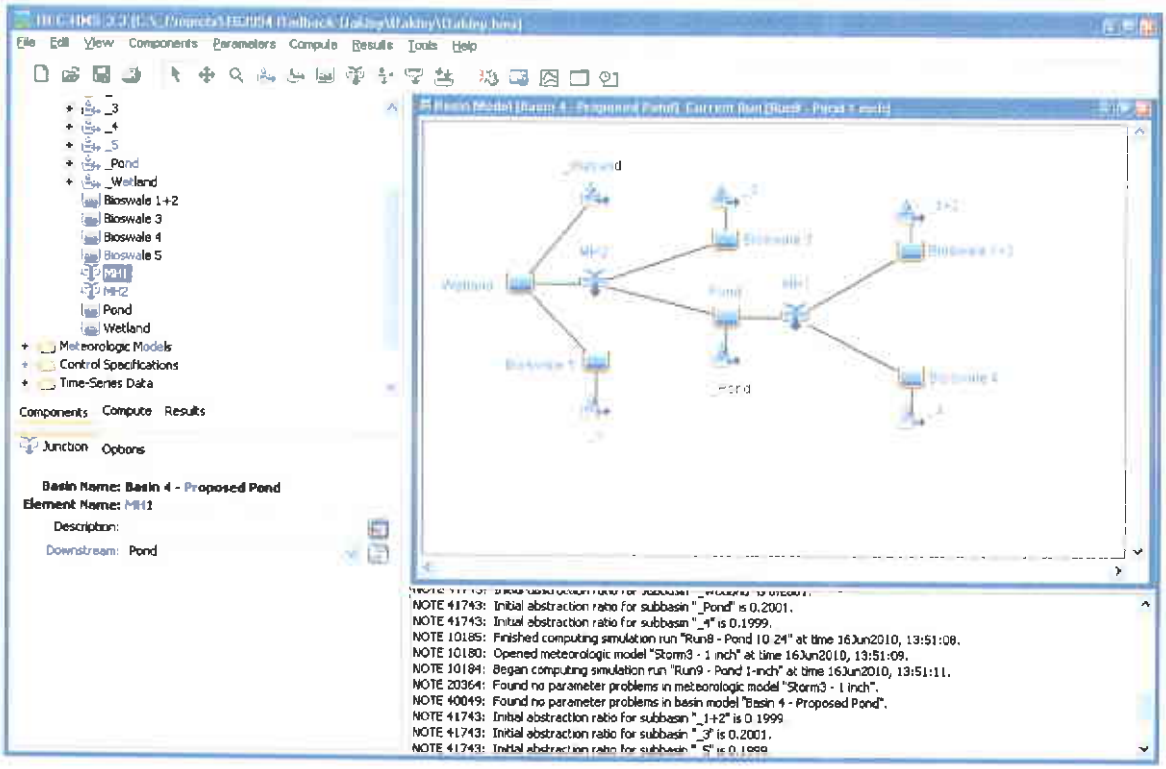




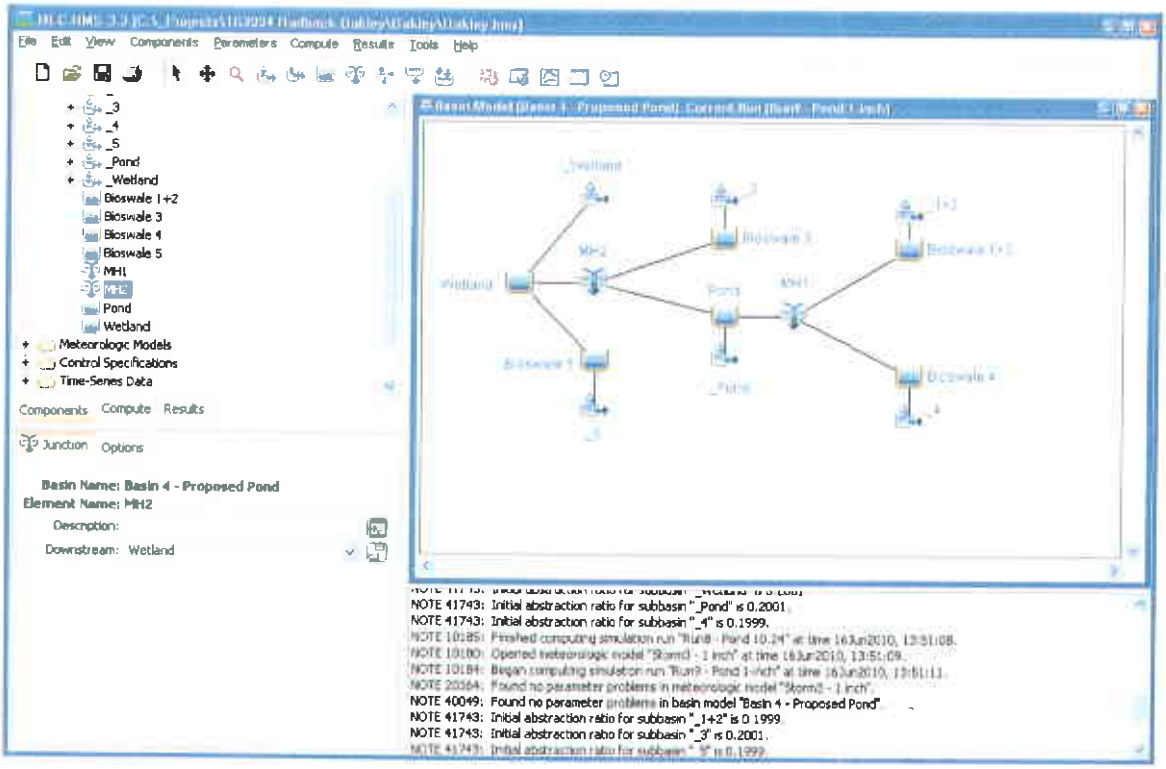

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Wetland
Graph Type: Standard
Lag Time (MIN) 3.6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.


File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Wetland
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

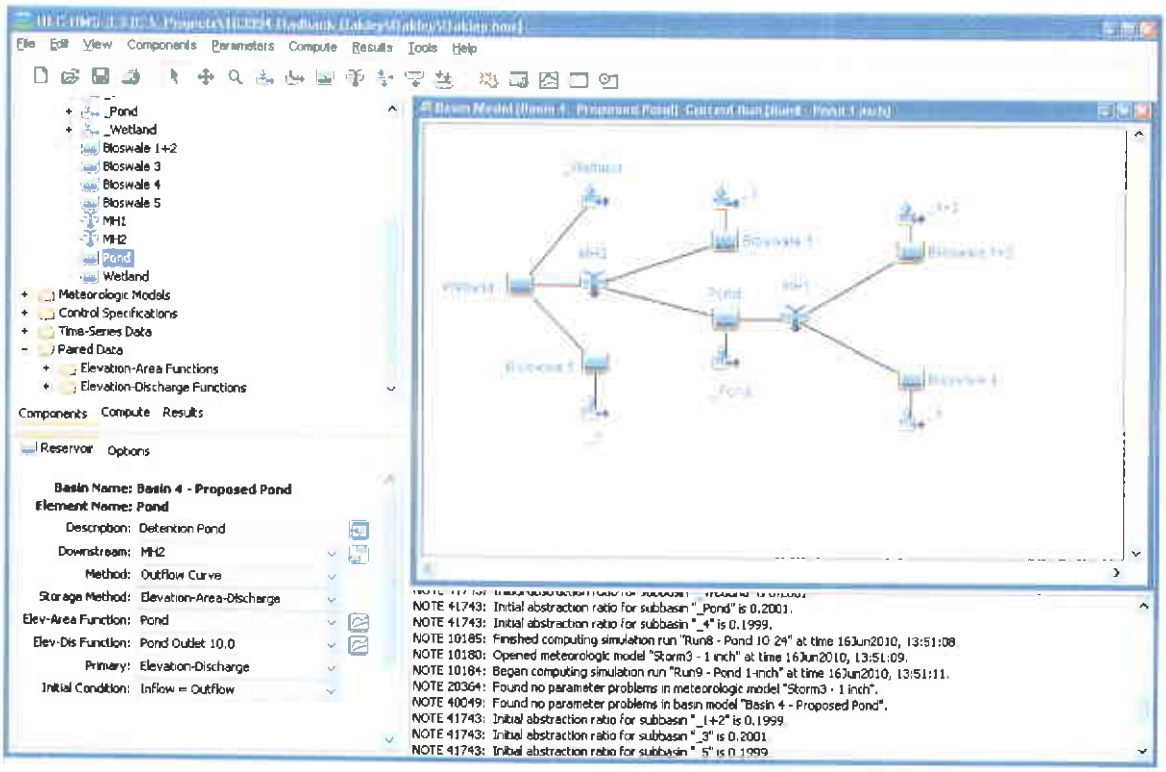
Junction connecting Bioswales 1+2 and 4 prior to pond

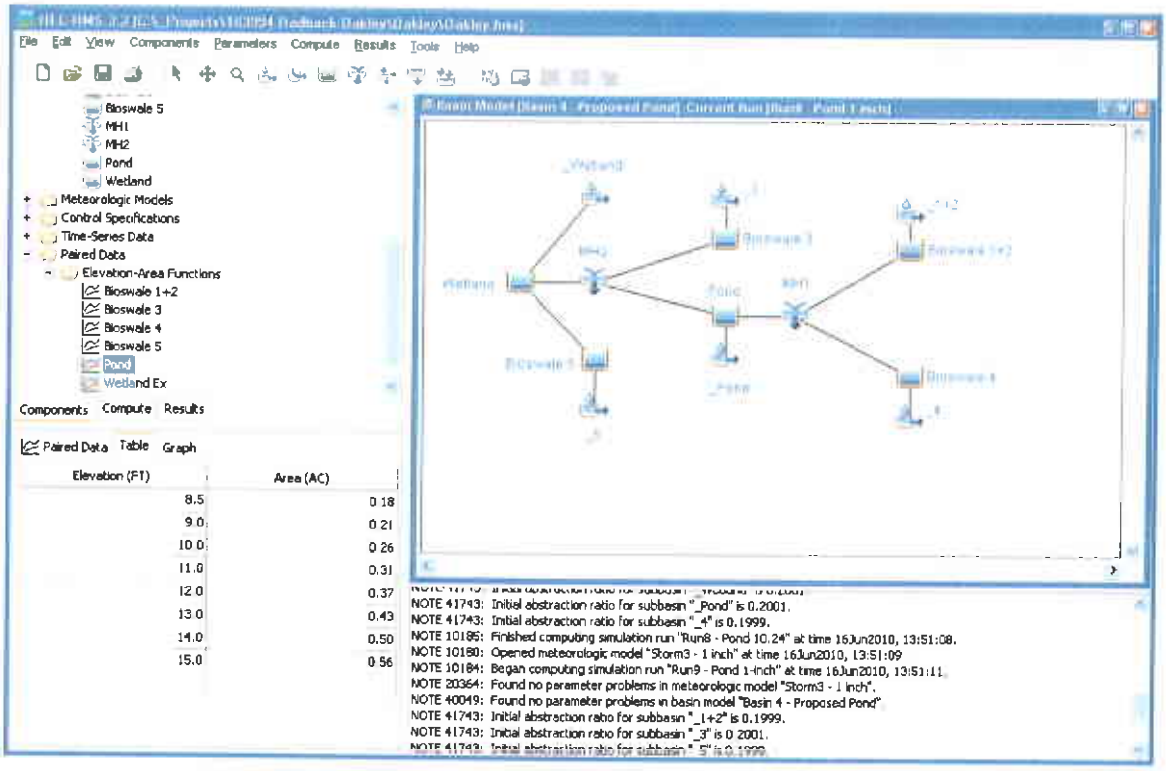


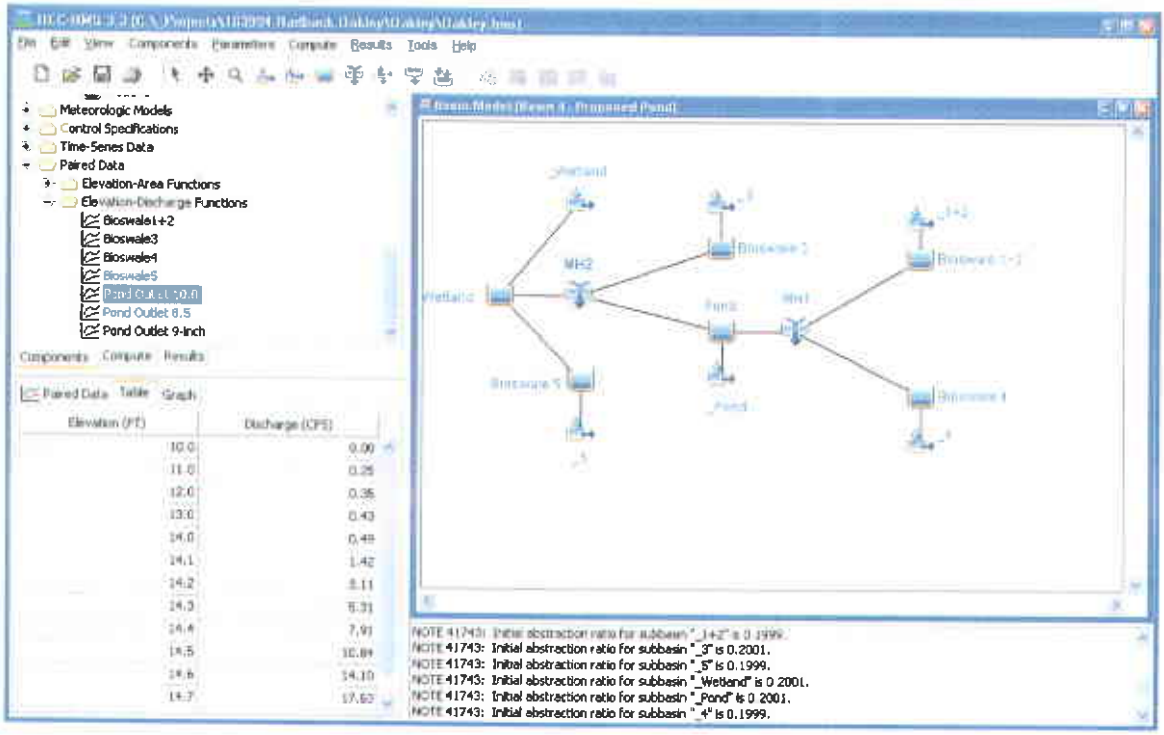
Junction connecting Pond outlet and Bioswale 3 prior to Wetland



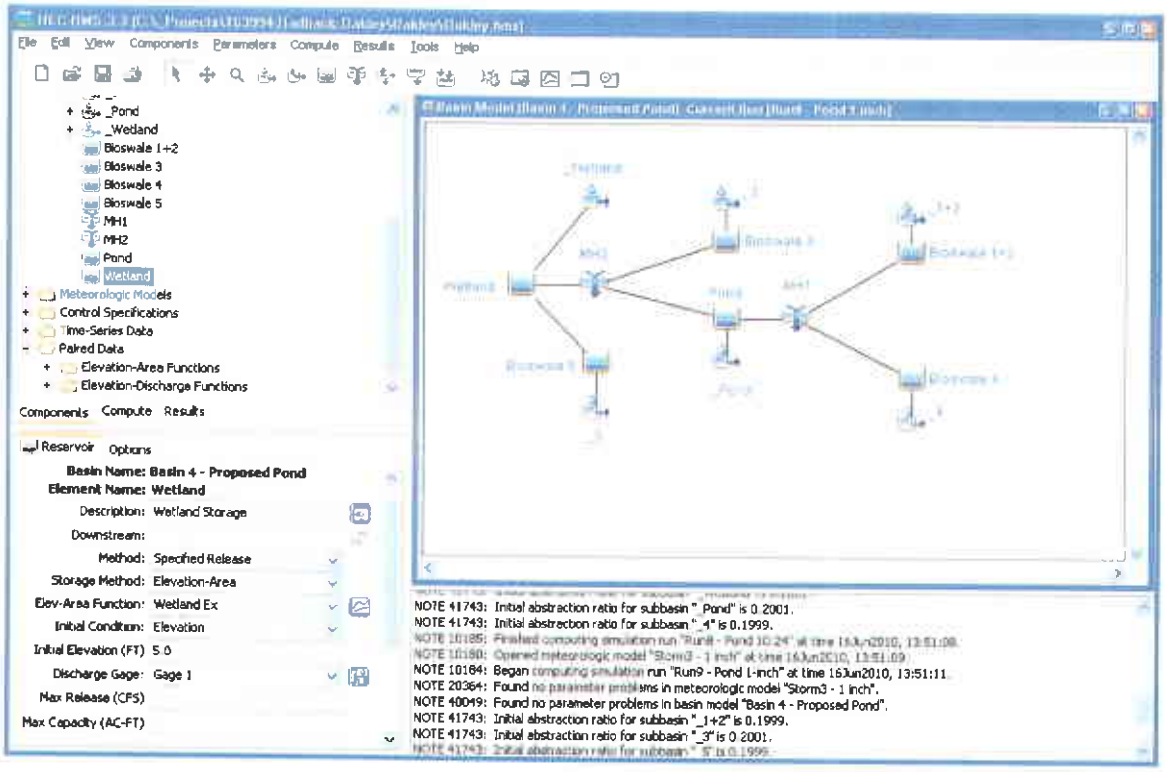
HEC-HMS Input – Pond Data

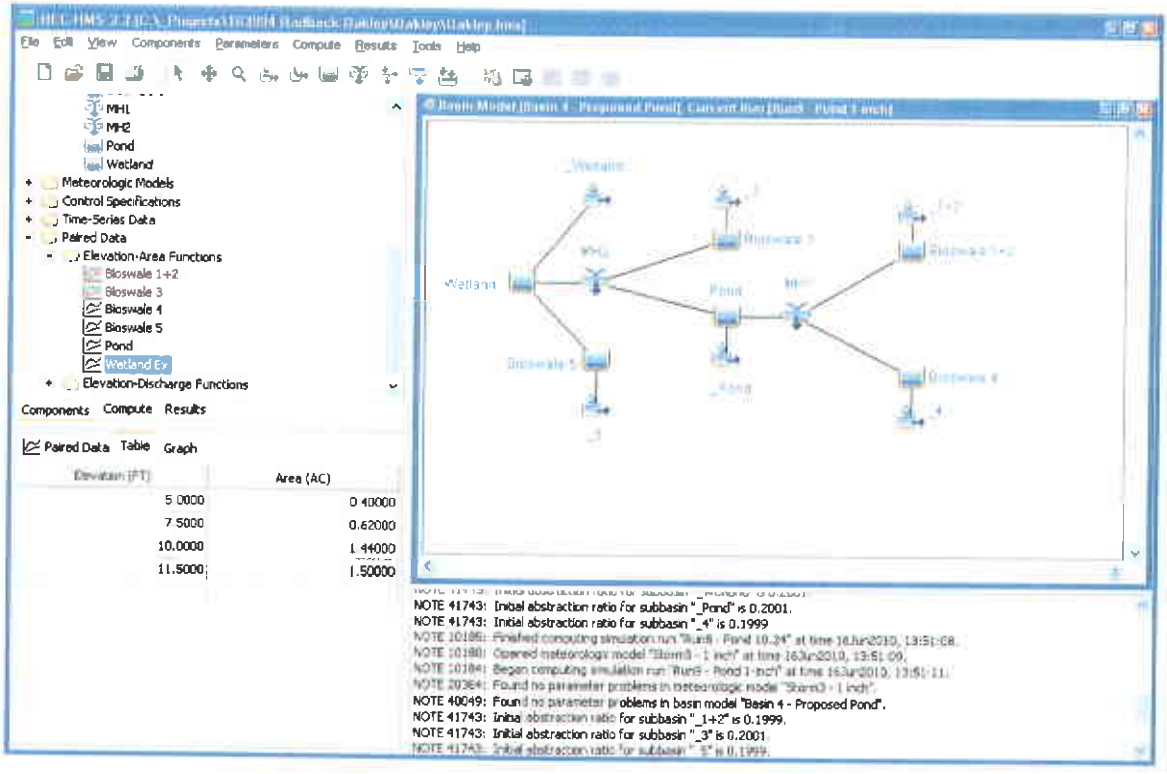


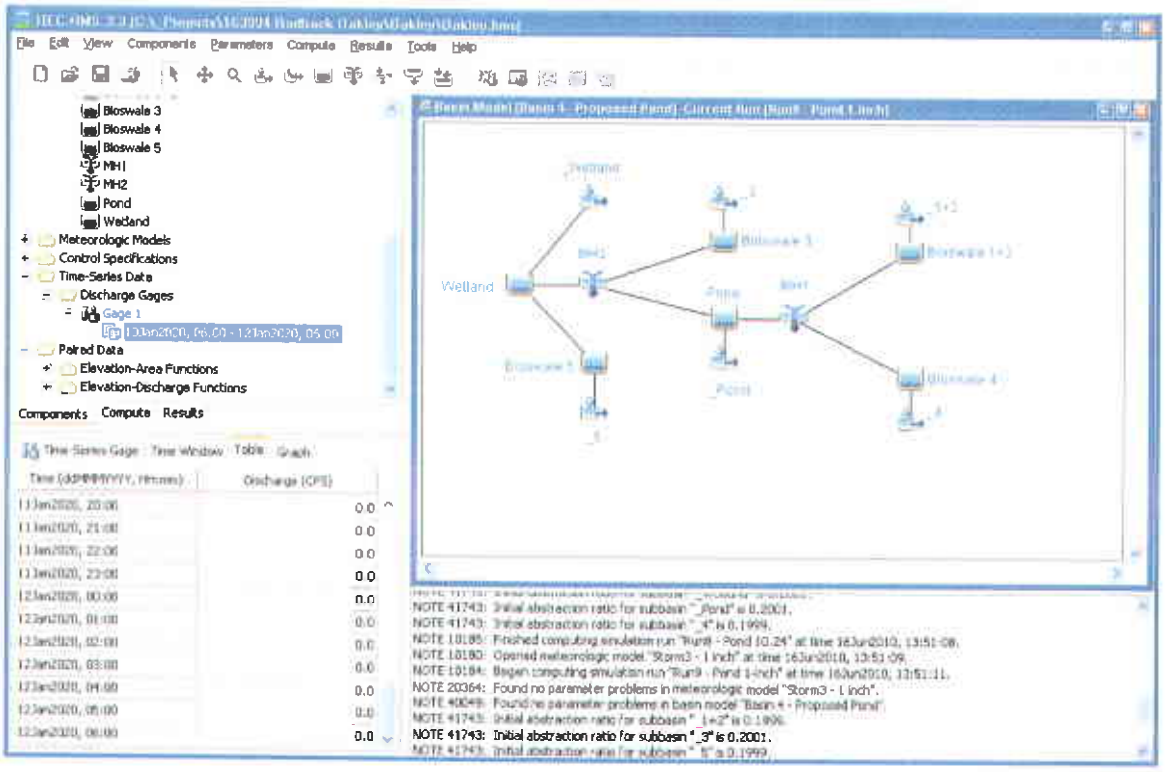



File Edit View Components Parameters Compute Results Tools Help
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 8.0
Pond Outlet 8.5
Pond Outlet 9-Inch
Components Compute Results
Paired Data Table Graph
Elevation (FT)
Discharge (CFS)
10.0 0.00
11.0 0.25
12.0 0.35
13.0 0.43
14.0 0.49
14.1 1.42
14.2 3.11
14.3 5.31
14.4 7.91
14.5 10.84
14.6 14.10
14.7 17.62
Basin Model (Base + Proposed Pond)
Wetland
MH2
Pond
MH1
Bioswale 5
Bioswale 4
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_5" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_Wetland" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.

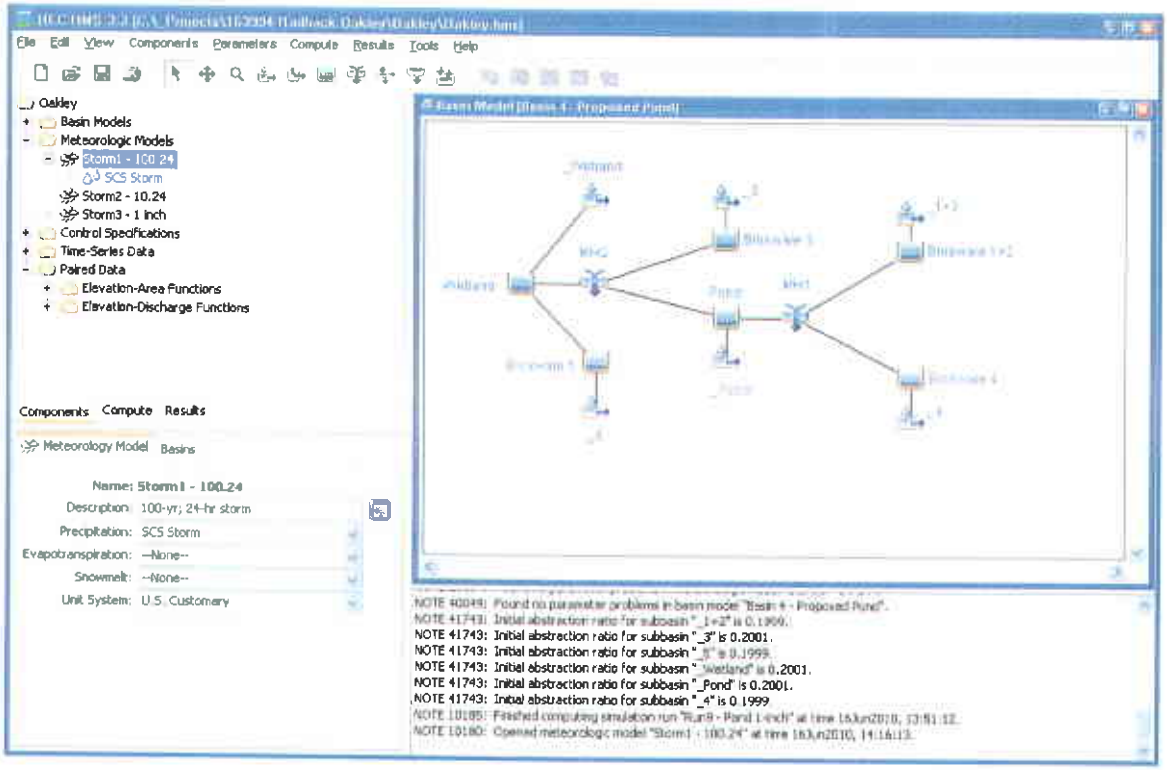
HEC-HMS Input – Wetland Data

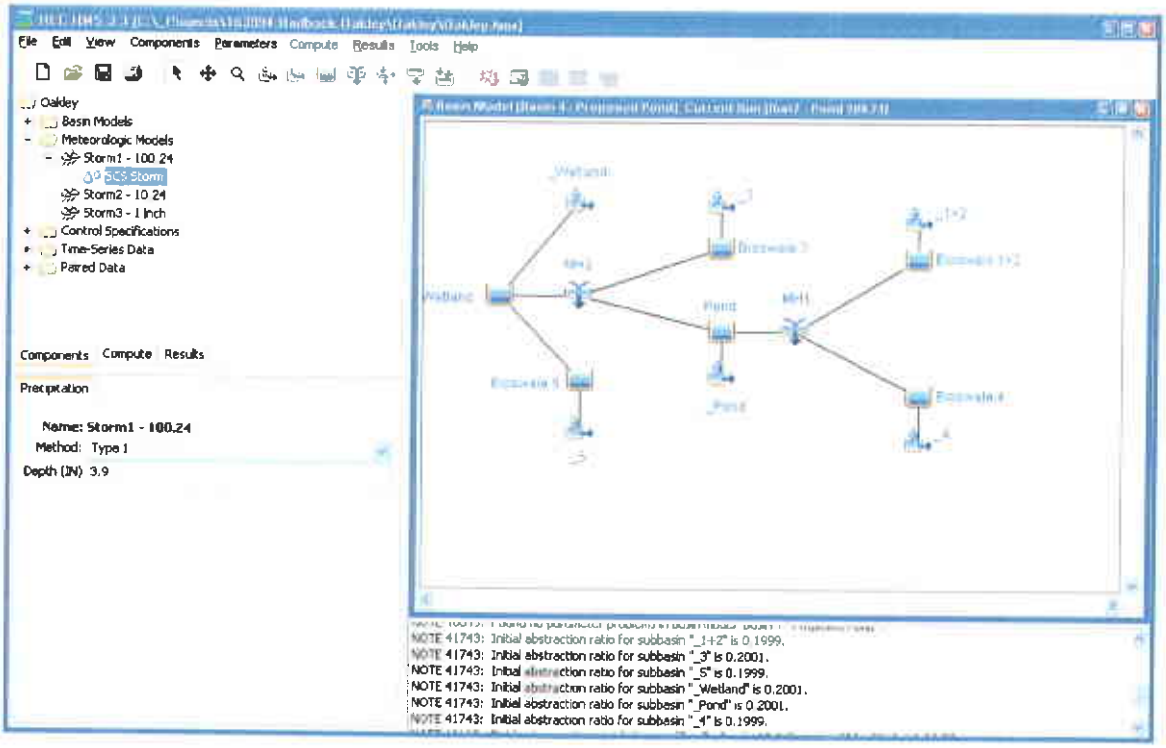




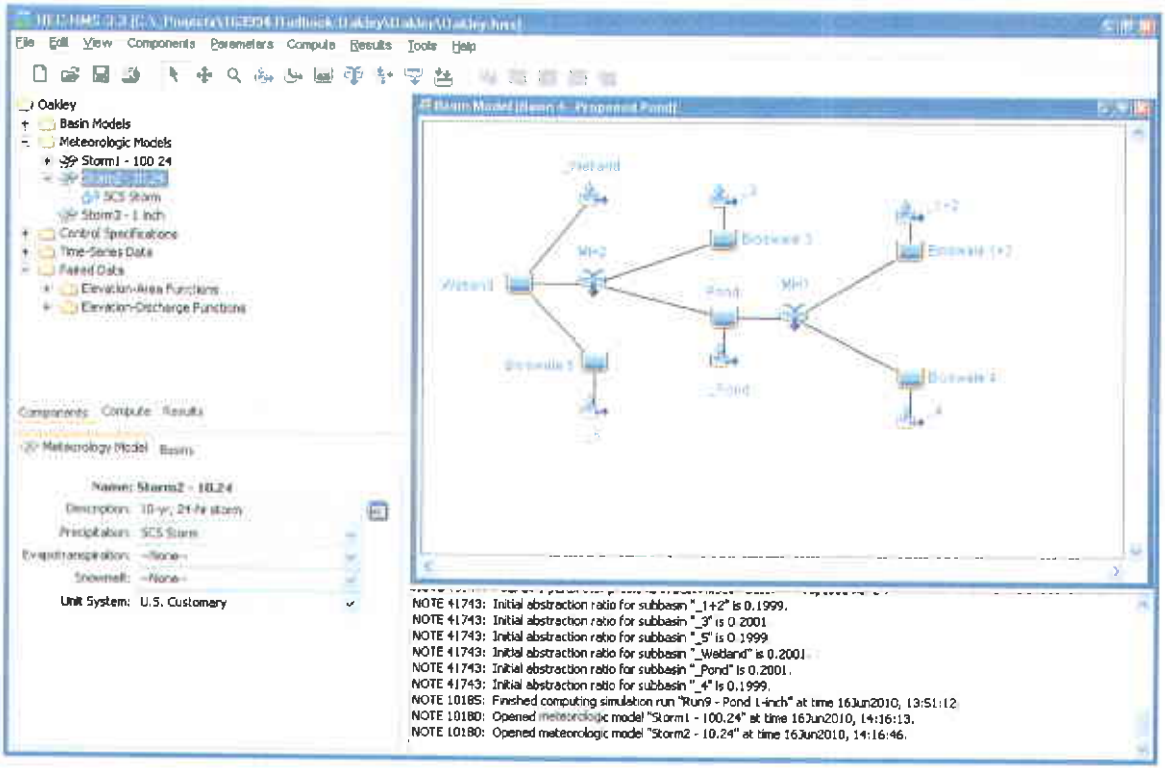

File Edit View Components Parameters Compute Results Tools Help
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Discharge Gages
Gage 1
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Components Compute Results
Wetland
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run1 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

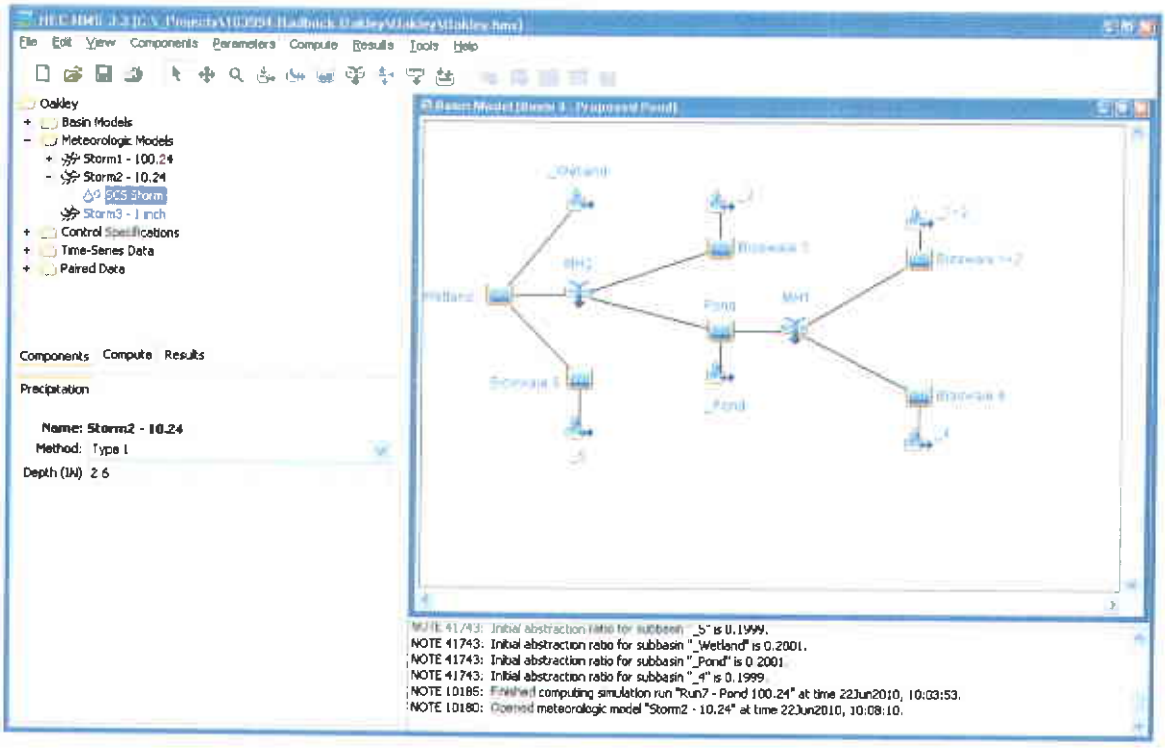
HEC-HMS Input – Meteorologic Model Storm1 – 100-year, 24-hour storm)



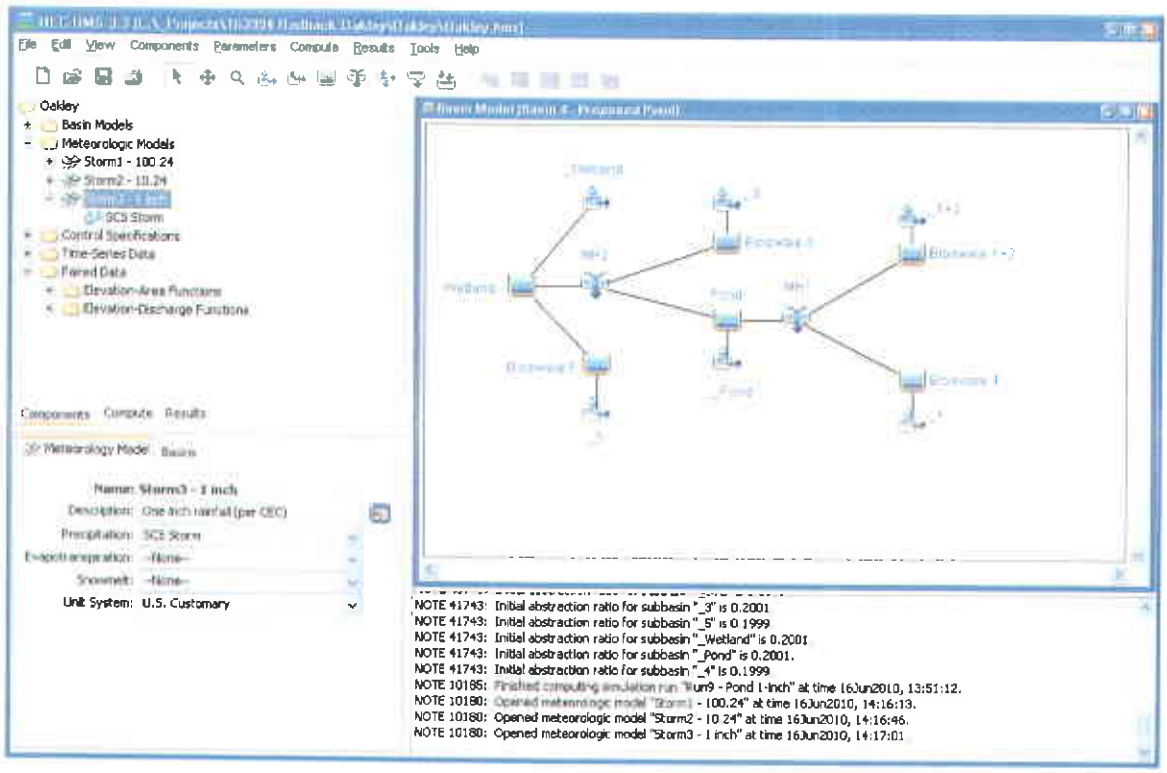


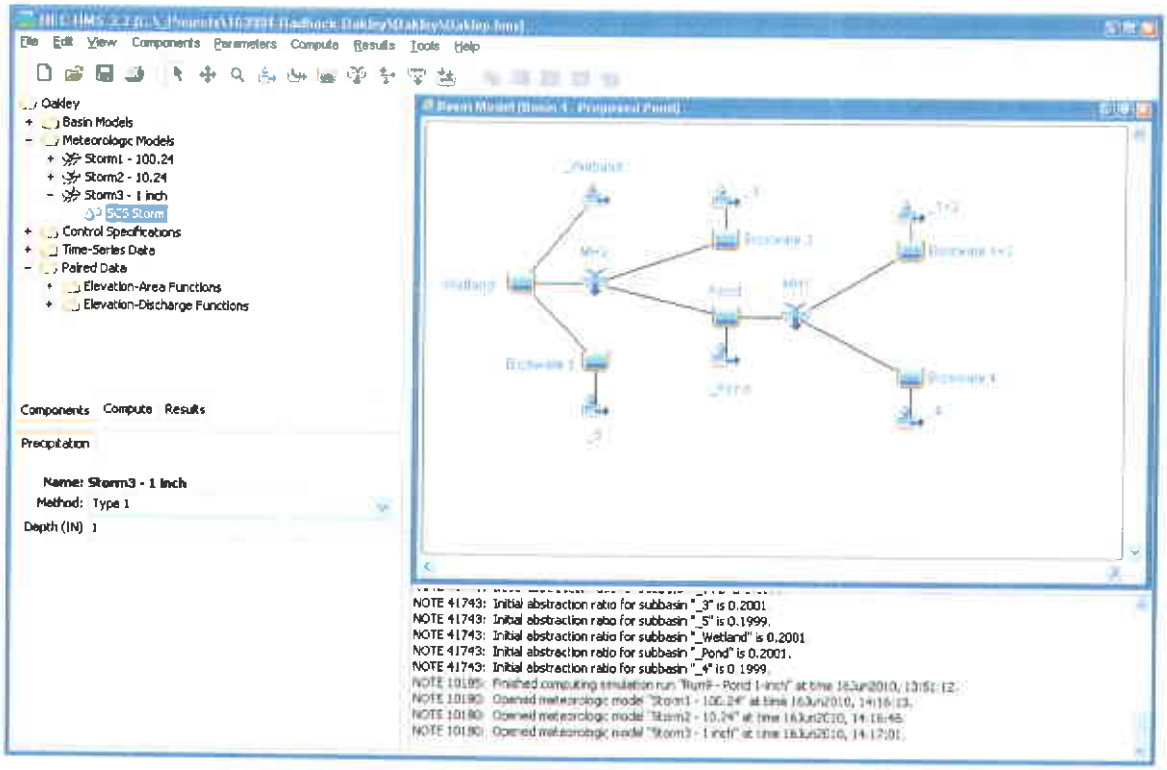
HEC-HMS Input – Meteorologic Model Storm2 – 10-year, 24-hour storm)



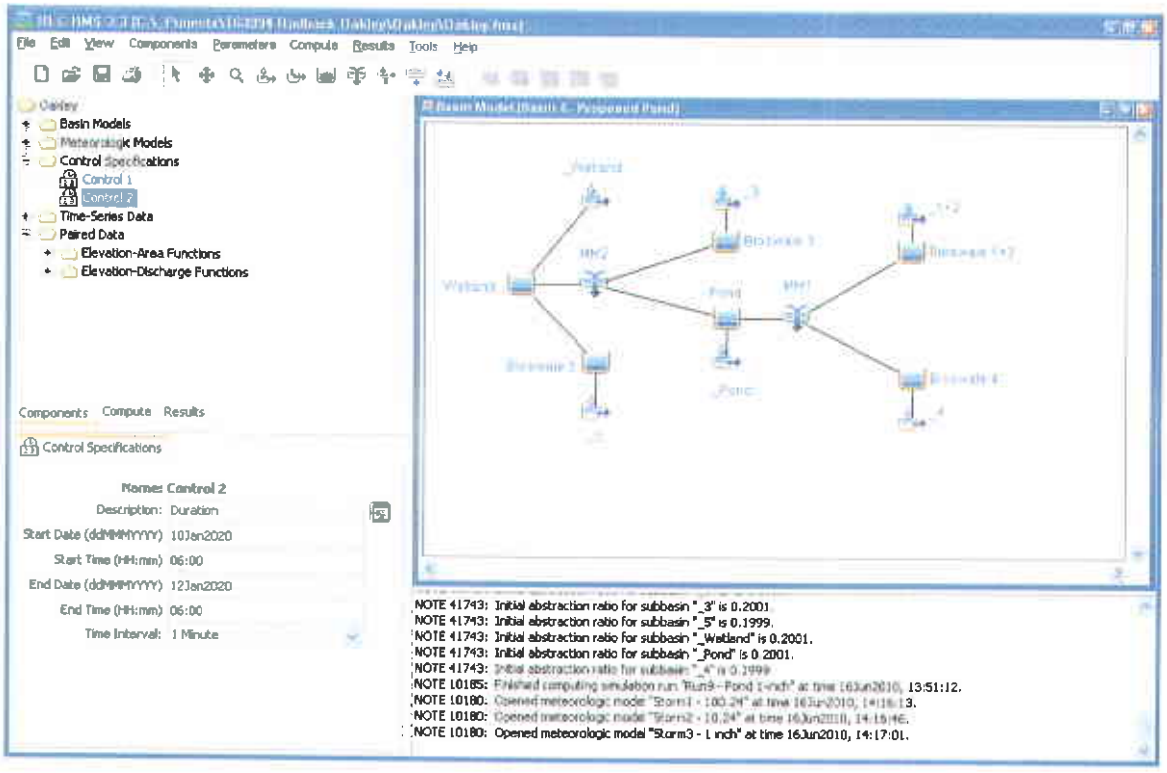


HEC-HMS Input – Meteorologic Model Storm3 – 1-inch rainfall)





HEC-HMS Input – Control Data



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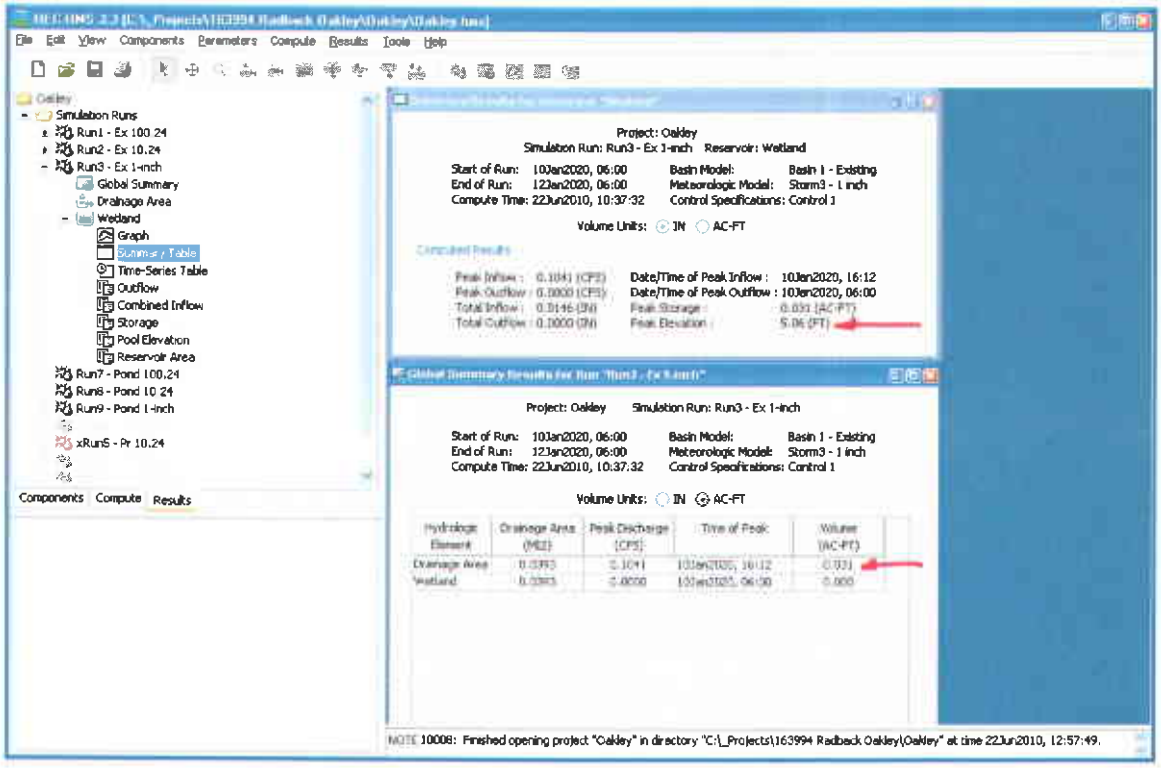
Attachment 2

HEC-HMS Output

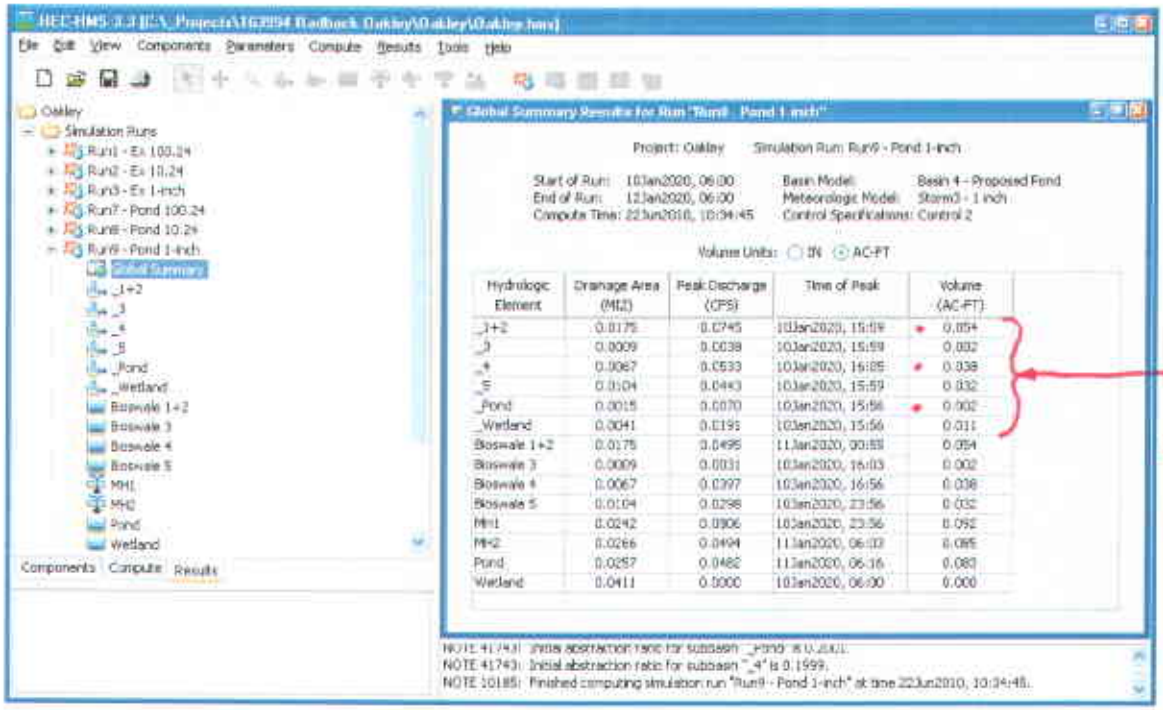
Description Key for HEC-HMS Input/Output Data

Hydrologic Element	Description
_1+2	Drainage area flowing to Bioswale 1+2
_3	Drainage area flowing to Bioswale 3
_4	Drainage area flowing to Bioswale 4
_5	Drainage area flowing to Bioswale 5
_Pond	Drainage area flowing directly to Pond
_Wetland	Drainage area flowing directly to Wetland
Bioswale 1+2	Flow from Bioswale 1+2 outlet (to MH1)
Bioswale 3	Flow from Bioswale 3 outlet (to MH2)
Bioswale 4	Flow from Bioswale 4 outlet (to MH1)
Bioswale 5	Flow from Bioswale 5 outlet (to Wetland)
MH1	Flow from Bioswales 1+2 and 4 (to Pond)
MH2	Flow from Pond and Bioswale 3 (to Wetland)
Pond	Flow from Pond Outlet (to MH2)
Wetland	Flow from Wetland (set to 0.0)

HEC-HMS Output – Pre-Construction 1-Inch Rainfall Runoff Volume



HEC-HMS Output – Post-Construction 1-Inch Rainfall Runoff Volume



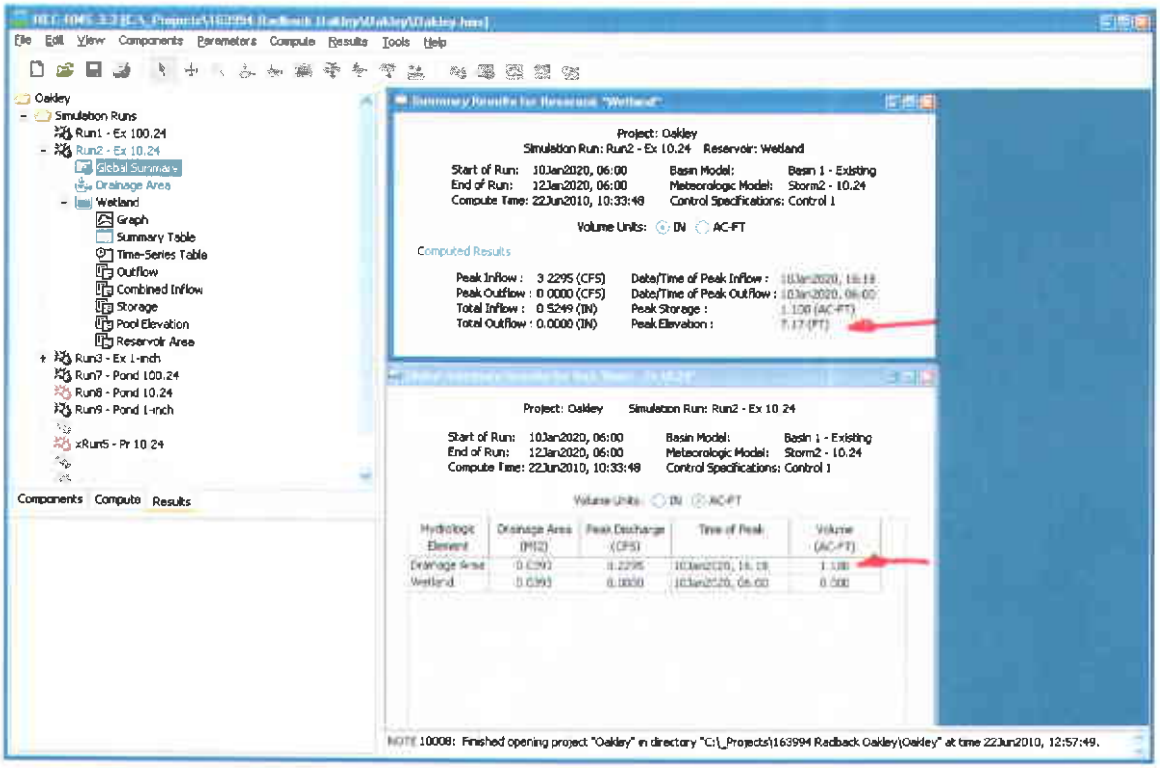
0.14 ac-ft total

- 0.09 ac-ft to pond

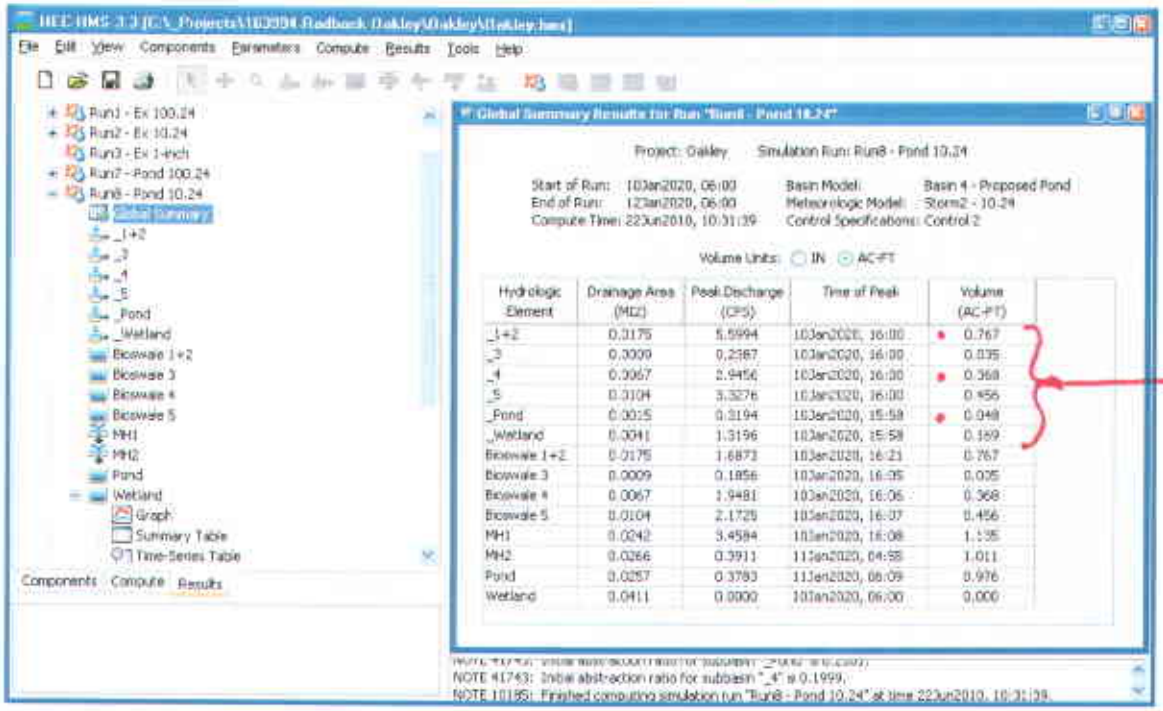
0.09 ac-ft < 0.33 ac-ft pond retention

∴ total to wetland = 0.14 - 0.09 = 0.05 ac-ft

HEC-HMS Output – Pre-Construction 10-Year, 24 Hour Runoff Volume



HEC-HMS Output – Post-Construction 10-Year, 24 Hour Runoff Volume



1.84 ac-ft total

- 1.18 ac-ft to pond

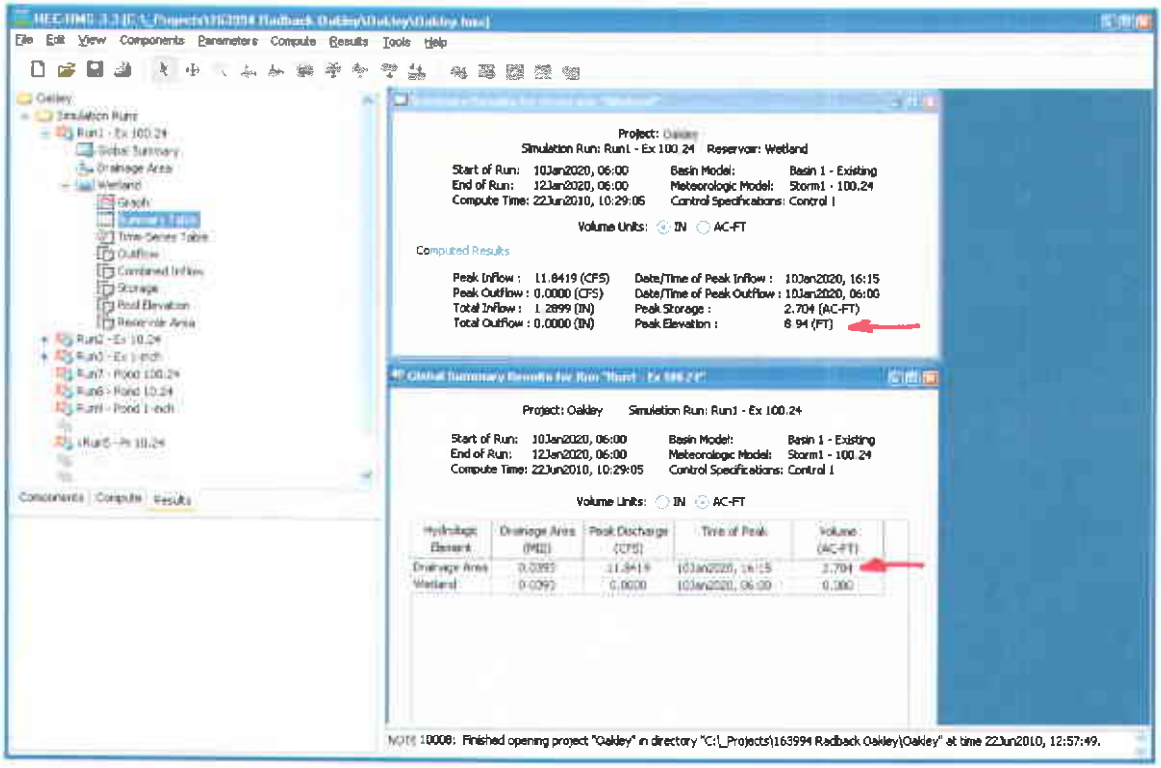
0.33 ac-ft retained in Pond

∴ total to wetland

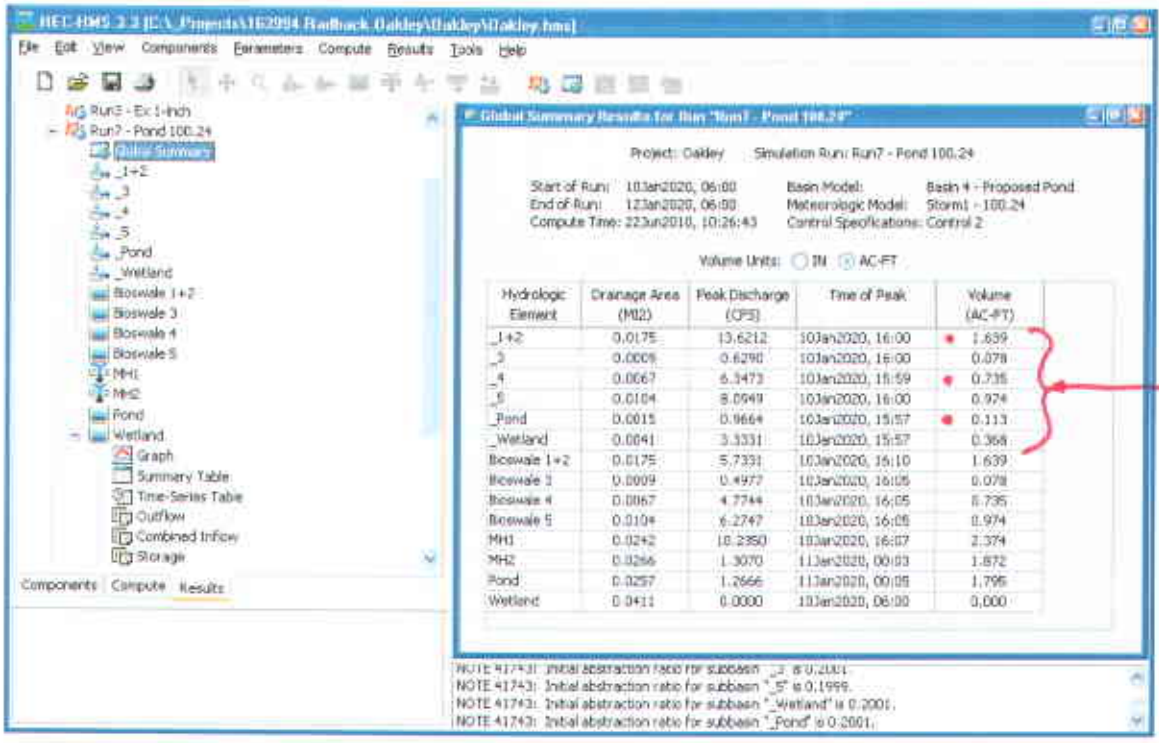
= 1.84 - 0.33

= 1.51 ac-ft

HEC-HMS Output – Pre-Construction 100-Year, 24 Hour Runoff Volume



HEC-HMS Output – Post-Construction 100-Year, 24 Hour Runoff Volume



3.91 ac-ft total

• 2.49 ac-ft to pond

0.33 ac-ft retained in pond

∴ total to wetland

= 3.91 - 0.33

= 3.58 ac-ft

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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

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

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:

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

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: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
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 $I_a = 0.2S$.

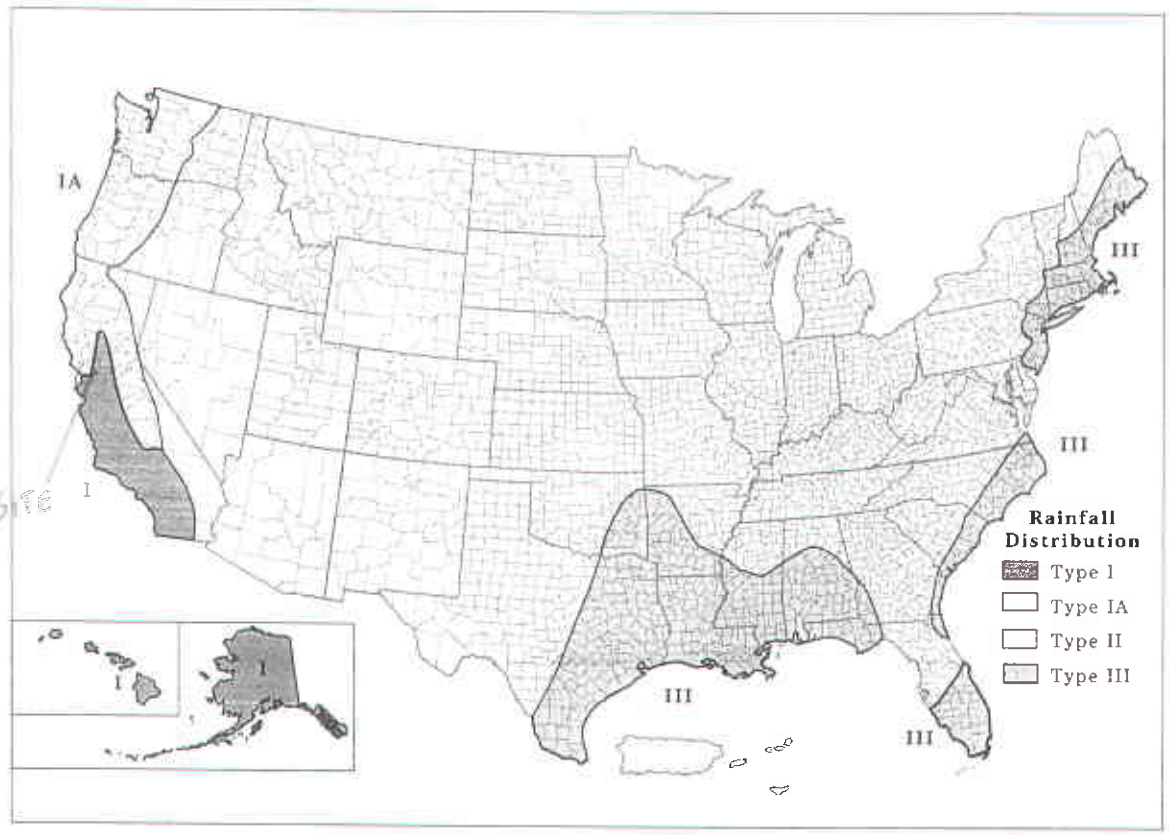
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. 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.

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.

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Attachment 4

Reference 6

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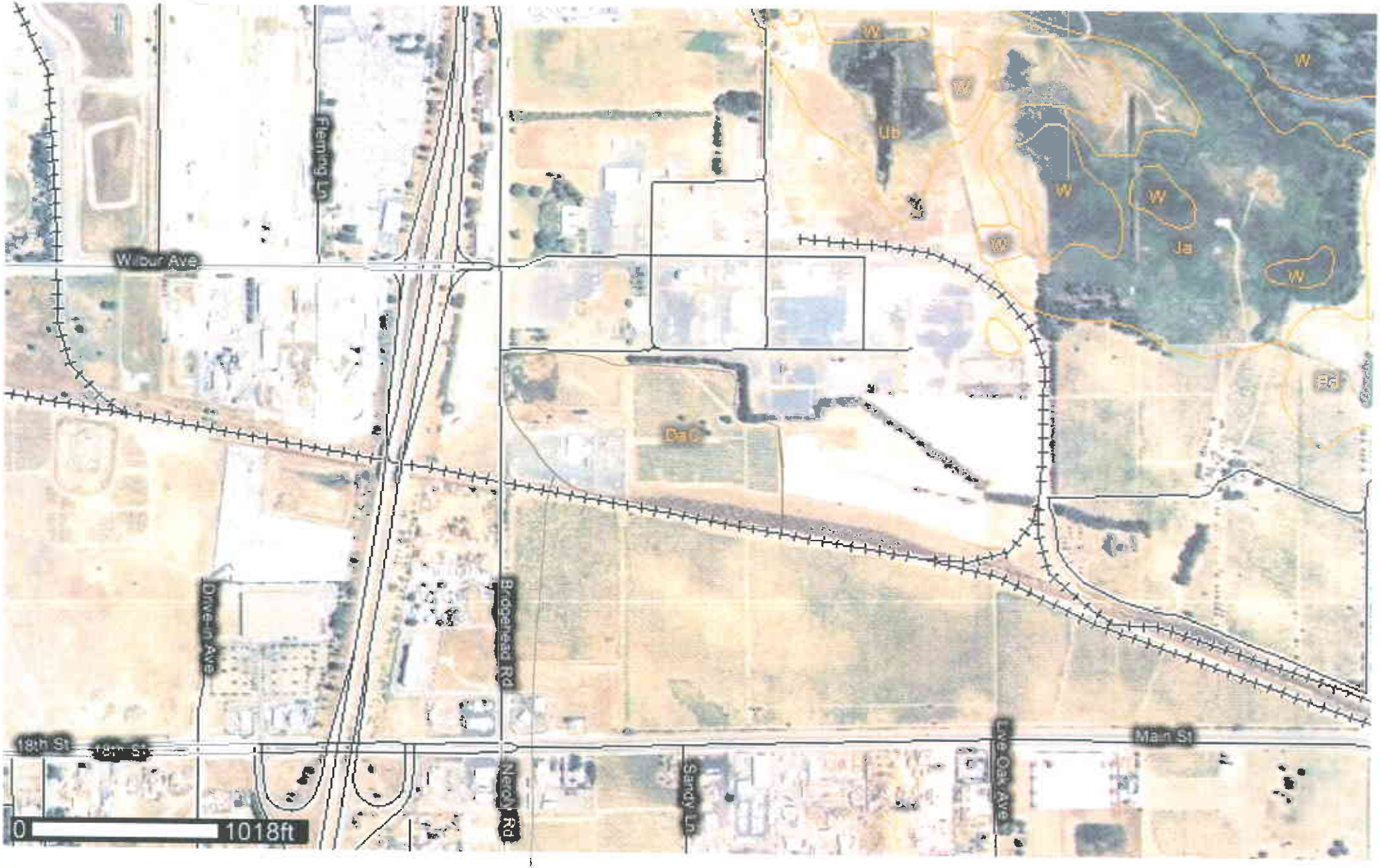
(printed out from the Online Web Soil Survey)



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

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Attachment 5

Reference 8

Select Pages

IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 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	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

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 "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.

Consequently,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{matrix} DMA \\ Runoff \\ Factor \end{matrix} = (54{,}900 \times 1 + 65{,}113 \times 1 + 100{,}200 \times 0.6 + 198{,}264 \times 0.1 + 4{,}491 \times 0 + 68{,}200 \times 0.1)$$

$$= 206{,}779 \text{ ft}^2.$$

IMP Sizing for Bioswale #3

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 25,711 ft^2 (0.59 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	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

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,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{matrix} DMA \\ Runoff \\ Factor \end{matrix} = (3{,}873\text{x}1.0+2{,}086\text{x}1.0+19{,}752\text{x}0.1)$$

$$= 7{,}934 \text{ ft}^2.$$

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:

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

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,

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

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

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.

IMP Sizing for Bioswale #5

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 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	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

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,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{matrix} DMA \\ Runoff \\ Factor \end{matrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133 \text{ ft}^2.$$

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.

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Attachment 6

Reference 9

Select Pages

0.06 (Rev 2) PW 6/19/09 < (Rev 2)

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

Existing conditions have sparse ground coverage based on aerial photos | Rev 2

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

1.6 (Rev 2) PW 6/19/09 (Rev 2)

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)

0.06 (Rev 2) 0.37 (Rev 2)

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

1.6 (Rev 2) PW 6/19/09

(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:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$
$= 0.76 + 0.17 + 0$
(Rev 2) 0.37
$= 0.93$ hour.
0.54 hr (Rev 2) PW 6/19/09

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.

0.54 x 0.324 hr = 19.4 min (Rev 2)
PW 6/19/09

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~~ 3.5 (Rev. 2) PLN 6/10/09 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

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:

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

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

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Attachment 7

Kantola, Craig

From: Jorge Hernandez [jhern@pw.cccounty.us]
Sent: Tuesday, May 18, 2010 8:37 PM
To: Kantola, Craig
Cc: Teri Rie; Tim Jensen
Subject: RE: Flood Control Standards - Oakley, CA
Attachments: CCCo Isohyet Map-Low Color.pdf; 025yr-Low.pdf; 050yr-Low.pdf; 100yr-Low.pdf; 005yr-Low.pdf; 010yr-Low.pdf; Supplemental Detention Basin Design Guidelines.doc

Mr. Kantola,

1. Per your request we are emailing a copy of our standard Isohyet map to determine the standard storm event.
2. For offsite conveyance of storm water runoff for an area less than 1-sqaure mile, the design storm event should be a 10-year event, however a detention/retention system should be able to store at the very least the 100-year design storm event.
3. See attached supplemental for suggested design of on-site facilities. Ultimately, the City will approve onsite facilities.
4. For the initial 100-year event, the assumption of an empty basin is acceptable, however a 10-year event after a recent 100-year occurrence should be analyzed. Additionally, the overland release of the basin should be directed north, per the current drainage pattern and not allowed to drain south to the existing inlet under the railroad crossing (bridge), which currently is outside of your parcel's drainage area and does not have the capacity to convey additional storm runoff.

If you have any additional question, you may contact me by either phone or email.

Thank you,

Jorge Hernandez
Staff Engineer

Contra Costa County
Flood Control
& Water Conservation District
255 Glacier Drive
Martinez, CA 94553-4897
Phone: (925) 313-2304
Fax: (925) 229-7955
A Division of the Public Works Department

From: Kantola, Craig [mailto:KantolaCA@bv.com]
Sent: Friday, May 14, 2010 10:21 AM
To: Jorge Hernandez
Subject: FW: Flood Control Standards - Oakley, CA

Jorge,
Good afternoon, I have left you a voice mail responding to your call from Wednesday. Any information you may be able to provide would be greatly appreciated. Please forward any design requirements for flood control in Contra Costa County

Attachment WSQ8-1
Stormwater Analysis for Wetland – Peak Flows
(Calculation 52.5406.1007)

BLACK & VEATCH
Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 31

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: Stormwater Analysis for Wetland - Peak Flows

Calculation No./File No.: 52.5406.1007

Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective To determine the peak flow rates to the wetland area for the pre-construction and post-construction site conditions. The analysis compares pre-construction and anticipated post-construction ground conditions at the site.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: HEC-HMS Version: 3.3

Standard B&V Application Used? ☒ Yes ☐ No
If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola SKK	17 June 2010	PLNelson	18 JUNE 2010	PLNelson	18 JUNE 2010

Purpose

To determine the stormwater runoff peak flows entering the existing wetland at the Oakley project site for storm events including the 1-inch rainfall, 10-year/24-hour storm, and 100-year/24-hour storm events. The analyses are performed for pre-construction and post-construction ground conditions at the project site.

References

1. Black & Veatch Drawing 163994-SS-3001, Rev. 1, "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; NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume XI - California; 1973.
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.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1008 Rev 0, Same project, June, 2010
9. Black & Veatch Calculation, "Stormwater Analysis", File No. 52.5406.1003 Rev 2, Same project, June 2010
10. Black & Veatch Calculation, "Storm Sewer Pipe Design", File No. 52.5406.1005 Rev 0, Same project, April 2009
11. Black & Veatch Calculation, "Post-Construction Wetland – Volume and Water Surface Elevation", File No. 52.5406.1006 Rev 0, Same project, June 2010
12. Ferguson, Bruce K., "Introduction to Stormwater", John Wiley & Sons, 1998
13. McCuen, Richard H., "Hydrologic Analysis and Design"; Prentice Hall, 1998
14. Contra Costa County Dept. of Public Works Maps; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977; Precipitation Duration-Frequency-Depth Curves (100-yr and 10-yr); Drawing Nos. B-159 and B-162; July 1977

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
5. Reference 8 – Select Pages
6. Reference 9 – Select Pages
7. Reference 11 – Select Pages
8. Reference 12 – Select Page
9. Reference 7 – Select Page
10. Reference 13 – Select Page

Summary

Based on the HEC-HMS analyses with current and proposed ground cover conditions, the stormwater runoff flow rates to the wetland will change due to the proposed site construction. The pre-construction (existing) models determine flows to the wetland area under undeveloped conditions. The post-construction models determine flows to the wetland area for developed conditions, considering the effects of the bioswales and detention pond for peak flow attenuation. Below is a summary table showing the pre-construction and post-construction peak flow rates determined by the HEC-HMS models.

Summary of Runoff Peak Flow Rates to Wetland

Rainfall Event	Pre-Construction Peak Flow Rate to Existing Wetland	Post-Construction Peak Flow Rate to Existing Wetland
1-inch	0.1 cfs	0.1 cfs
10-year	3.2 cfs	3.1 cfs
100-year	11.8 cfs	9.1 cfs

Hydrology Modeling – HEC-HMS

For the runoff peak flow rate analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	-	-	-	-	1.93
Gravel	3.96	2.30	-	2.51	3.35	-	-
Railroad Yard	0.94	-	-	-	0.94	-	-
Wetland	0.40	-	-	-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55	0.45	0.54	1.50	0.85	-
Impervious Surface ***	-	2.75	0.14	1.21	0.88	0.13	0.27 (ex. roads)
Transformer Contain ****	-	0.10	-	0.12	-	-	-
Open Graded Aggregate	-	1.57	-	-	-	-	-
Total Acres:	25.15	11.17	0.59	4.26	6.67	0.98	2.60
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0.0009**	**0.0067**	**0.0104**	**0.0015**	**0.0041**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

BIOSWALE #3

BIOSWALE #1

POND

WETLAND

BIOSWALE #5

BIOSWALE #4

DRAINAGE AREA FOR EA. BIOSWALE (TYP)

ALL BACKCIRCLED CHANGES PER ECN-N-S-00XX

OPEN
05/27/10

MATCHLINE E 6202810 – SEE DWG \SS--3002 FOR CONTINUATION

SEE NOTE 8

Redbank Oakley
Project #163994
Stormwater Analysis
52.54-6.1007
page 6 of 31

BY CK
Date 6/17/10
Ver: plans
Date: 6/17/10

Bid Dwg
163994-55-3001 Rev 1

Section 1.0 – Determine the Time of Concentration (Tc) and Lag Time

For the pre-construction condition, the time of concentration of 0.54 hours (32.4 minutes) and lag time of 19.4 minutes were determined in Reference 9 – see Attachment 6.

For the post-construction condition, the peak flow from the plant area to the wetland will be most impacted by the peak runoff from the area draining through Bioswale 5. This is due to the proximity of Bioswale 5 to the wetland and the runoff conditions from Bioswale 5 being similar to the remainder of the plant. Bioswales 1+2 and 4 are routed through the detention pond (which significantly reduces the peak flows through the outlet control structure) while the drainage area for Bioswale 3 is relatively small and therefore contributes little flow.

Therefore the Tc and Lag Time for the area draining to Bioswale 5 will be determined and applied to the model for all bioswale area drainage (Bioswales 1-5). Using the same Lag Time for each bioswale area within the model will result in a conservative peak flow determination from the plant area, since all areas into the bioswales are modeled to peak concurrently.

Bioswale 5 (Post-Construction condition)
Time of concentration (T_c) can be calculated as:

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

Where:

T_{sheet} = travel time in sheet flow to drainage basin;
$T_{shallow}$ = travel time in shallow concentrated flow;
$T_{channel}$ = travel time in open channels.

The flow path from the hydraulically most distant point of this drainage area to the outlet structure for Bioswale 5 is identified as shown on Page 8. The total flow length is measured to be approximately 900 feet (using AutoCAD).
(1) Sheet Flow
Sheet flow travel time can be calculated as:

$$T_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$ (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).

BIOSWALE #3

BIOSWALE #1

POND

BIOSWALE #5

TC FLOW PATH

DRAINAGE AREA FOR EA. BIOSWALE (TYP)

BIOSWALE #4

ALL BACKCIRCLED CHANGES PER ECN-N-S-00XX

OPEN
05/27/10

MATCHLINE E 6202810 – SEE DWG SS-3002 FOR CONTINUATION

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Project # 163994
Stormwater Analysis
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By: C. Kantola
6/17/10

Ver: PCN

Date: 6/18/10

Roughness coefficient n = 0.011 for "smooth surfaces (gravel)". (Ref. 2, Table 3-1)

Per Ref. 2, "After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow". Therefore sheet flow length will be limited to a maximum of 300 feet. BV Drawing SS-3001 and AutoCAD data show that the ground slope for sheet flow can be separated into two sections, each approximately 120 feet long. L = 120 ft.

2-year, 24-hour rainfall P_2 = 1.6 inch for this site per Ref. 5 (see Page 10).

The land slope for the first sheet flow section is from EL 20.80 to the 20.0 contour. This slope is (20.8-20.0)/120 = 0.0067 ft/ft

Thus, $T_{sheet} = \frac{0.007 \times (0.011 \times 120)^{0.8}}{1.6^{0.5} \times 0.0067^{0.4}}$ = 0.051 hour = 3.1 minutes for sheet flow 1.

The land slope for the second sheet flow section is from EL 20.0 to EL 17.7 at the edge of the access road (data from AutoCAD). This slope is (20.0-17.7)/120 = 0.0192 ft/ft

Thus, $T_{sheet} = \frac{0.007 \times (0.011 \times 120)^{0.8}}{1.6^{0.5} \times 0.0192^{0.4}}$ = 0.034 hour = 2.0 minutes for sheet flow 2.

The sum of sheet flow travel times is: T_{sheet} = 3.1 min + 2.0 min = 5.1 minutes

(2) Shallow Concentrated Flow
From AutoCAD, the flow length for shallow concentrated flow is measured as L = 365 feet from EL 17.7 to the top of bioswale 5 at EL 14.5.

The average watercourse slope = (17.7-14.5) / 365 = 0.0088 ft/ft.

Based on a slope of 0.0088 ft/ft, from Ref. 2, Figure 3-1, the average velocity (V) for "unpaved" surface is found to be: V = 1.5 ft/sec.

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

$$T_{shallow} = \frac{L}{3600 \times V} = \frac{365}{3600 \times 1.5}$$ = 0.07 hour = 4.2 minutes.

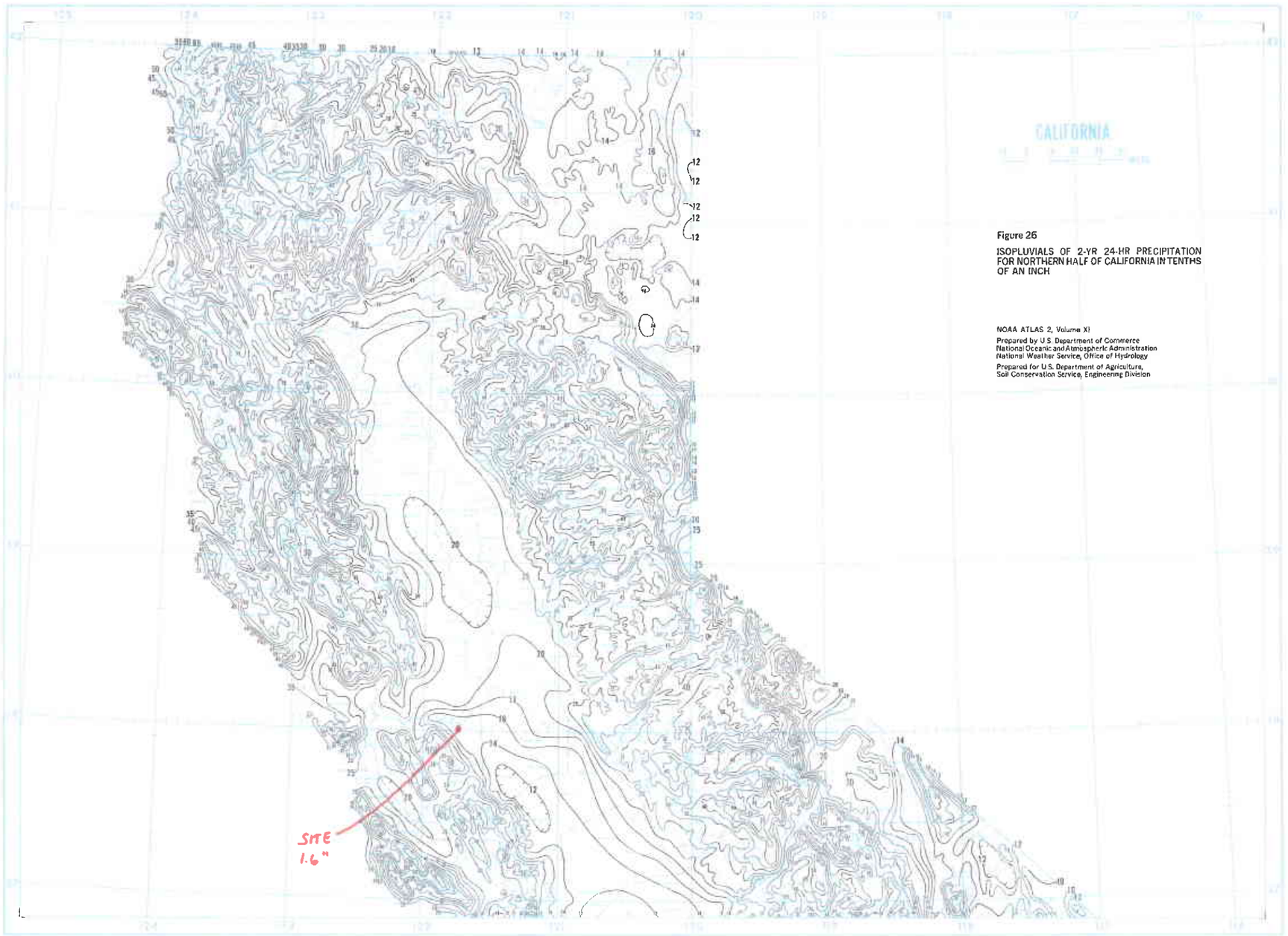

Figure 26

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

~~Rev 2~~ Radback ~~Tenaska~~ Oakley Project
Stormwater Analysis

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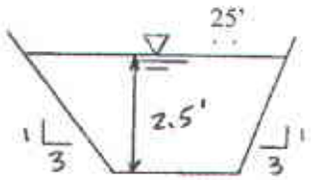
Note:
This page is from Ref. ~~X~~ 5

CK 6/17/10
Ver: PLN
Date: 6/18/10

(3) Open Channel Flow

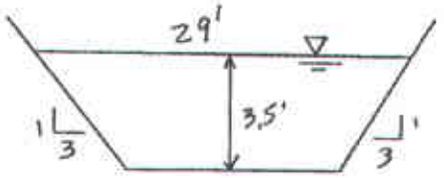
Calculate open channel flow within the bioswales. There are two differing bioswale cross-sections in Bioswale 5 and Individual travel times for each section are calculated below. From Reference 8, the bioswale cross-sections are shown below:



10'

Section 2

DWG 55-3001



8'

Section 2A

DWG 55-3001

Travel time for each portion of open channel flow is calculated by

T_t (hours) = $\frac{L}{3600 \times V}$ where L = length of flow path (feet) and V = flow velocity (ft/sec)

Length of flow path is measured from the site grading plan (Refer to Page 8)

For open channel flow, V is based on Manning's equation where V = $\frac{1.49}{n} \times R^{2/3} \times \sqrt{s}$

R is the hydraulic radius, defined as R = $\frac{Area}{WettedPerimeter}$

For Bioswale 5 / Section 2 (a trapezoidal channel):

Area, A (trapezoidal channel) = (10 ft + 25 ft)/2 x 2.5 ft = 43.75 sf

Wetted Perimeter, P (trapezoidal channel) = 10 ft + 2 x $\sqrt{\left(2.5^2 + .(2.5 \times 3)^2\right)}$ = 25.8 ft

Hydraulic Radius, R = A / P = 43.75 sf / 25.8 ft = 1.7 ft

The bioswale can be described as an earthen channel, straight & uniform with short grass and few weeds. This corresponds to a Manning's 'n' = 0.027 (Refer to Reference 7).

The swale from C16 to the point the swale turns north has a length L = 175 ft and grade from EL 12.0 to 11.5, the slope is calculated as (12.0 – 11.5) / 175 = 0.0029 ft/ft

The resulting full-flow velocity in the swale is V = $\frac{1.49}{0.027} \times 1.7^{2/3} \times \sqrt{0.0029}$ = 4.2 ft/s

Thus the travel time for open channel flow in this swale section is calculated to be:

$$T_{open} = \frac{L}{3600 \times V} = \frac{175}{3600 \times 4.2} = 0.011 \text{ hour} = 0.7 \text{ minutes}$$

For Bioswale 5 / Section 2a (a trapezoidal channel):

Area, A (trapezoidal channel) = (8 ft + 29 ft)/2 x 3.5 ft = 64.75 sf

Wetted Perimeter, P (trapezoidal channel) = $8 \text{ ft} + 2 \times \sqrt{\left(3.5^2 + .(3.5 \times 3)^2\right)} = 30.1$ ft

Hydraulic Radius, R = A / P = 64.75 sf / 30.1 ft = 2.15 ft

Manning's 'n' = 0.027 as noted above.

The swale from the point the swale turns north to OS-5 a length L = 120 ft and grade from EL 11.5 to 11.0, the slope is calculated as (11.5 – 11.0) / 120 = 0.0042 ft/ft

The resulting full-flow velocity in the swale is $V = \frac{1.49}{0.027} \times 2.15^{2/3} \times \sqrt{0.0042} = 6.0$ ft/s

Thus the travel time for open channel flow in this swale section is calculated to be:

$$T_{open} = \frac{L}{3600 \times V} = \frac{120}{3600 \times 6.0} = 0.006 \text{ hour} = 0.4 \text{ minutes}$$

The sum of open channel flow travel times is: T_{open} = 0.4 min + 0.7 min = 1.1 minutes

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

$T_c = T_{sheet} + T_{shallow} + T_{channel}$ = 5.1 min + 4.2 min + 1.1 min = 10.4 minutes.

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 13. The SCS UH lag time (T_{lag}) is an input parameter into the HEC-HMS computer program. Thus T_{lag} = 0.6 x 10.4 = 6.2 minutes; (use 6 minutes in model for Bioswale areas).

The areas draining directly to the pond and wetland areas have significantly different runoff characteristics than the main plant, therefore a different Lag Time is used in the model. Since the drainage areas are small, the times of concentration will be very short. Per Reference 10, use a minimum starting Tc in drainage basin of 0.1 hr.

Thus model input for the direct runoff to the pond and wetland areas can be determined:

Tc = 0.1 hr = 6 minutes and T_{lag} = 0.6 x 6 = 3.6 minutes

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

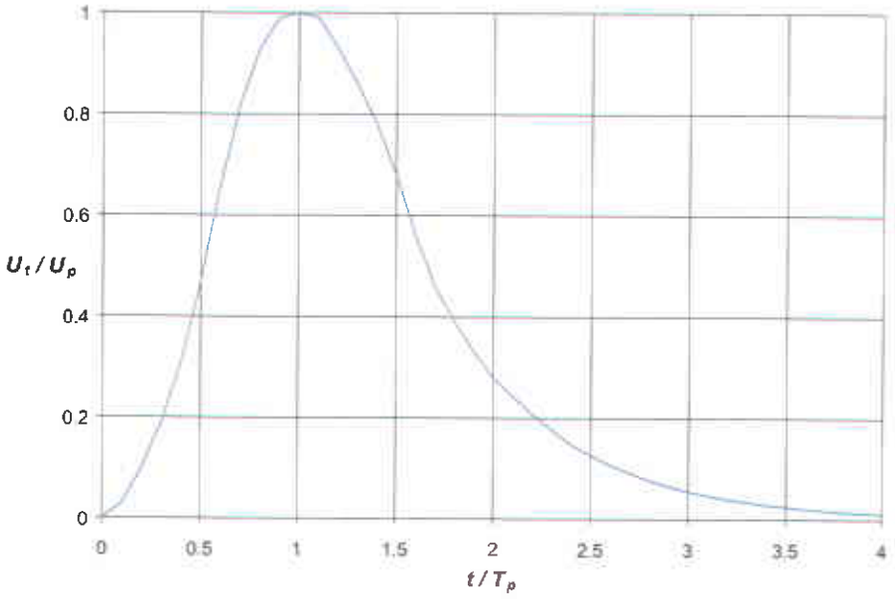


Figure 6-2. SCS unit hydrograph

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

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. 14, the 24-hour rainfall amounts for the site are: (See Pages 15 & 16)

Storm Event	100-year	10-year	Small event*
Rainfall	3.9 in.	2.6 in.	1.0 in.

* A smaller "typical" rain event of 0.75-1.0 inch was requested to be modeled by CEC

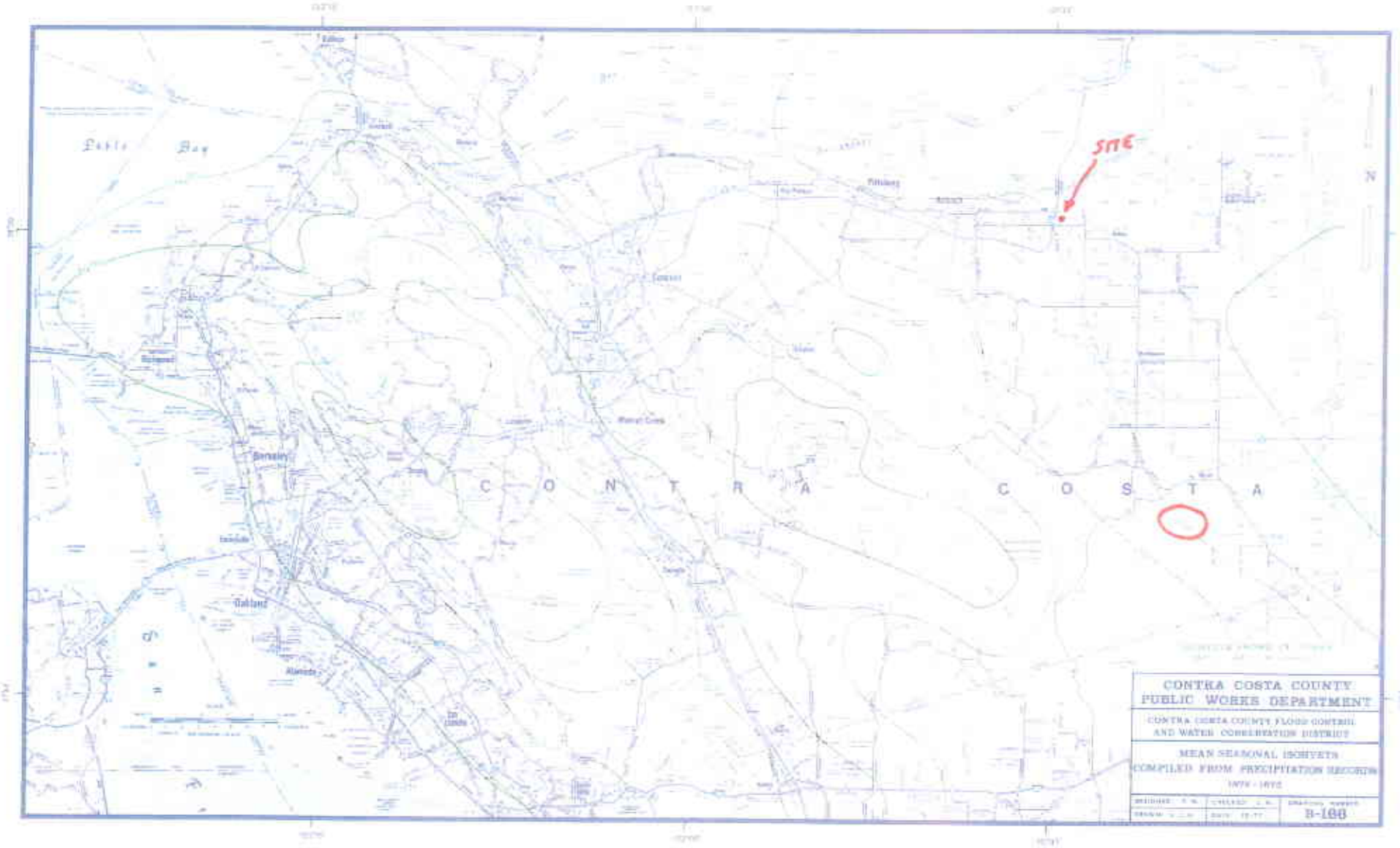
Section 3.0 – Determine Composite SCS Curve Number, Initial Abstraction & Impervious %

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area. The SCS Curve Number (CN), Initial Abstraction (Ia) and Impervious % for the pre-construction site were determined in Reference 9 – see attachment 5.

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.

The proposed site drainage areas as determined earlier are summarized below, with individual CN values assigned to each type of ground cover (for Group A soils). CN values are based on Reference 2, Tables 2-2a and 2-2b.

For the pre-construction condition, the SCS Curve Number (CN = 70), Initial Abstraction (Ia = 0.857) and Impervious (% = 1) were determined in Reference 9 – see Attachment 6.



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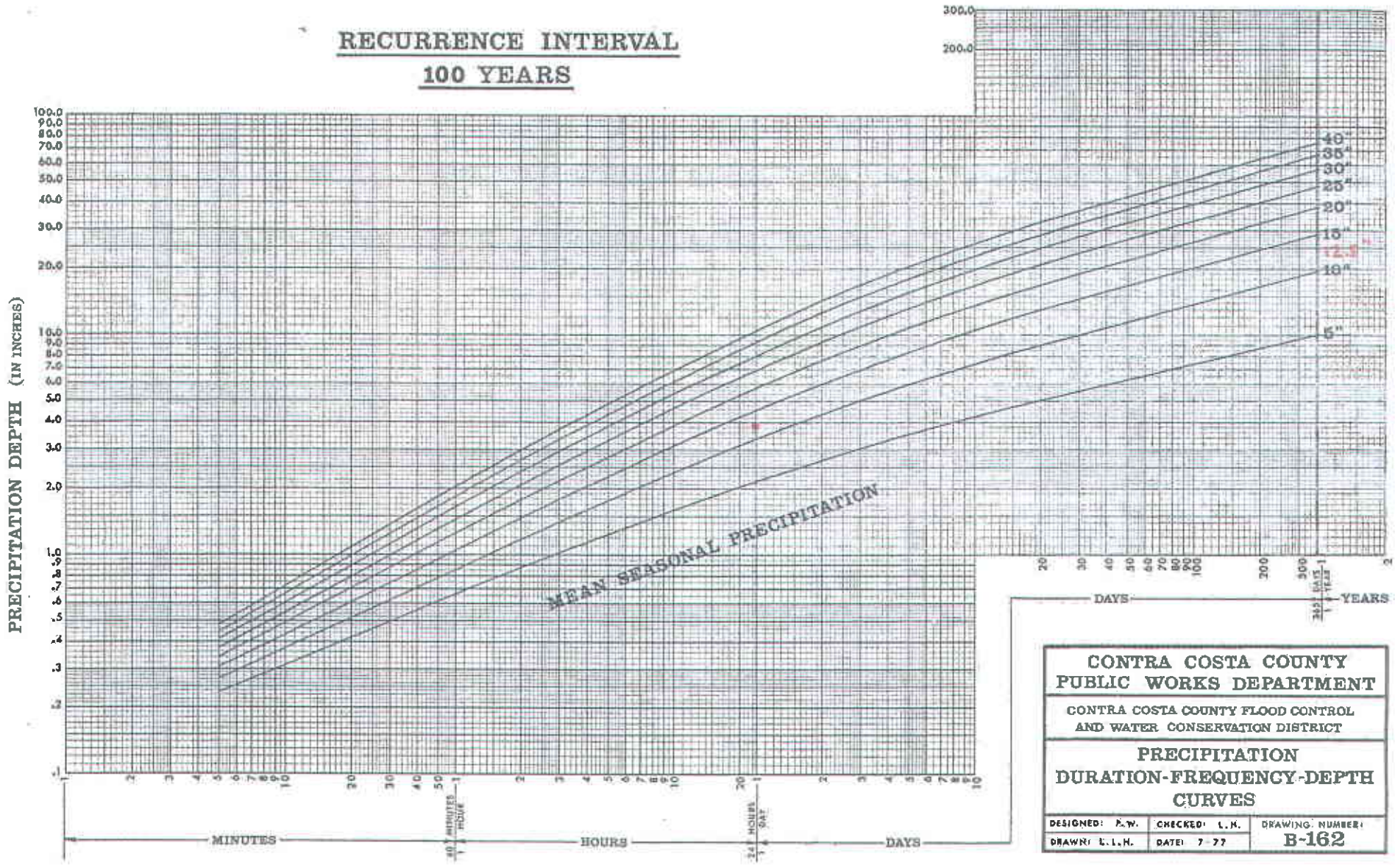
MSP = 12.5"

RECURRENCE INTERVAL
100 YEARS

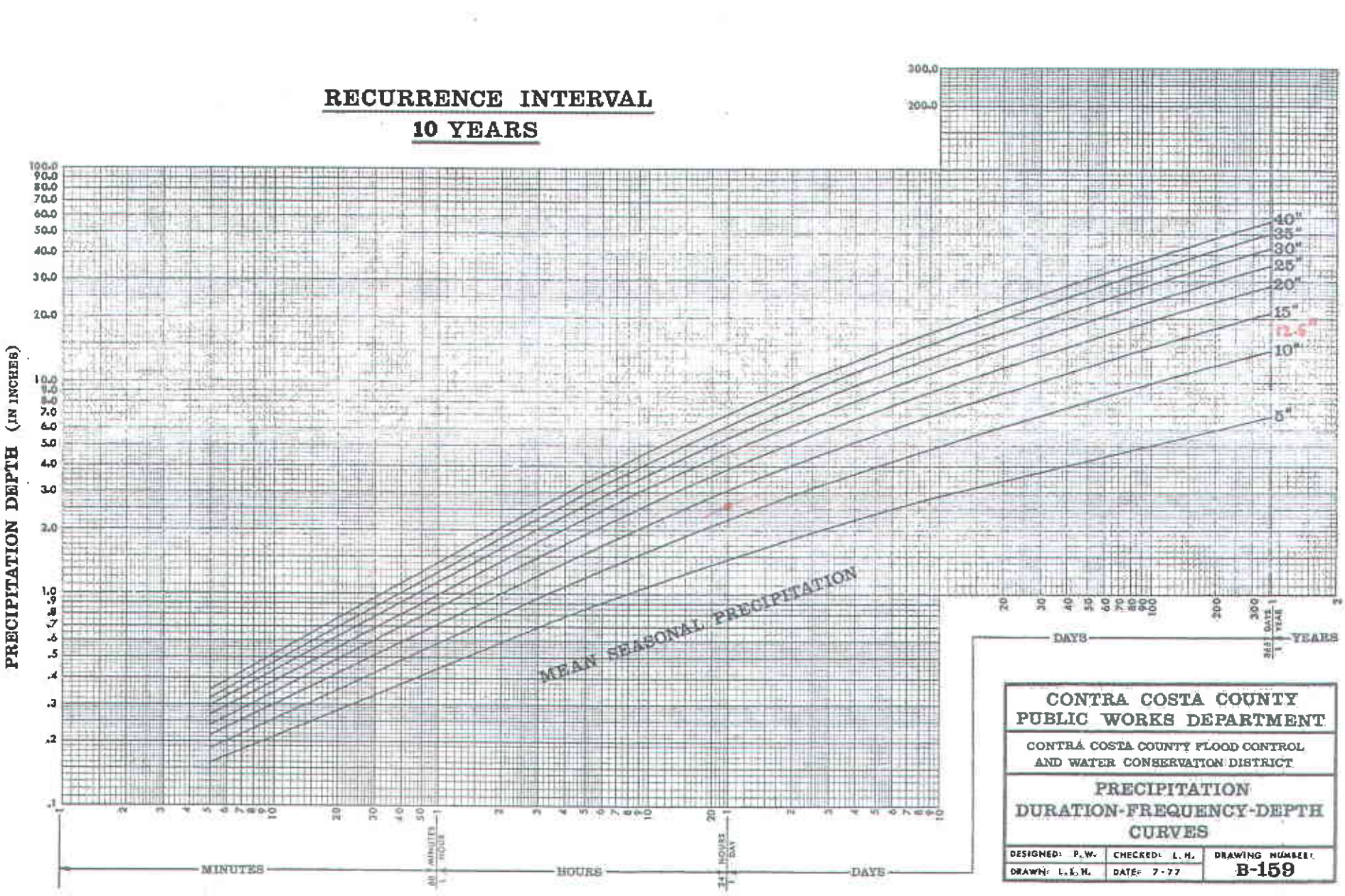


CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: R.W.	CHECKED: L.H.	DRAWING NUMBER: B-162
DRAWN: L.L.H.	DATE: 7-77	

MSP = 12.5" (DWG B-166)

24-HR = 3.3" (ABOVE)

RECURRENCE INTERVAL
10 YEARS



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P.W.	CHECKED: L.H.	DRAWING NUMBER: B-159
DRAWN: L.L.H.	DATE: 7-77	

MSP = 12.5" (DWG B-166)

24-HR = 2.6" (ABOVE)

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(FROM REF. 14) ✓ Rev 5/19/10

Bioswale 1+2 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface	98	2.75 ac.	269.5
Open Graded Aggregate	68	1.57 ac.	106.76
Total		11.17 ac.	860.46
Composite CN = 860.46 / 11.17 = 77			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 3 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.45 ac.	30.6
Impervious Surface	98	0.14 ac.	13.7
Total		0.59 ac.	44.3
Composite CN = 44.3 / 0.59 = 75			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = 0.667 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 4 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface	98	1.21 ac.	118.6
Total		4.26 ac.	346.1
Composite CN = 346.1 / 4.26 = 81			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/81 - 10)$ = 0.469 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Bioswale 5 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	3.35 ac.	254.6
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	1.50 ac.	102
Impervious Surface	98	0.88 ac.	86.2
Total		6.67 ac.	514.2
Composite CN = 514.2 / 6.67 = 77			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Direct to Pond (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.85 ac.	57.8
Impervious Surface	98	0.13 ac.	12.74
Total		0.98 ac.	70.54
Composite CN = 514.2 / 6.67 = 72			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/72 - 10)$ = 0.778 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Direct to Wetland (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.27 ac.	26.5
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Total		2.6 ac.	196.9
Composite CN = 196.9 / 2.6 = 76			

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 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 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10) =$ 0.632 inch.

Impervious % = 1% (Consistent with other drainage areas)

A summary of the pre- and post-construction basin parameter values determined above and input into the HEC-HMS model are included in the table below:

Condition	Area (sq. mi.)	Composite CN	Initial Abstraction (in)	Impervious %	Lag Time (min)
Pre-Construction					
Entire Site	0.0393	70	0.857	1	19.4
Post-Construction					
Bioswale 1-2	0.0175	77	0.597	1	6.0
Bioswale 3	0.0009	75	0.667	1	6.0
Bioswale 4	0.0067	81	0.469	1	6.0
Bioswale 5	0.0104	77	0.597	1	6.0
Direct to Pond	0.0015	72	0.778	1	3.6
Direct to Wetland	0.0041	76	0.632	1	3.6

Section 4.0 – Elevation versus Area and Outflow Rate

The proposed pond and each bioswale provide volumetric storage for runoff and also ~~has~~ an outlet control structure to limit flows entering the wetland area. The relationship of Elevation versus Area and Elevation versus Discharge Flow Rate are used within the HEC-HMS model to accurately determine flow rates within the system. For the bioswales, areal measurements are based on the length of swale multiplied by the width of the swale. The swale width at each elevation is based on the bottom width plus the width with 3H:1V side slopes for each depth (each 1-foot of depth increases the width by 6 feet (3 feet on each side)).

For example, Bioswale 1-2 is 1,323 feet long, 2 foot wide at EL 12.5 and 3H:1V slopes.

Area at EL 12.5 = 1,323 ft x 2 ft = 2646 sf (0.06 ac)

Area at EL 13.0 = 1,323 ft x [2 ft + (3 H:V x 0.5' depth x 2 (slope on both sides)]
= 1,323 x 5 ft wide = 6,615 sf (0.15 ac)

Using the above method, Elevation vs Area tables are determined and included for each Bioswale in the following pages. Each table includes the elevation and area up to one foot above the rim of the control structure. This is to consider the effects of flow into the structure when water levels exceed the rim elevation.

For purposes of determining elevation versus discharge rate, the rim of the outlet structure is modeled as a weir. Using the weir equation $Q = C \times L \times H^{3/2}$ the flow rate at each elevation can be determined by considering the head (H) above the weir (rim elevation). The length of the weir is the circumference of the outlet structure which is dependent on the diameter of pipe selected for the standpipe. L = Circumference = π x diameter.

Thus for Bioswale 1-2, the elevation – discharge table can be determined:

Rim EL = 15.5 (per Reference 9)

Discharge at 0.1' intervals can be determined:

At EL 15.6, H = 15.6 – 15.5 = 0.1 ft
L = π x 24" (diameter) * 1 ft / 12 in = 6.28 ft
C = 3.1 (per Reference 12)

Discharge at EL 15.6 $Q = 3.1 \times 6.28 \times 0.1^{3/2} = 0.62$ cfs

Discharge at EL 15.7 $Q = 3.1 \times 6.28 \times 0.2^{3/2} = 1.74$ cfs

Using the above method, Elevation vs Discharge tables are determined and included for each Bioswale in the following pages. Note that any orifices placed within the vertical barrel of the standpipe will allow discharge prior to peaking over the rim elevation. For the purposes of this calculation the peak flow is determined without allowing orifice flow, to be conservative and maximize peak flows in the system.

Bioswale 1-2

Bottom Width = 2 ft; Length = 1,323 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	2646	0.06
13.0	5	6615	0.15
14.0	11	14553	0.33
15.0	17	22491	0.51
15.5	20	26460	0.6
16.0	23	30429	0.69
16.5	26	34398	0.78

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0
15.5 (rim)	0
15.6	0.62
15.7	1.74
15.8	3.2
15.9	4.93
16.0	6.88
16.1	9.05
16.2	11.4
16.3	13.93
16.4	16.62
16.5	19.47

Bioswale 3

Bottom Width = 2 ft; Length = 187 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
11.0	2	374	0.01
12.0	8	1496	0.03
13.0	14	2618	0.06
14.0	20	3740	0.08

Standpipe diameter = 24"; Rim Elevation = 13.0 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
11.0 (bottom)	0
13.0 (rim)	0
13.1	0.62
13.2	1.74
13.3	3.2
13.4	4.93
13.5	6.88
13.6	9.05
13.7	11.4
13.8	13.93
13.9	16.62
14	19.47

Bioswale 4

Bottom Width = 2 ft; Length = 391 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	782	0.01
13.0	5	1955	0.04
14.0	11	4301	0.09
15.0	17	6647	0.15
15.5	20	7820	0.17
16.0	23	8993	0.2
16.5	26	10166	0.23

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Using the method for weir flow discharge provided on Page 27, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0
15.5 (rim)	0
15.6	0.62
15.7	1.74
15.8	3.2
15.9	4.93
16.0	6.88
16.1	9.05
16.2	11.4
16.3	13.93
16.4	16.62
16.5	19.47

Bioswale 5

Section 2: Bottom Width = 10 ft; Length = 265 ft

Section 2a: Bottom Width = 8 ft; Length = 120 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)		Area (sf)		Total Area (ac)
	Section 2	Section 2a	Section 2	Section 2a	
11.0	-	8	-	960	0.02
12.0	10	14	2650	1680	0.09
13.0	16	20	4240	2400	0.15
14.0	22	26	5830	3120	0.2
14.5	25	29	6625	3480	0.23
15.0	28	32	7420	3840	0.25
15.5	31	35	8215	4200	0.28

Standpipe diameter = 36"; Rim Elevation = 14.5 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
11.0 (bottom)	0
14.5 (rim)	0
14.6	0.92
14.7	2.61
14.8	4.8
14.9	7.39
15.0	10.32
15.1	13.57
15.2	17.1
15.3	20.9
15.4	24.93
15.5	29.2

Pond

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Elevation versus Area (areas measured using AutoCAD).

Elevation – Area Summary

Elevation (ft)	Pond Area (acres)
8.5	0.18
9.0	0.21
10.0	0.26
11.0	0.31
12.0	0.37
13.0	0.43
14.0	0.50
15.0	0.56

The pond outlet structure consists of orifice holes in the vertical standpipe to reduce peak flows and also allows discharge through the rim via weir flow. The method for determining weir flow is consistent with the weir discharge for bioswales. For orifice flow through the standpipe barrel, the orifice equation Q = $C \times A \times \sqrt{2gh}$ is used to determine discharge by considering the head (h) above the orifice discharge elevation. In the pond this elevation is set at EL 10.0 per Reference 11. A is the orifice area. For this calculation, nine 1-inch holes are provided to limit maximum flows to 0.5 cfs until the water level is at EL 14.0 (rim).

at EL 10.0 PLW 6/18/10

The elevation – discharge table can be determined:

Orifice EL = 10.0

Discharge at each depth can be determined:

At EL 14.0 (rim), H = 14.0 – 10.0 = 4.0 ft

A = $9 \times (\pi \times r^2)$ = 9 x (π x (0.5 in / 12 in/ft)^2) in = 0.495 sf

C = 0.62 (per Reference 13)

Discharge at EL 14.0 Q = $0.62 \times 0.0495 \times \sqrt{2 \times 32.2 \times 4.0}$ = 0.49 cfs (< 0.50 cfs)

Discharge at EL 12.0 Q = $0.62 \times 0.0495 \times \sqrt{2 \times 32.2 \times 2.0}$ = 0.35 cfs

Standpipe diameter = 36"; Rim Elevation = 14.0 ft

Using the method for weir flow discharge provided on Page 23, and the orifice discharge method on the previous page, the following table summarizes the relationship of elevation versus discharge (weir and orifice) at the pond outlet. This data is input into the HEC-HMS model. Weir discharge is calculated at 0.1-foot intervals due to the rapid increase in discharge as the depth increases. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Pond Elevation – Discharge Summary

Elevation (ft)	Orifice Discharge (cfs)	Weir Discharge (cfs)	Total Discharge (cfs)
8.5 (bottom)	-	-	0
10.0 (orifice)	0	-	0
11.0	0.25	-	0.25
12.0	0.35	-	0.35
13.0	0.43	-	0.43
14.0	0.49	0	0.49
14.1	0.5	0.92	1.42
14.2	0.5	2.61	3.11
14.3	0.51	4.8	5.31
14.4	0.52	7.39	7.91
14.5	0.52	10.32	10.84
14.6	0.53	13.57	14.1
14.7	0.53	17.1	17.63
14.8	0.54	20.9	21.44
14.9	0.55	24.93	25.48
15.0	0.55	29.2	29.75

The capacity of each riser pipe is determined for weir flow and orifice flow based on the peak head above the rim elevation for each outlet control structure. To determine the elevation at which the flow transitions from weir flow over the riser rim to orifice flow when the rim becomes submerged, the value of the head, H that results in weir flow equal to orifice flow is computed. This head value is compared to the peak elevation in the bioswales and pond to determine if weir flow or orifice flow would govern.

Weir flow, Qw = Cw x L x $H^{3/2}$

Orifice Flow, Qo = $Co \times A \times \sqrt{2gH}$

Gravitational Constant, g = 32.2

Setting Qw = Qo, the above equations are reduced to solve for H: $H = \frac{8.025 \times Co \times A}{Cw \times L}$

Weir Coefficient, Cw = 3.1

Orifice Coeff, Co = 0.62

Area, A and Length, L are dependent on the diameter of the riser pipe.

For a 24" riser pipe, A = π x r^2 = 3.14 x (1 ft)² = 3.14 sf
L = π x d = 3.14 x 2 ft = 6.28 ft

For a 36" riser pipe, A = π x r^2 = 3.14 x (1.5 ft)² = 7.07 sf
L = π x d = 3.14 x 3 ft = 9.42 ft

The Head, H at which weir flow is equal to orifice flow is thus:

For a 24" riser $H = \frac{8.025 \times 0.62 \times 3.14}{3.1 \times 6.28}$ = 0.8 ft. Weir flow will govern up to 0.8' above rim

For a 36" riser $H = \frac{8.025 \times 0.62 \times 7.07}{3.1 \times 9.42}$ = 1.2 ft. Weir flow will govern up to 1.2' above rim

Referring to the HEC-HMS output in Attachment 2, the maximum head above the riser is for Bioswale 1-2 (Peak elevation – rim elevation = 15.99 ft – 15.5 ft = 0.5' of head). This is below the minimum head that results in orifice flow (0.8' for 24" riser). Therefore the use of the weir flow discharge values is correct for all overflow structures for this calculation.

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 peak discharge rate to the wetland for each storm event was calculated by running the HEC-HMS program. The table below summarizes the runoff rate produced in the pre-construction and post-construction site conditions for each storm event. The output results are included in Attachment 2.

Summary of Runoff Peak Flow Rates to Wetland

Rainfall Event	Pre-Construction Peak Flow Rate to Existing Wetland	Post-Construction Peak Flow Rate to Existing Wetland
1-inch	0.1 cfs	0.1 cfs
10-year	3.2 cfs	3.1 cfs
100-year	11.8 cfs	9.1 cfs

Conclusion:

Based on the HEC-HMS analysis for the pre- and post-construction conditions, the peak flows to the wetland area will be changed as a result of the proposed development. The increase in runoff volume due to the proposed development is attenuated within the proposed bioswales and detention pond. By installing the bioswales and pond along with outlet control structures, the peak flows are controlled in the post-development condition and result in equal-to or less-than pre-developed conditions.

Radback Oakley Project

Project # 163994

Stormwater Analysis

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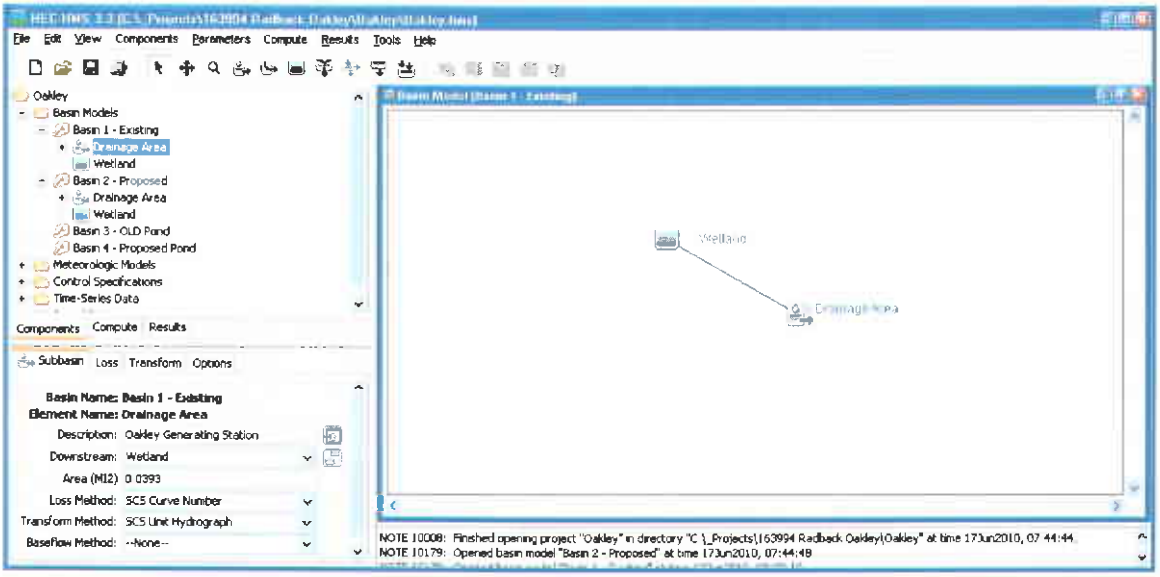
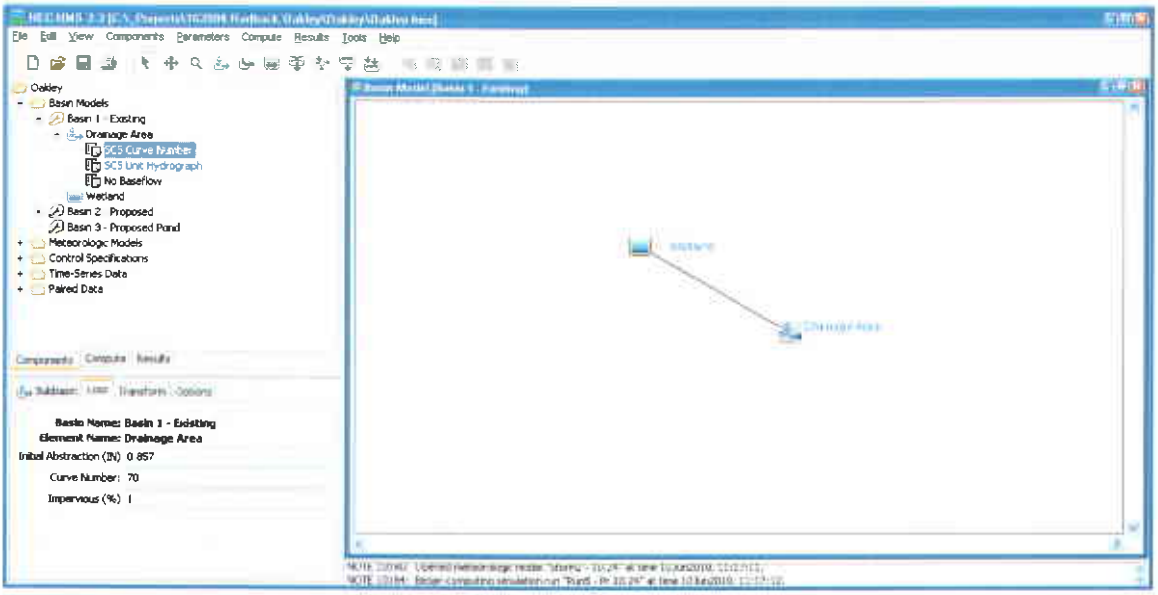
Attachment 1

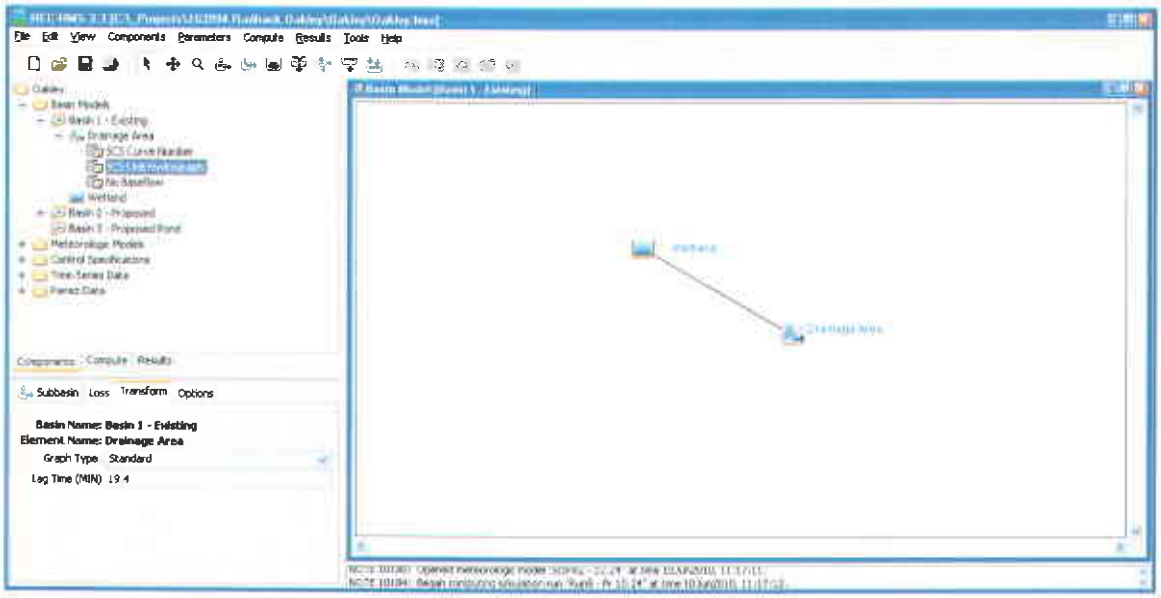
~~Reference~~

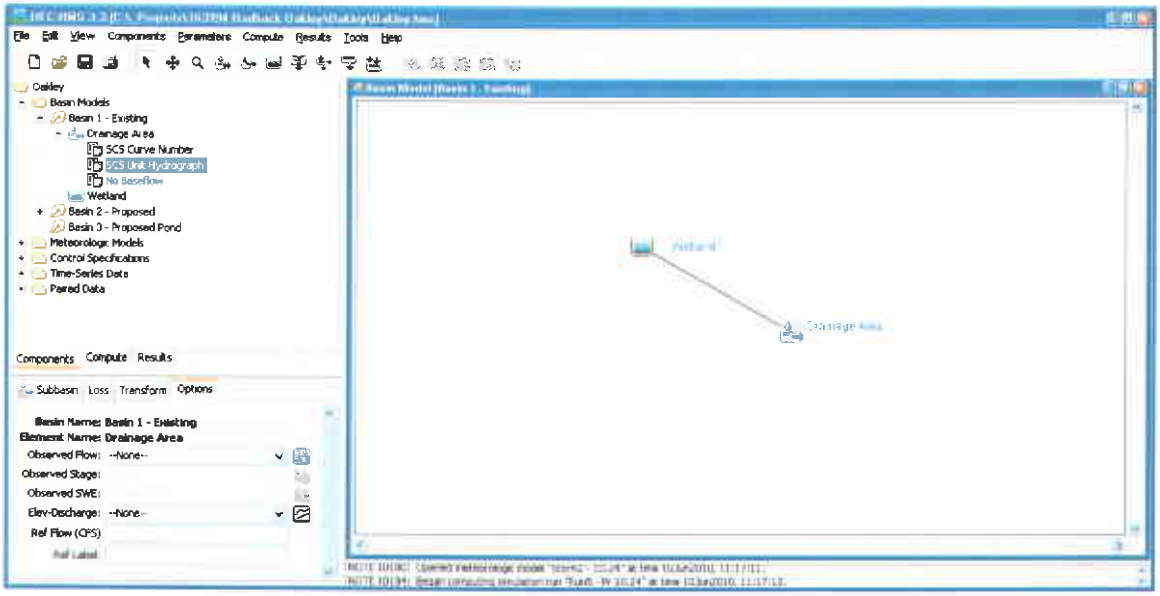
HEC-HMS INPUT

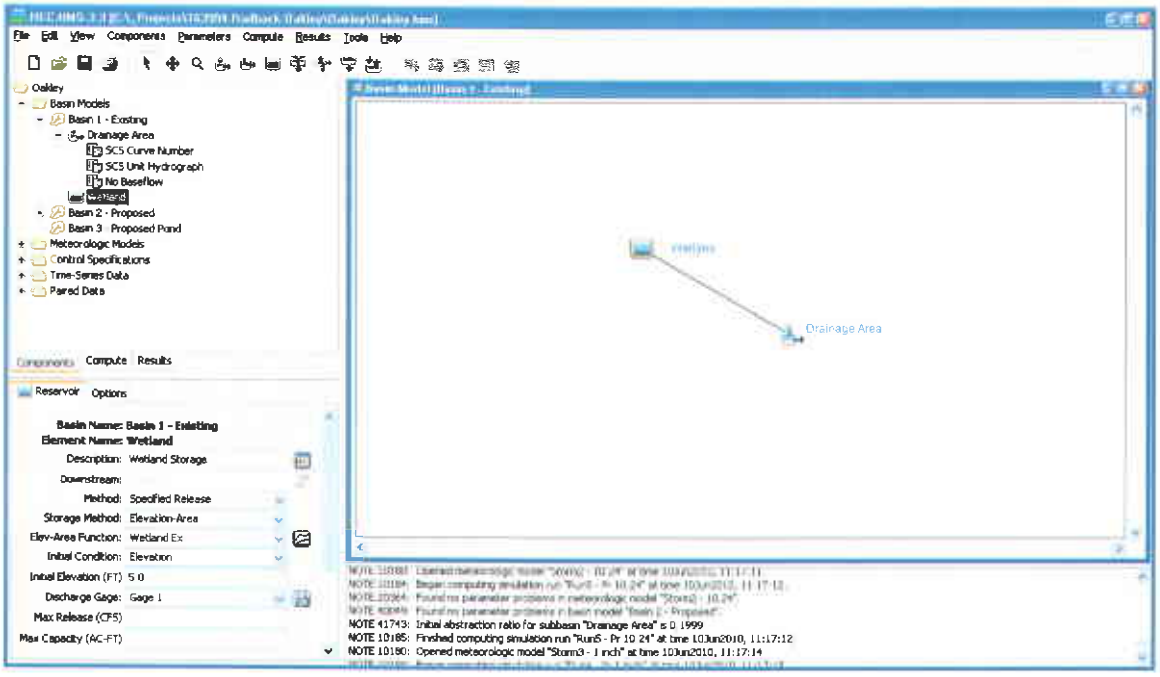
HEC-HMS Input – Basin Model 1 – Existing (Pre-Construction Condition)





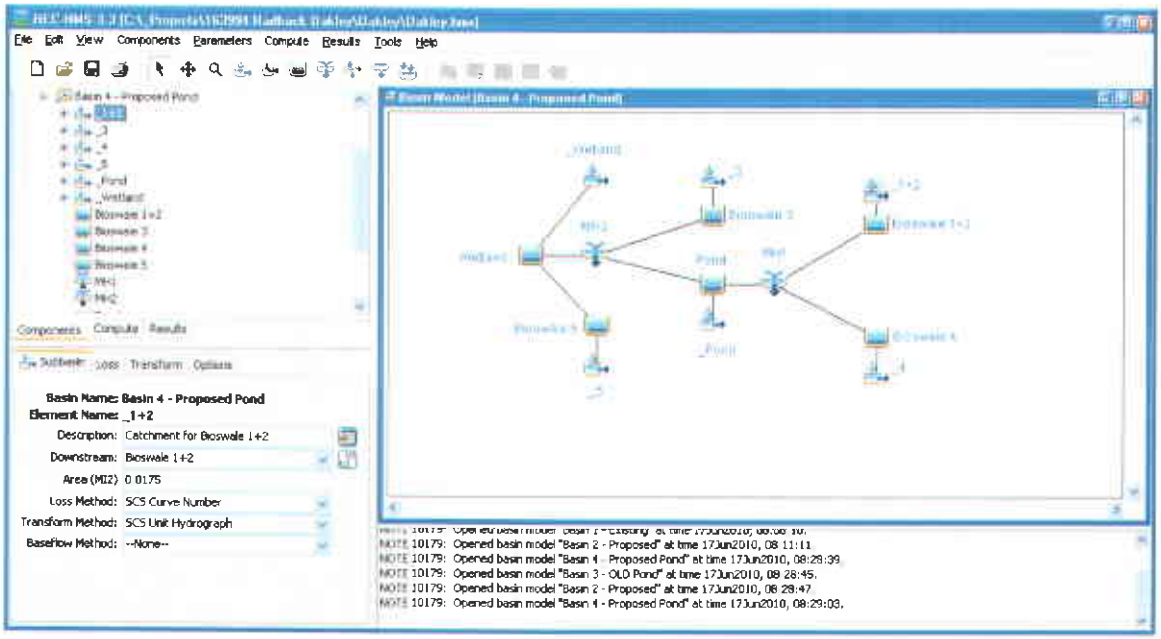

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Basin 2 - Proposed
Basin 3 - Proposed Pond
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1 - Existing
Element Name: Drainage Area
Graph Type Standard
Lag Time (MIN) 19.4

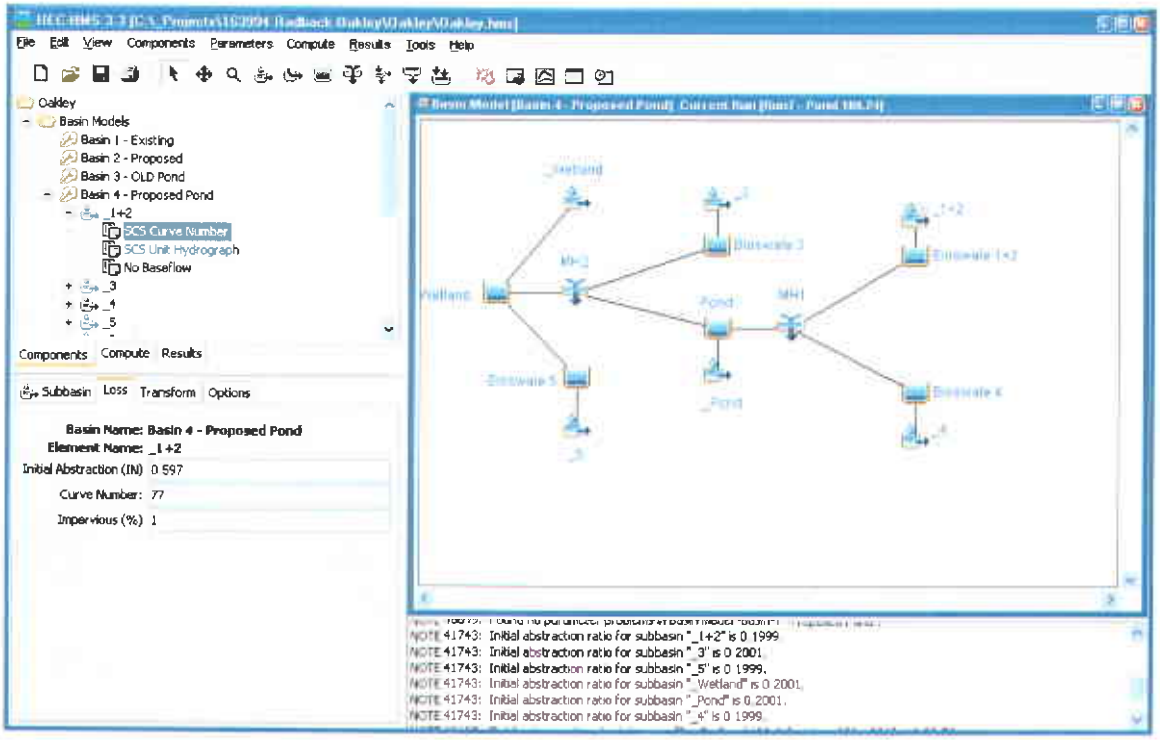

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Basin 2 - Proposed
Basin 3 - Proposed Pond
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1 - Existing
Element Name: Drainage Area
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label

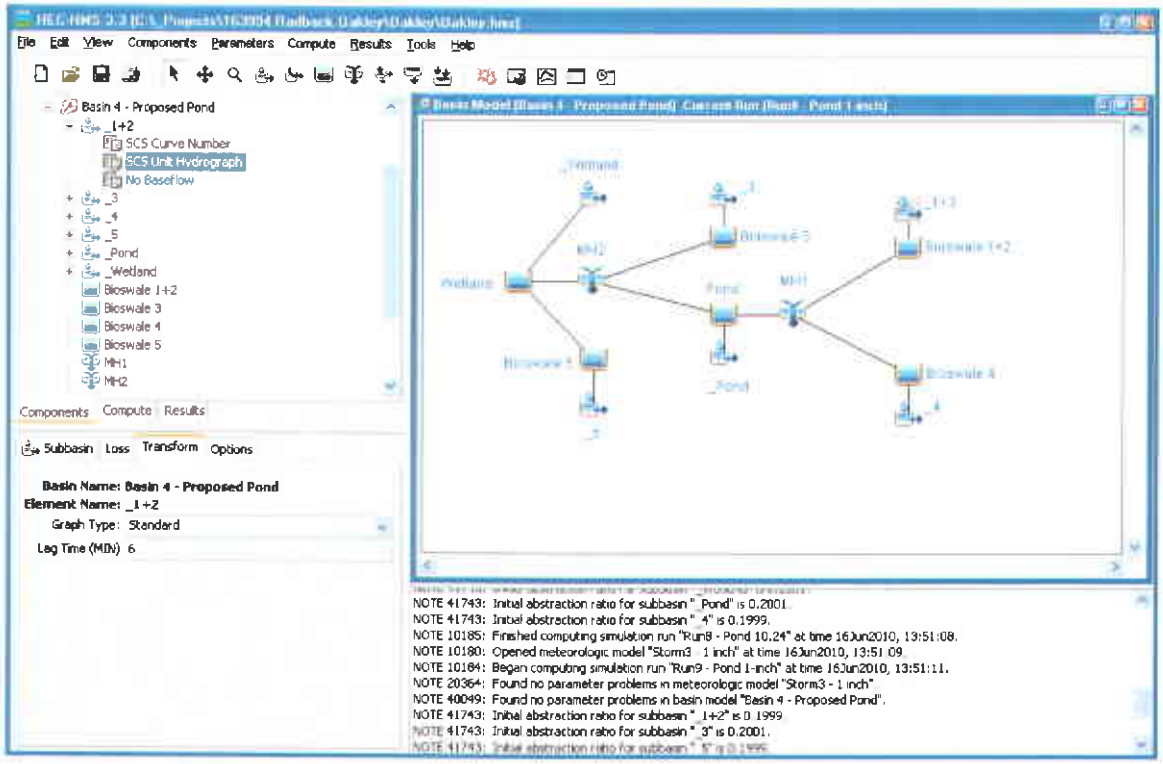

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Basin 2 - Proposed
Basin 3 - Proposed Pond
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components Compute Results
Reservoir Options
Basin Name: Basin 1 - Existing
Element Name: Wetland
Description: Wetland Storage
Downstream:
Method: Specified Release
Storage Method: Elevation-Area
Elev-Area Function: Wetland Ex
Initial Condition: Elevation
Initial Elevation (FT) 5.0
Discharge Gage: Gage 1
Max Release (CFS)
Max Capacity (AC-FT)
Drainage Area
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.1999
NOTE 10185: Finished computing simulation run "Run5 - Pr 10 24" at time 10Jun2010, 11:17:12
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 10Jun2010, 11:17:14

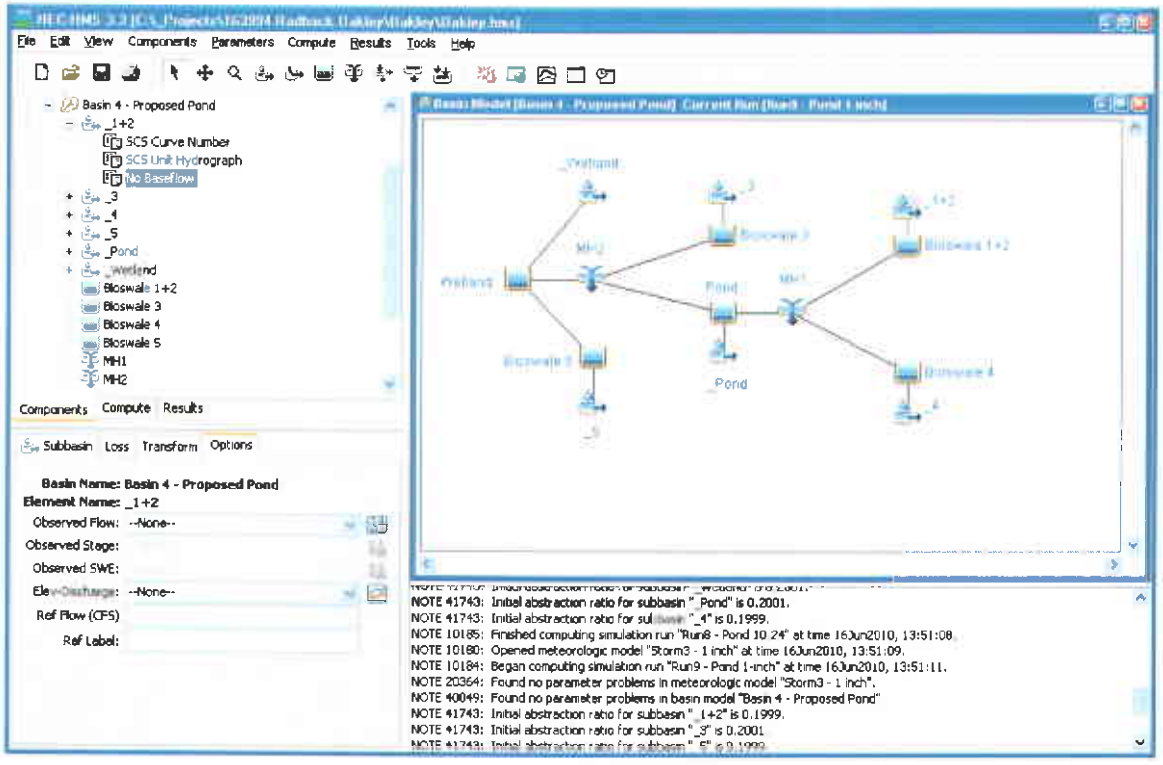
HEC-HMS Input – Basin Model 4 – Proposed (Post-Construction Condition)

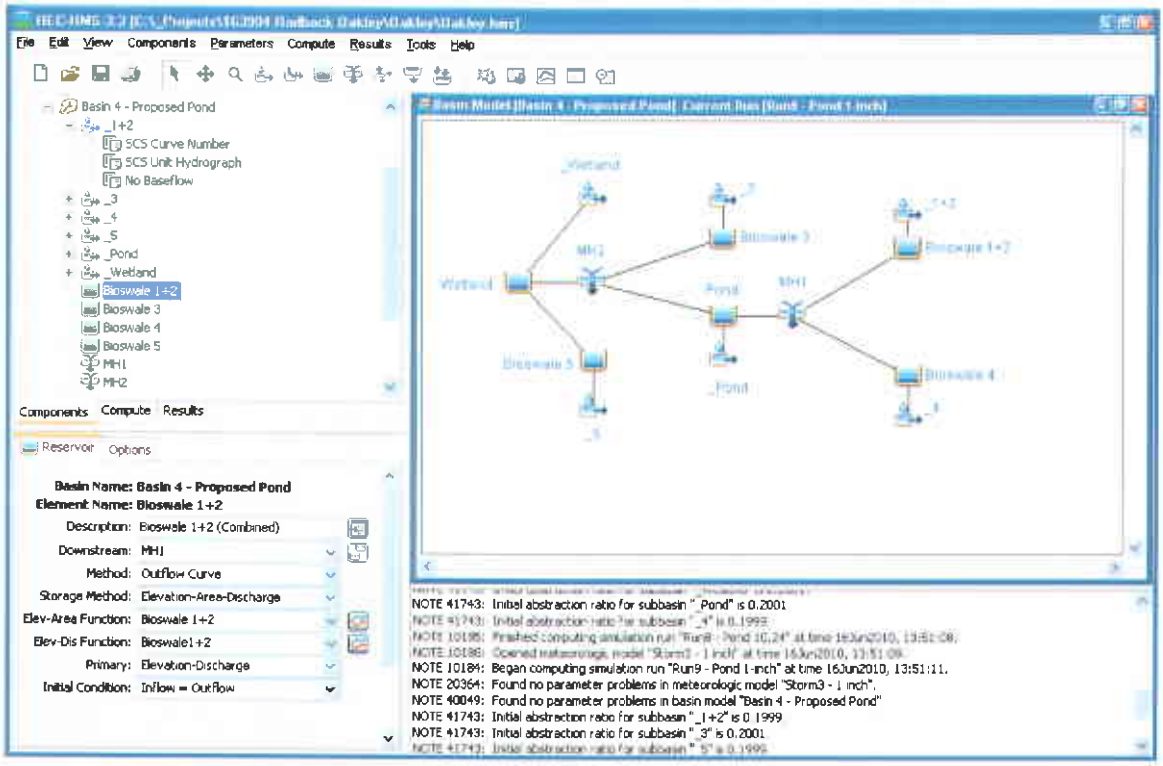
Bioswale 1+2 (Combined)

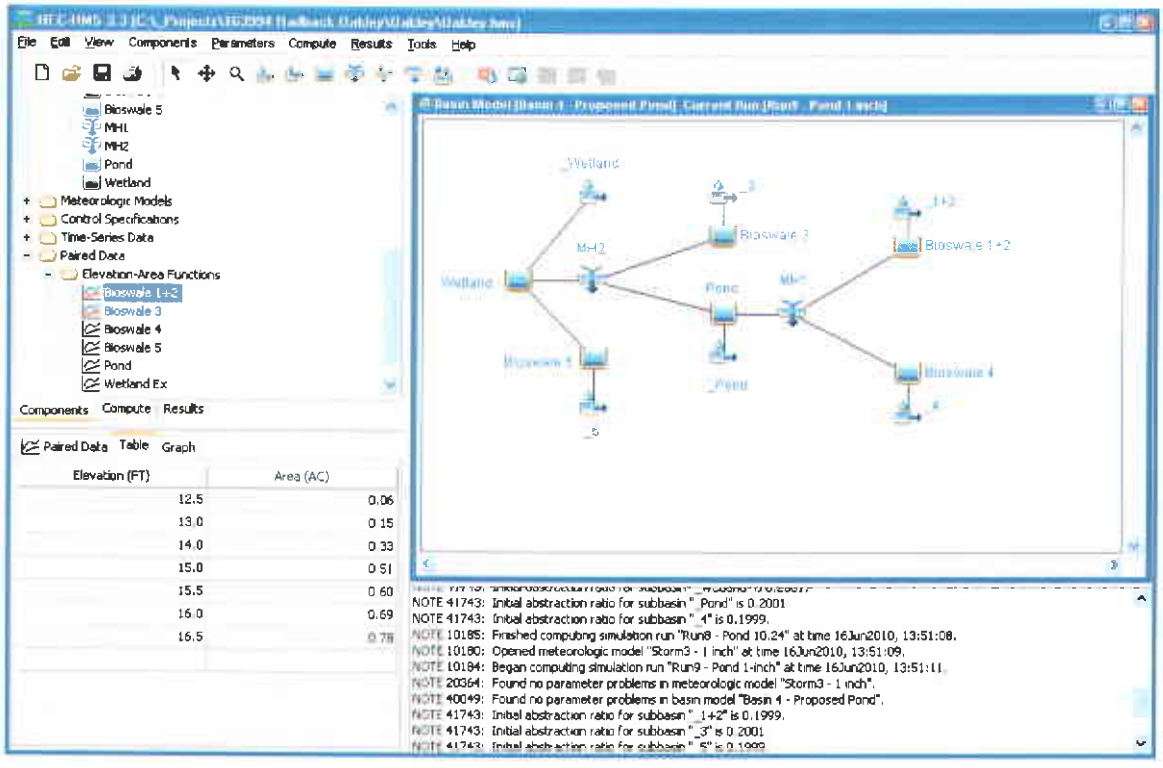


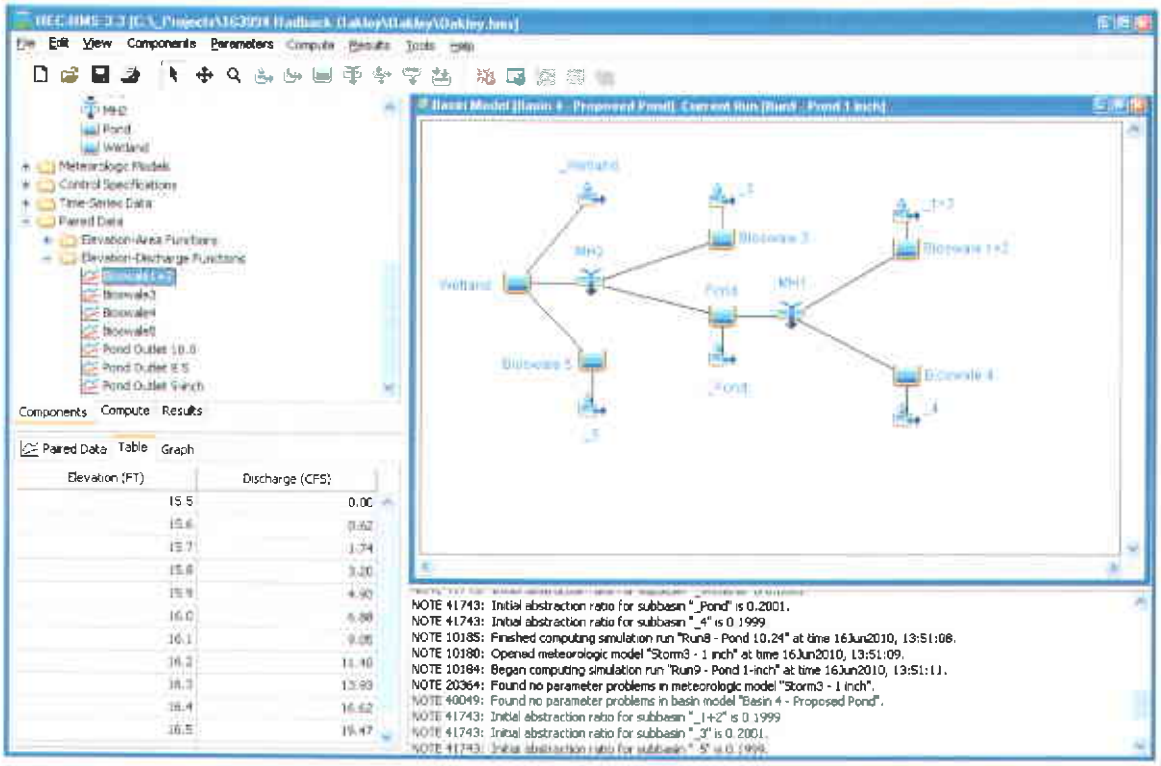



File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _1+2
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

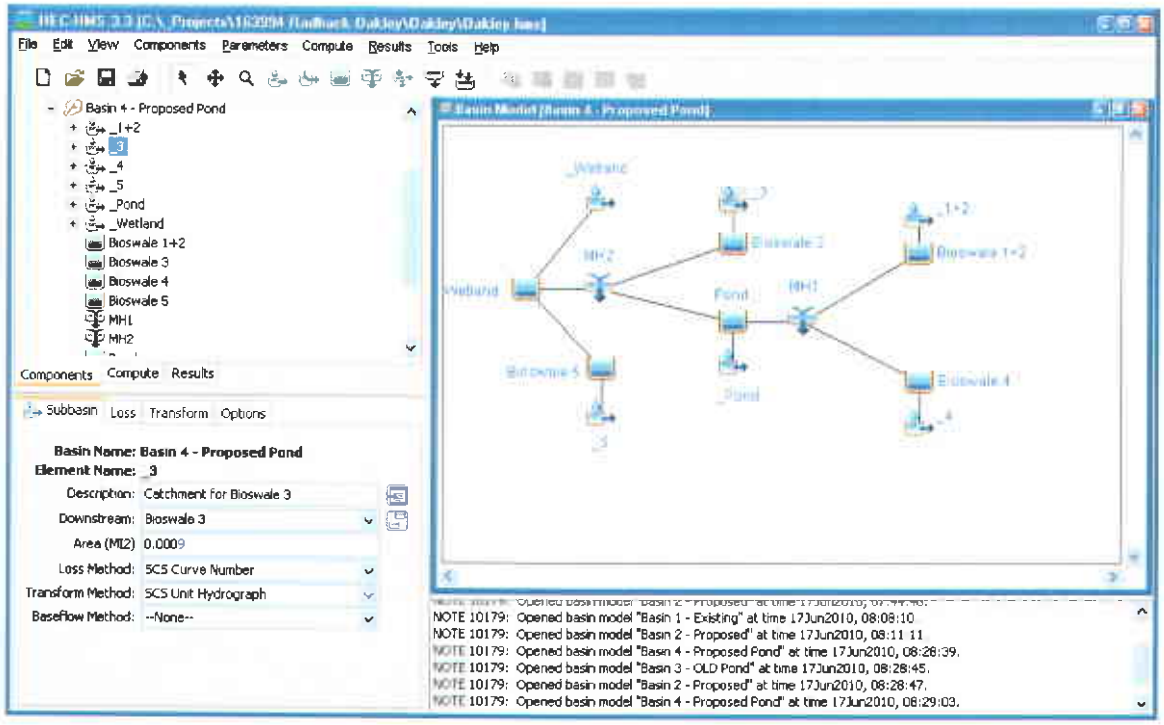

File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _1+2
Observed Flow: --None--
Observed Stage:
Observed SWE:
Ele-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

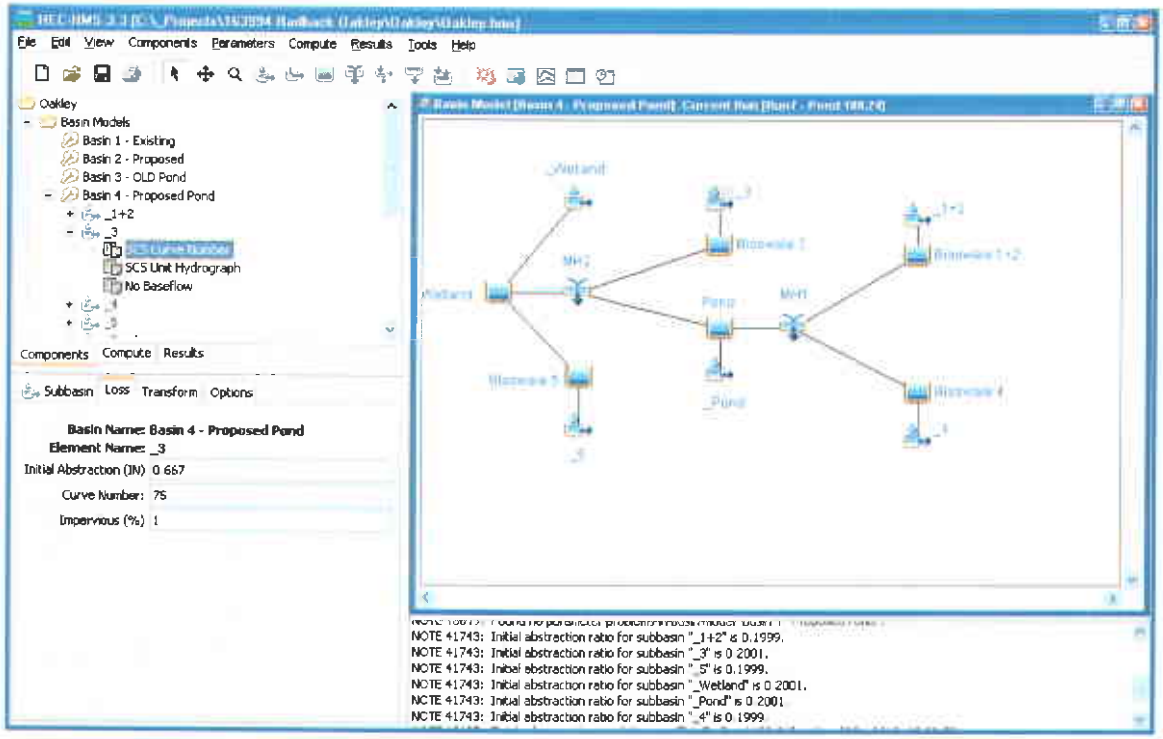

File Edit View Components Parameters Compute Results Tools Help
Basin 4 - Proposed Pond
_1+2
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 1+2
Description: Bioswale 1+2 (Combined)
Downstream: MH1
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 1+2
Elev-Dis Function: Bioswale1+2
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond"
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

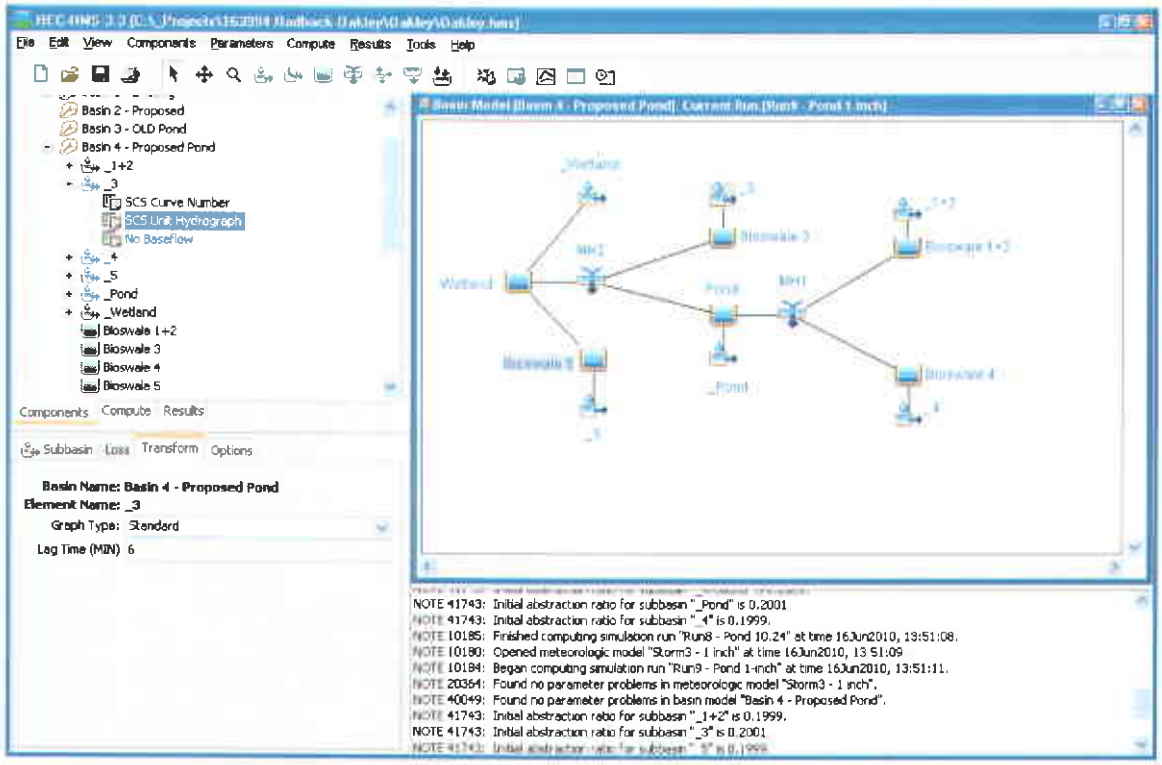

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
12.5 0.06
13.0 0.15
14.0 0.33
15.0 0.51
15.5 0.60
16.0 0.69
16.5 0.78
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

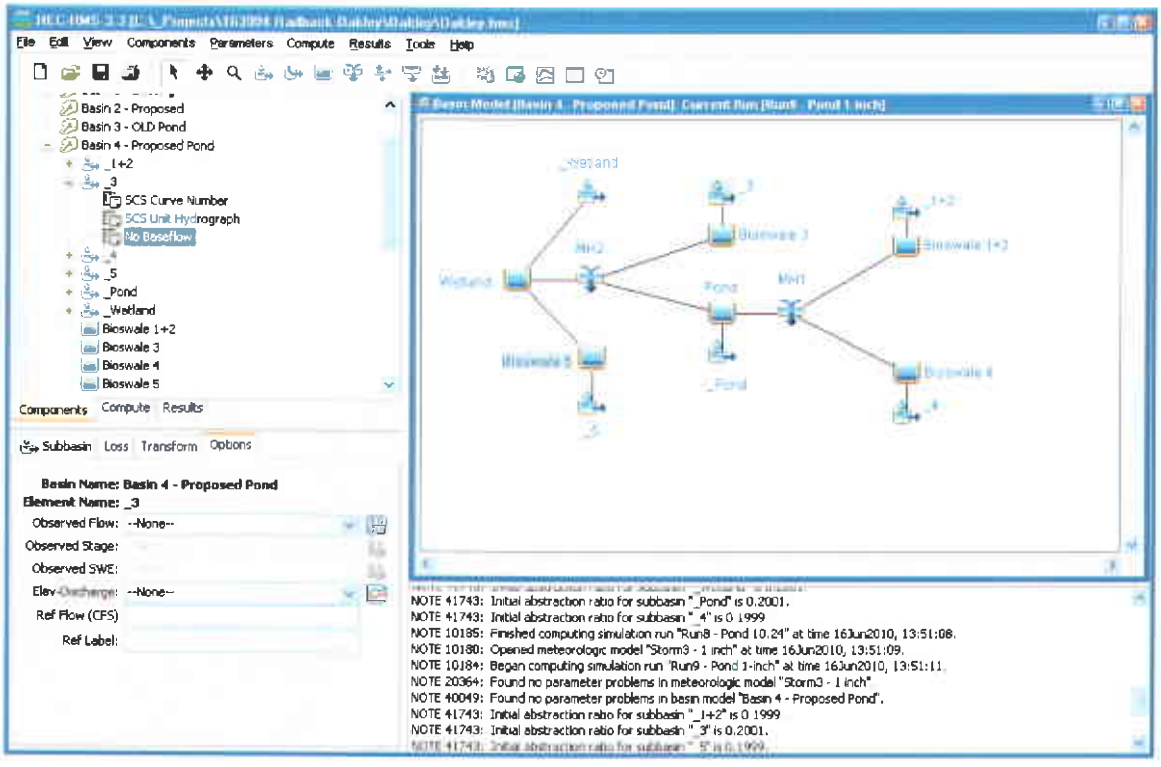

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 5-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
15.5 0.00
15.6 0.62
15.7 1.74
15.8 3.20
15.9 4.90
16.0 6.88
16.1 9.05
16.2 11.40
16.3 13.93
16.4 16.62
16.5 19.47
Wetland
MH2
Bioswale 3
Bioswale 1+2
Pond
MH1
Bioswale 5
_Pond
Bioswale 4
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

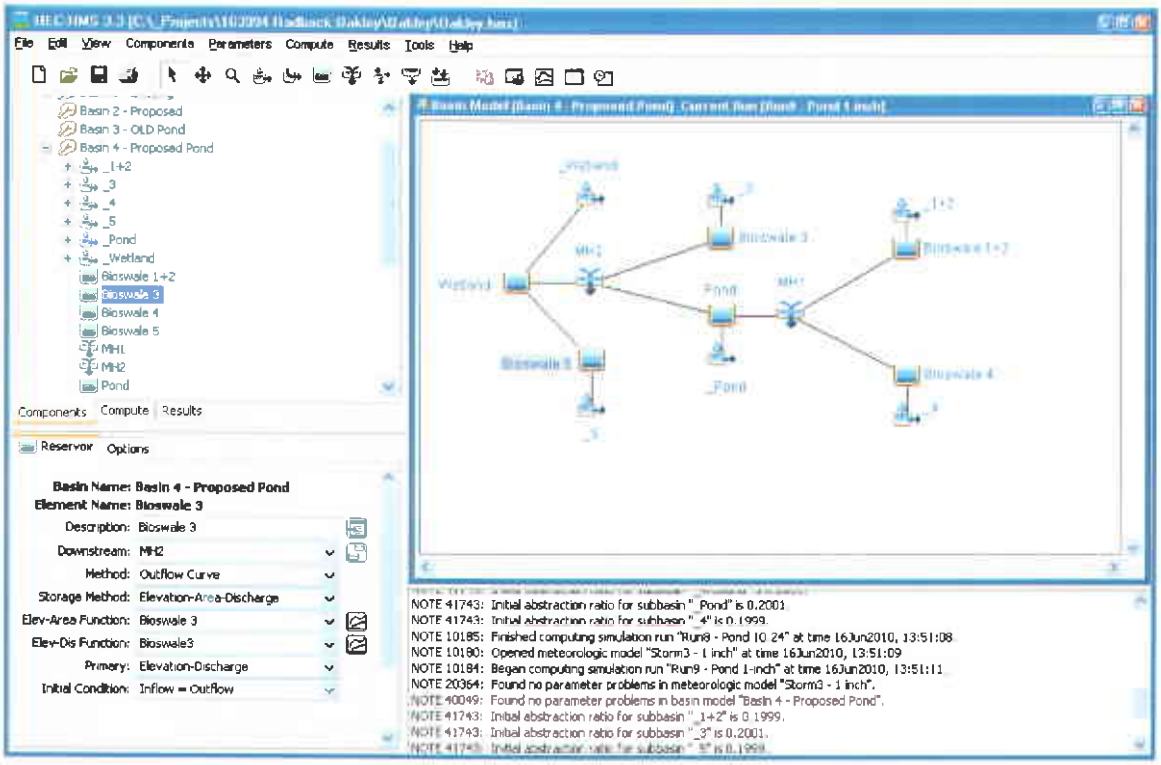
HEC-HMS Input – Bioswale 3

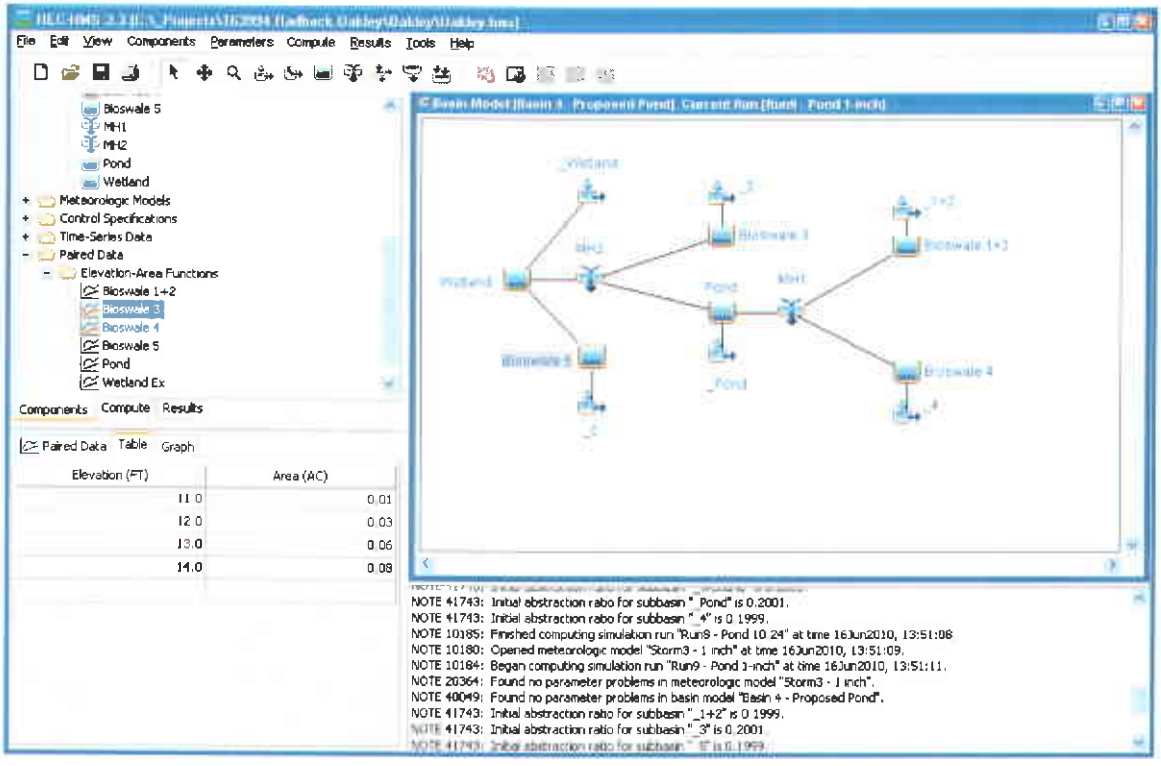


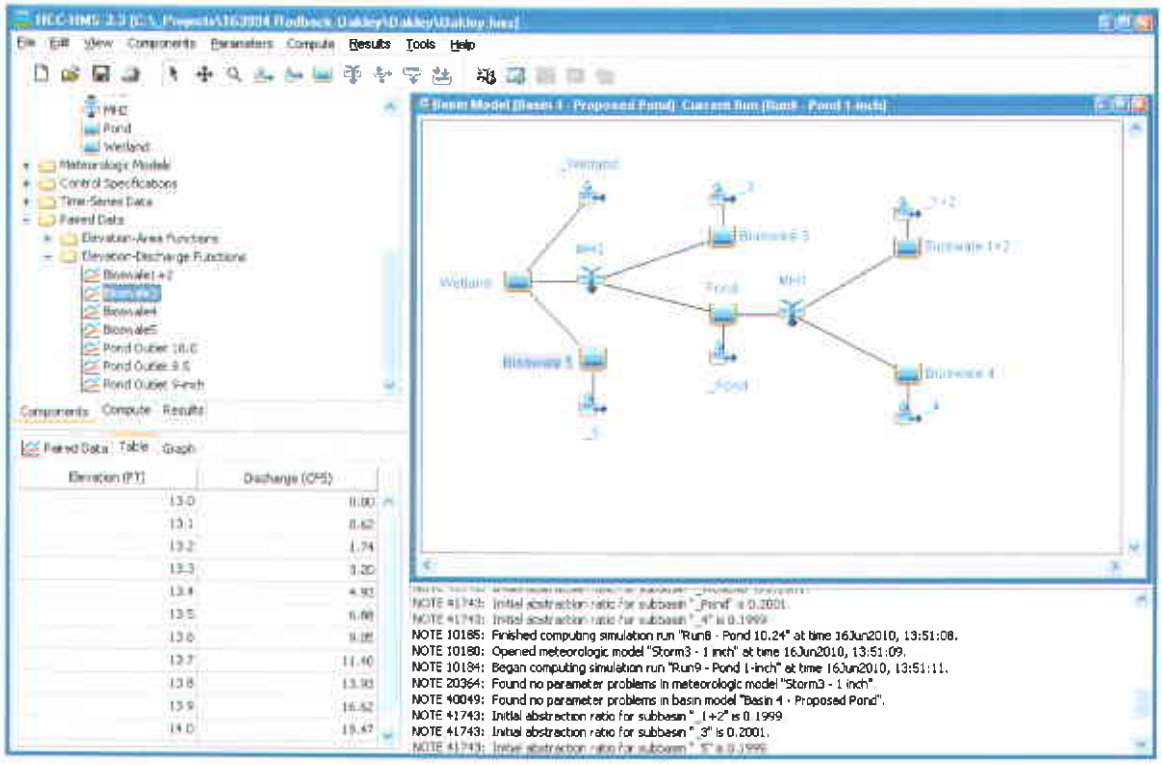



File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _3
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

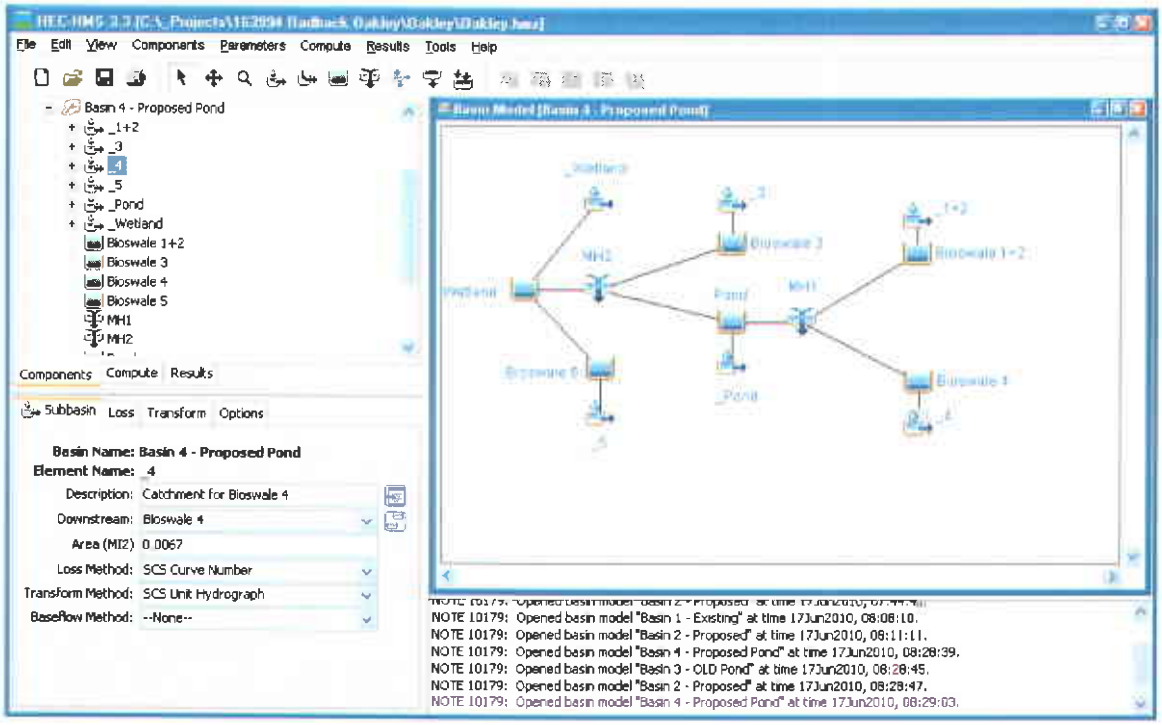

File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _3
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch"
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

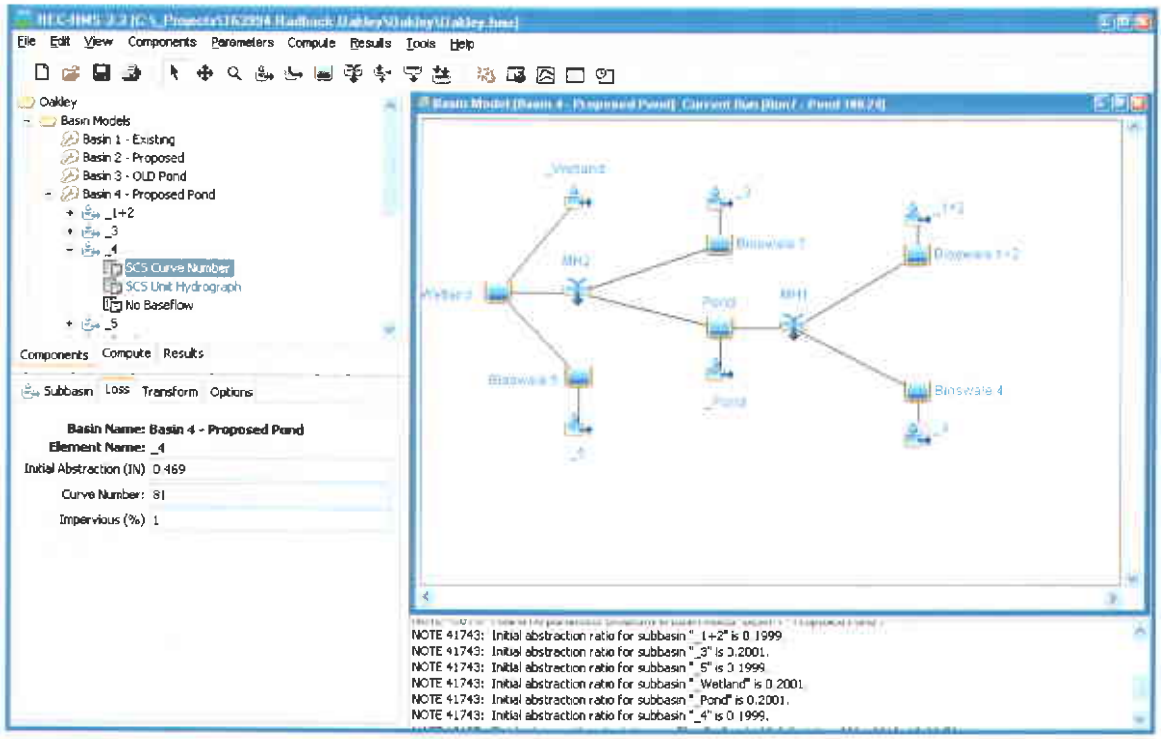

File Edit View Components Parameters Compute Results Tools Help
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 3
Description: Bioswale 3
Downstream: MH2
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 3
Elev-Dis Function: Bioswale3
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

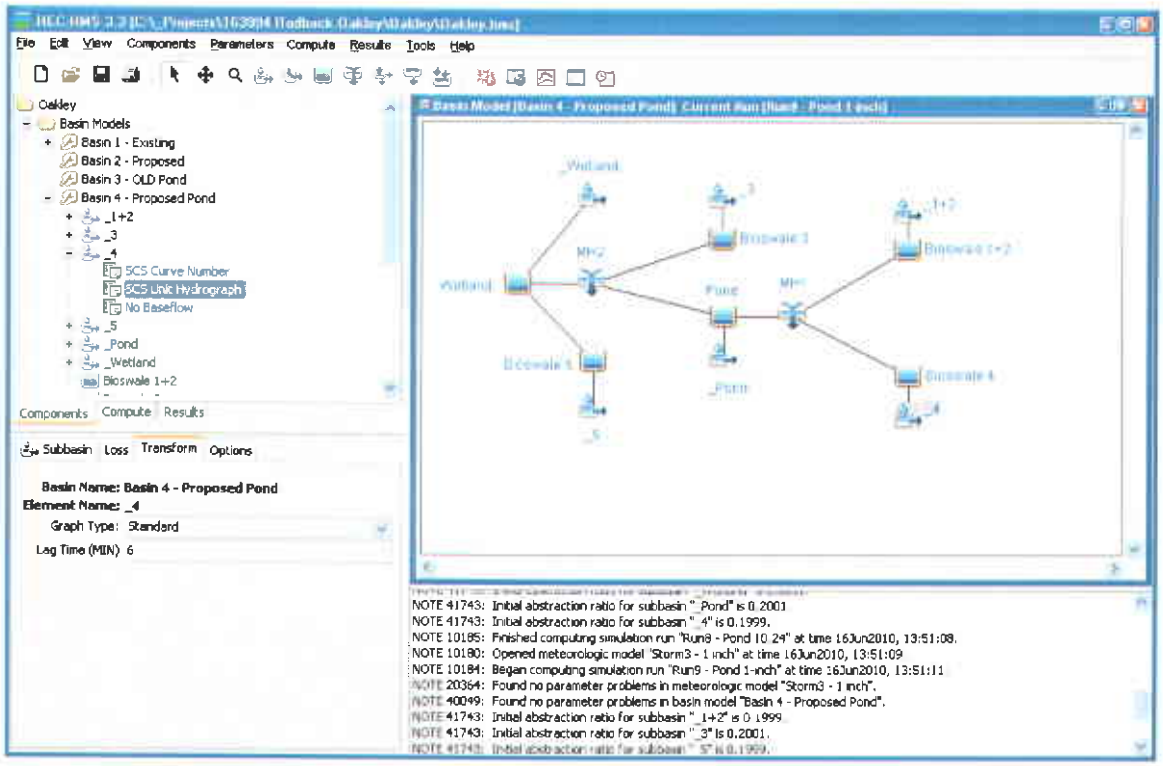

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
11.0 0.01
12.0 0.03
13.0 0.06
14.0 0.08
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

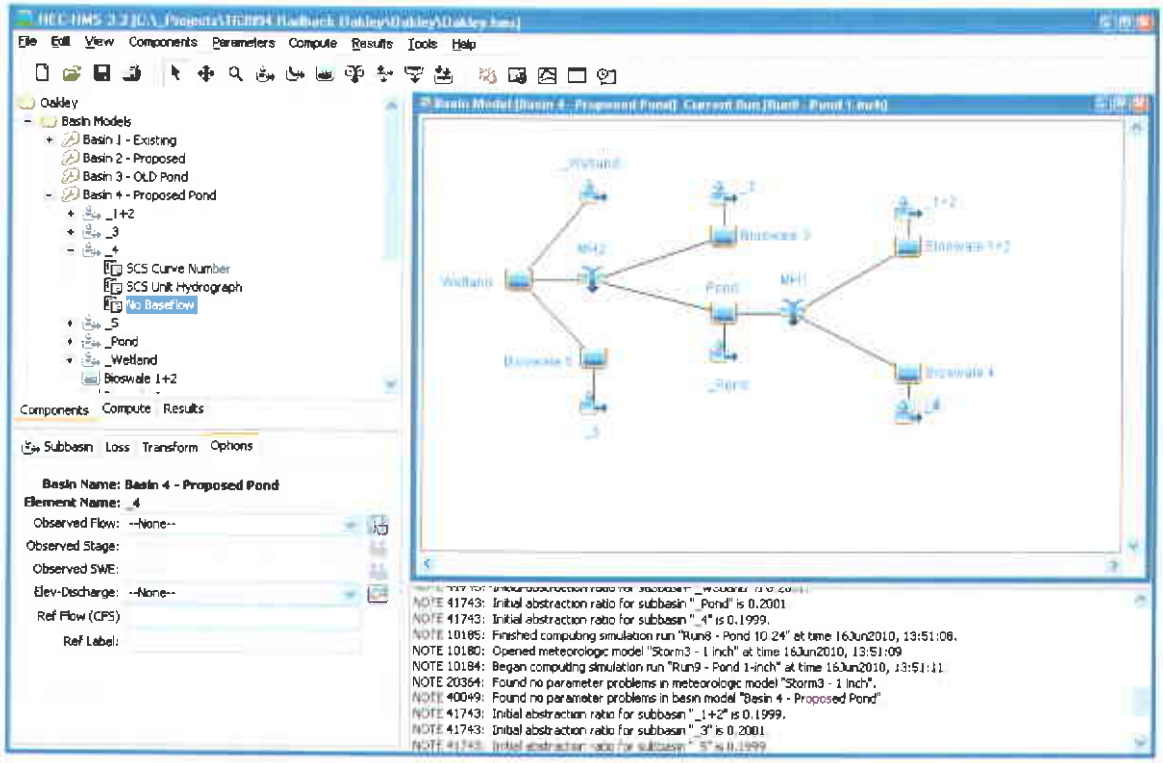

File Edit View Components Parameters Compute Results Tools Help
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
13.0 0.00
13.1 0.62
13.2 1.74
13.3 3.20
13.4 4.93
13.5 6.88
13.6 9.05
13.7 11.40
13.8 13.93
13.9 16.62
14.0 19.47
Basin Model Basin 4 - Proposed Pond) Current Run (Run8 - Pond 10.24")
Wetland
Pond
MH1
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch"
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

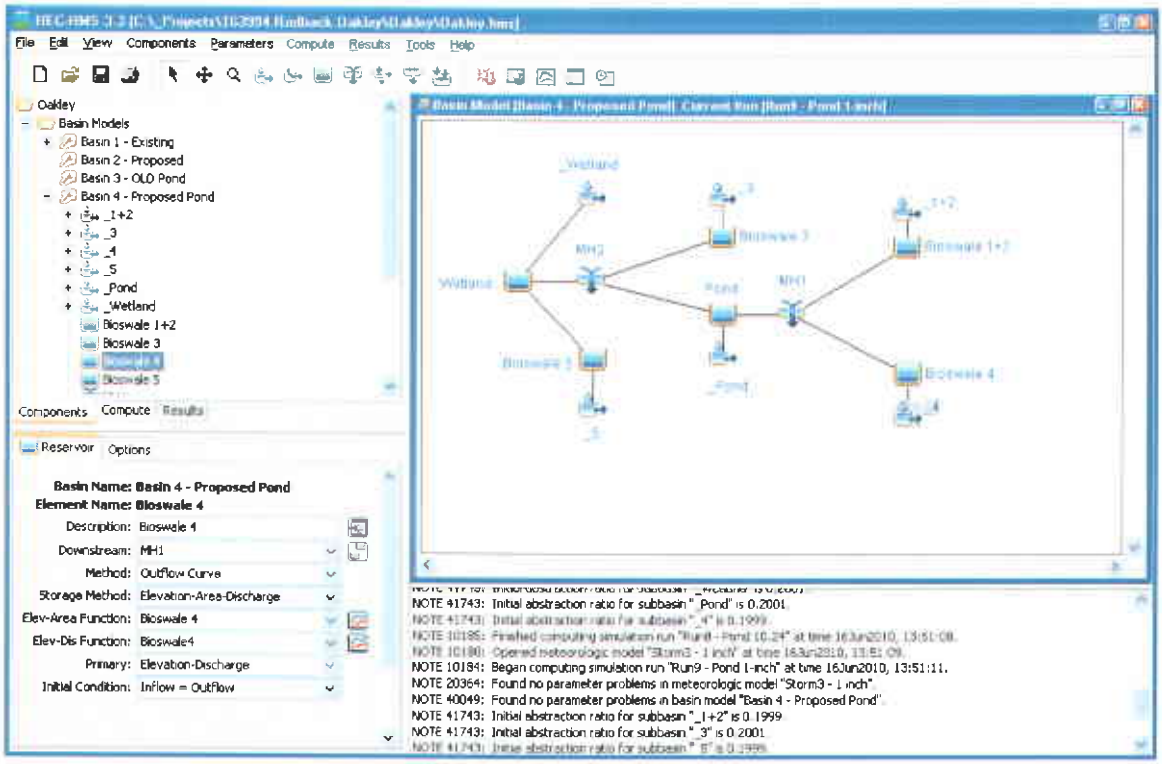
HEC-HMS Input – Bioswale 4

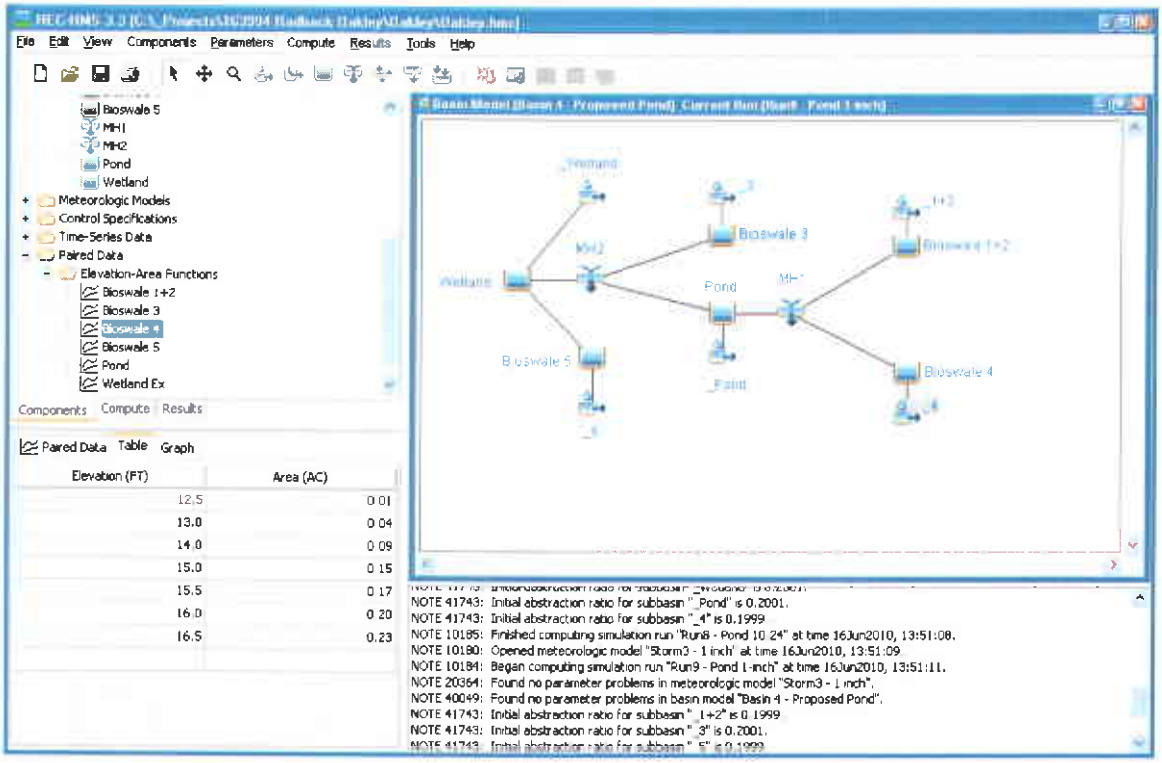


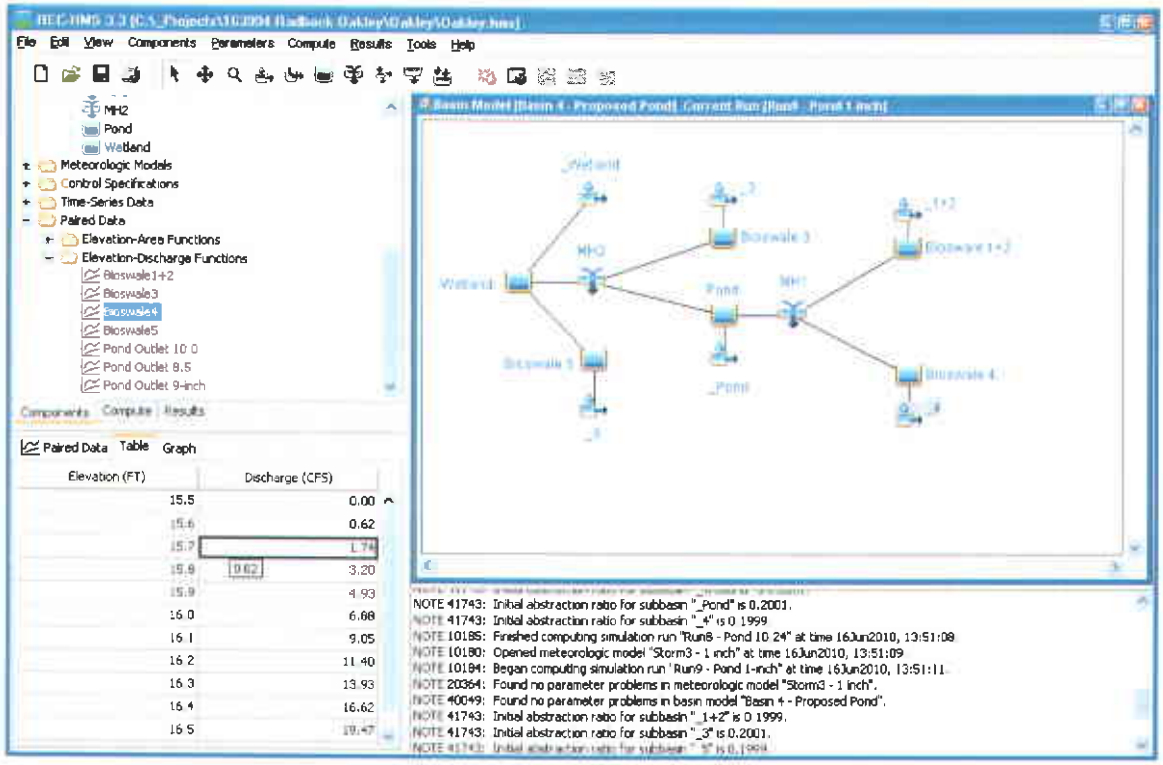



File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_5
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _4
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

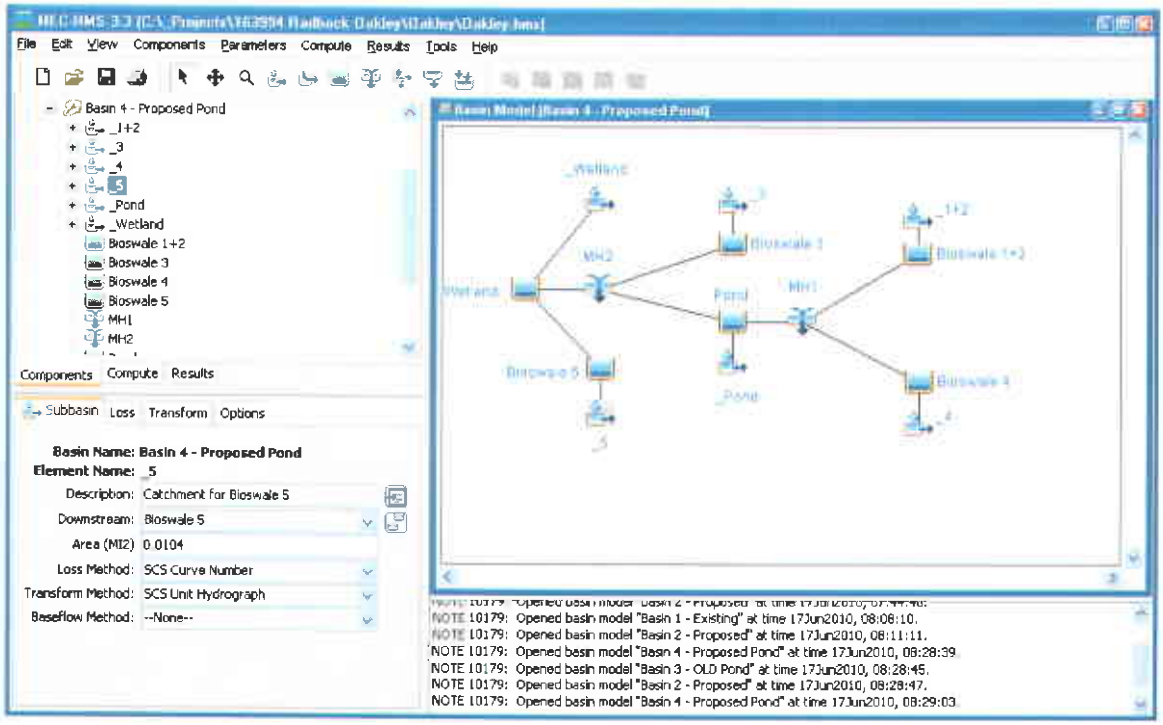

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_5
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _4
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond"
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

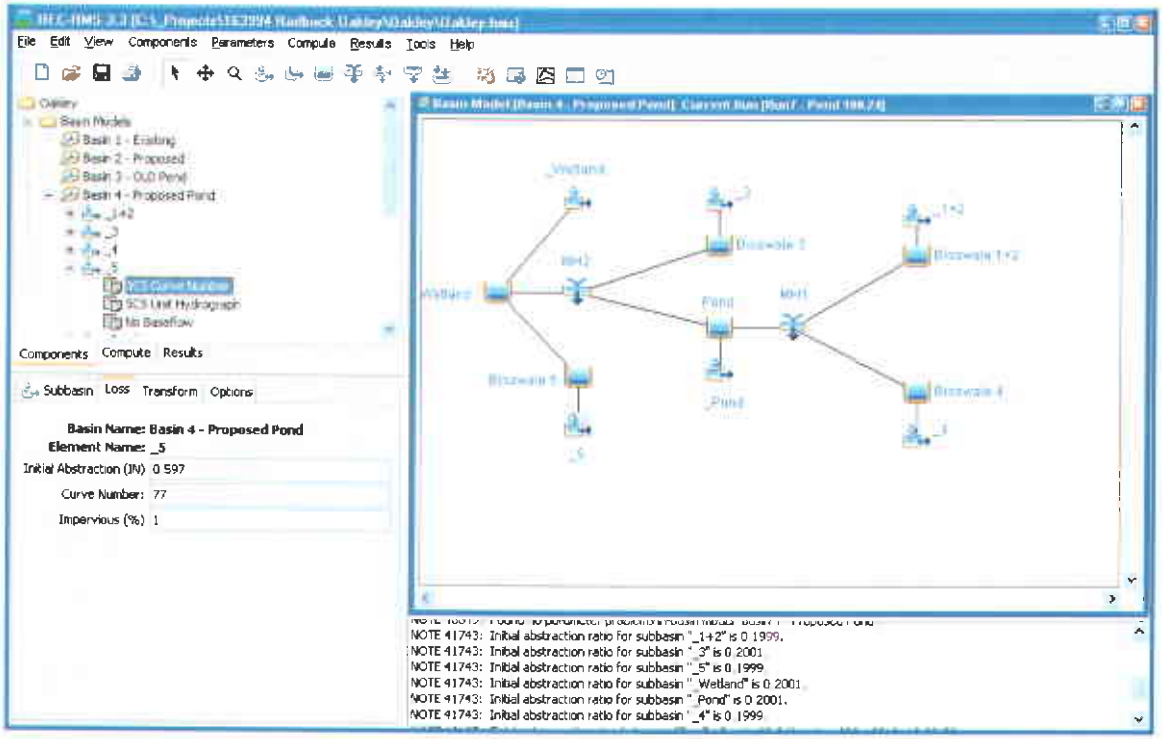

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 4
Description: Bioswale 4
Downstream: MH1
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 4
Elev-Dis Function: Bioswale4
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

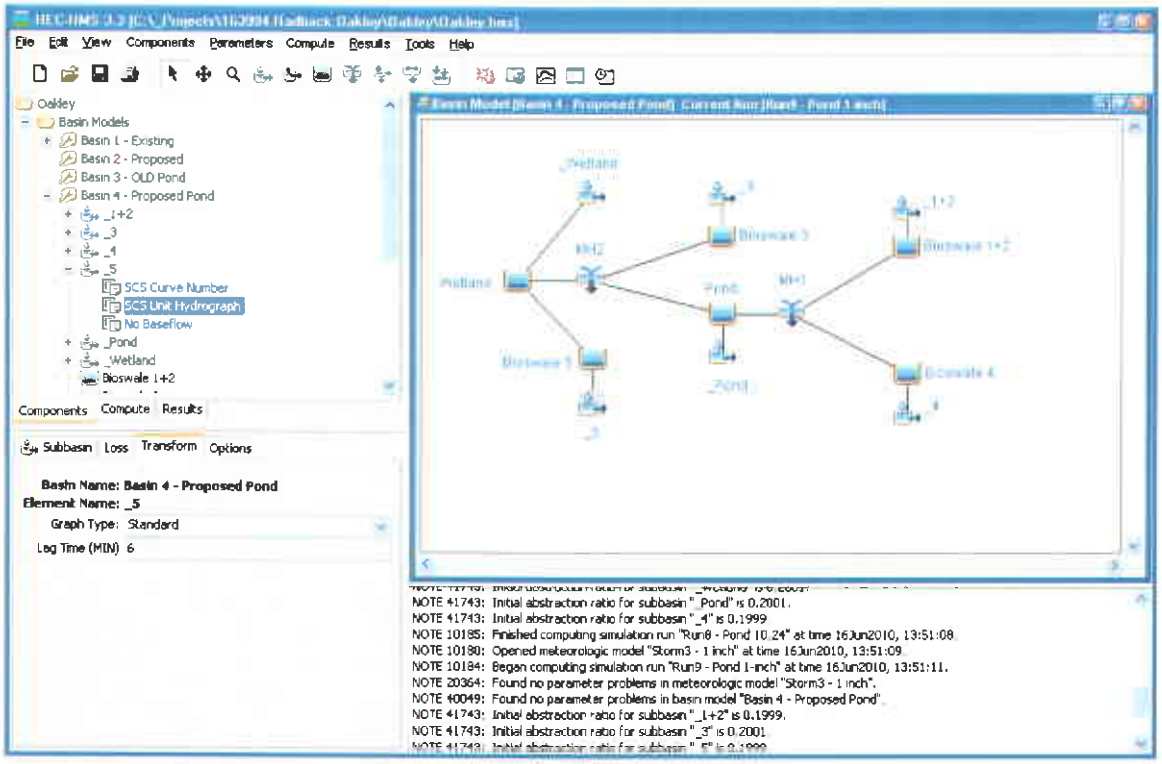

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
12.5 0.01
13.0 0.04
14.0 0.09
15.0 0.15
15.5 0.17
16.0 0.20
16.5 0.23
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

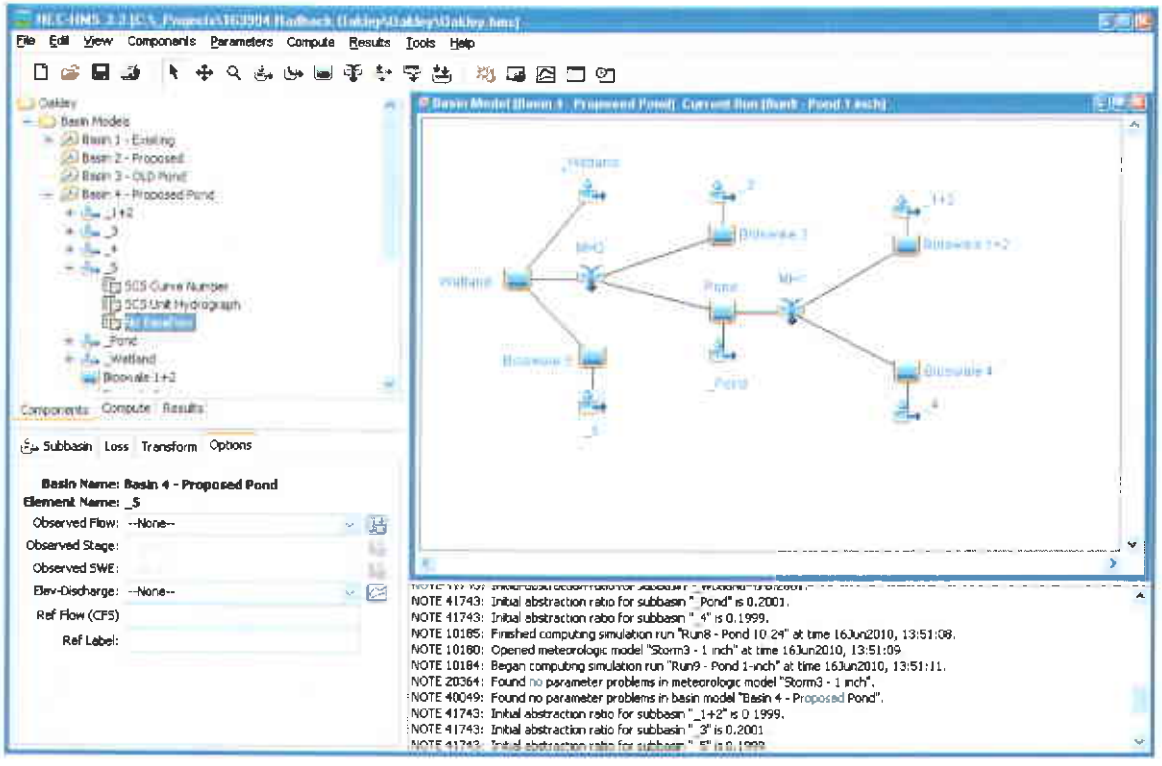

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
15.5 0.00
15.6 0.62
15.7 1.74
15.8 3.20
15.9 4.93
16.0 6.88
16.1 9.05
16.2 11.40
16.3 13.93
16.4 16.62
16.5 19.47
Wetland
MH2
Bioswale 3
Bioswale 1+2
Pond
MH1
Bioswale 5
Bioswale 4
_Pond
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

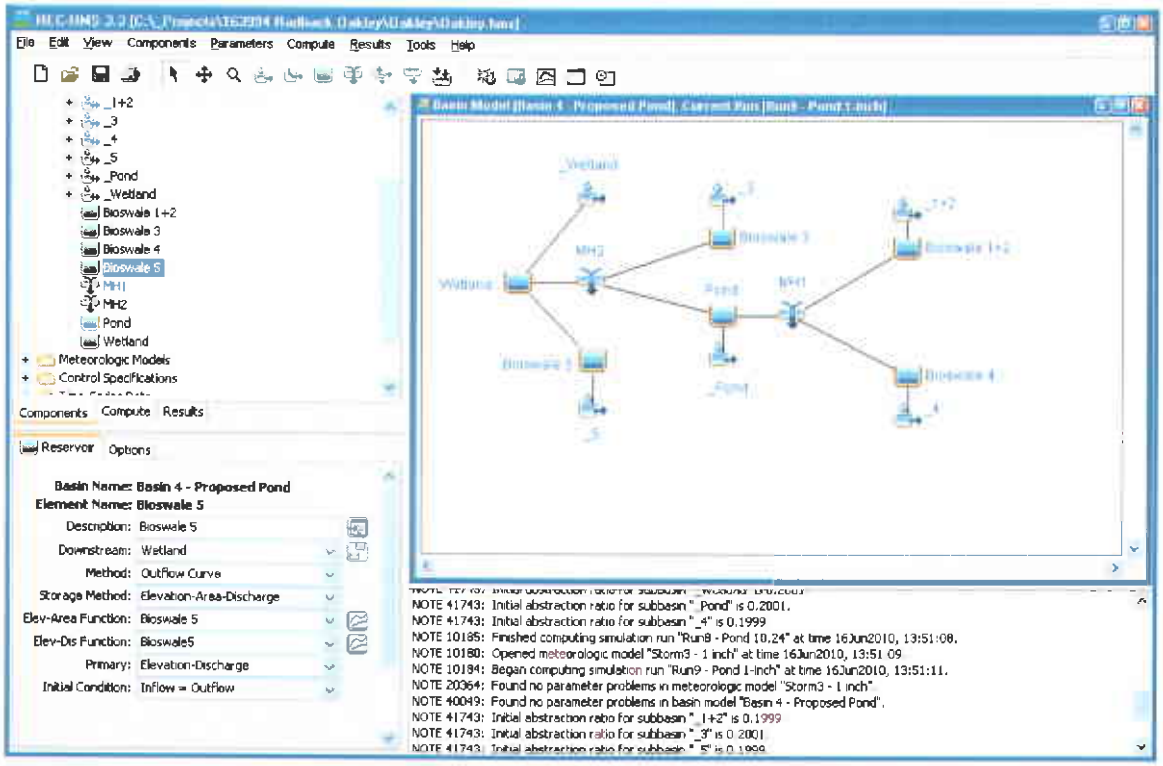
HEC-HMS Input – Bioswale 5

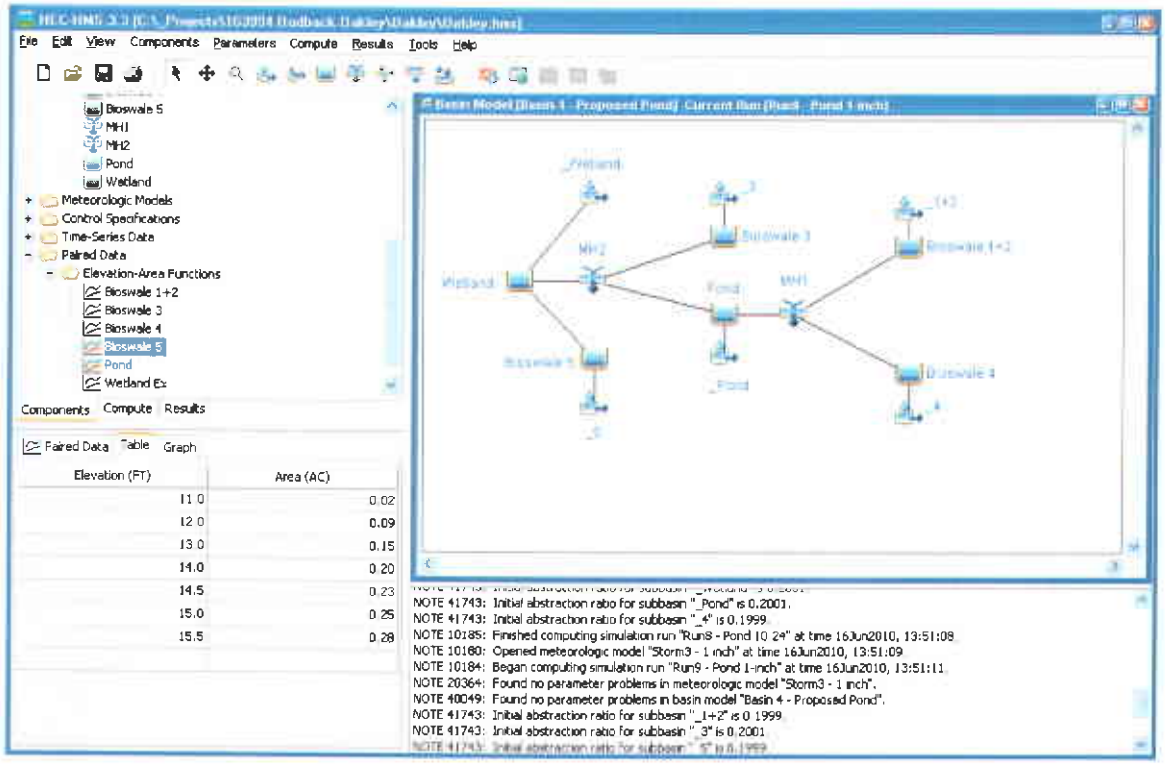


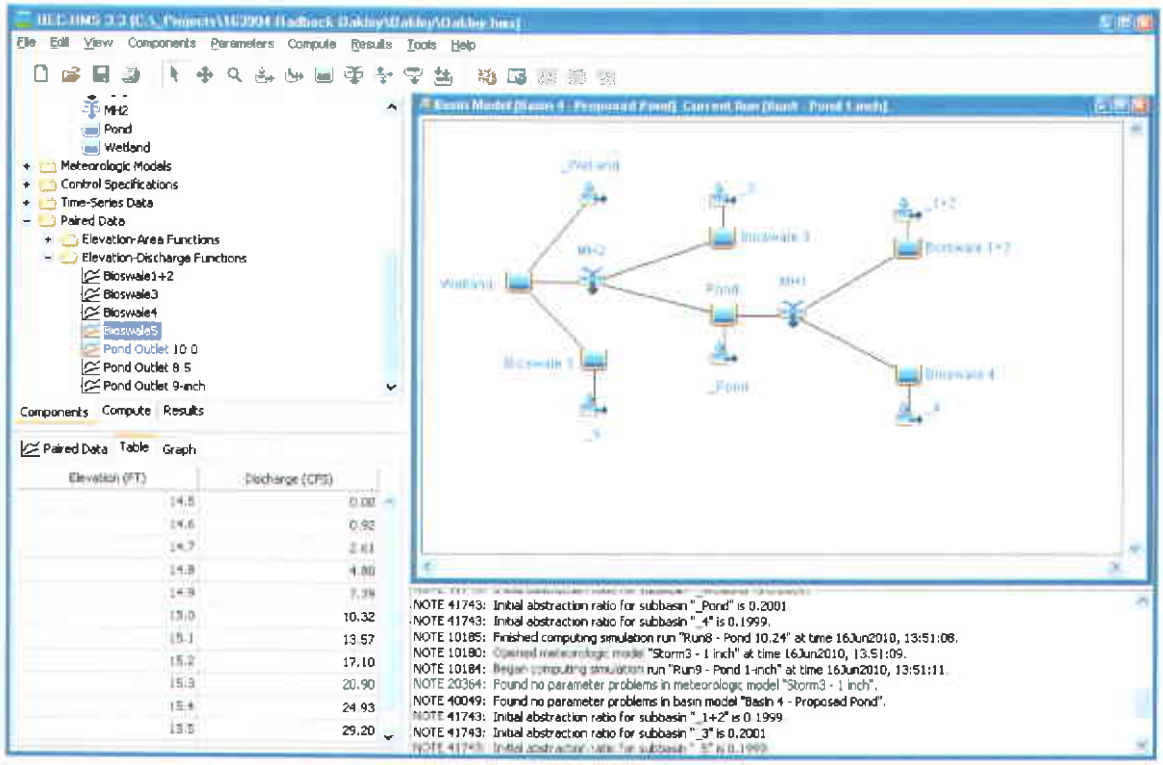



File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _5
Graph Type: Standard
Lag Time (MIN) 6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

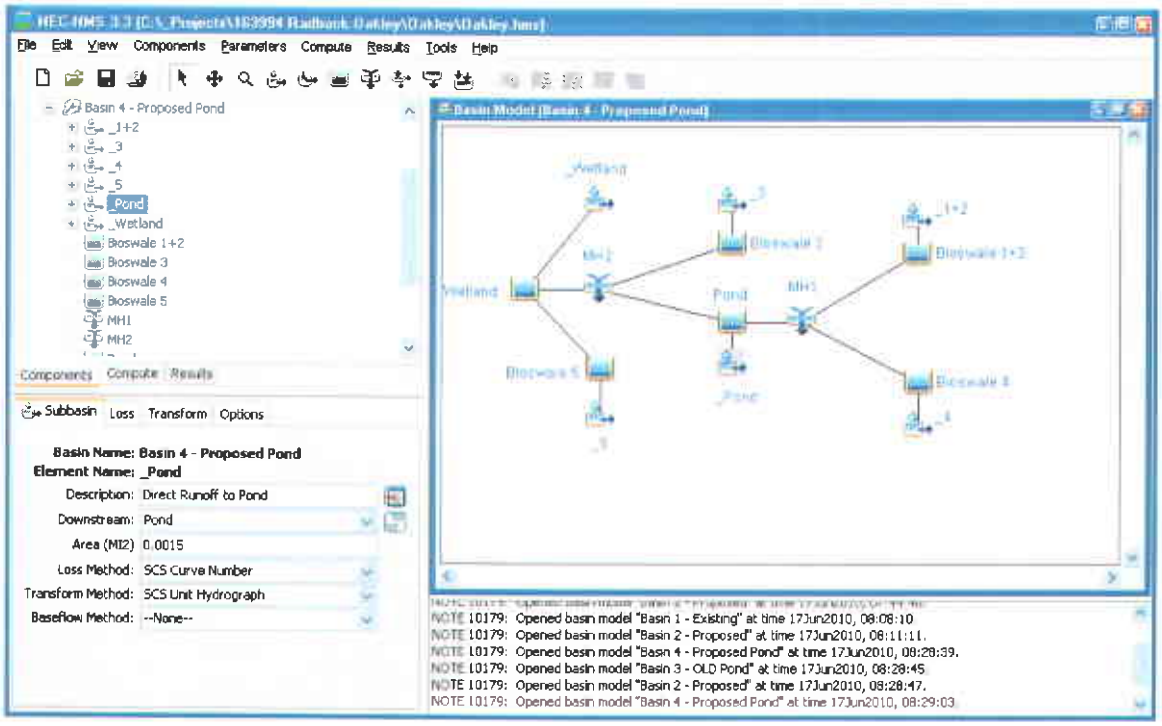

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Pond
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _5
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

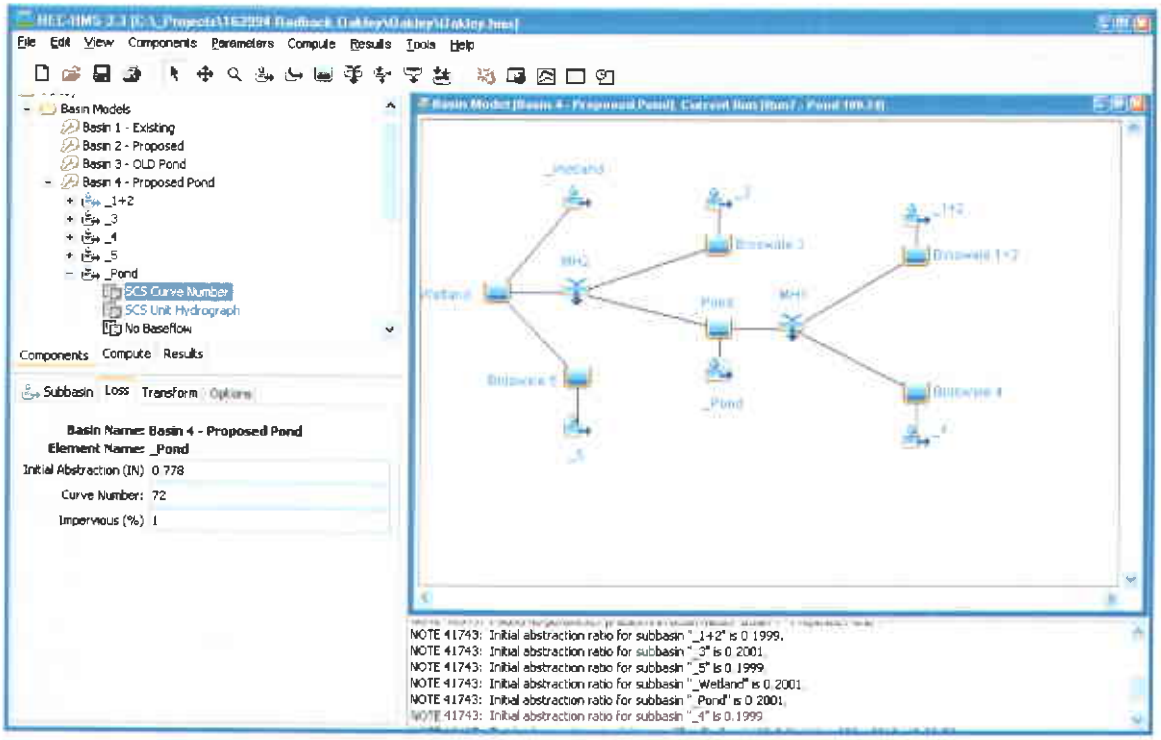

File Edit View Components Parameters Compute Results Tools Help
_1+2
_3
_4
_5
_Pond
_Wetland
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Components Compute Results
Reservoir Options
Basin Name: Basin 4 - Proposed Pond
Element Name: Bioswale 5
Description: Bioswale 5
Downstream: Wetland
Method: Outflow Curve
Storage Method: Elevation-Area-Discharge
Elev-Area Function: Bioswale 5
Elev-Dis Function: Bioswale5
Primary: Elevation-Discharge
Initial Condition: Inflow = Outflow
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

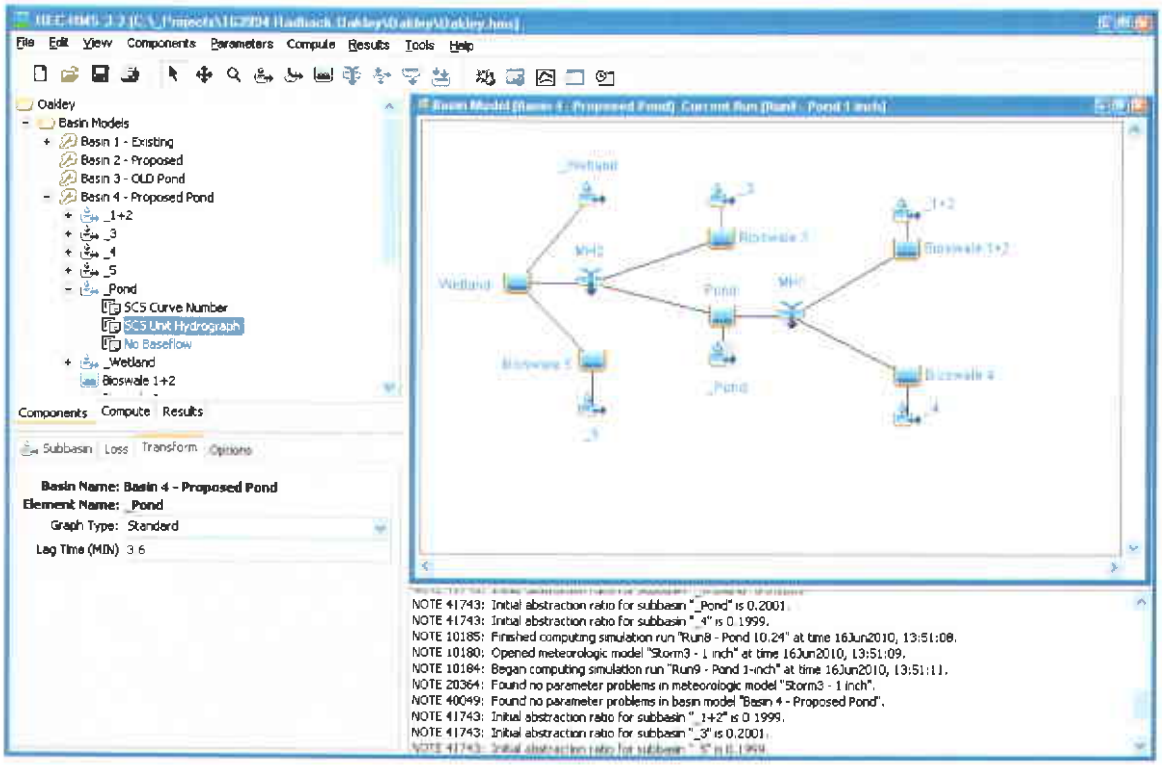

File Edit View Components Parameters Compute Results Tools Help
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 3
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Components Compute Results
Paired Data Table Graph
Elevation (FT) Area (AC)
11.0 0.02
12.0 0.09
13.0 0.15
14.0 0.20
14.5 0.23
15.0 0.25
15.5 0.28
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

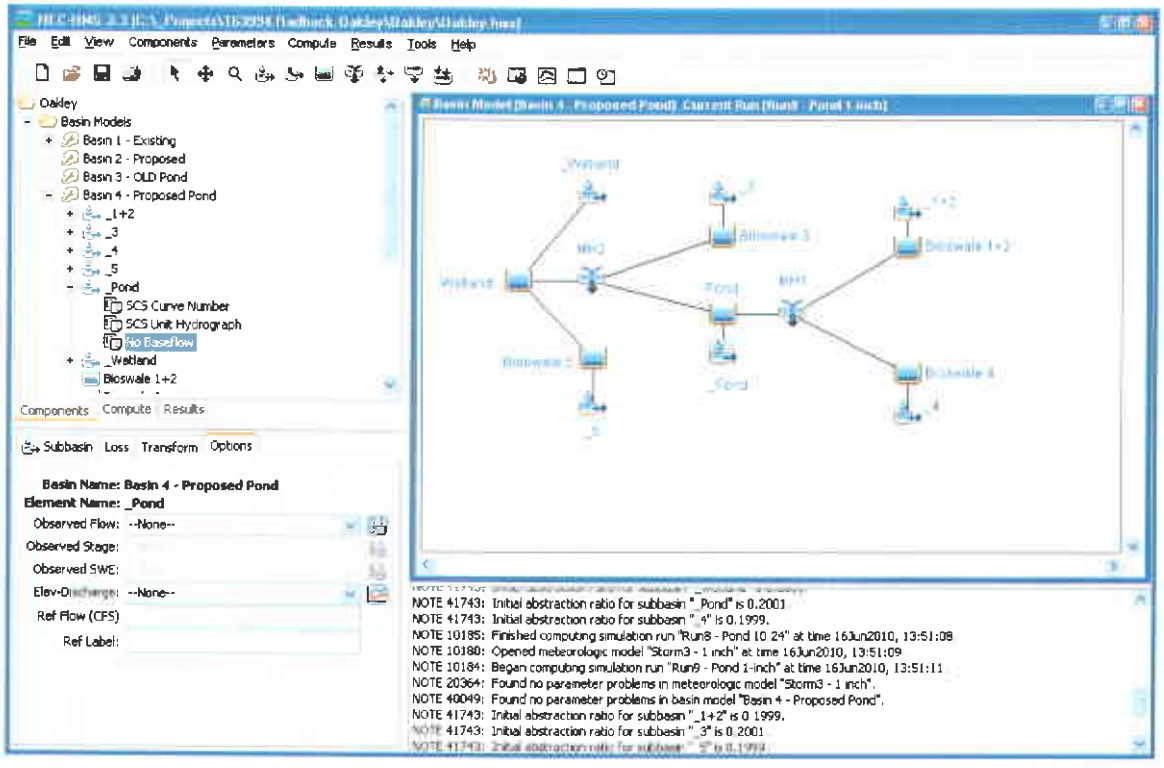

File Edit View Components Parameters Compute Results Tools Help
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
14.5 0.00
14.6 0.92
14.7 2.61
14.8 4.80
14.9 7.39
15.0 10.32
15.1 13.57
15.2 17.10
15.3 20.90
15.4 24.93
15.5 29.20
Wetland
MH2
Pond
MH1
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001

HEC-HMS Input – Direct Runoff to Pond

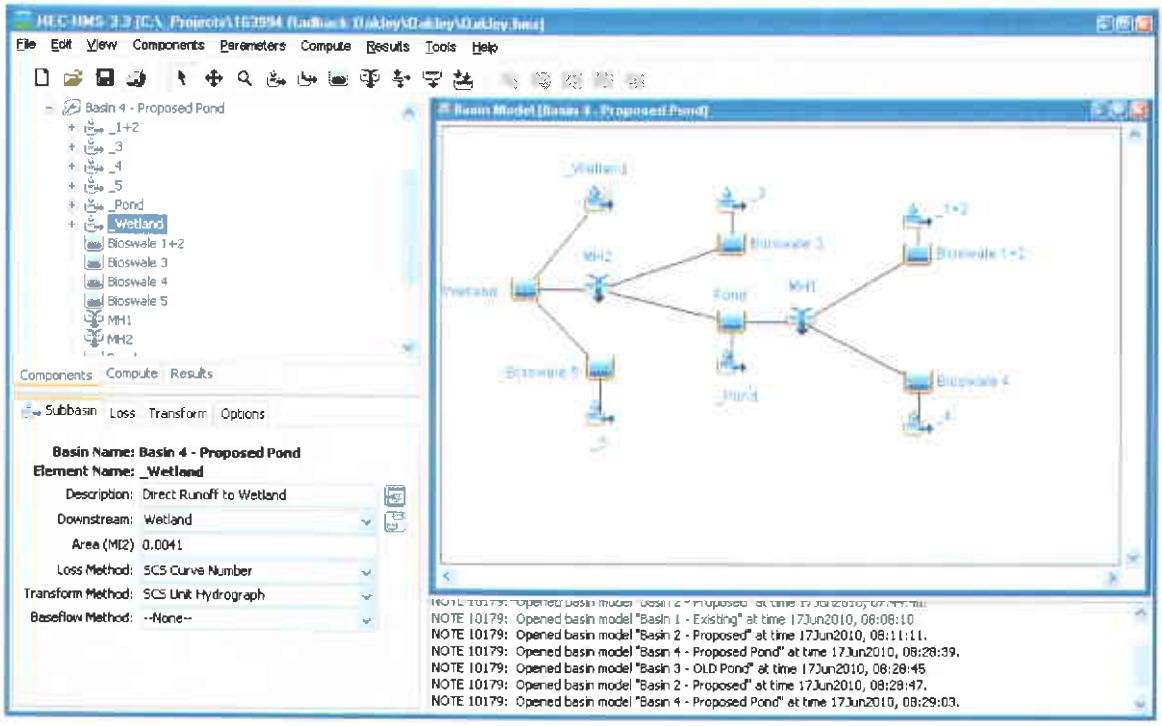


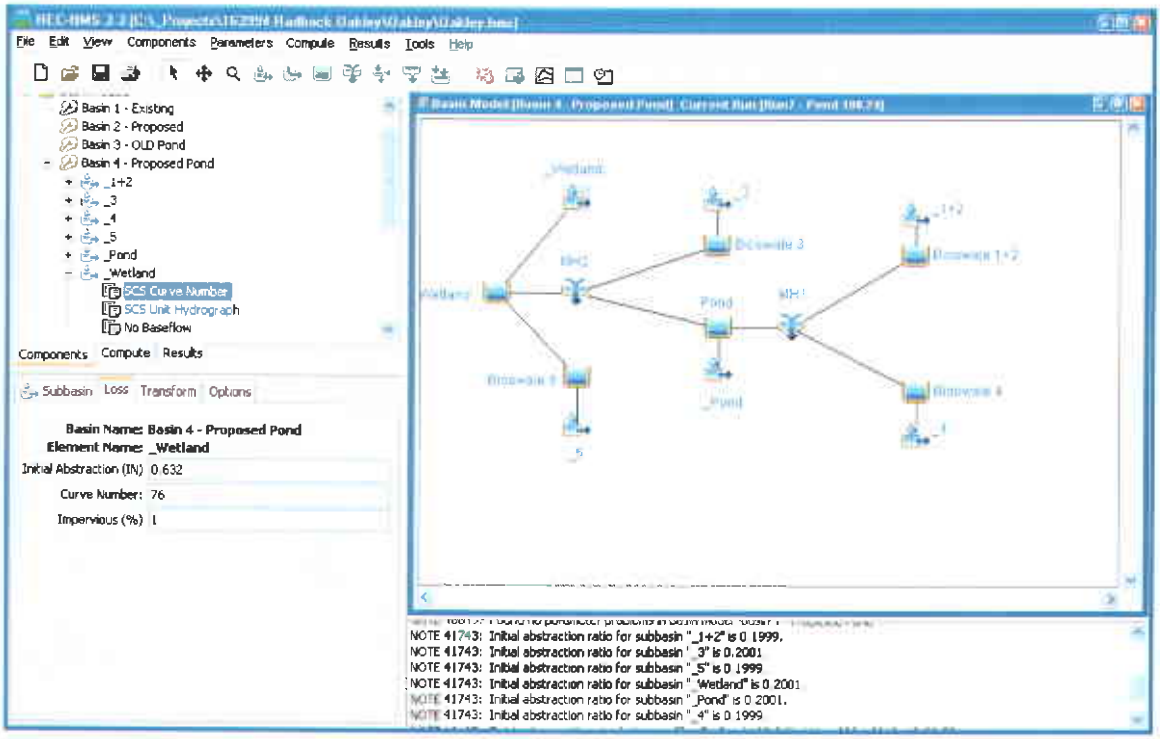


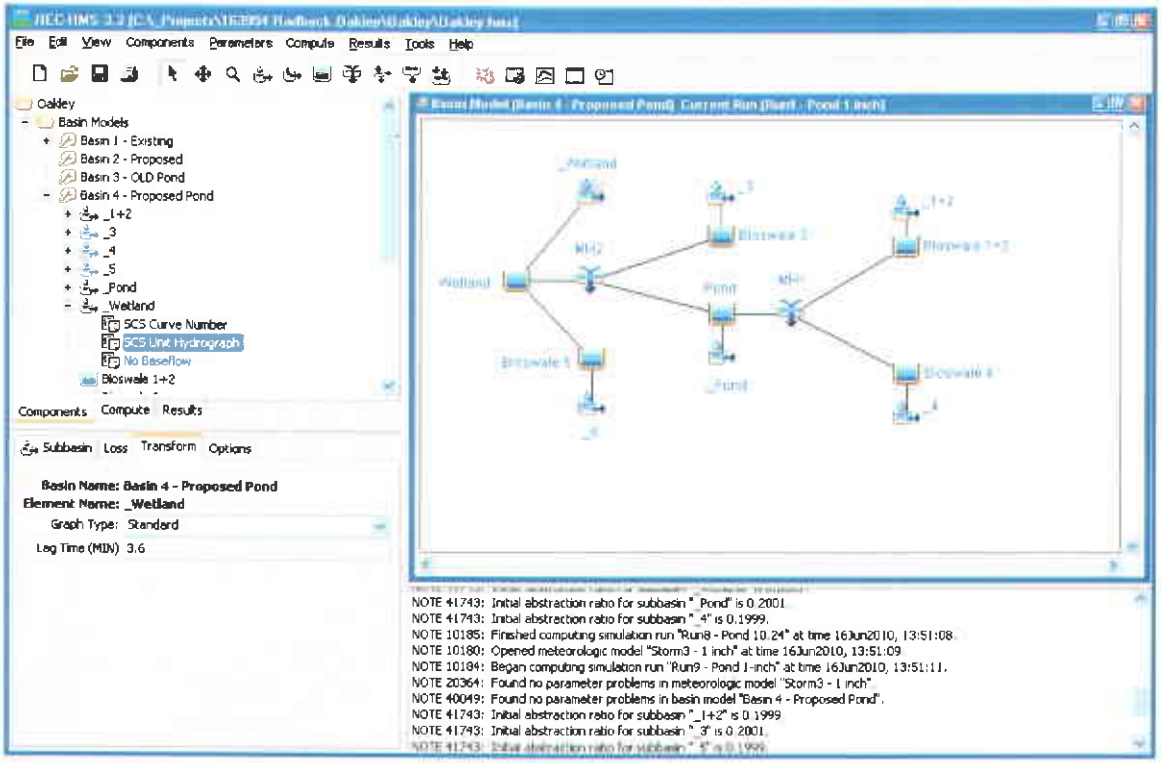

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Pond
Graph Type: Standard
Lag Time (MIN) 3.6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

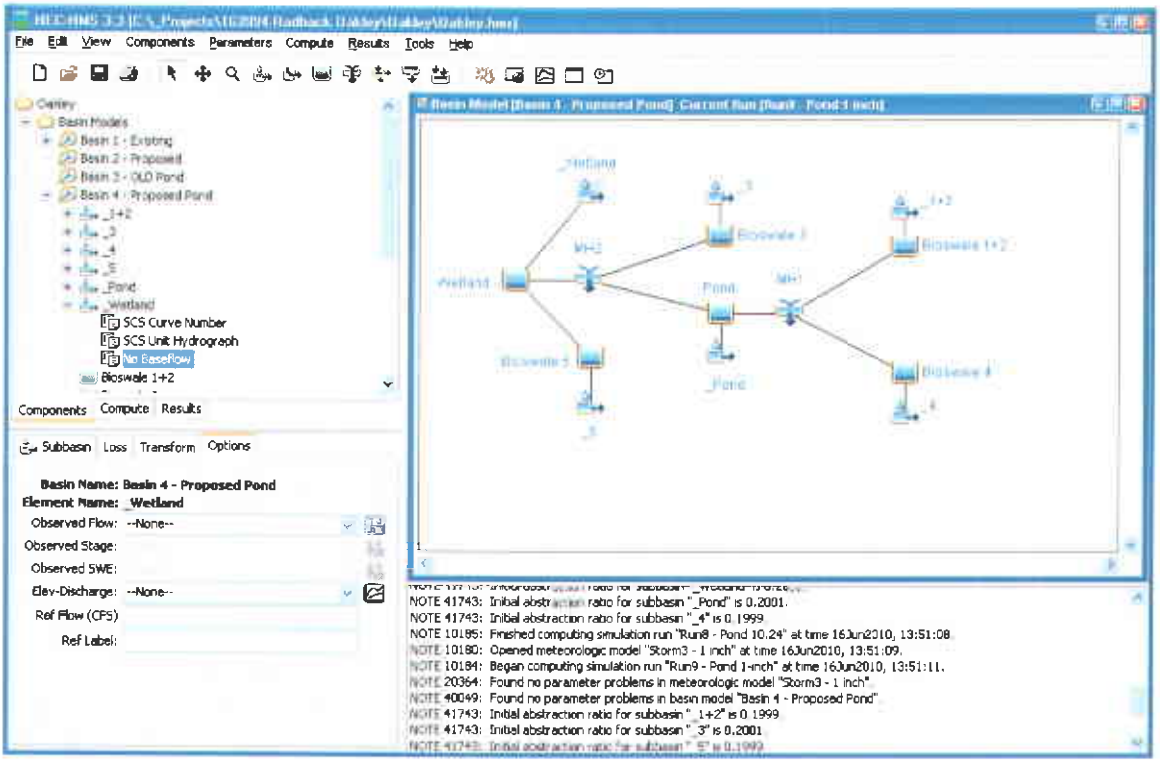

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
_Wetland
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Pond
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

HEC-HMS Input – Direct Runoff to Wetland

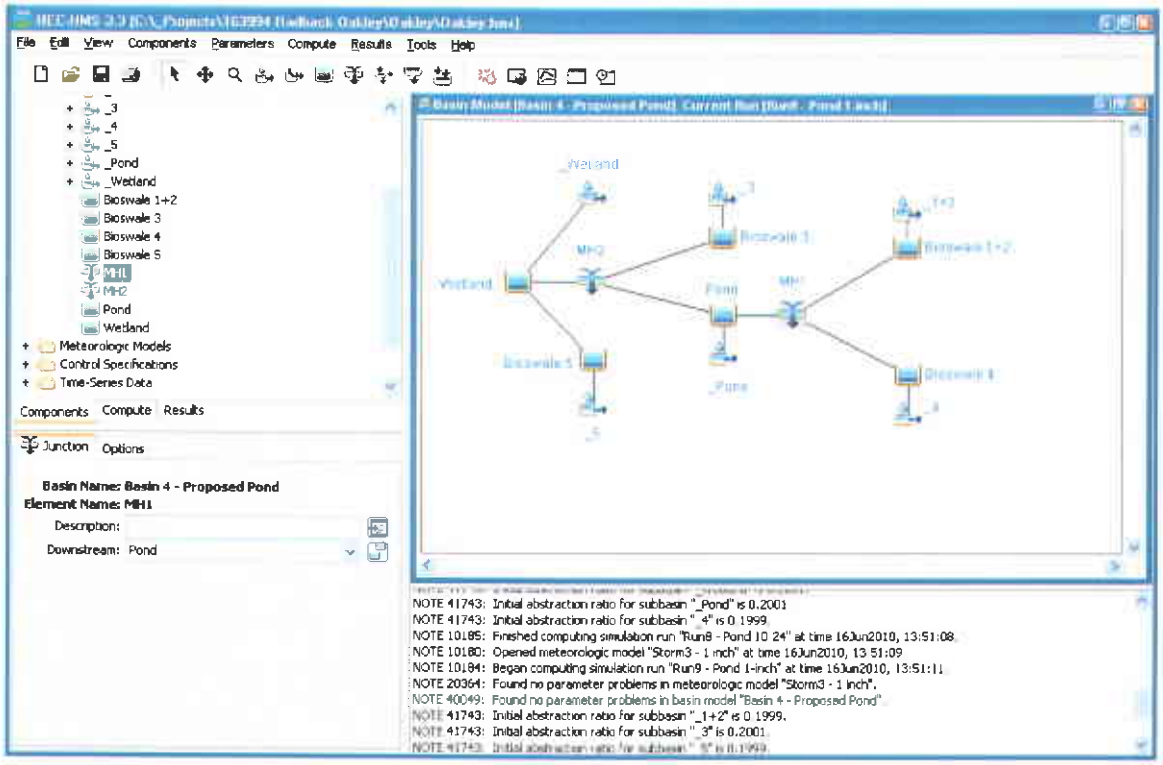




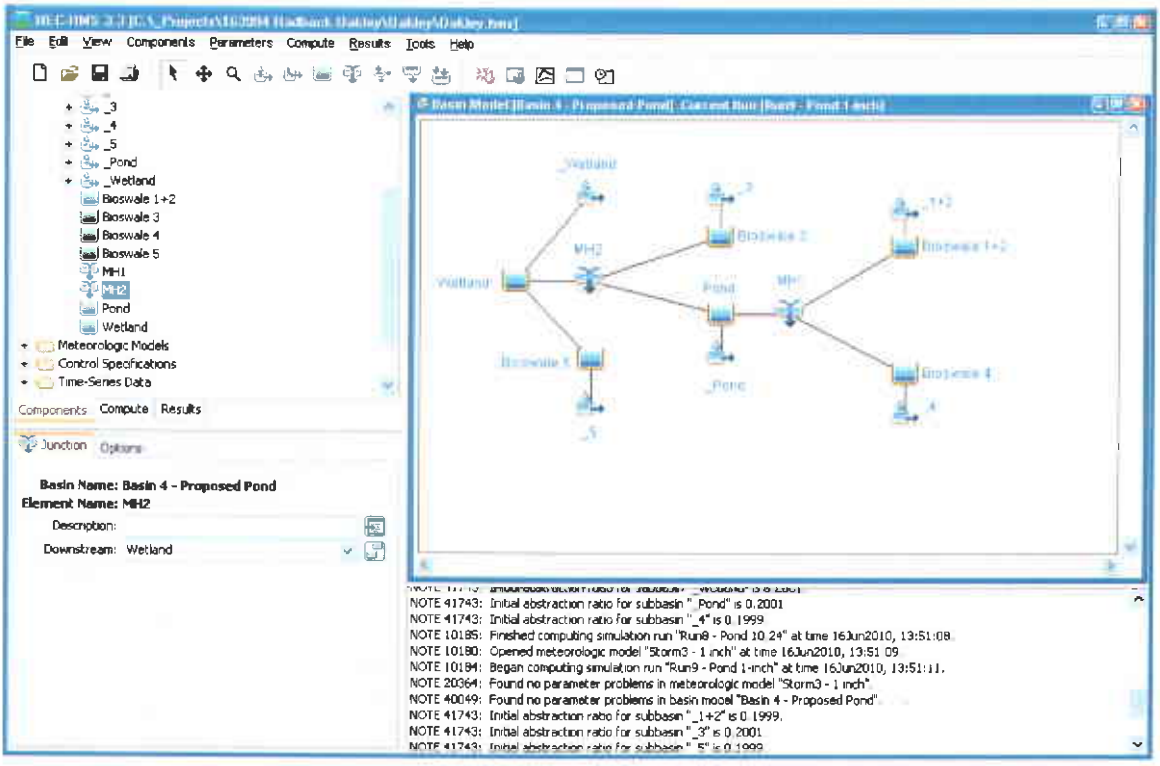

File Edit View Components Parameters Compute Results Tools Help
Oakley
Basin Models
Basin 1 - Existing
Basin 2 - Proposed
Basin 3 - OLD Pond
Basin 4 - Proposed Pond
_1+2
_3
_4
_5
_Pond
_Wetland
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Bioswale 1+2
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Wetland
Graph Type: Standard
Lag Time (MIN) 3.6
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.


File Edit View Components Parameters Compute Results Tools Help
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 4 - Proposed Pond
Element Name: _Wetland
Observed Flow: --None--
Observed Stage:
Observed SWE:
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

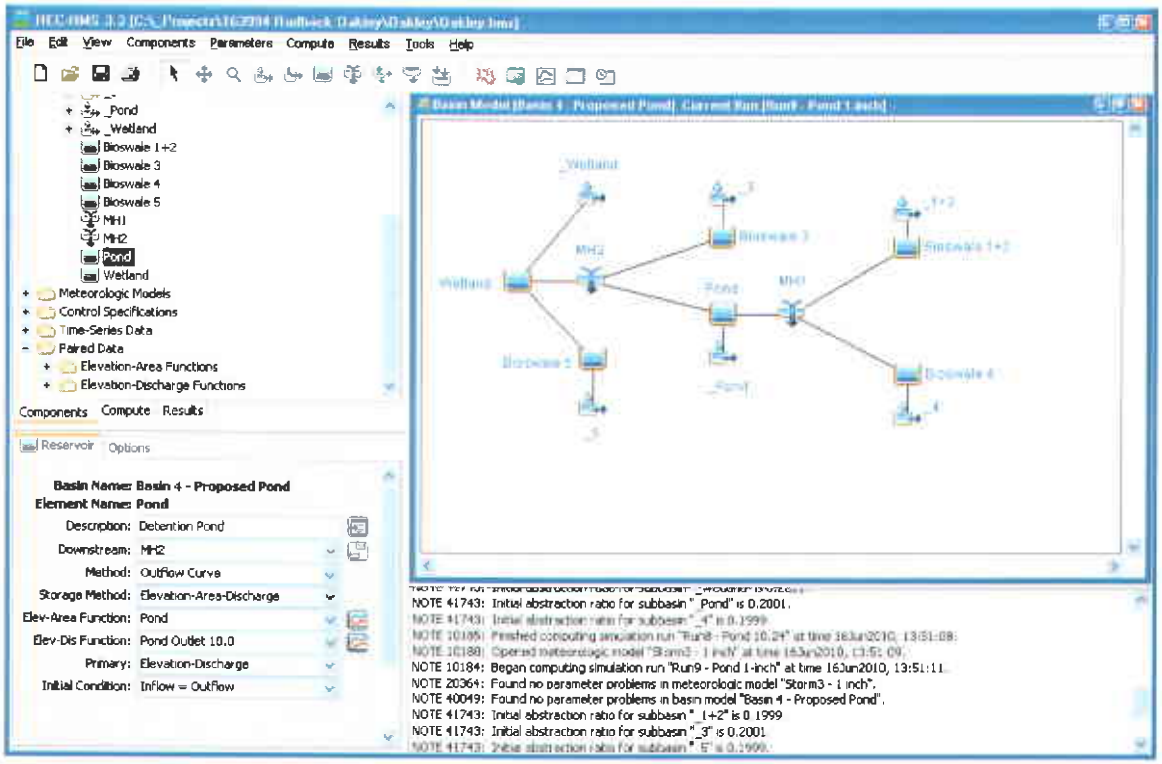
Junction connecting Bioswales 1+2 and 4 prior to pond

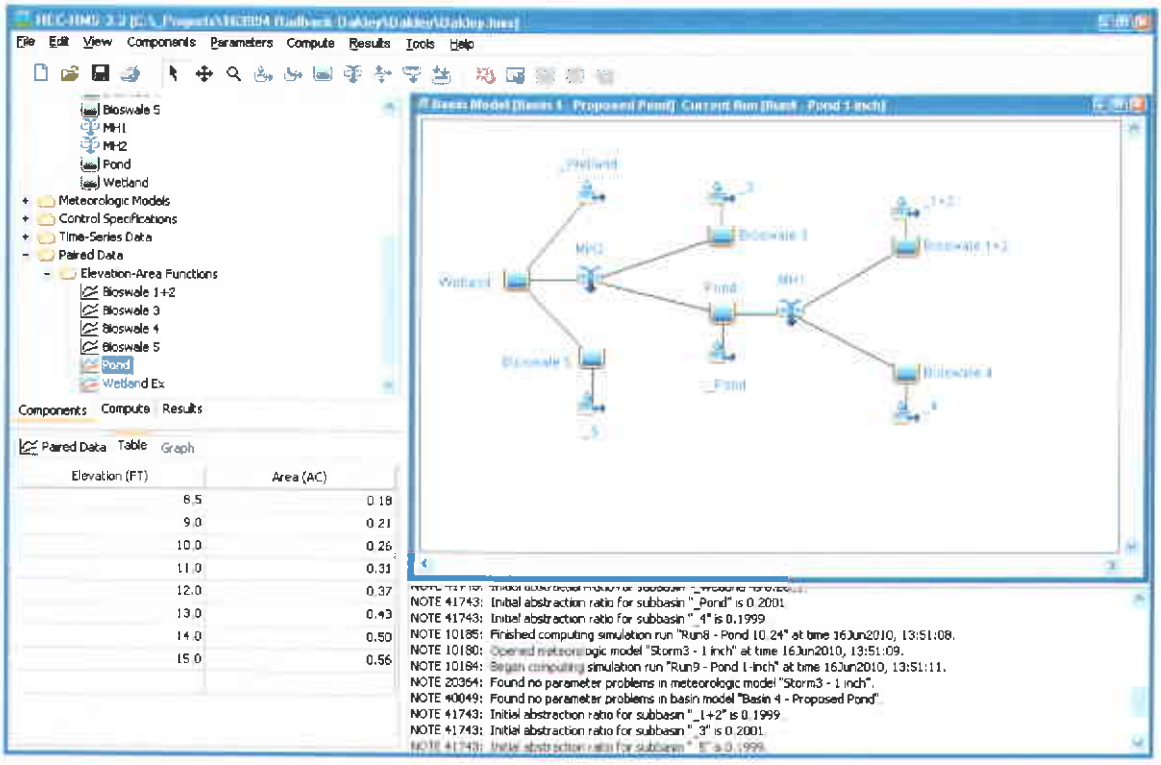


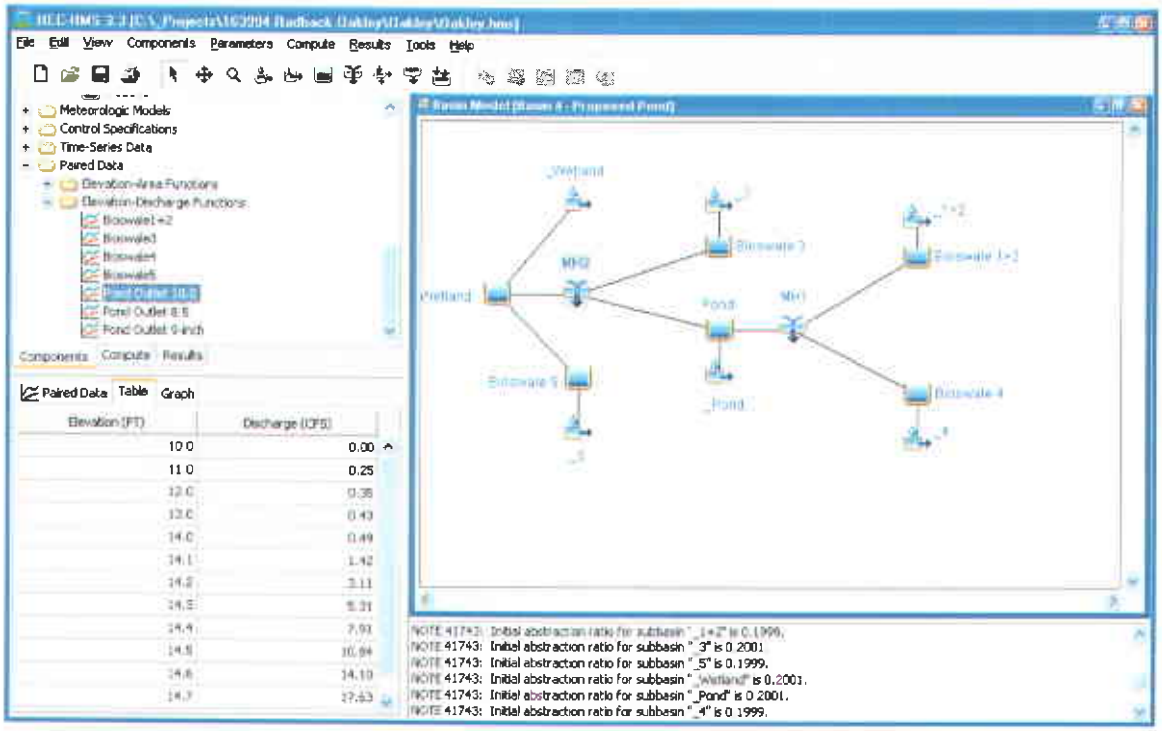
Junction connecting Pond outlet and Bioswale 3 prior to Wetland



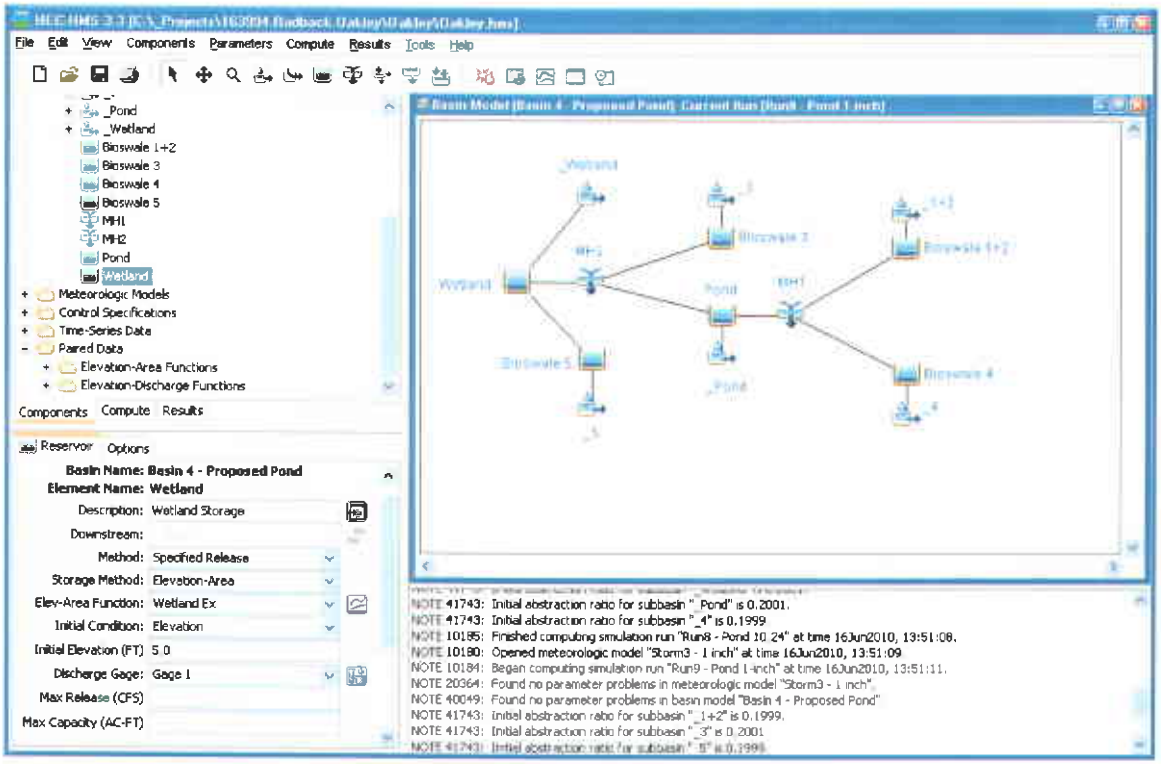
HEC-HMS Input – Pond Data

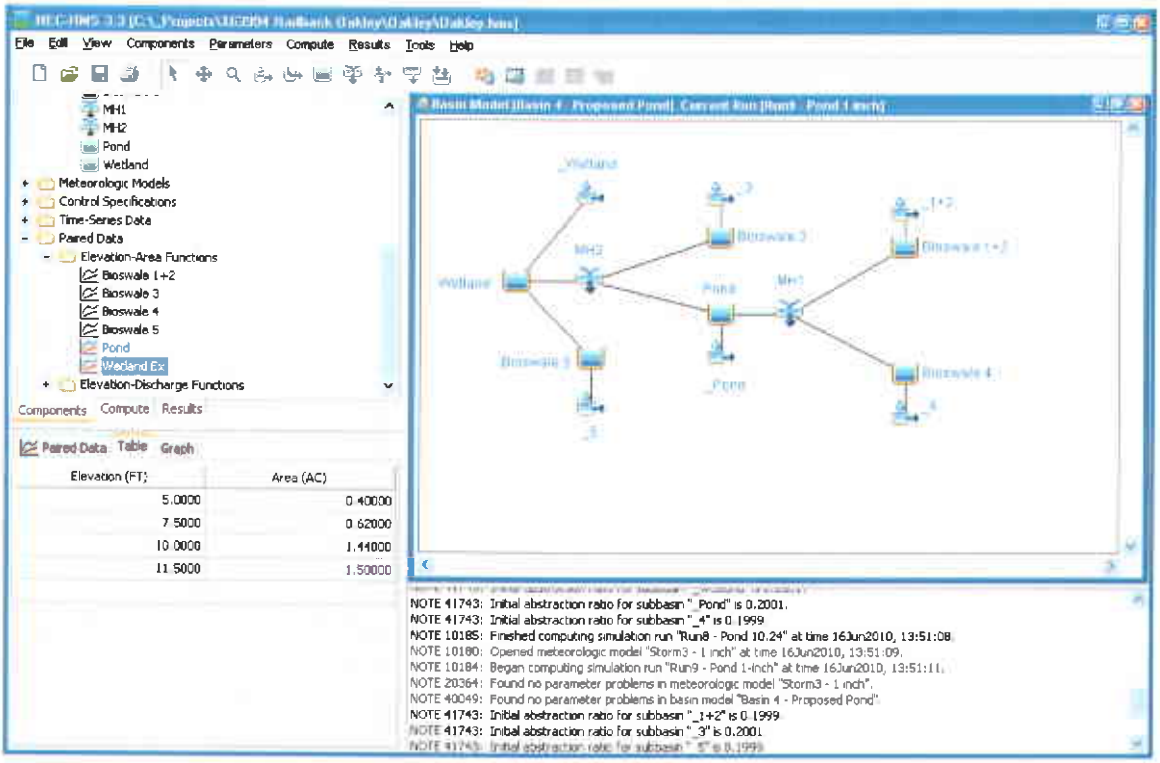


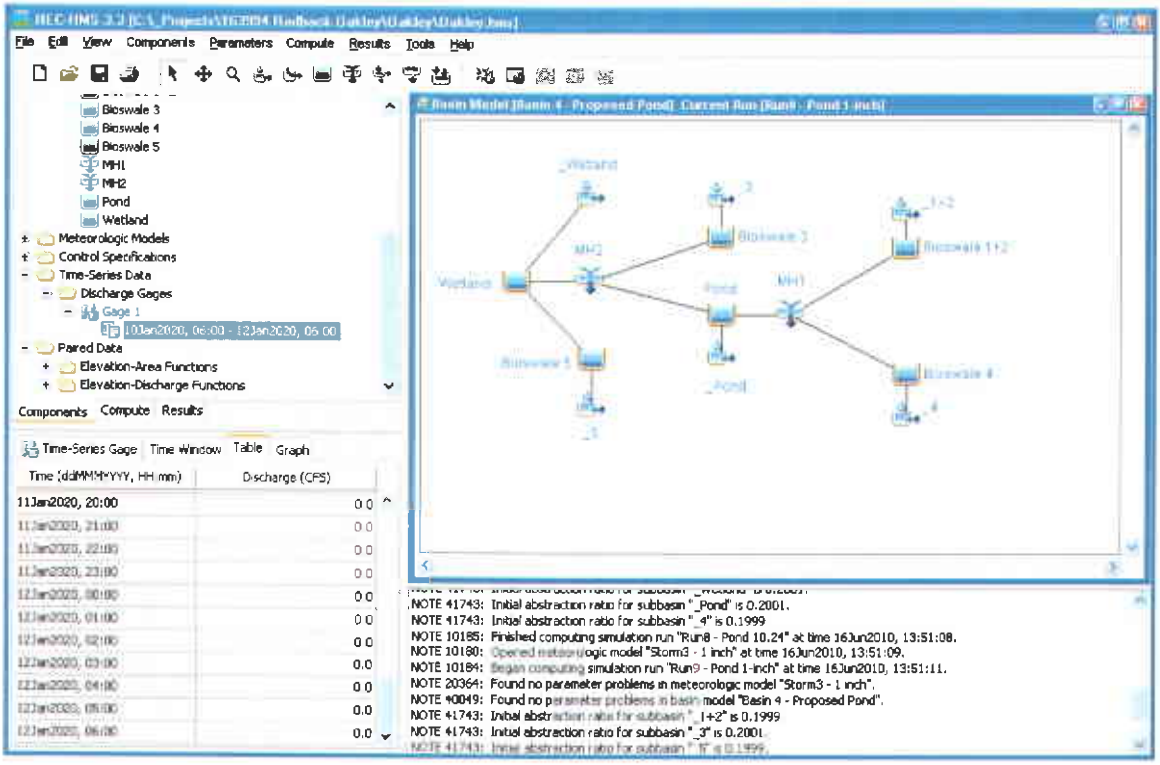



File Edit View Components Parameters Compute Results Tools Help
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale3
Bioswale4
Bioswale5
Pond Outlet 10.0
Pond Outlet 8.5
Pond Outlet 9-inch
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
10.0 0.00
11.0 0.25
12.0 0.38
13.0 0.43
14.0 0.49
14.1 1.42
14.2 3.11
14.3 5.31
14.4 7.91
14.5 10.84
14.6 14.10
14.7 17.63
_Wetland
Bioswale 3
Bioswale 1+2
MH2
Wetland
Pond
MH1
Bioswale 5
_Pond
Bioswale 4
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001
NOTE 41743: Initial abstraction ratio for subbasin "_5" is 0.1999.
NOTE 41743: Initial abstraction ratio for subbasin "_Wetland" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999.

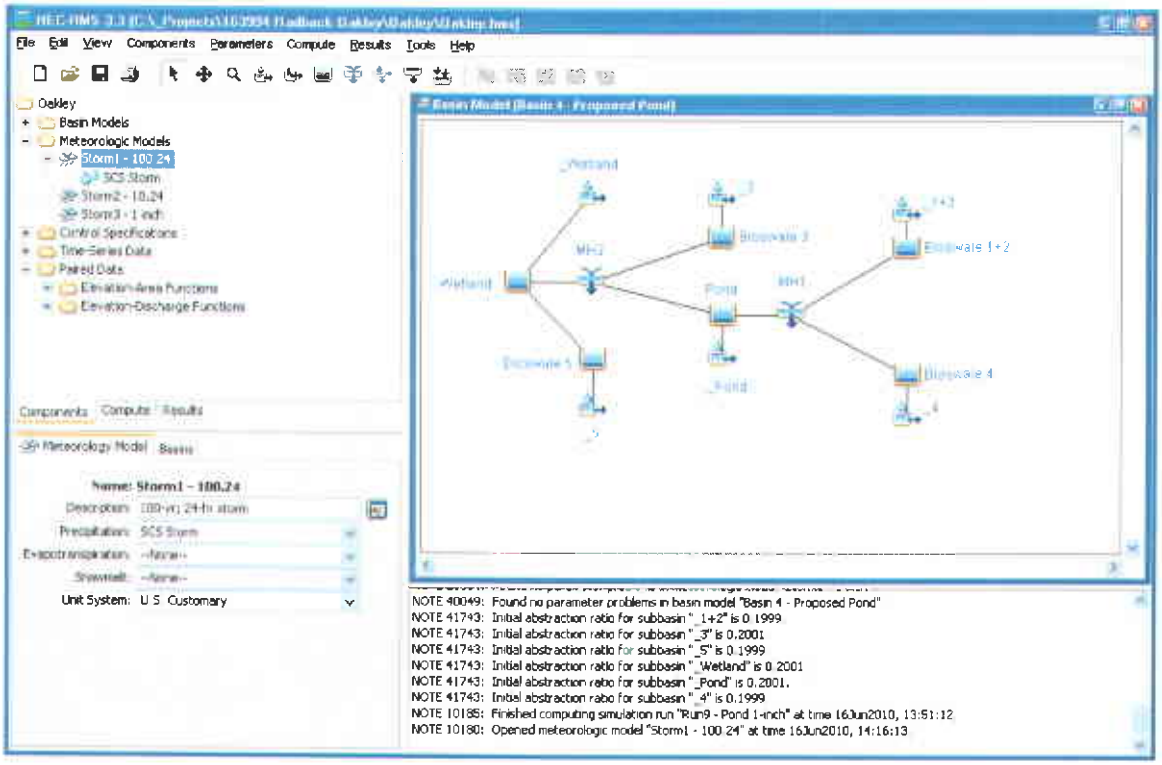
HEC-HMS Input – Wetland Data

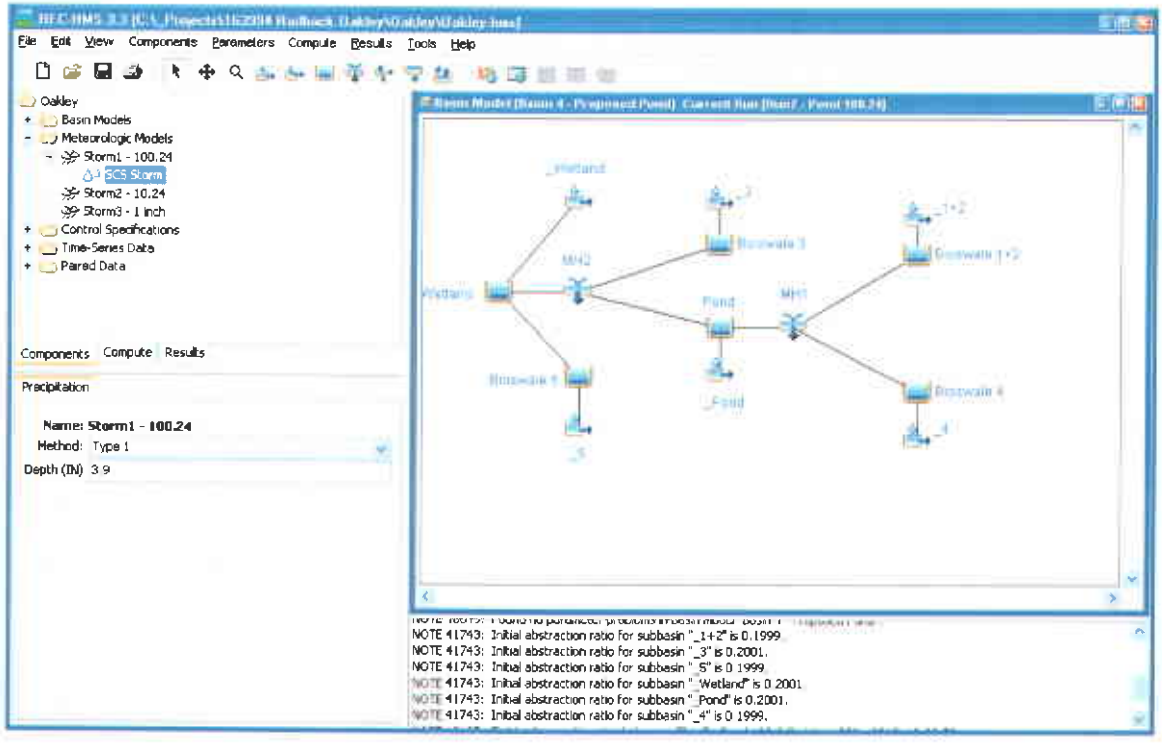




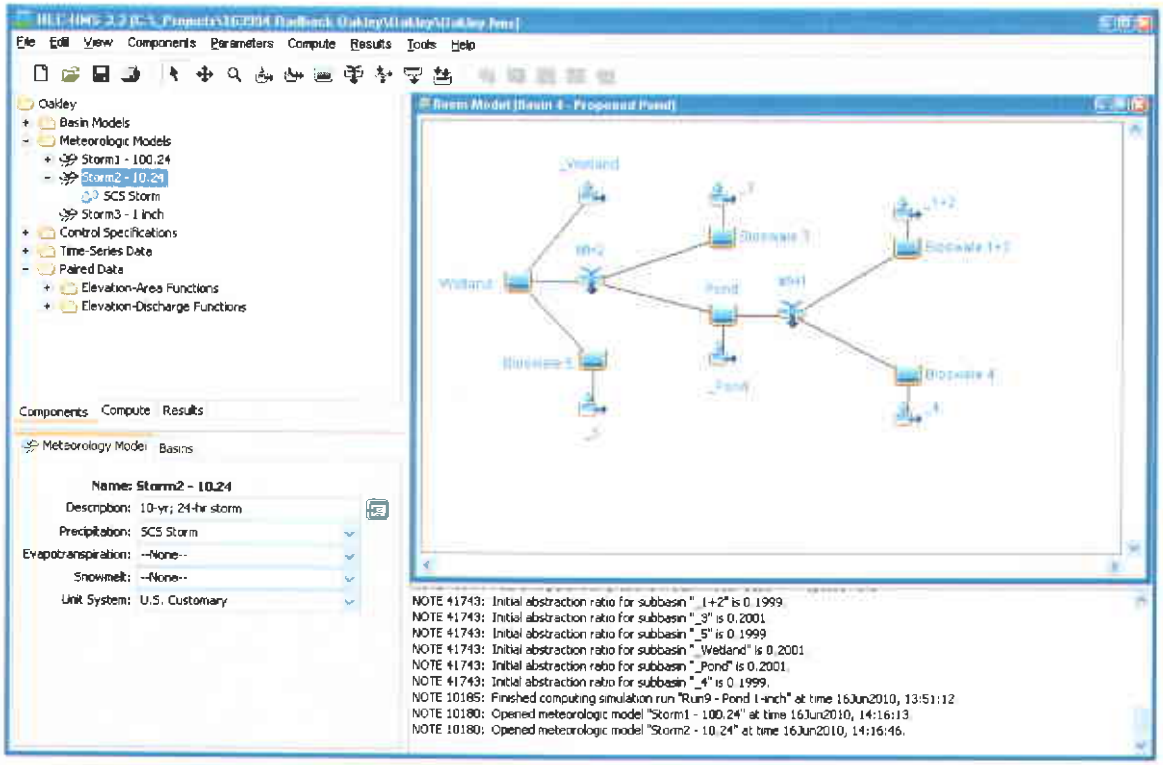

File Edit View Components Parameters Compute Results Tools Help
Bioswale 3
Bioswale 4
Bioswale 5
MH1
MH2
Pond
Wetland
Meteorologic Models
Control Specifications
Time-Series Data
Discharge Gages
Gage 1
10Jan2020, 06:00 - 12Jan2020, 05:00
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Components Compute Results
Time-Series Gage Time Window Table Graph
Time (ddMMMYYYY, HH:mm)
Discharge (CFS)
11Jan2020, 20:00 0.0
NOTE 41743: Initial abstraction ratio for subbasin "_Pond" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_4" is 0.1999
NOTE 10185: Finished computing simulation run "Run8 - Pond 10.24" at time 16Jun2010, 13:51:08.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 16Jun2010, 13:51:09.
NOTE 10184: Began computing simulation run "Run9 - Pond 1-inch" at time 16Jun2010, 13:51:11.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 4 - Proposed Pond".
NOTE 41743: Initial abstraction ratio for subbasin "_1+2" is 0.1999
NOTE 41743: Initial abstraction ratio for subbasin "_3" is 0.2001.

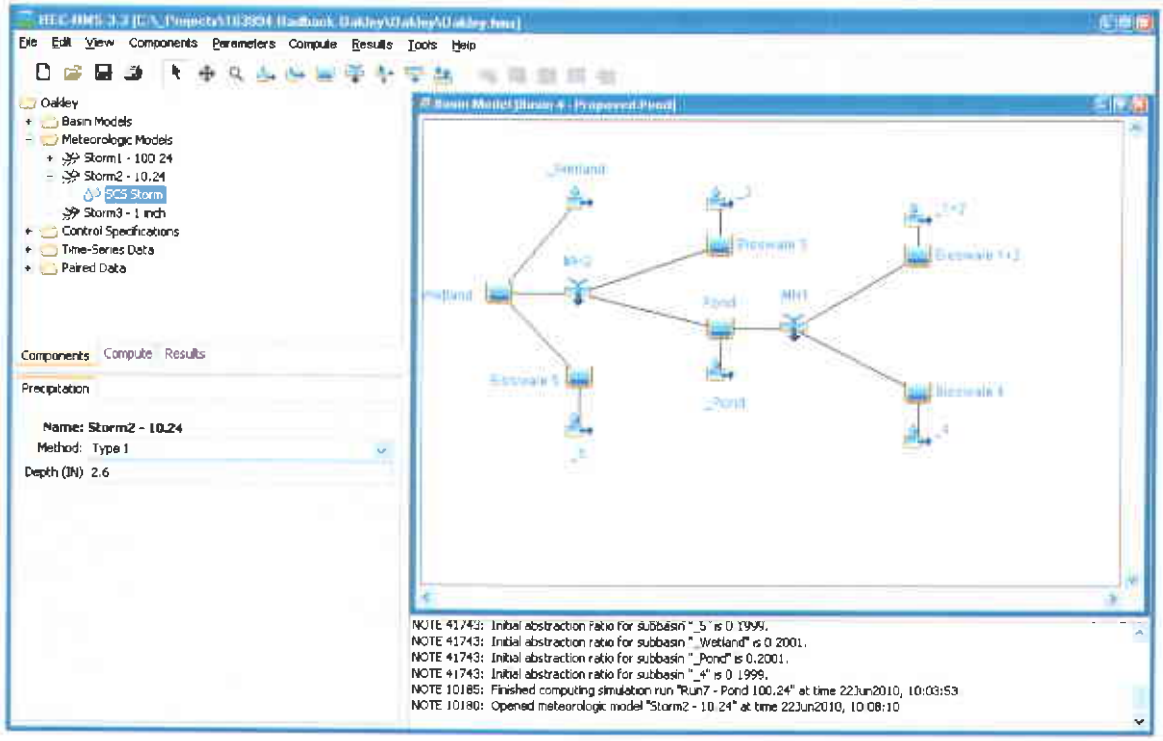
HEC-HMS Input – Meteorologic Model Storm1 – 100-year, 24-hour storm)



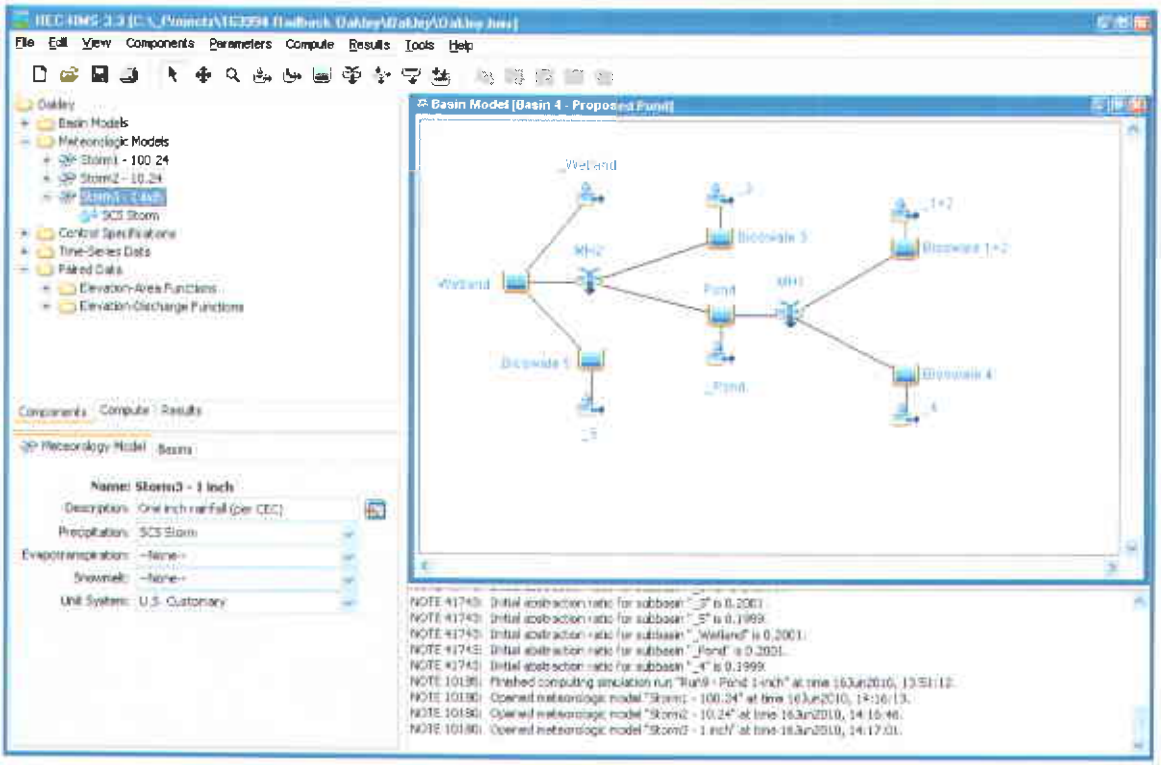


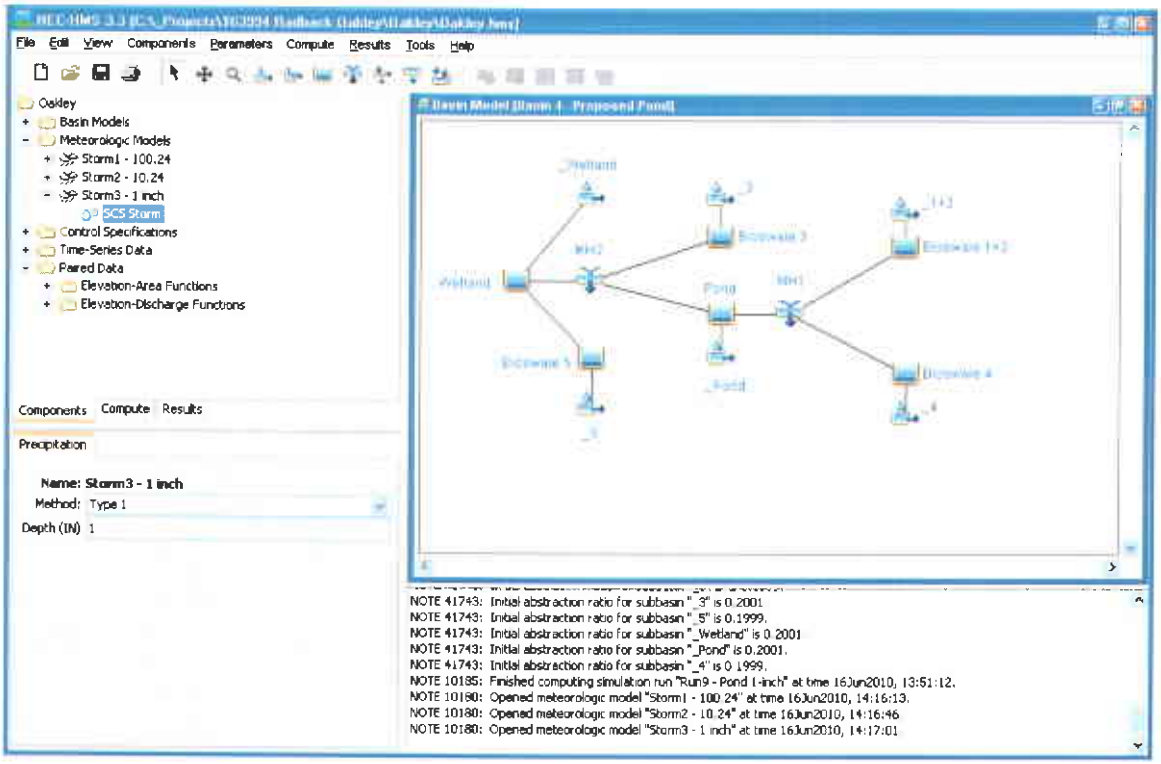
HEC-HMS Input – Meteorologic Model Storm2 – 10-year, 24-hour storm)



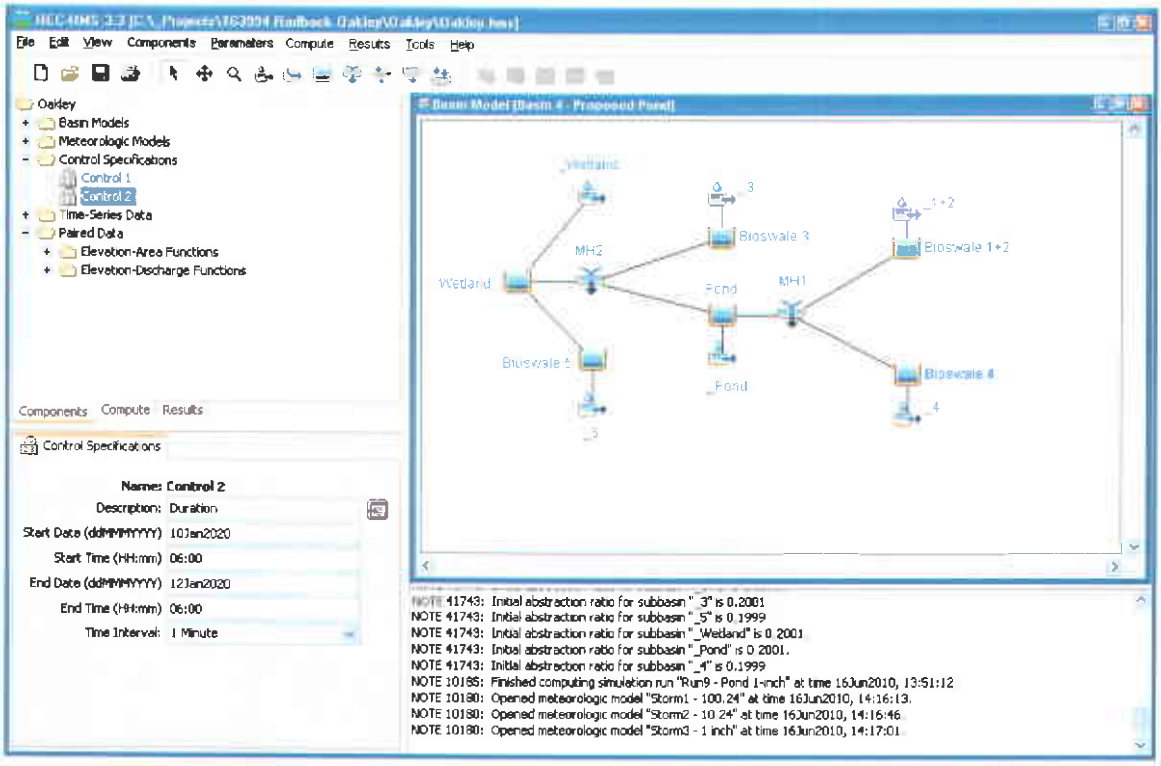


HEC-HMS Input – Meteorologic Model Storm3 – 1-inch rainfall)





HEC-HMS Input – Control Data



Radback Oakley Project

Project # 163994

Stormwater Analysis

CK 6/17/10

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52.5406.1007

Attachment 2

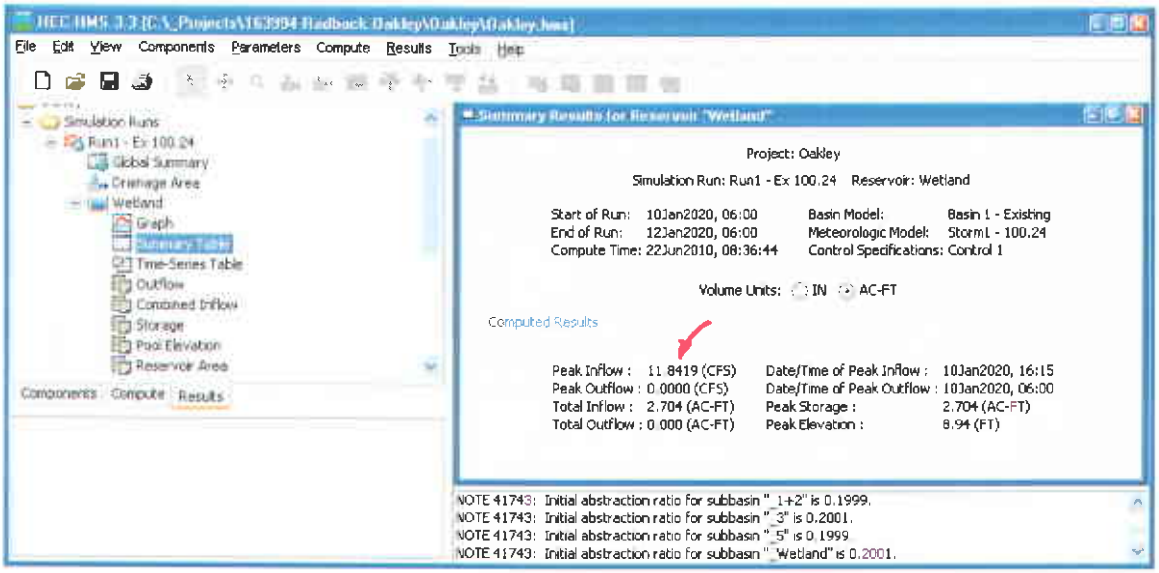
~~Reference~~

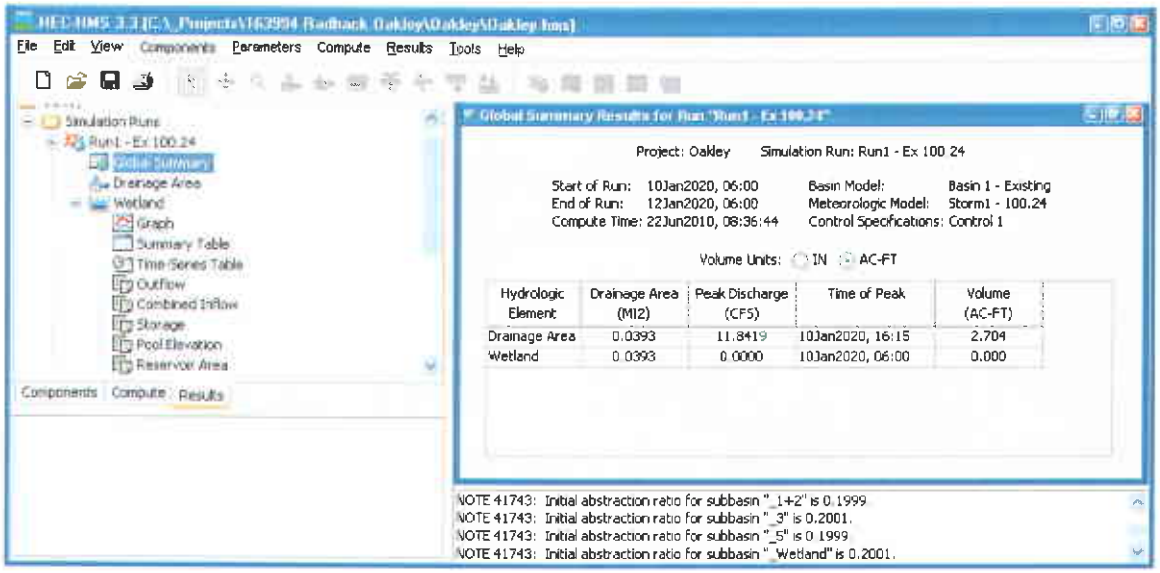
HEC-HMS OUTPUT

Description Key for HEC-HMS Input/Output Data

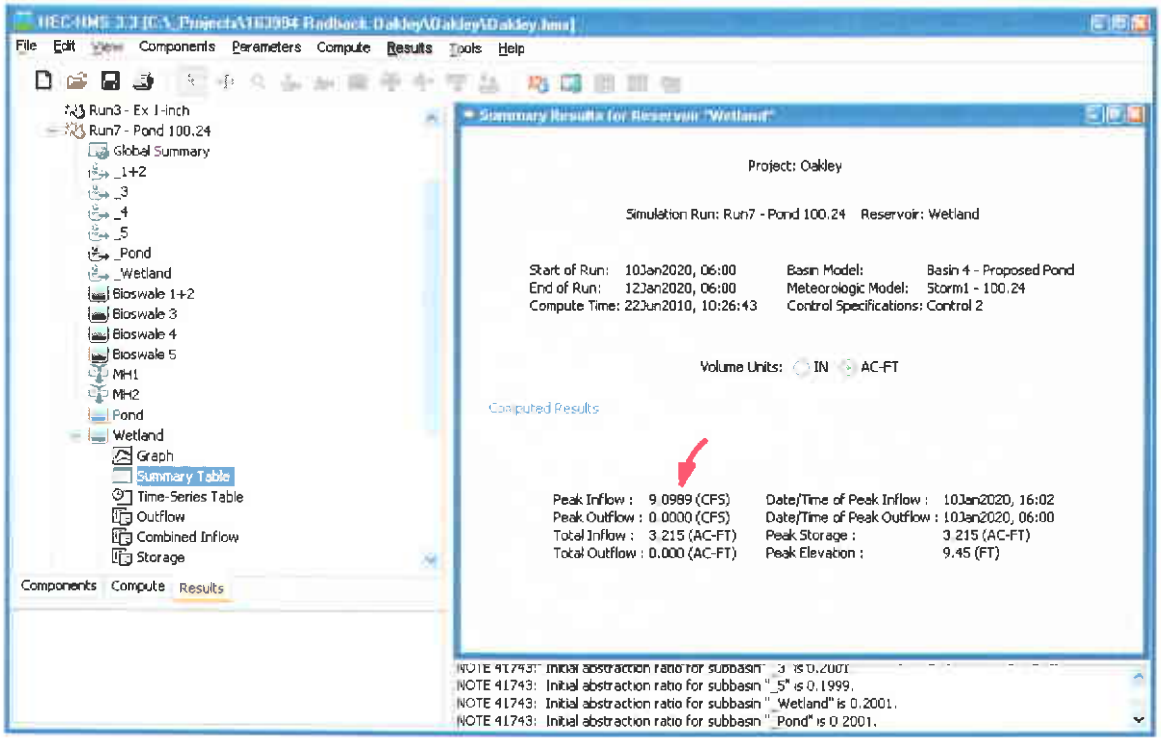
Hydrologic Element	Description
_1+2	Drainage area flowing to Bioswale 1+2
_3	Drainage area flowing to Bioswale 3
_4	Drainage area flowing to Bioswale 4
_5	Drainage area flowing to Bioswale 5
_Pond	Drainage area flowing directly to Pond
_Wetland	Drainage area flowing directly to Wetland
Bioswale 1+2	Flow from Bioswale 1+2 outlet (to MH1)
Bioswale 3	Flow from Bioswale 3 outlet (to MH2)
Bioswale 4	Flow from Bioswale 4 outlet (to MH1)
Bioswale 5	Flow from Bioswale 5 outlet (to Wetland)
MH1	Flow from Bioswales 1+2 and 4 (to Pond)
MH2	Flow from Pond and Bioswale 3 (to Wetland)
Pond	Flow from Pond Outlet (to MH2)
Wetland	Flow from Wetland (set to 0.0)

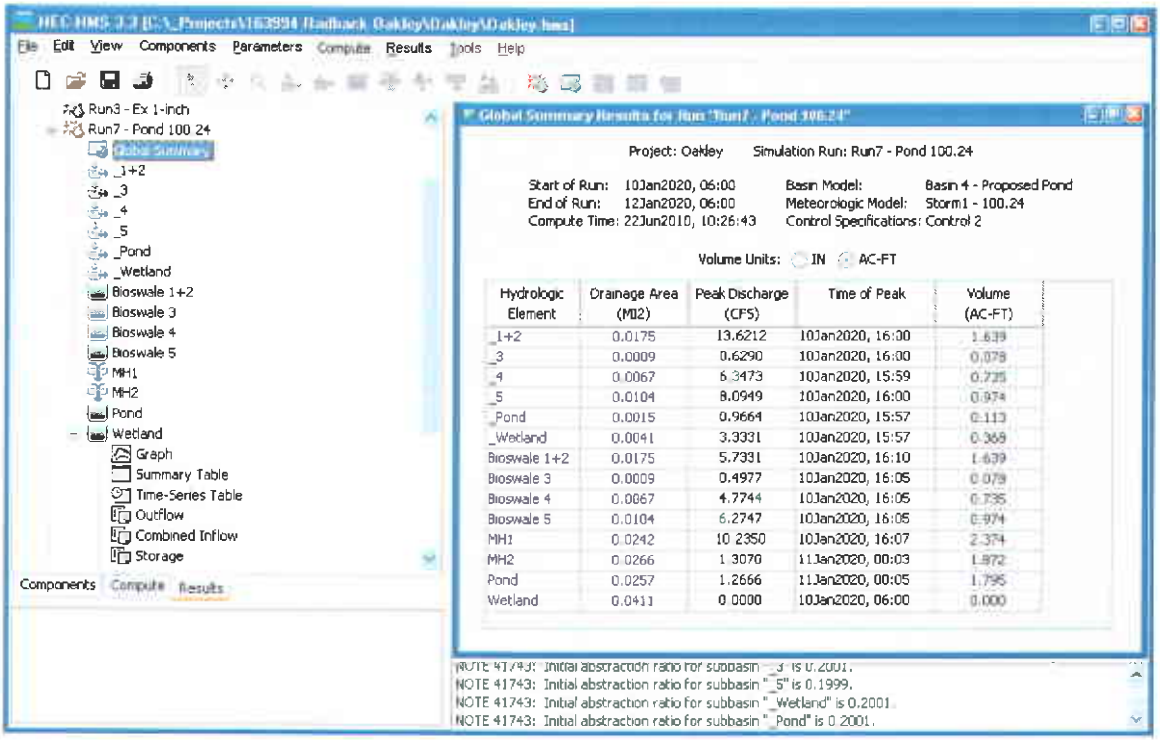
HEC-HMS Output – Pre-Construction 100-Year, 24-Hour Flow to Wetland





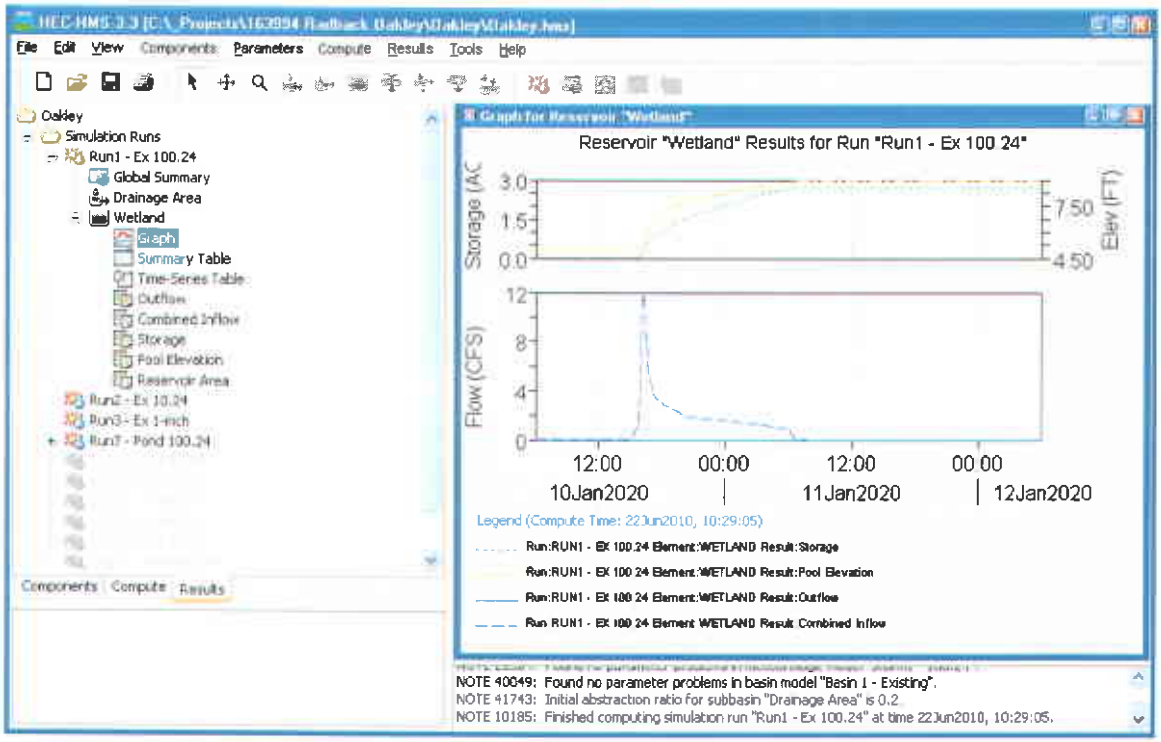
HEC-HMS Output – Post-Construction 100-Year, 24-Hour Flow to Wetland



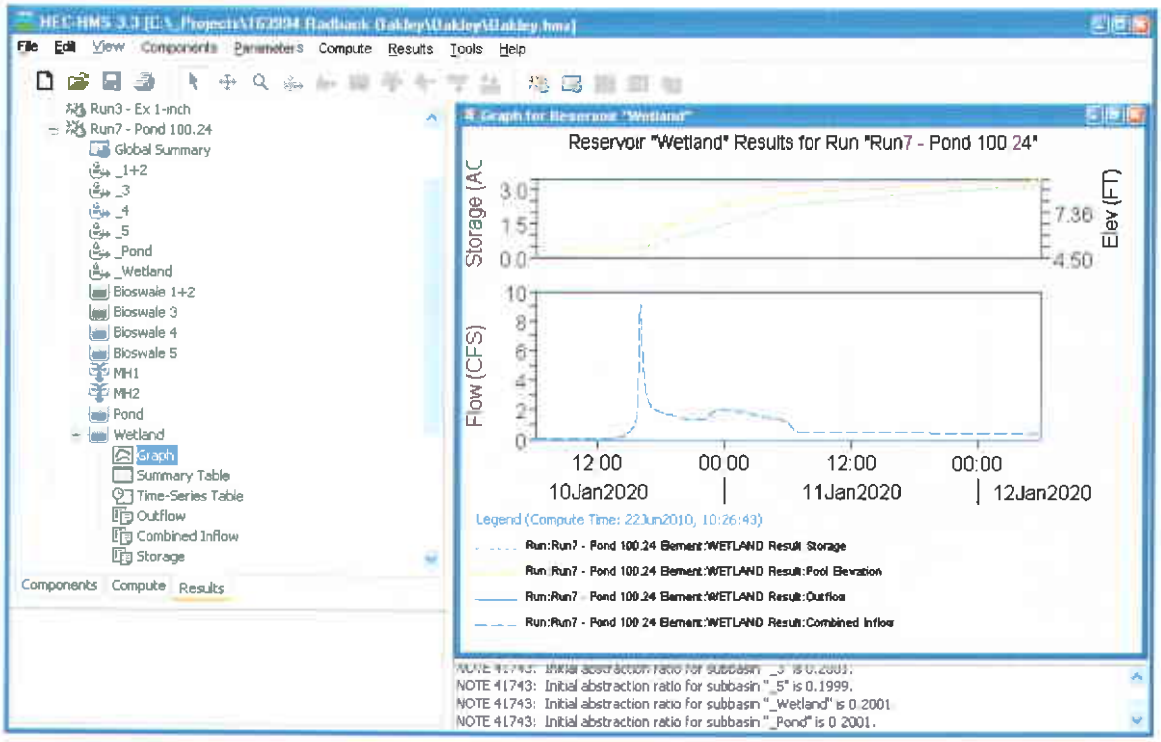


HEC-HMS Output – Comparison Graphs 100-Year, 24-Hour Flow to Wetland

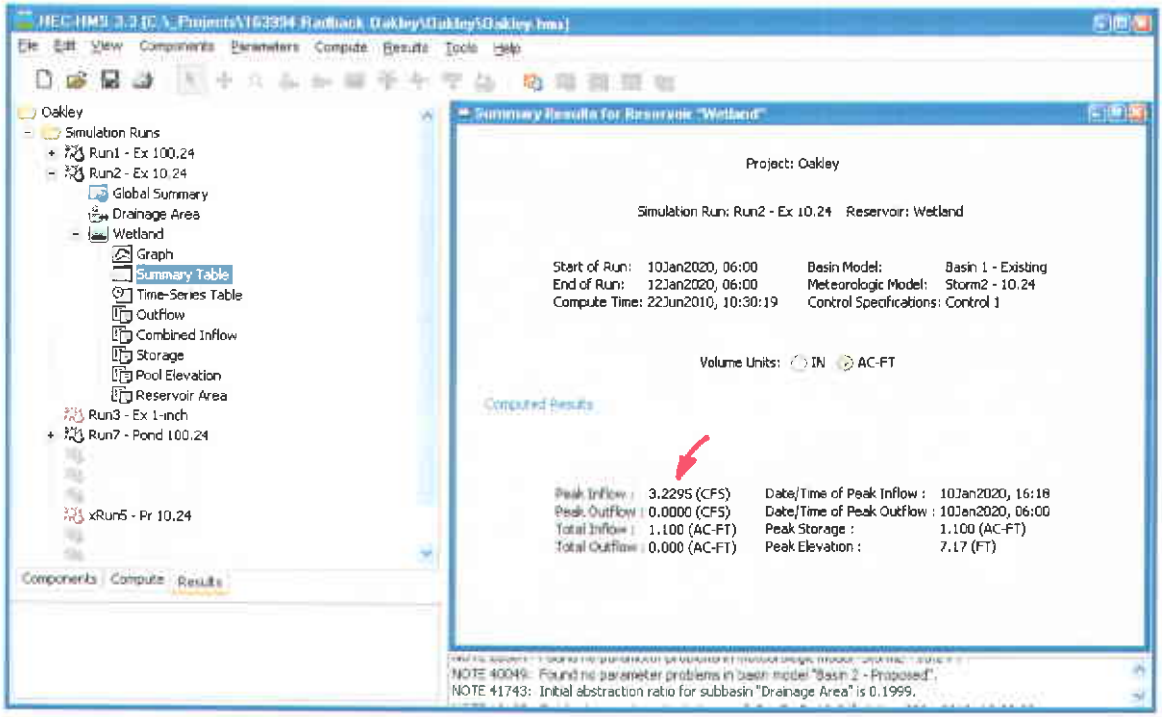
Pre-Construction

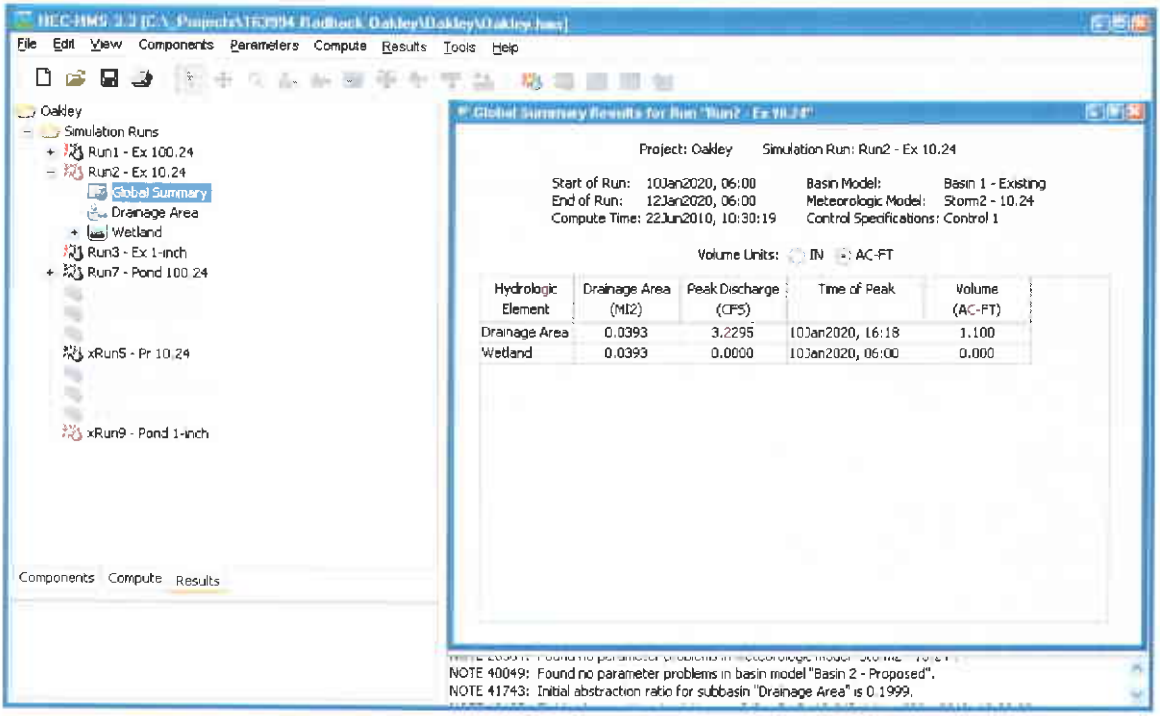


Post-Construction

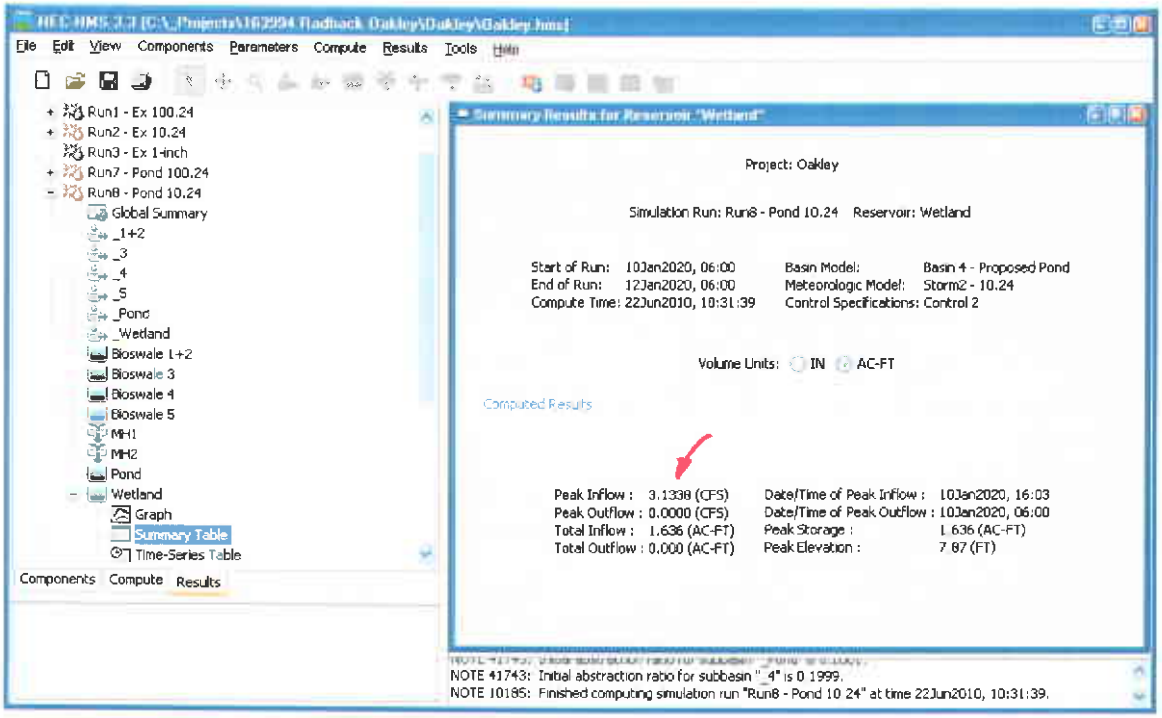


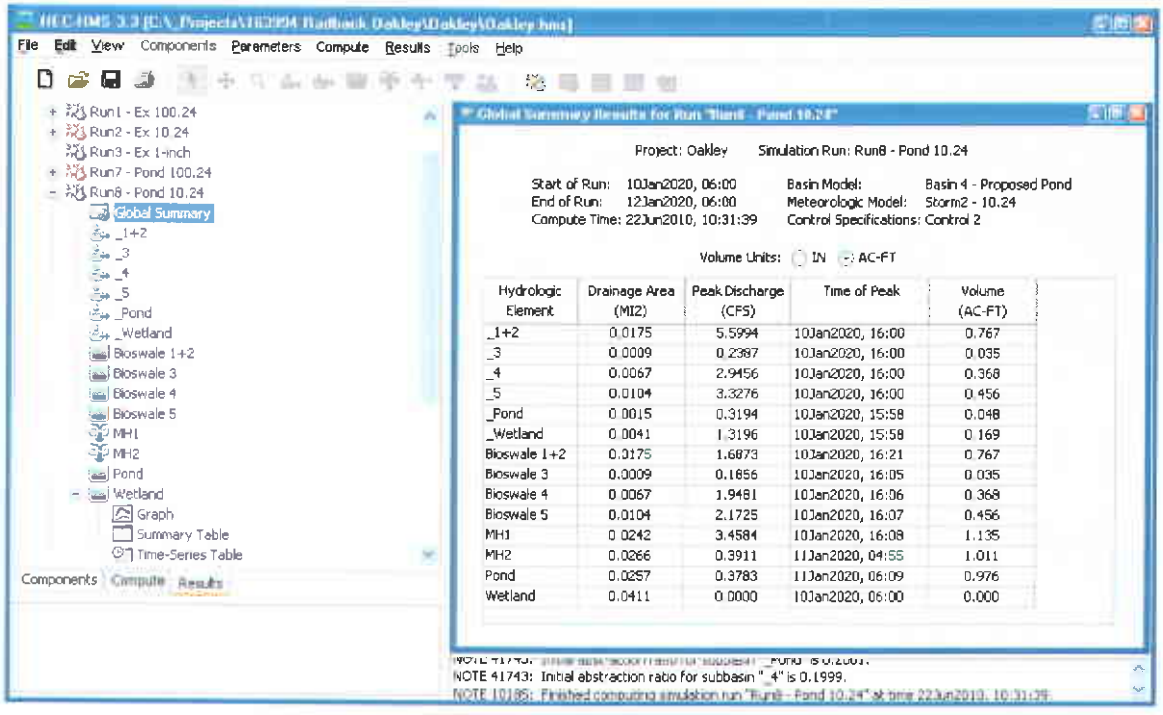
HEC-HMS Output – Pre-Construction 10-Year, 24-Hour Flow to Wetland





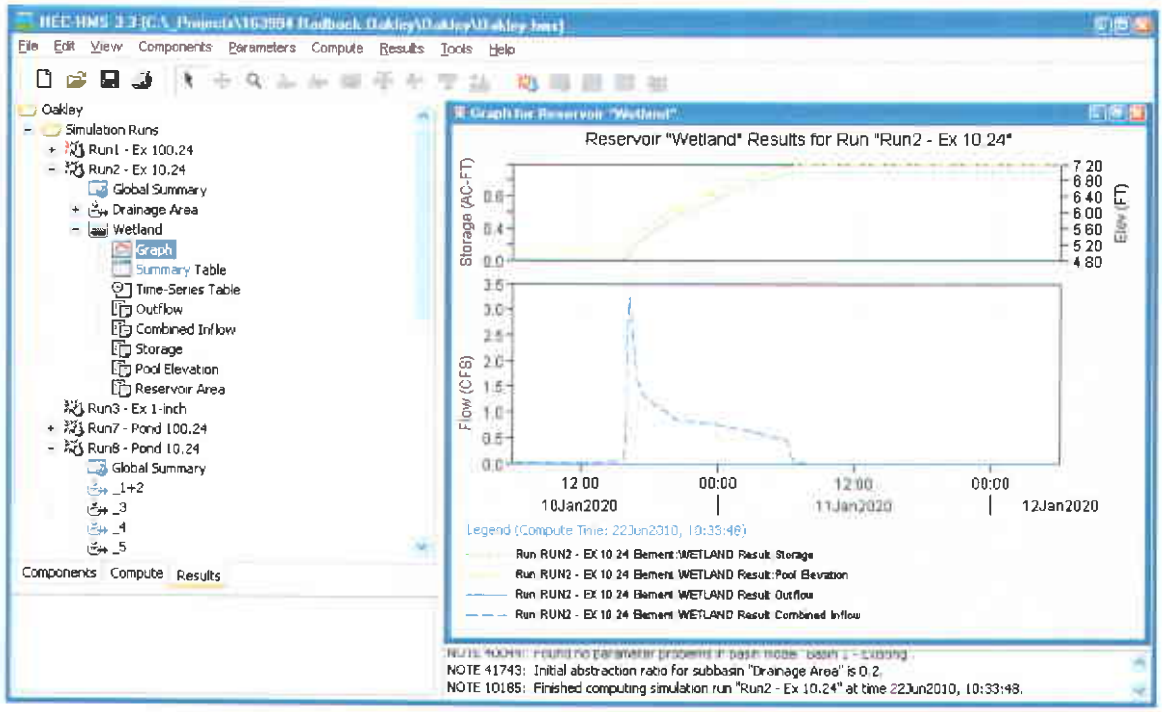
HEC-HMS Output – Post-Construction 10-Year, 24-Hour Flow to Wetland



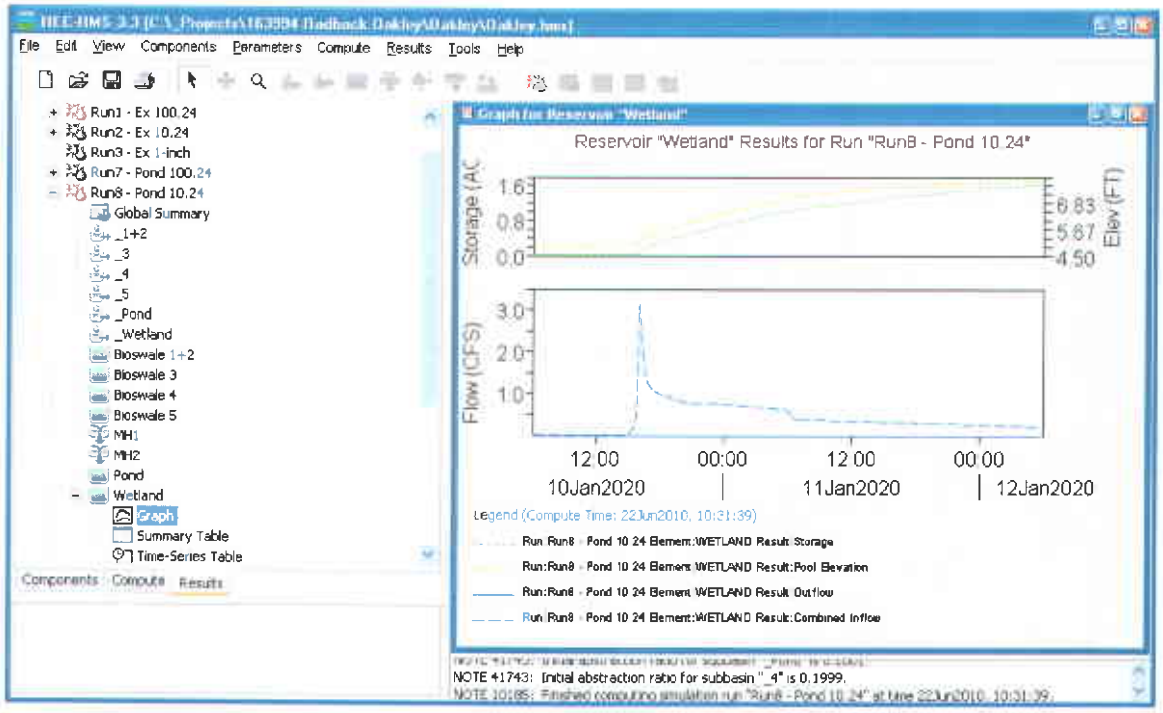


HEC-HMS Output – Comparison Graphs 10-Year, 24-Hour Flow to Wetland

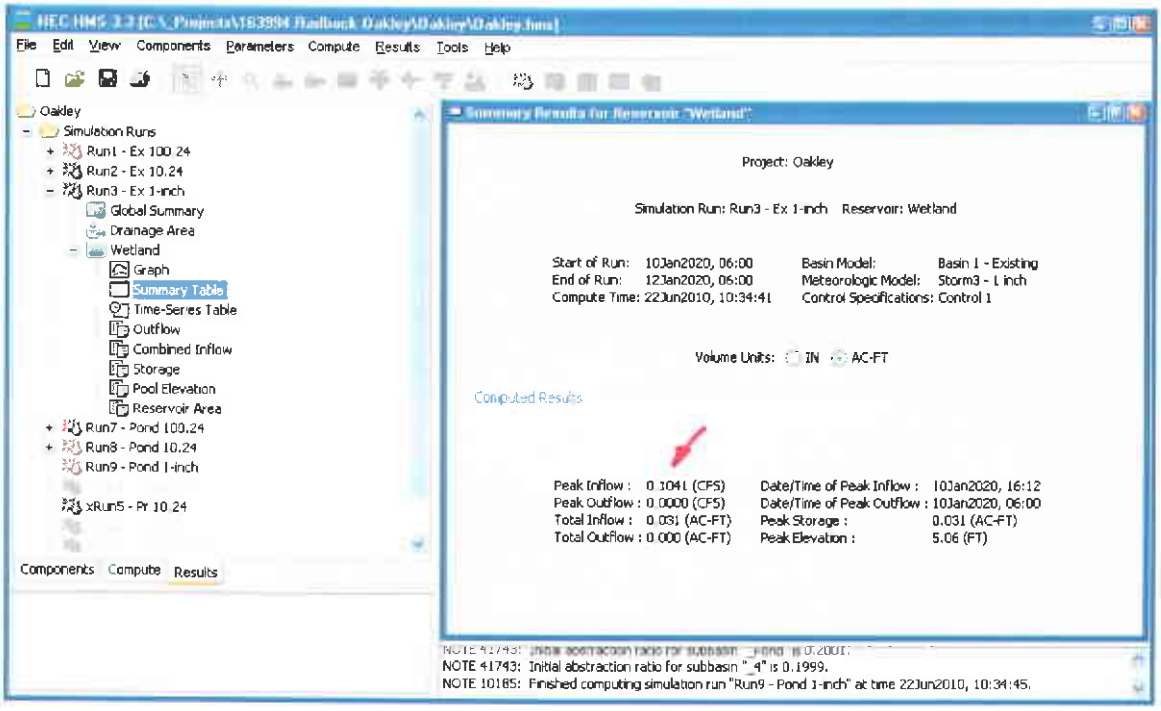
Pre-Construction

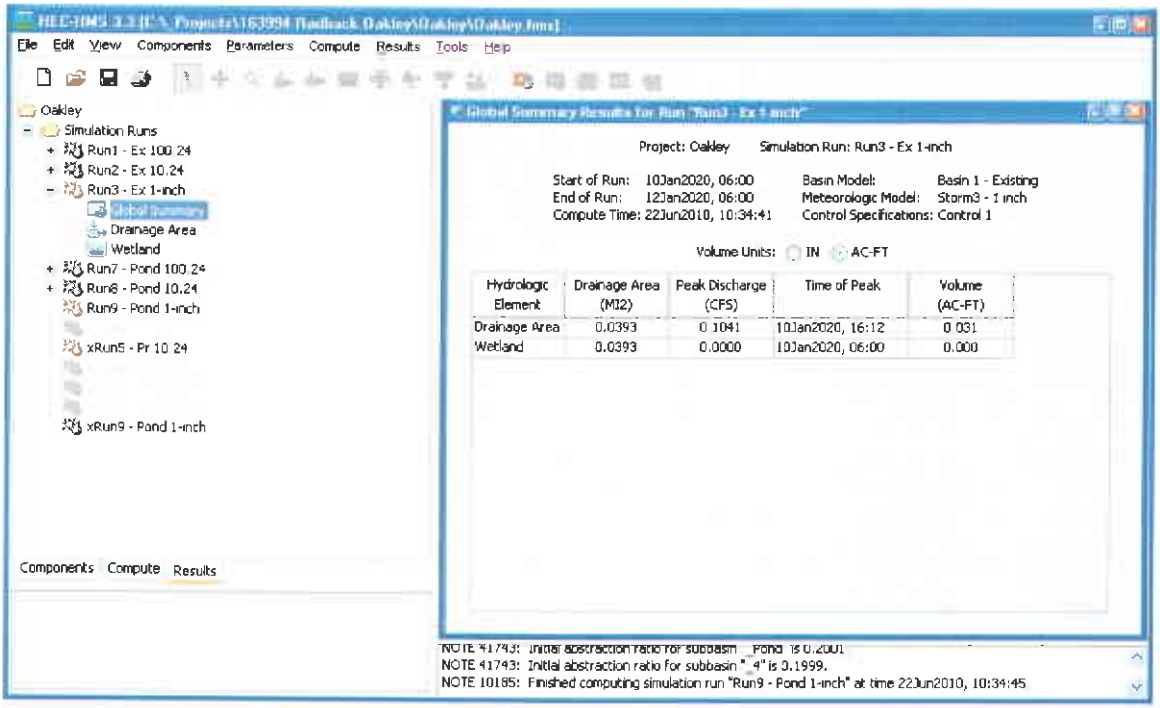


Post-Construction

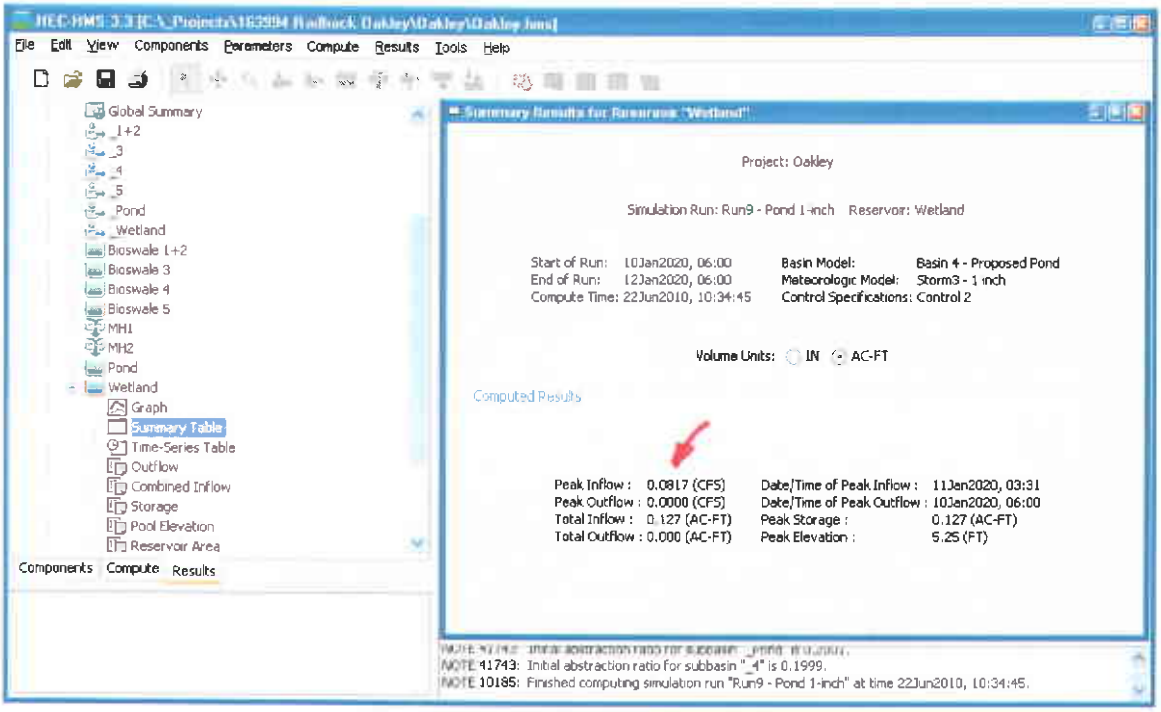


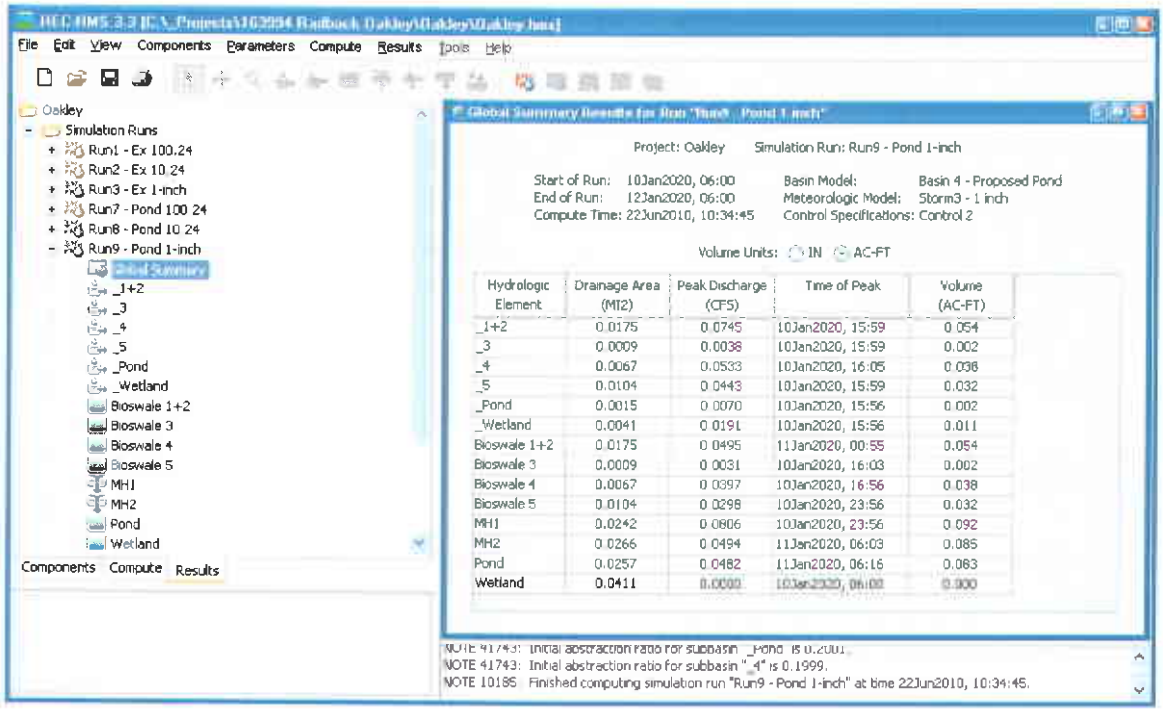
HEC-HMS Output – Pre-Construction 1-Inch Rainfall Flow to Wetland





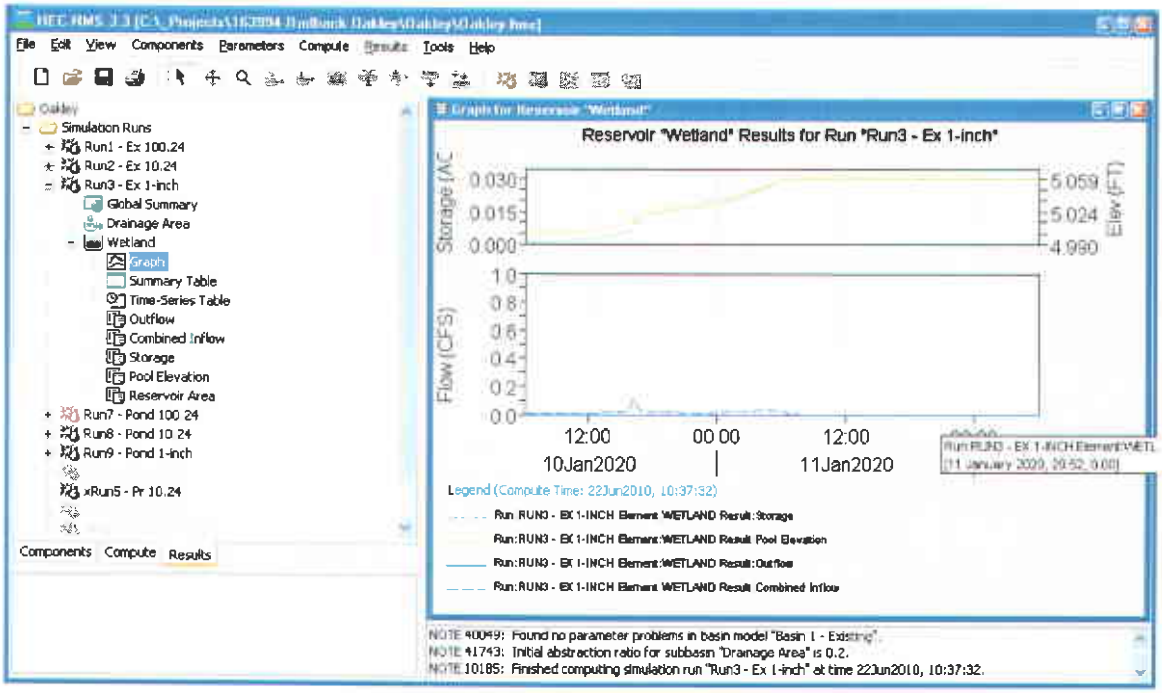
HEC-HMS Output – Post-Construction 1-Inch Rainfall Flow to Wetland



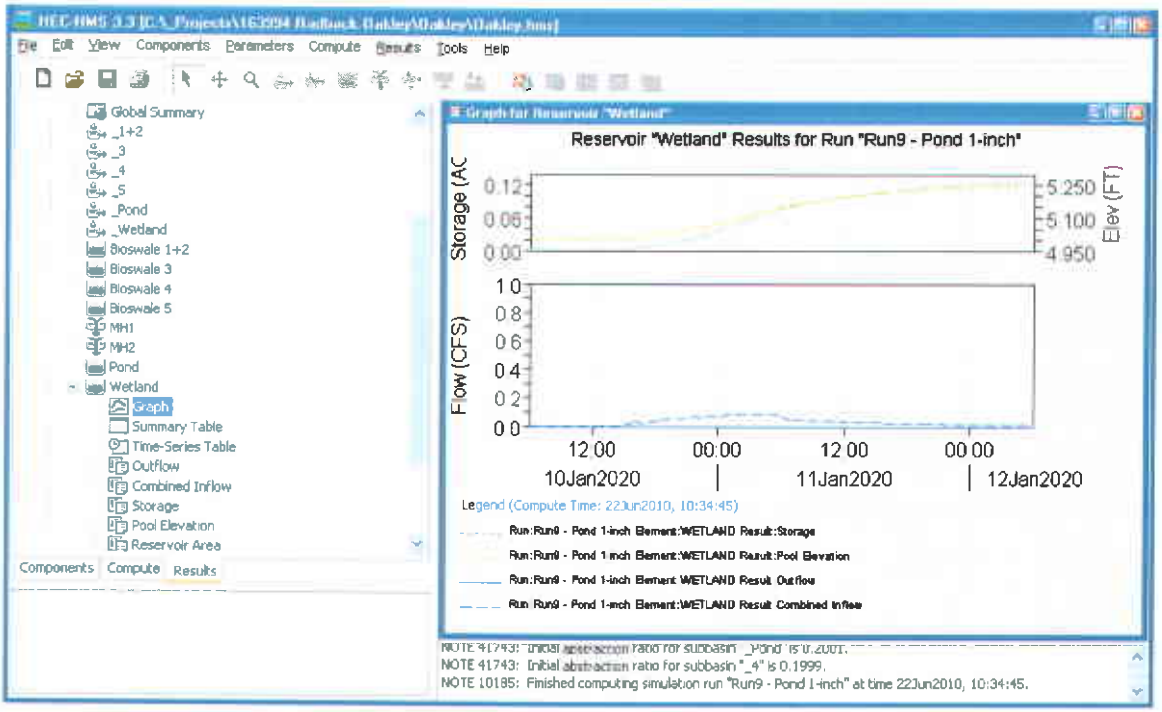


HEC-HMS Output – Comparison Graphs 1-Inch Event Flow to Wetland

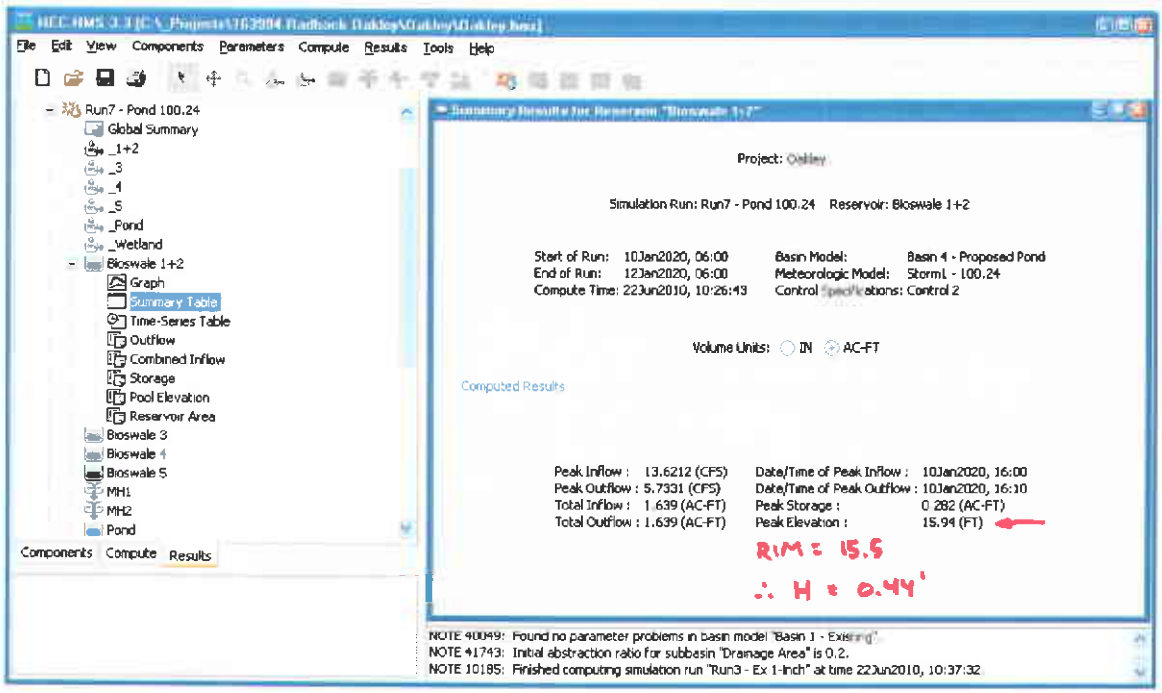
Pre-Construction



Post-Construction



HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 1-2



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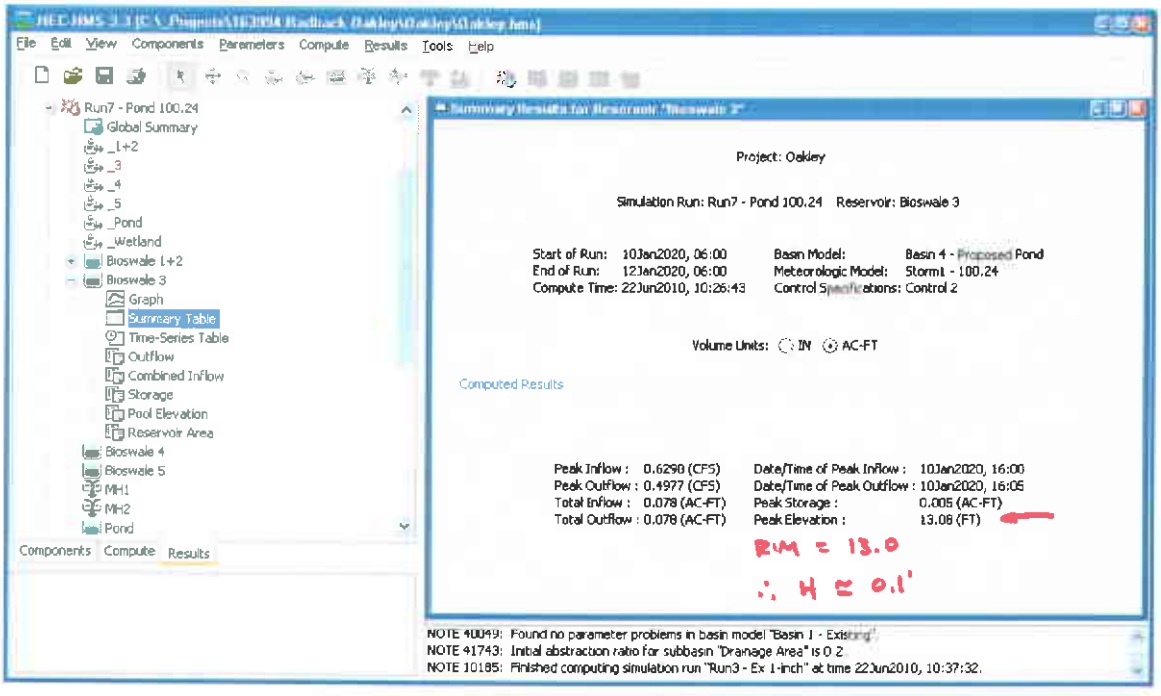
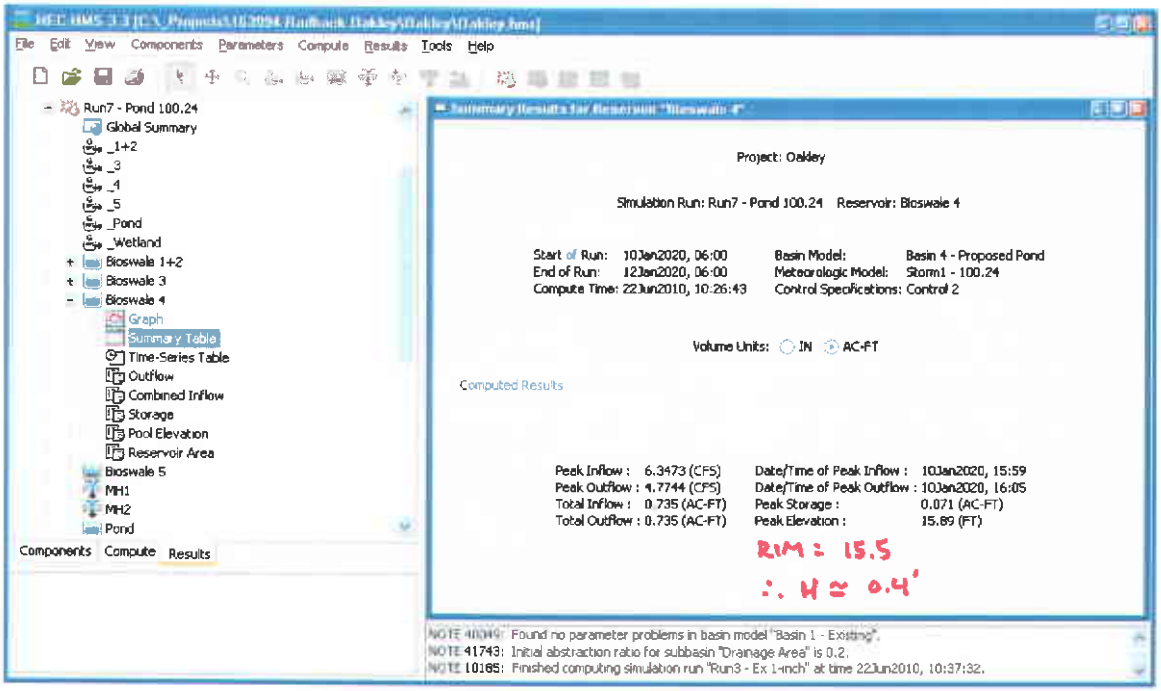
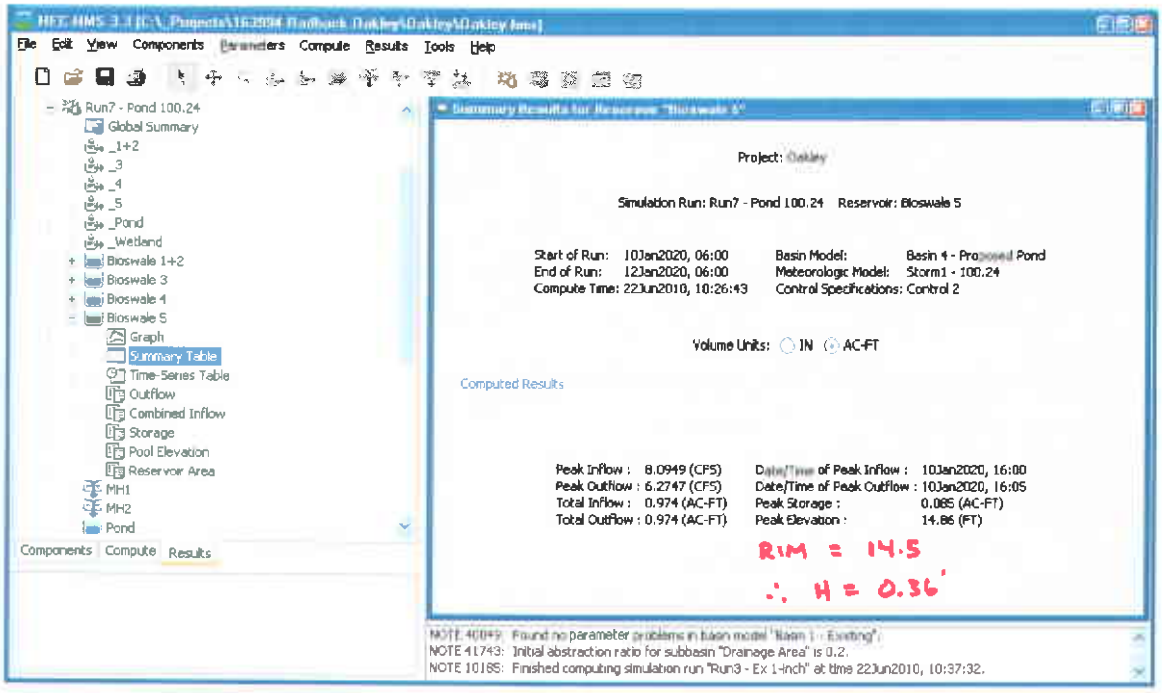


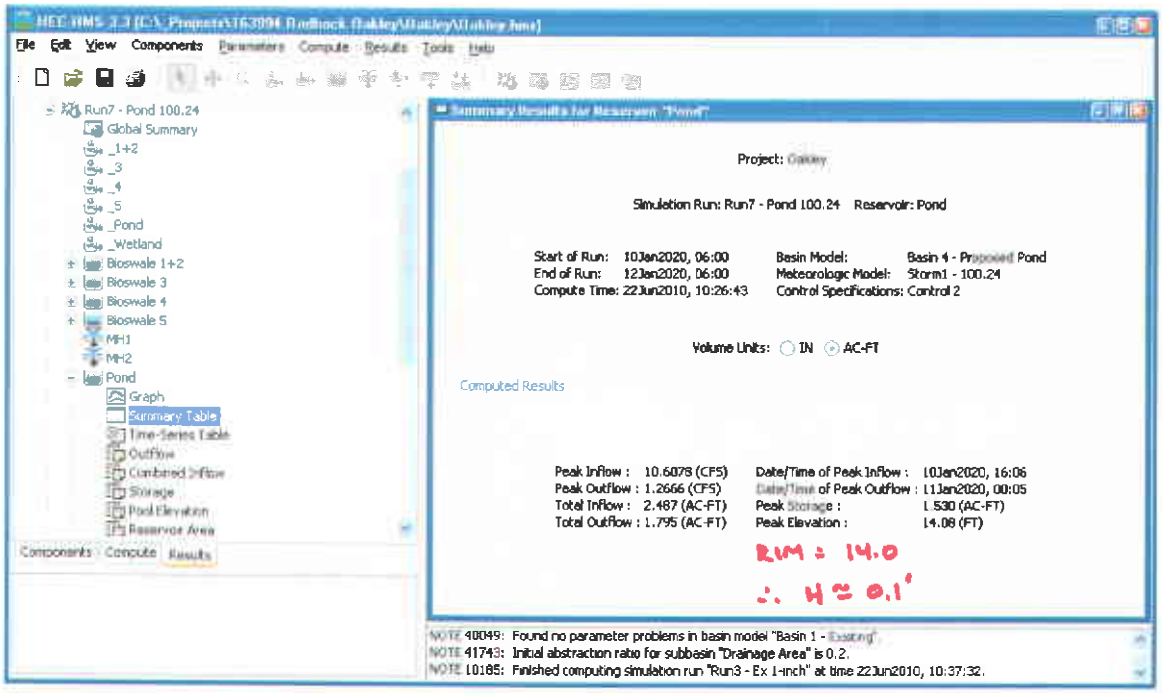
HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 4



HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 5



HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Pond



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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

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

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:

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

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 bankfull 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:

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

where:

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

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

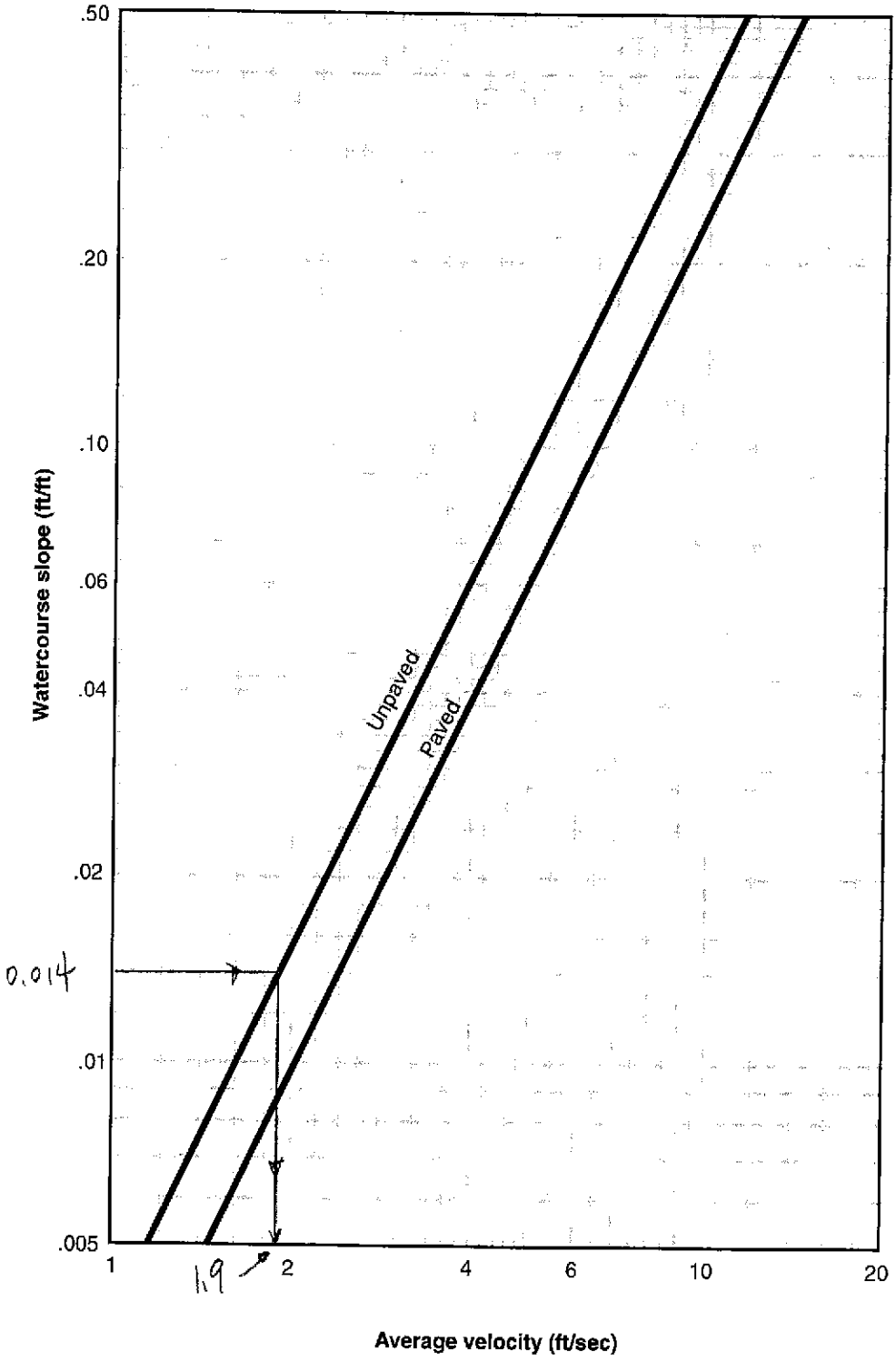
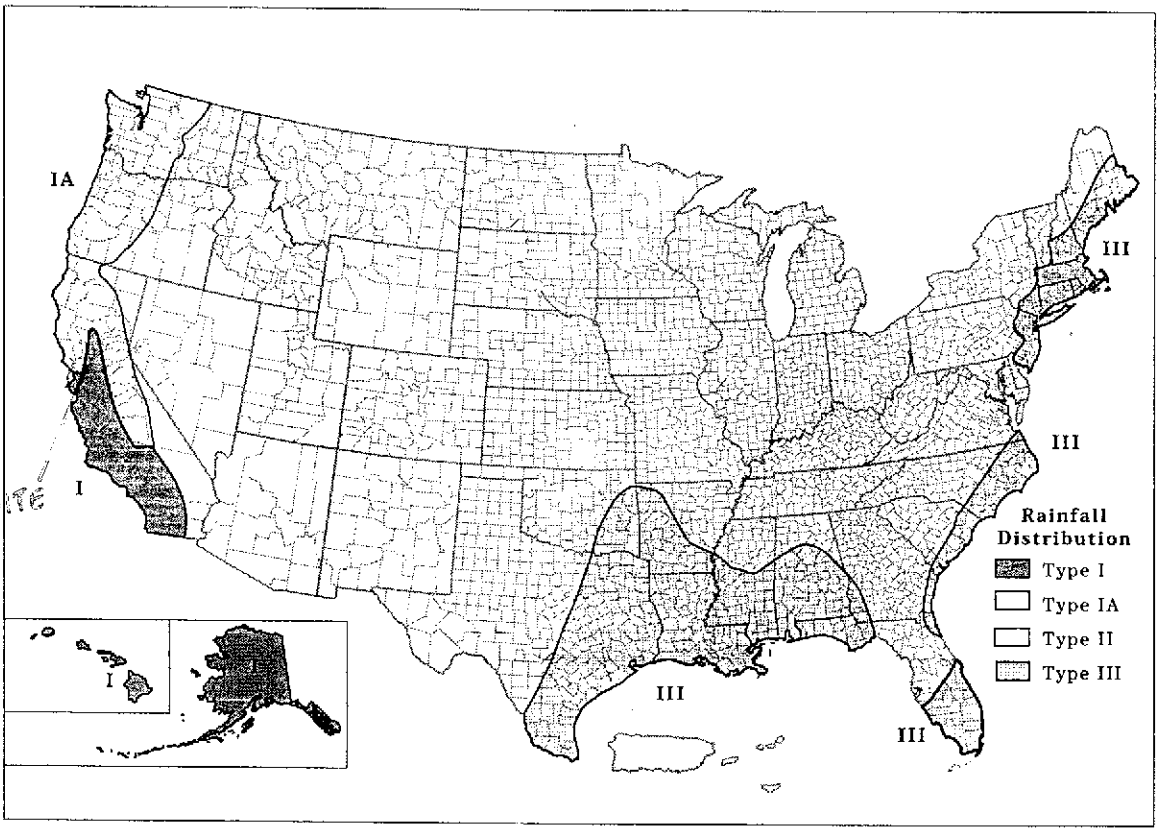


Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



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.

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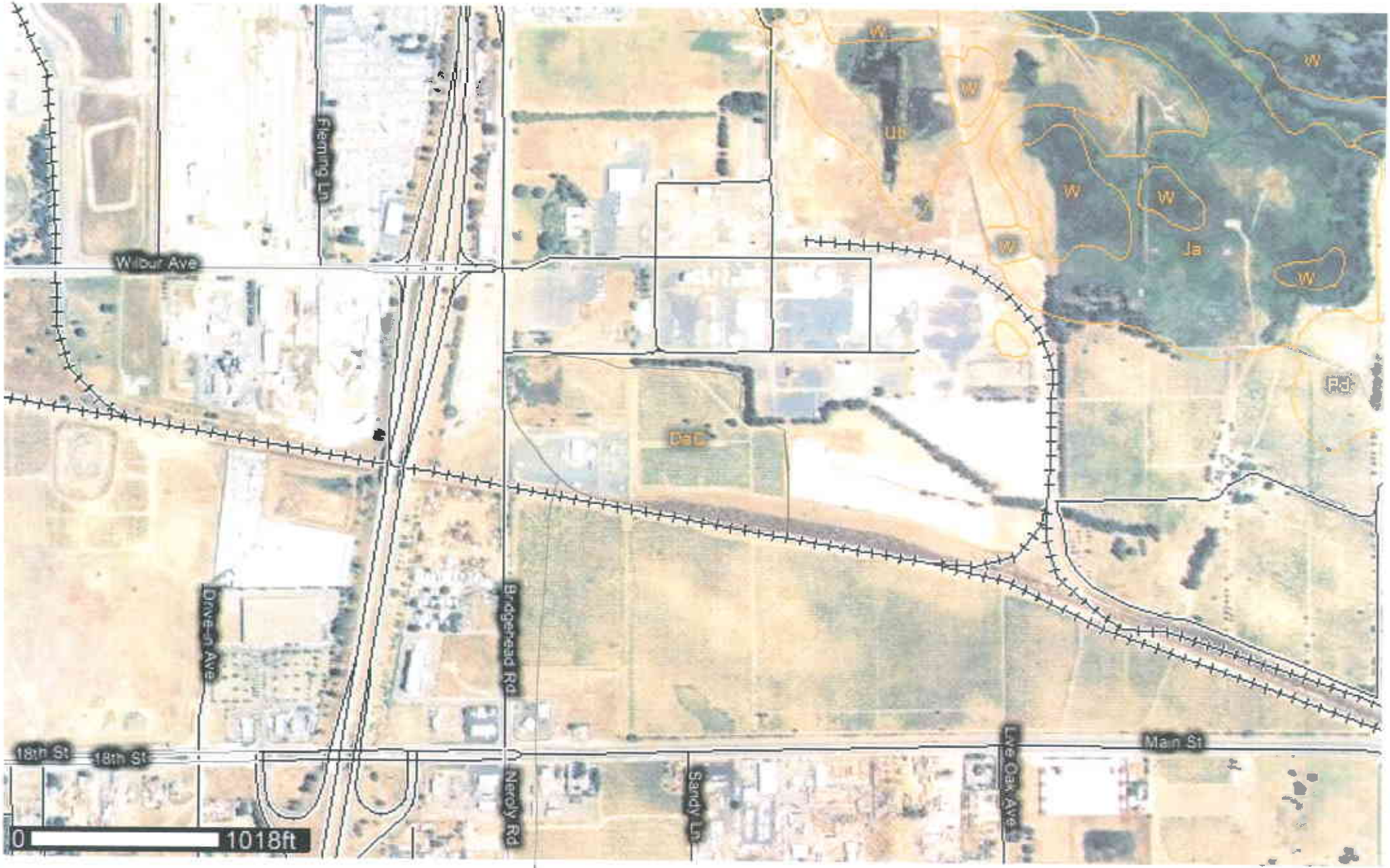
(printed out from the online web soil survey)



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

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Attachment 5

Reference 8

IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 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	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

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 "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.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (54{,}900 \times 1 + 65{,}113 \times 1 + 100{,}200 \times 0.6 + 198{,}264 \times 0.1 + 4{,}491 \times 0 + 68{,}200 \times 0.1)$$

$$= 206{,}779 \text{ ft}^2.$$

IMP Sizing for Bioswale #3

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 25,711 ft^2 (0.59 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	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

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,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{pmatrix} DMA \\ Runoff \\ Factor \end{pmatrix} = (3{,}873\text{x}1.0+2{,}086\text{x}1.0+19{,}752\text{x}0.1)$$

$$= 7{,}934 \text{ ft}^2.$$

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:

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

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,

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

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

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.

IMP Sizing for Bioswale #5

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 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	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

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,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{pmatrix} DMA \\ Runoff \\ Factor \end{pmatrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133 \text{ ft}^2.$$

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.

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Attachment 6

Reference 9

Select pages

N 2193000

N 2192750

N 2192500

N 2192250

N 2192000

E 6201500

E 6201750

E 6202000

E 6202250

E 6202500

E 6202750

C

D

E

F

G

BRIDGEHEAD ROAD

FLOW PATH

DRAINAGE AREA BOUNDARY

BIOSWALE HP EL 15.0

BIOSWALE HP EL 17.5

HP 20.0

HP 20.0

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prepared by: J zhong
Date 3/4/09
checked by: PW
Date: 3/6/09

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

ACAD 16.1s (LMS Tech)
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Hydrology Modeling – HEC-HMS

PRE-CONSTRUCTION

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:

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

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:

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

Where:

n = roughness coefficient;
L = flow length (ft);
P_2 = 2-year, 24-hour rainfall (in);
s = land slope (ft/ft).

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Attachment 7

Reference 11

$$\text{Incremental Storage Volume} = \left(\frac{AreaHi + AreaLo}{2} \times (ElevHi - ElevLo) \right)$$

For the volume between elevations 5.0 and 7.5:

$$\text{Incremental Storage Volume} = \left(\frac{0.62 + 0.40}{2} \times (7.5 - 5.0) \right) = 1.28 \text{ ac-ft}$$

Wetland Elevation – Area – Storage Summary (See Ref. 9, Pg 11)

Elevation (ft)	Wetland Area (acre)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-
7.5	0.62	1.28	1.28
10.0	1.44	2.57	3.85
11.5	1.6	2.28	6.13

There is an outlet control structure proposed between the pond and wetland that will allow water to flow from the pond into the wetland when the water level in the pond is above elevation 10.0. The volume retained in the pond below elevation 10.0 prior to allowing discharge into the wetland is determined by calculating the total incremental storage provided below elevation 10.0 as shown in the table on the following page.

Retained Volume to Elevation 10.0 = 0.10 ac-ft + 0.23 ac-ft = 0.33 ac-ft

This storage volume reduces the runoff that reaches the wetland. The wetland water-surface elevation in the post-construction site condition takes this into account.

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Attachment 8

Reference 12

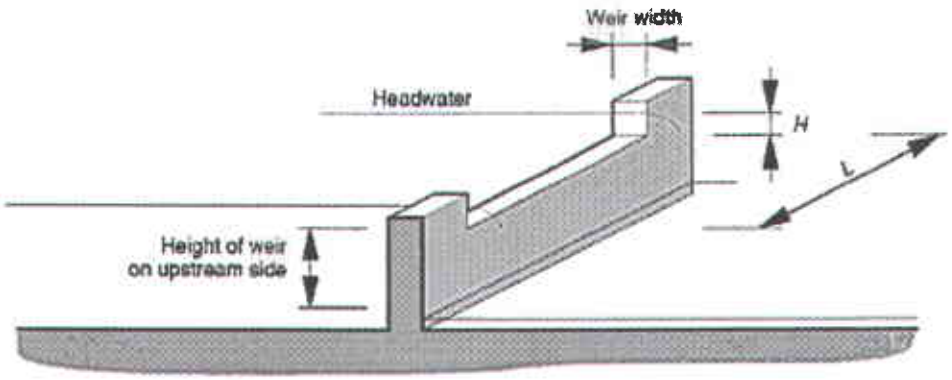

Figure 6.16 Dimensions of a rectangular weir.

WEIRS

A weir is a shelf that water falls over, such as the top of a barrel pipe, a timber check dam, or the crest of a concrete dam.

Weir discharge is governed by the simple principle that as head increases upstream of a weir, the flow over it increases. The type of material is irrelevant as long as the weir has only enough width for structural strength and water does not contact it long enough to be slowed down by friction.

A weir that is straight and level, with vertical sides, like that in Figure 6.16, is referred to as a rectangular weir. Discharge over this type of weir is predicted by the weir equation (U.S. Bureau of Reclamation, 1974, p. 373):

$$q = C\,L\,H^{3/2}$$

where

q = discharge, cfs

C = coefficient (no units) equal to 3.3 where a weir has significant height on the upstream side, such as at a dam or a barrel pipe, or 3.09 where a weir has no upstream height, such as at a drop structure in a channel

L = horizontal length of crest, ft

H = head of water above the crest, ft

USE C = 3.1

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Attachment 9

Reference 7

Type of channel	Values of the roughness coefficient n		
	Minimum	Normal	Maximum
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.014
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	—
8. On irregular excavated rock	0.022	0.027	—
d. Concrete bottom float with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement, rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	—
2. Rough	0.016	0.016	—
j. Vegetal cover	0.030	—	0.500
C. *Excavated or Dredged*			
C–1 General			
a. Earth, straight and uniform			
1. Clean and recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	**0.022**	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033

Use $n=0.027$ for vegetated ditch

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Attachment 10

Reference 13

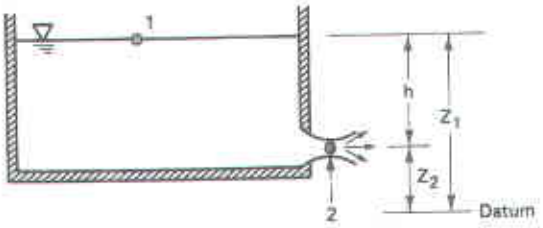

FIGURE 8–4 Schematic diagram of flow through an orifice.

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \tag{8–13}$$

This can be simplified by making the following assumptions: (1) The pressure at both points is atmospheric, therefore $p_1 = p_2$; (2) The surface area of the pool A_1 is very large relative to the area of the orifice A_2, so from the continuity equation, V_1 is essentially 0; and (3) $z_1 - z_2 = h$. Thus, Equation 8–13 becomes

$$h = V_2^2/2g \tag{8–14}$$

Solving for V_2 and substituting it into the continuity equation yields

$$q = AV = A\sqrt{2gh} \tag{8–15}$$

Equation 8–15 depends on two assumptions that are not always true: there are no losses and the pressure is atmospheric across the opening of the orifice; it is actually atmosphere at a point below the orifice, called the vena contracta, where the cross-sectional area is a minimum. Because of these violations, the discharge will be less than that given by Equation 8–15. The actual discharge through the orifice is estimated by applying a discharge coefficient C_d to Equation 8–15:

$$q = C_d A\sqrt{2gh} \tag{8–16}$$

in which C_d is called the discharge coefficient. Equation 8–16 is referred to as the orifice equation. For some design problems, the q of Equation 8–16 is multiplied by an efficiency factor f to reflect other types of losses that limit the discharge rate. Values of C_d range from 0.5 to 1.0, with a value of 0.6 often used. C_d is dimensionless.

use 0.62

Example 8–3

A forklift is accidentally driven into the side of an above-ground storage tank and it punctures an 11-in.^{2} hole 6 in. above the ground. In order to complete the environmental report, the engineer needs to estimate the amount of petroleum that leaked out of the tank during the 25 min between the time of the puncture and the time that the hole was plugged. The surface elevation of the petroleum above the ground was 8.46 ft after the leak was stopped. The tank has a diameter of 40 ft. The engineer estimates the discharge coefficient is 0.55, which is less than the 0.6 value because of the additional losses created by the jagged edges of the hole. Thus, the estimated discharge is

$$q = C_d A\sqrt{2gh} = 0.55\left(\frac{11}{144}\right)[2\,(32.2)\,(8.46 - 0.5)]^{0.5}$$
$$= 0.951\ \text{ft}^3/\text{sec}$$

Attachment WSQ8-2
Stormwater Analysis for Wetland
(Calculation 52.5406.1003)

BLACK & VEATCH

Calculation Record

Client Name: Radback Energy Page 1 of 53

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
1	J Zhong Jimmy Zhong	21 APR 09	[signature]	21 APR 09	[signature]	21 APR 09
2	C Kantola [signature]	8 Jun 10	[signature]	10 JUN 10	[signature]	10 JUN 10

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.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1002 Rev 0, Same project, March 2009 — Rev 1
9. Contra Costa County Public Works Department; Mean Seasonal Isohyets (Dwg B-166) Precipitation Duration - Frequency - Depth Curves (100-YR) (Dwg B-159); 1977 — Rev 2

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 8.9 (Rev 2) RLW 6/10/10 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. ~~Since the project site will be developed based on Contra Costa County's Stormwater C.3 Guidebook, the post development runoff will be no greater than pre-development runoff.~~ Rev 1

VOID Rev 2 RLW 6/10/10
See Calculations for 52.5406.1006 & 1007
for [illegible]
[illegible]

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:

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

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:

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

Where:

n = roughness coefficient;

L = flow length (ft);

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

s = land slope (ft/ft).

N 2193000

N 2192750

N 2192500

N 2192250

N 2192000

E 6201500

E 6201750

E 6202000

E 6202250

E 6202500

E 6202750

BRIDGEHEAD ROAD

FLOW PATH

GRAVEL

DRAINAGE AREA BOUNDARY

BIOSWALE HP EL 17.5

Radback Tenaska project
project # 163994
52.5466.1003

stormwater Analysis

page 5 of 53

prepared by: J zhang
Date: 3/4/09
checked by: PW
Date: 3/6/09

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

ACAD 16.1s (LMS Tech)
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E1
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0.06 (Rev. 2) PLW 6/10/10 < (Rev 2)

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

Existing conditions have sparse ground coverage based on aerial photos | Rev 2

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

1.6 (Rev 2) PLW 6/10/10 (Rev 2)

2-year, 24-hour rainfall P_2 = 2 inch for this site per Ref. 6 (see Page 8).

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

0.06 (Rev 2) 0.37 (Rev 2)

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

1.6 (Rev 2) PLW 6/10/10

(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:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$

$= 0.76 + 0.17 + 0$

(Rev 2) 0.37

$= 0.93$ hour.

0.54 hr (Rev 2) PLW 6/10/10

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

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

0.54 = 0.324 hr = 19.4 min (Rev. 2)

PLW 6/10/10

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

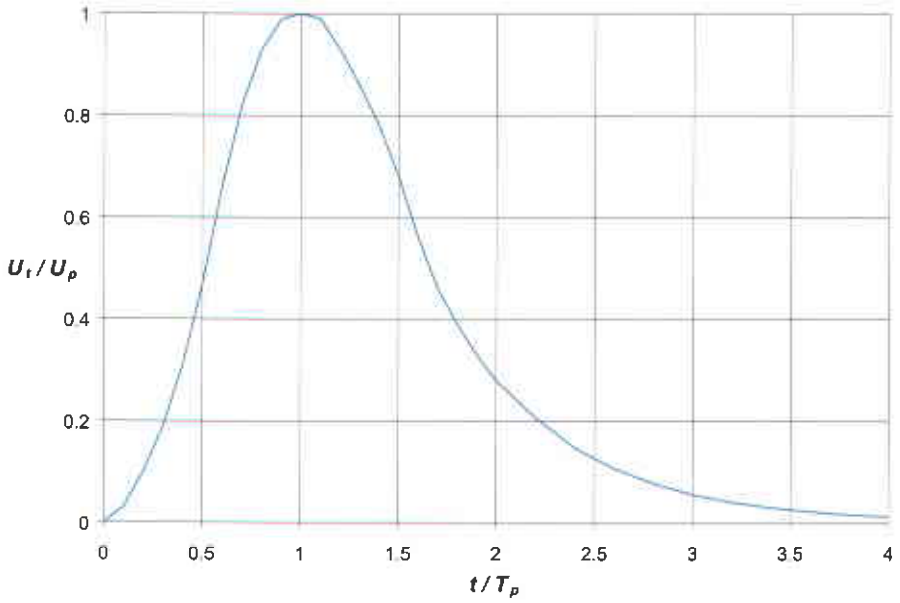

Figure 6-2. SCS unit hydrograph

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

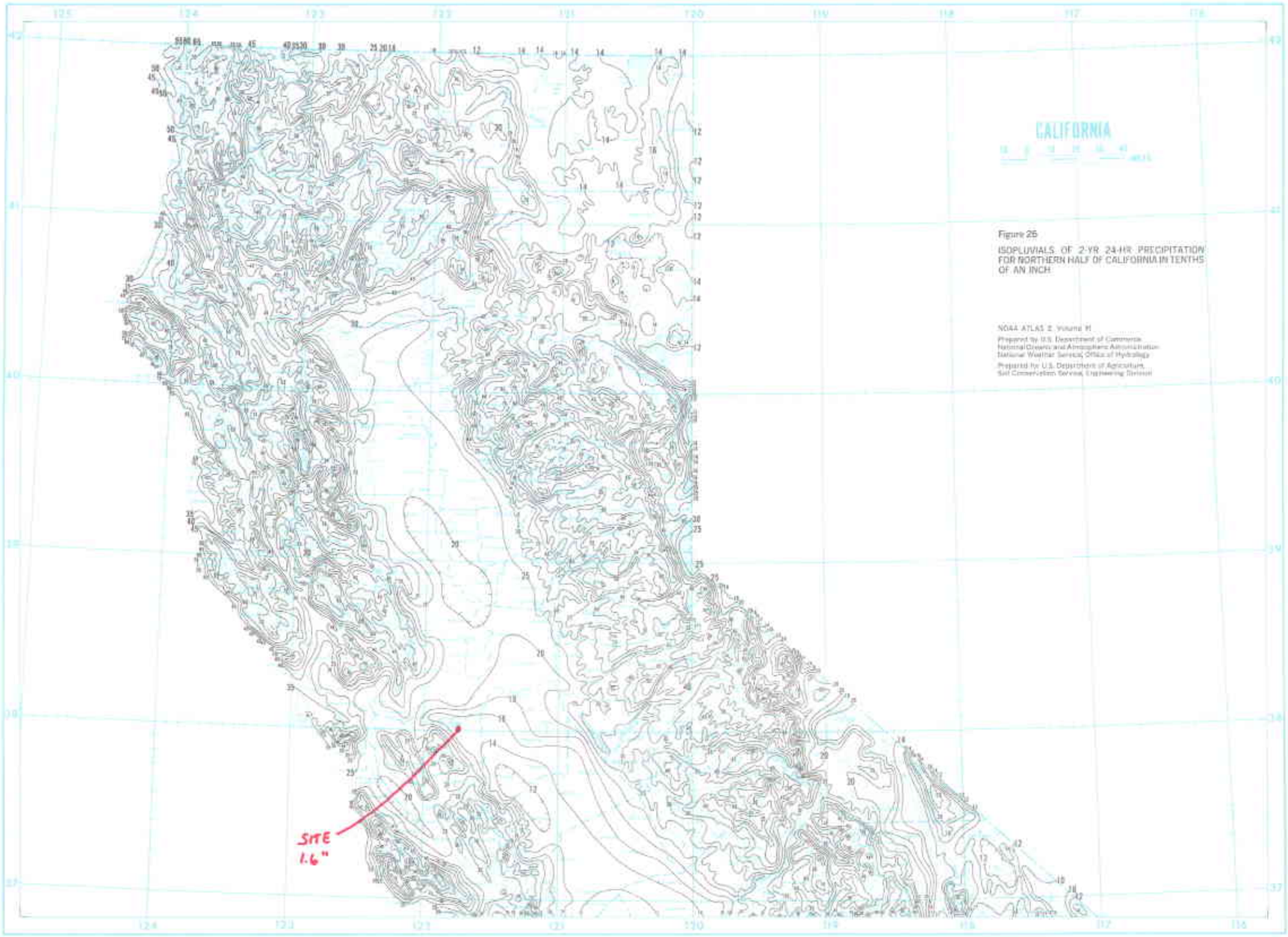

Figure 25

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared by U.S. Department of Agriculture
Soil Conservation Service, Engineering Division

REV 2) Radback Tenaska Project
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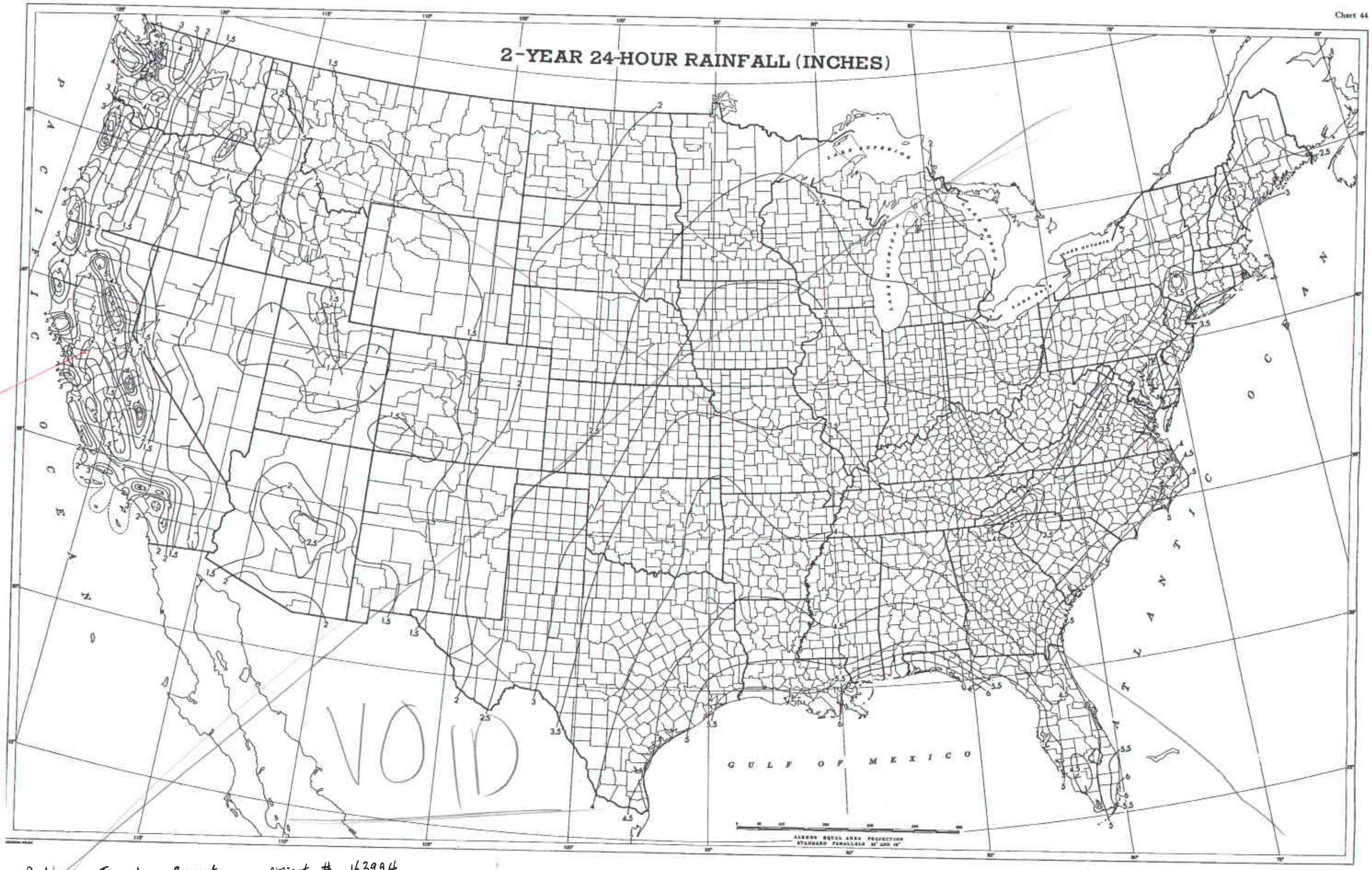
Note:
This page is from Ref. 9

2-YEAR 24-HOUR RAINFALL (INCHES)



SITE 2"

VOID

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NOTE: THIS PAGE IS FROM REF. 5.

SUPERSEDED BY REV 2

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~~ 3.9 (Rev. 2) PLN 6/10/10 inches. (See Page 10) + 10A

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

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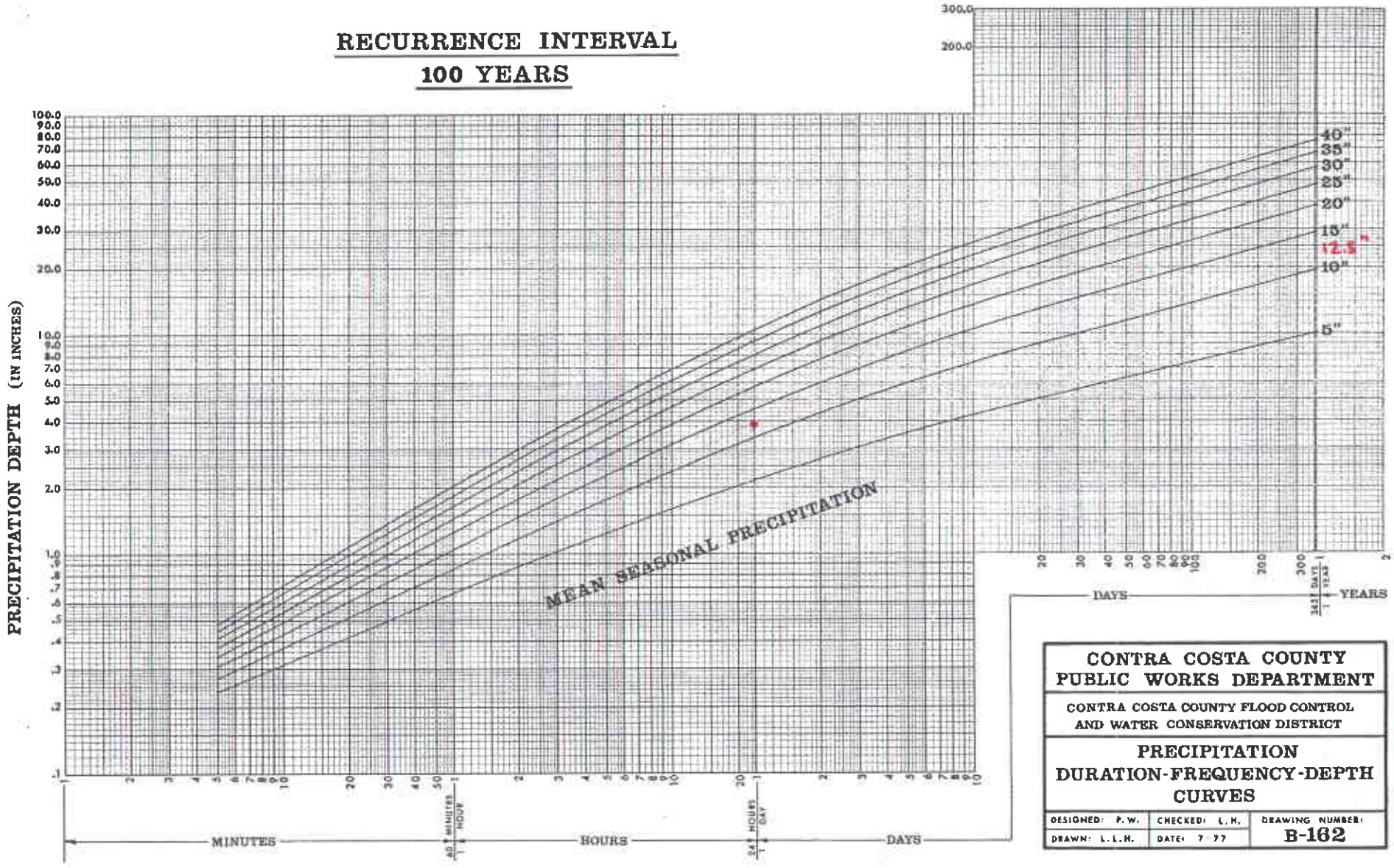
Note: this page is from Ref. 9

MSP = 12.5"



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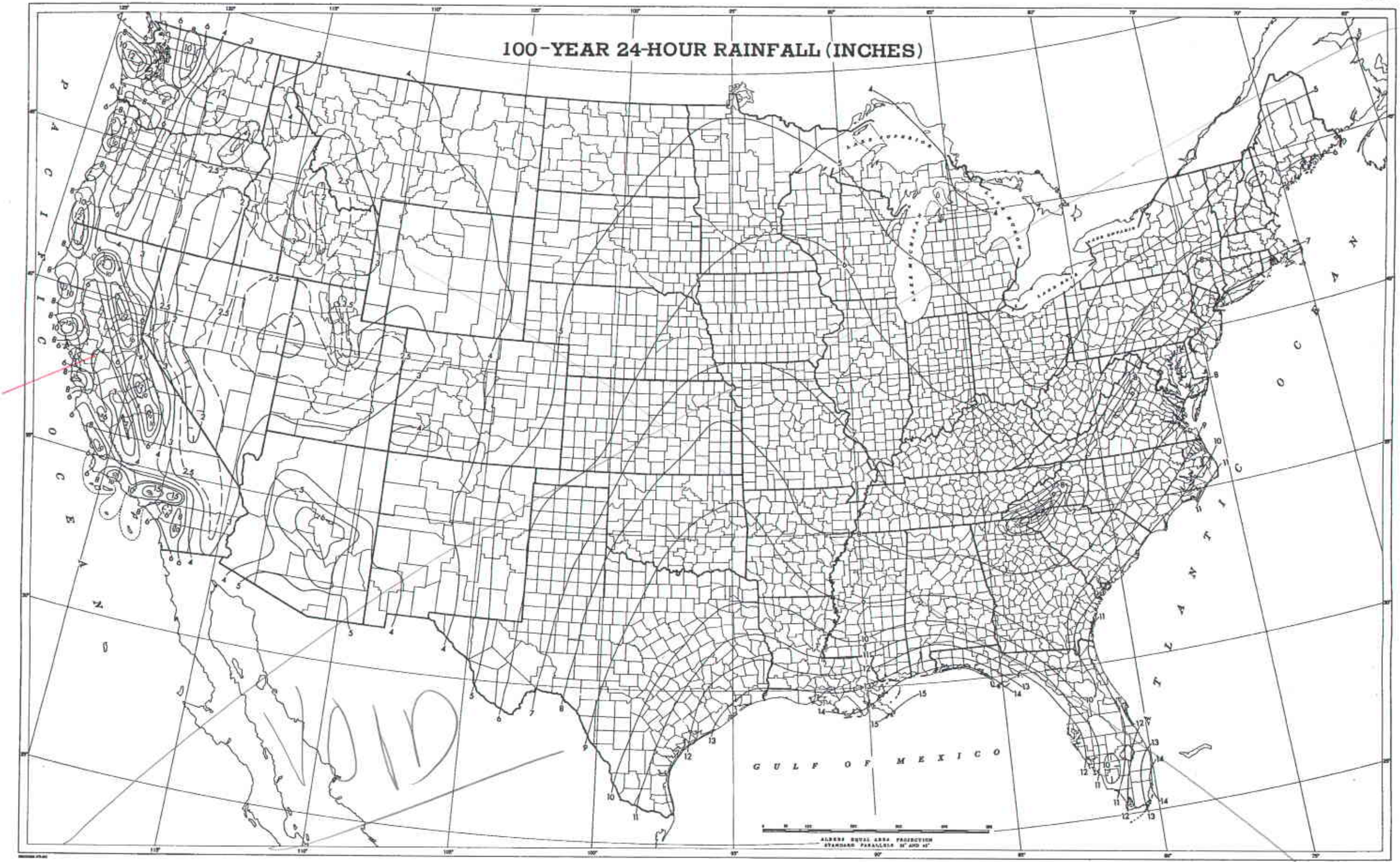
Note: This pg. is from Ref 9

MSP = 12.5" (DWG B-166)

24-HR = 3.9" (ABOVE)

100-YEAR 24-HOUR RAINFALL (INCHES)



SITE
4"

VOID

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SUPERSEDED BY REV. 2

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:

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

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 ft³/sec.
~~Peak Storage~~:	2.8 acre-feet
Peak Elevation:	9.1 feet.

Reference 8 demonstrates that the developed project meets the requirements of Contra Costa County's Stormwater C.3 Guidebook. The basis of the C.3 guidebook is flow control and treatment of stormwater runoff. Hence, the post development runoff will be no greater than pre-development runoff.

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. ~~Since the project site will be developed based on Contra Costa County's Stormwater C.3 Guidebook, the post development runoff will be no greater than pre-development runoff~~

Radback Tenaska project Stormwater Analysis JT 3/4/09

project # 163994

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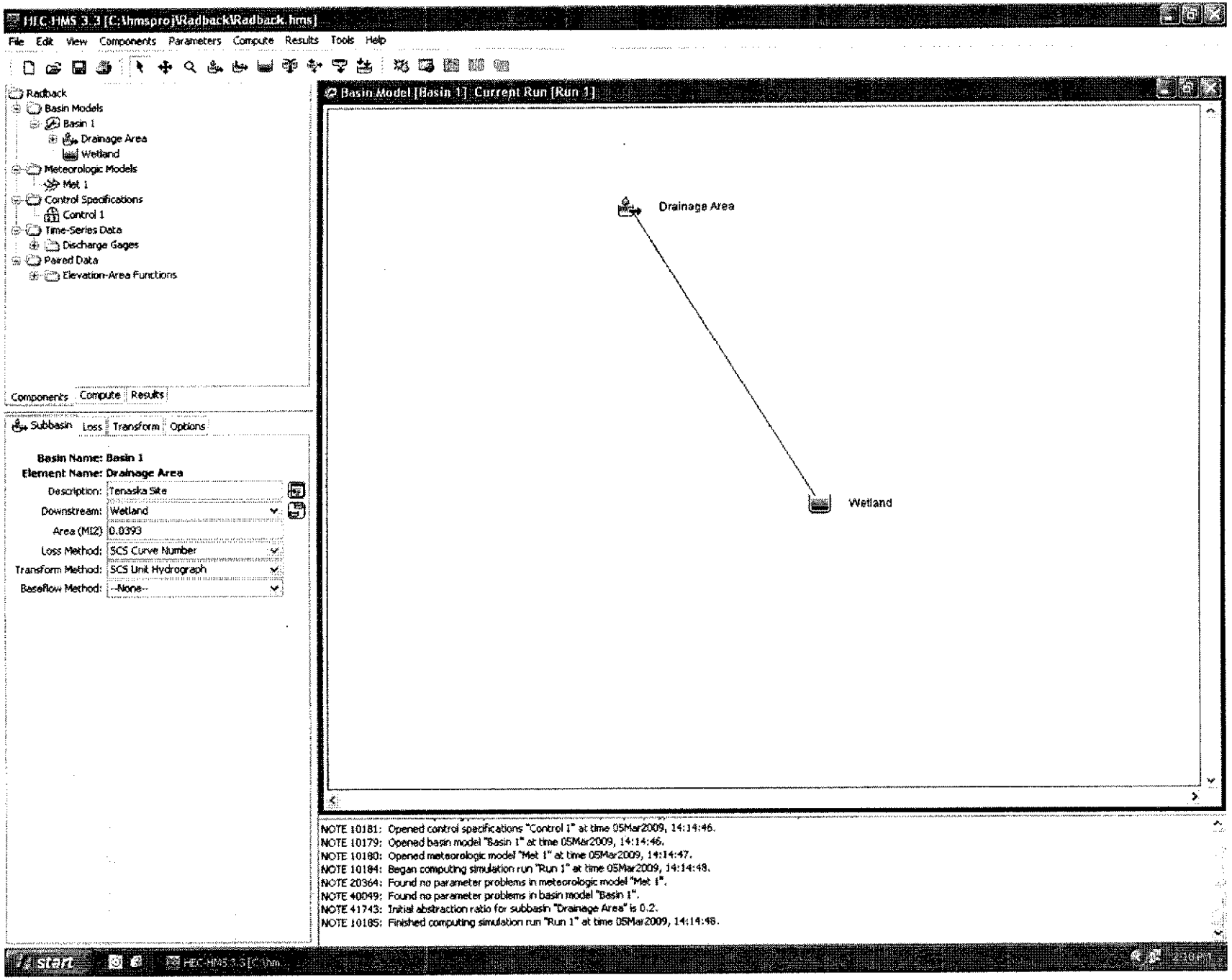
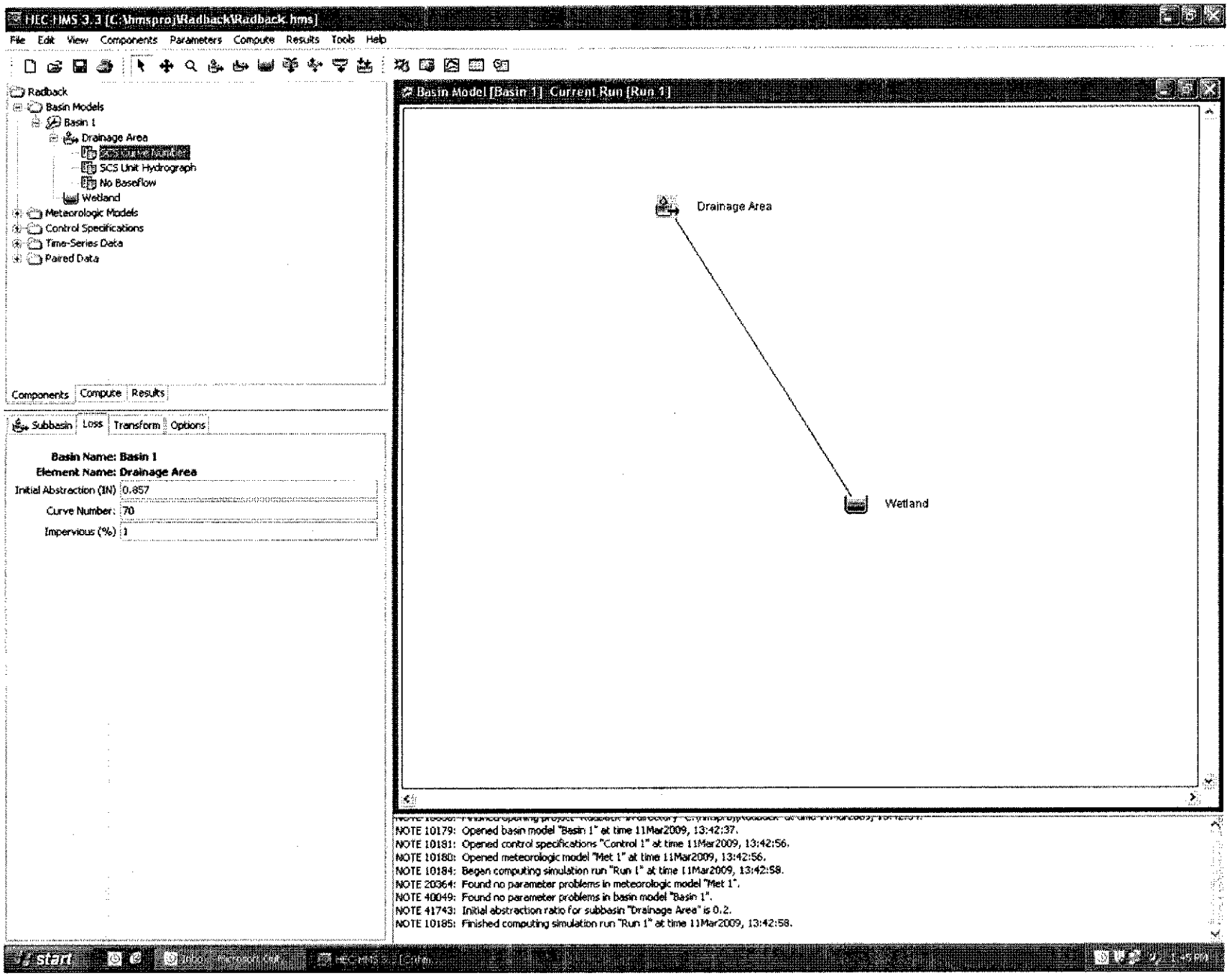
Attachment 1

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 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
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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.
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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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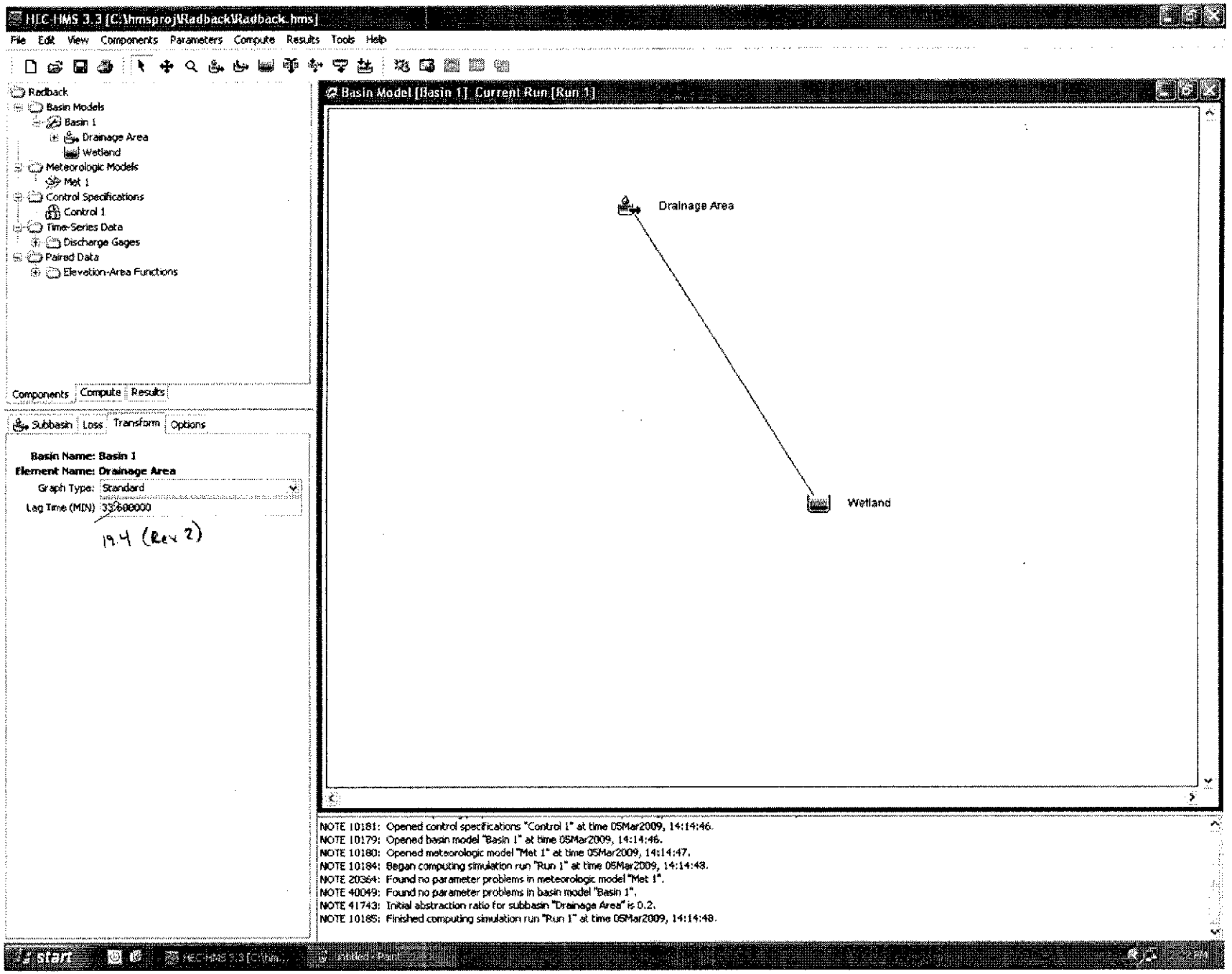
start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Radback
Basin Models
Basin 1
Drainage Area
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Subbasin Loss Transform Options
Basin Name: Basin 1
Element Name: Drainage Area
Graph Type: Standard
Lag Time (MIN) 35.000000
19.4 (Rev 2)
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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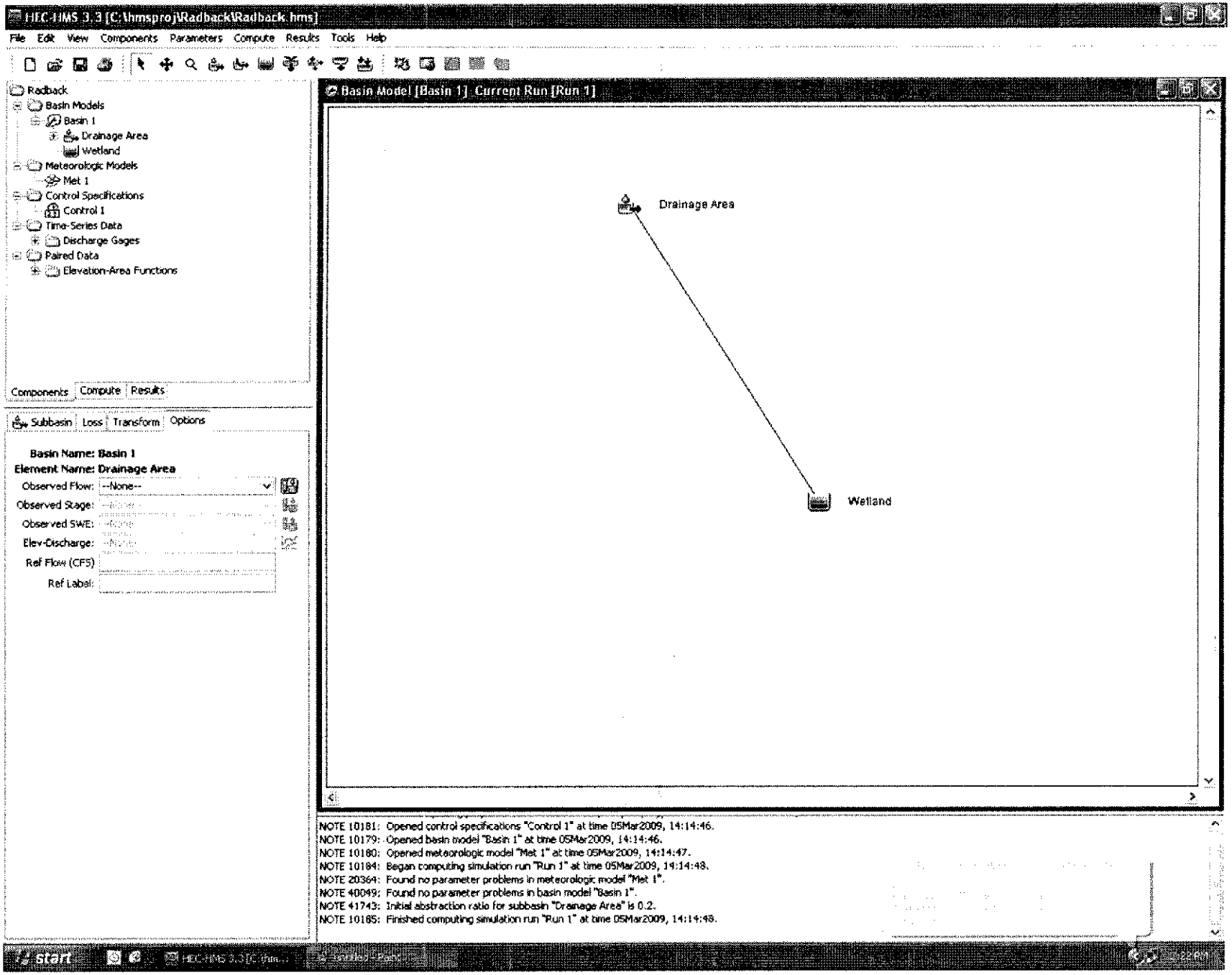
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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Radback
Basin Models
Basin 1
Drainage Area
Wetland
Meteorologic Models
Met 1
Control 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.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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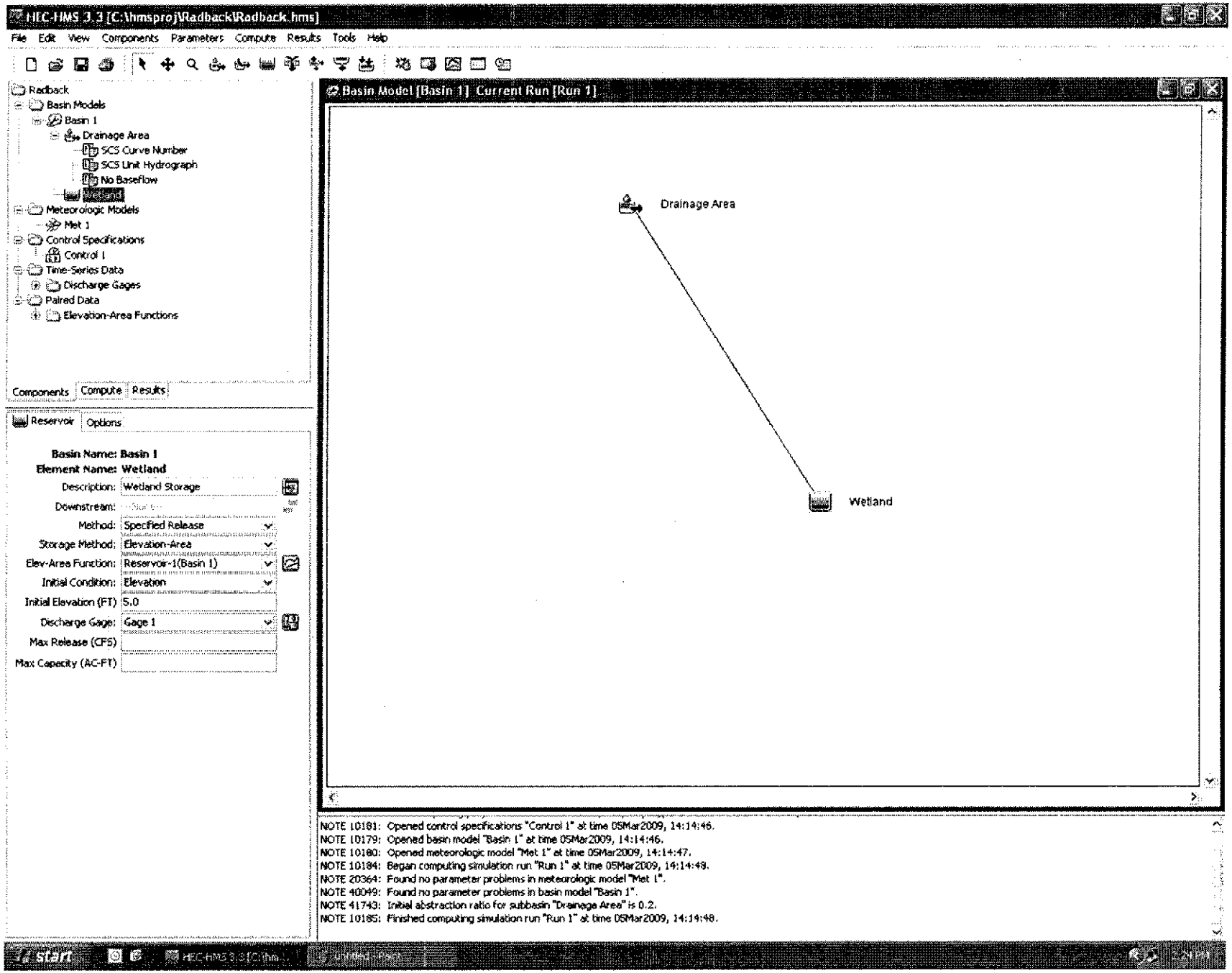
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic 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:
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.
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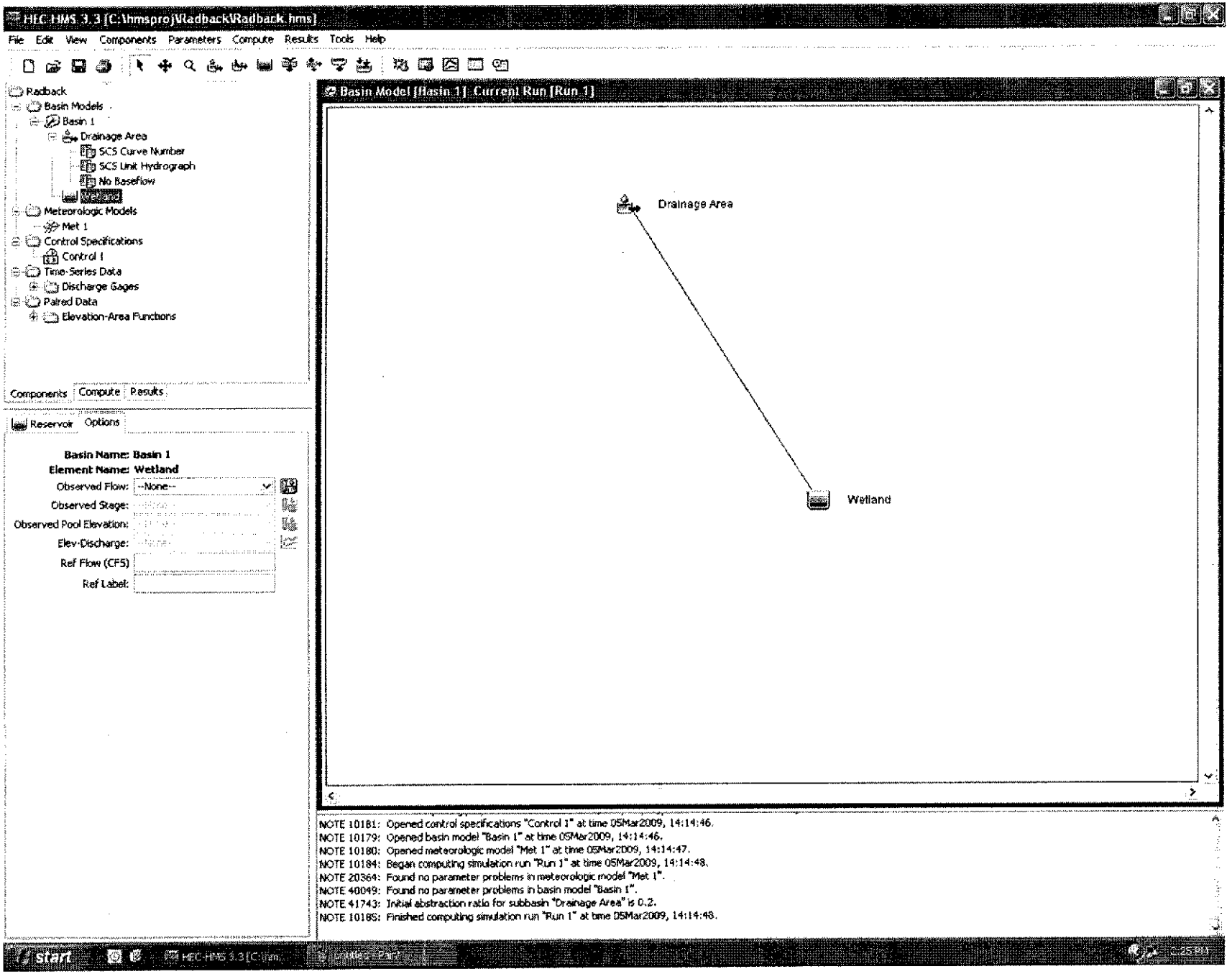
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Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Reservoir Options
Basin Name: Basin 1
Element Name: Wetland
Observed Flow: --None--
Observed Stage:
Observed Pool Elevation:
Elev-Discharge:
Ref Flow (CFS)
Ref Label:
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
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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.
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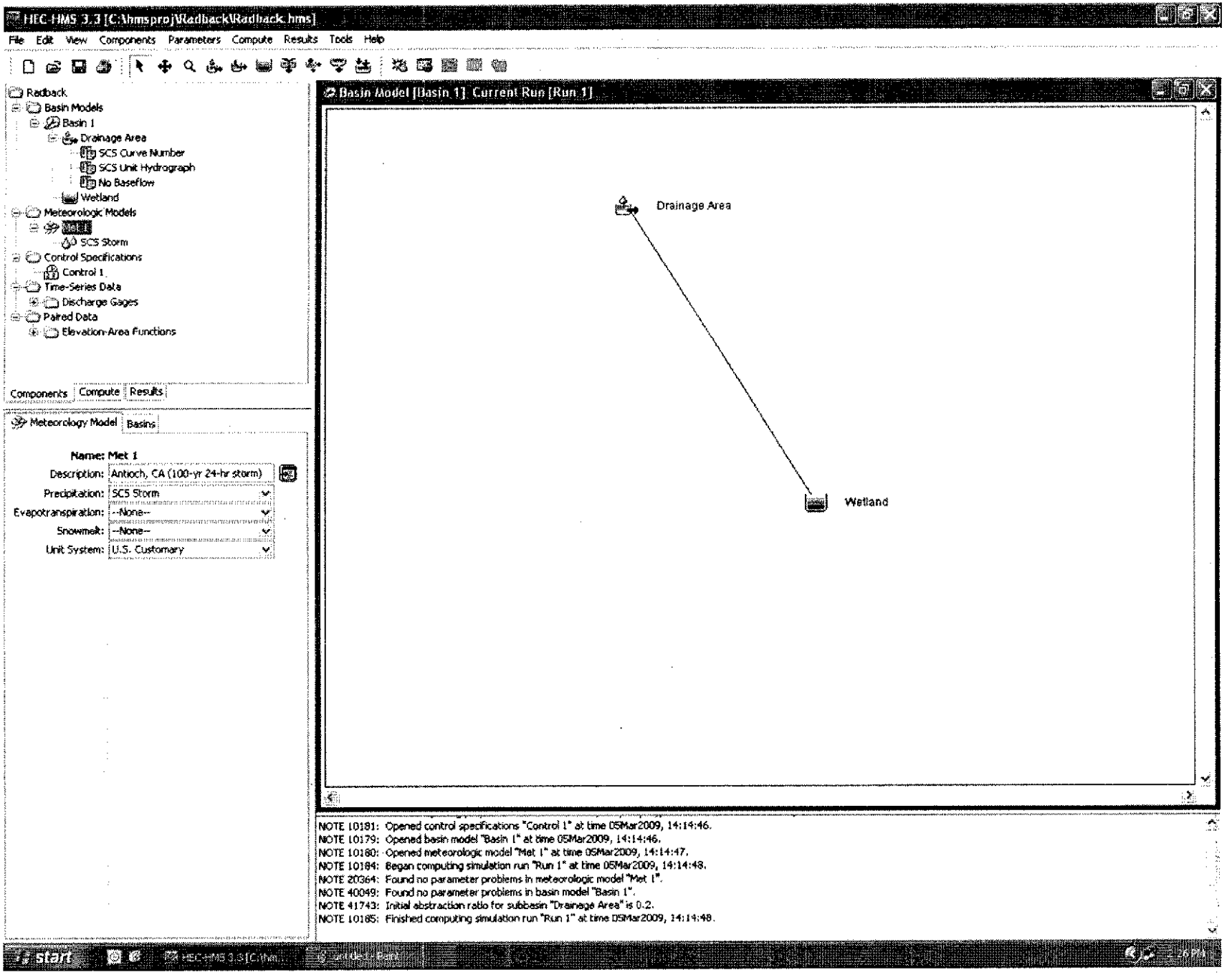
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Redback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components 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.
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NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
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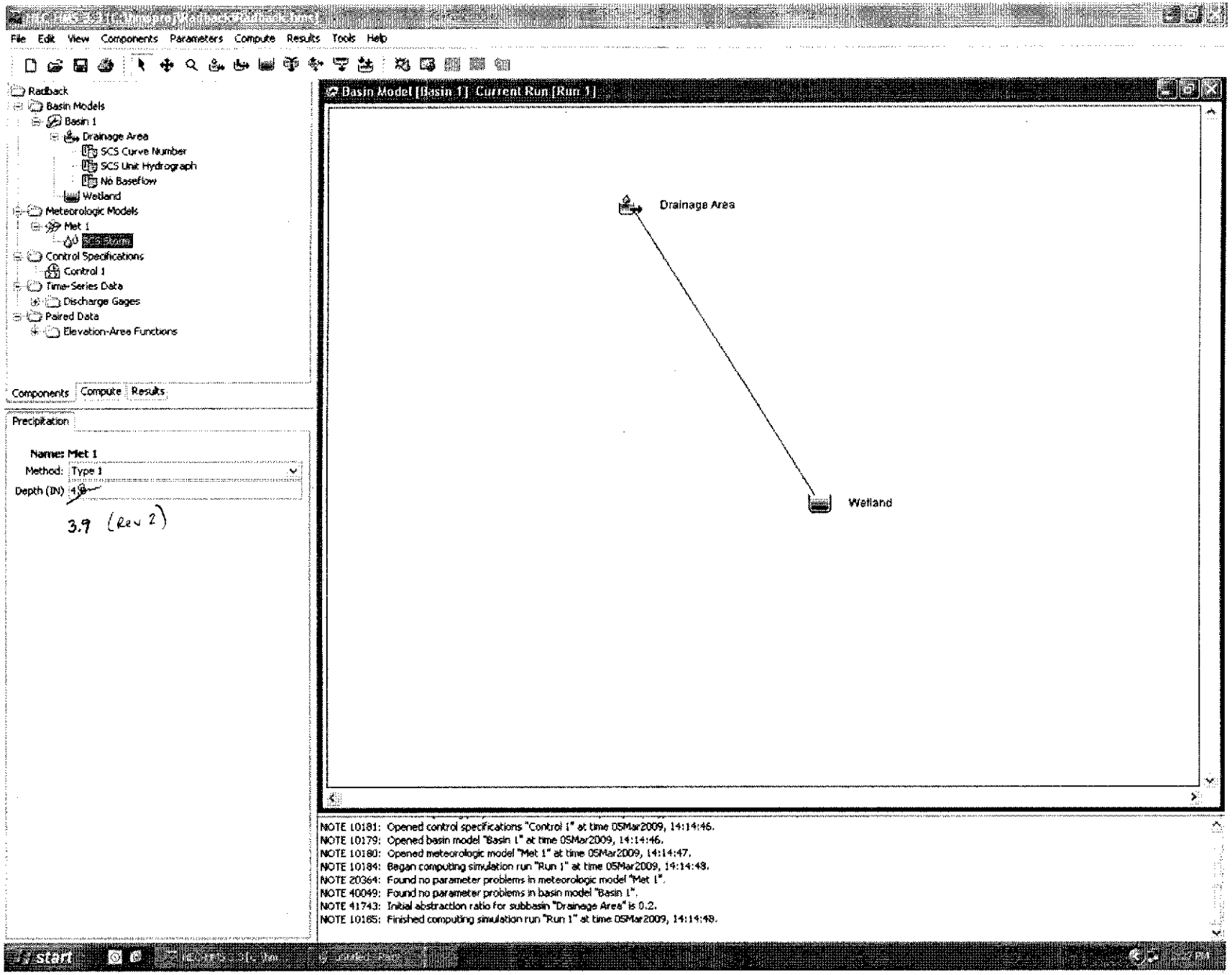
File Edit View Components Parameters Compute Results Tools Help
Radback
Basin Models
Basin 1
Drainage Area
SCS Curve Number
SCS Unit Hydrograph
No Baseflow
Wetland
Meteorologic Models
Met 1
SCS Storm
Control Specifications
Control 1
Time-Series Data
Discharge Gages
Paired Data
Elevation-Area Functions
Components Compute Results
Precipitation
Name: Met 1
Method: Type 1
Depth (IN): 4
3.9 (Rev 2)
Basin Model [Basin 1] Current Run [Run 1]
Drainage Area
Wetland
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NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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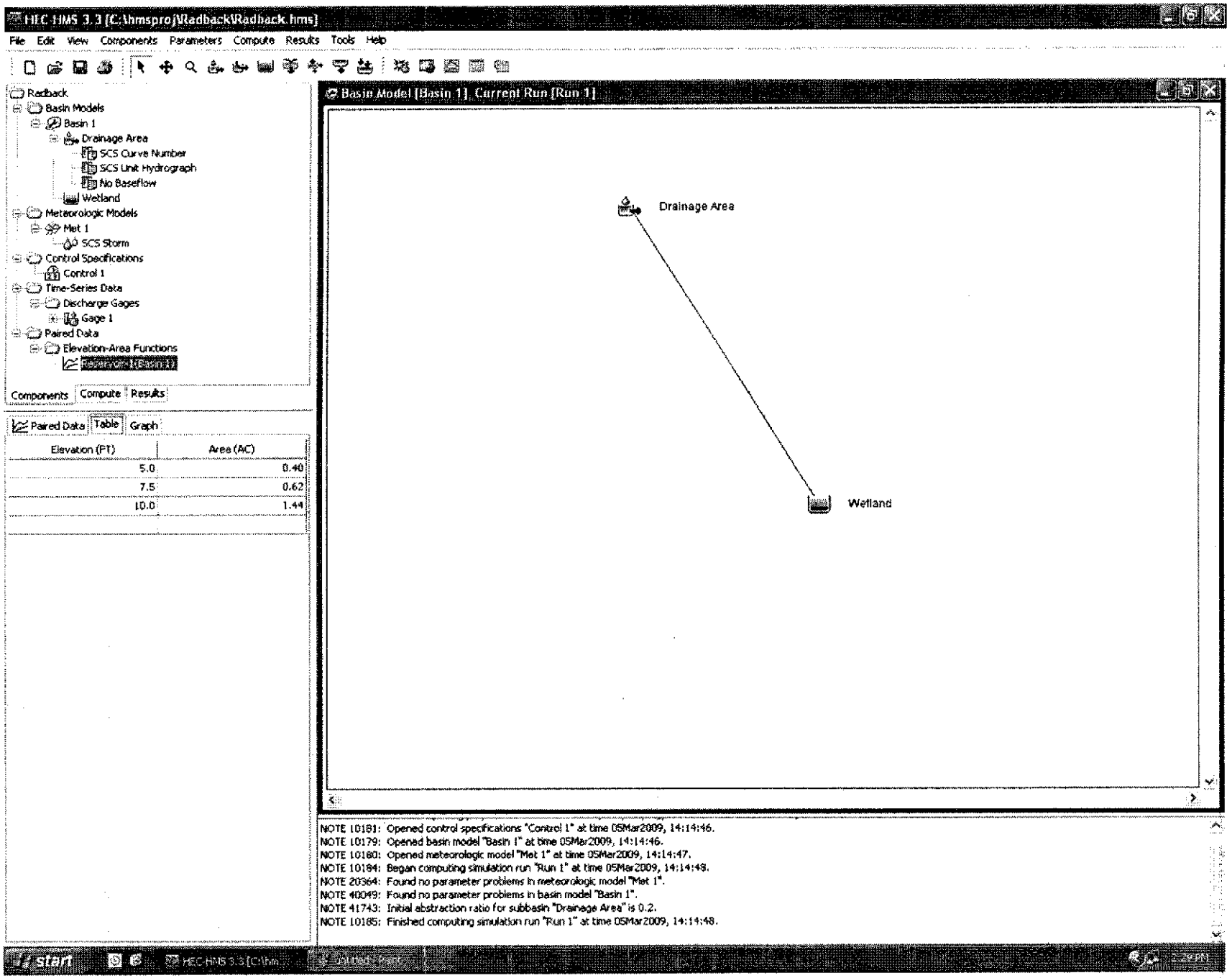
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
start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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
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
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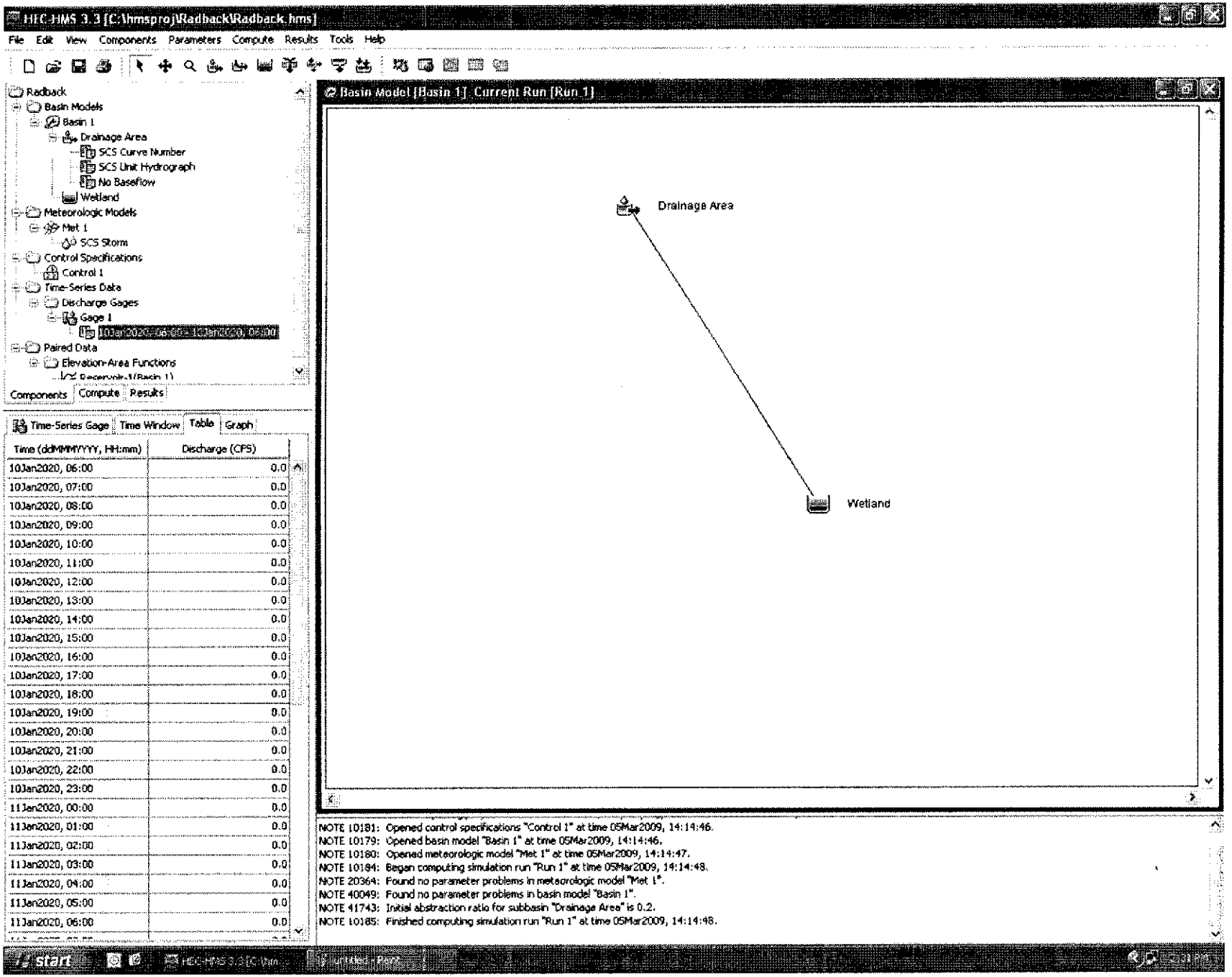
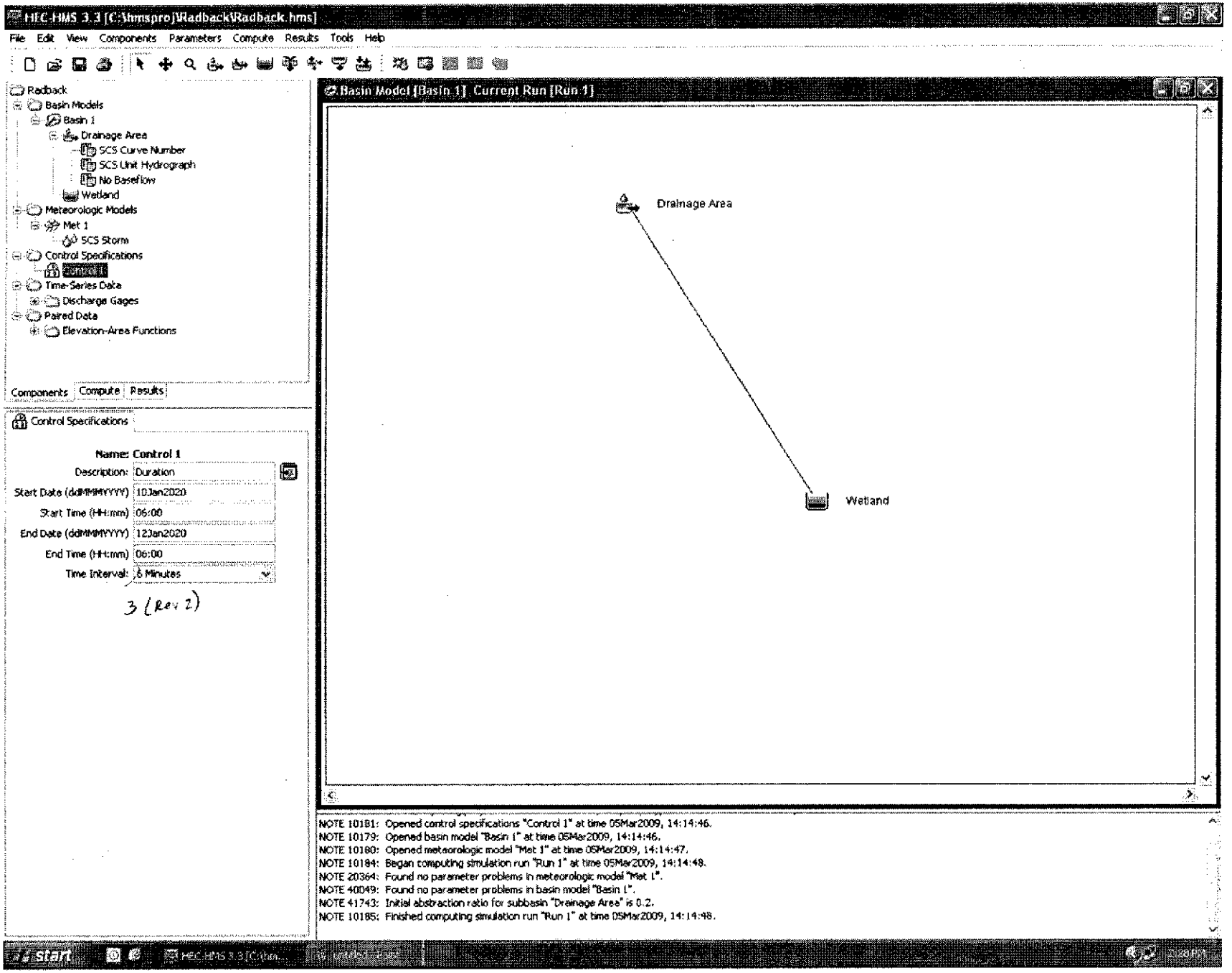
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20564: Found no parameter problems in meteorologic model "Met 1".
NOTE 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.


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
Paired Data
Elevation-Area Functions
Components Compute Results
Time-Series Gage Time Window Table Graph
Time (ddMMMYYYY, HH:mm) Discharge (CPS)
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
11Jan2020, 00:00 0.0
11Jan2020, 01:00 0.0
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.
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


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: 5 Minutes
3 (Rev 2)
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.

Radback Tenaska Project stormwater Analysis JZ 3/4/09

project # 163994

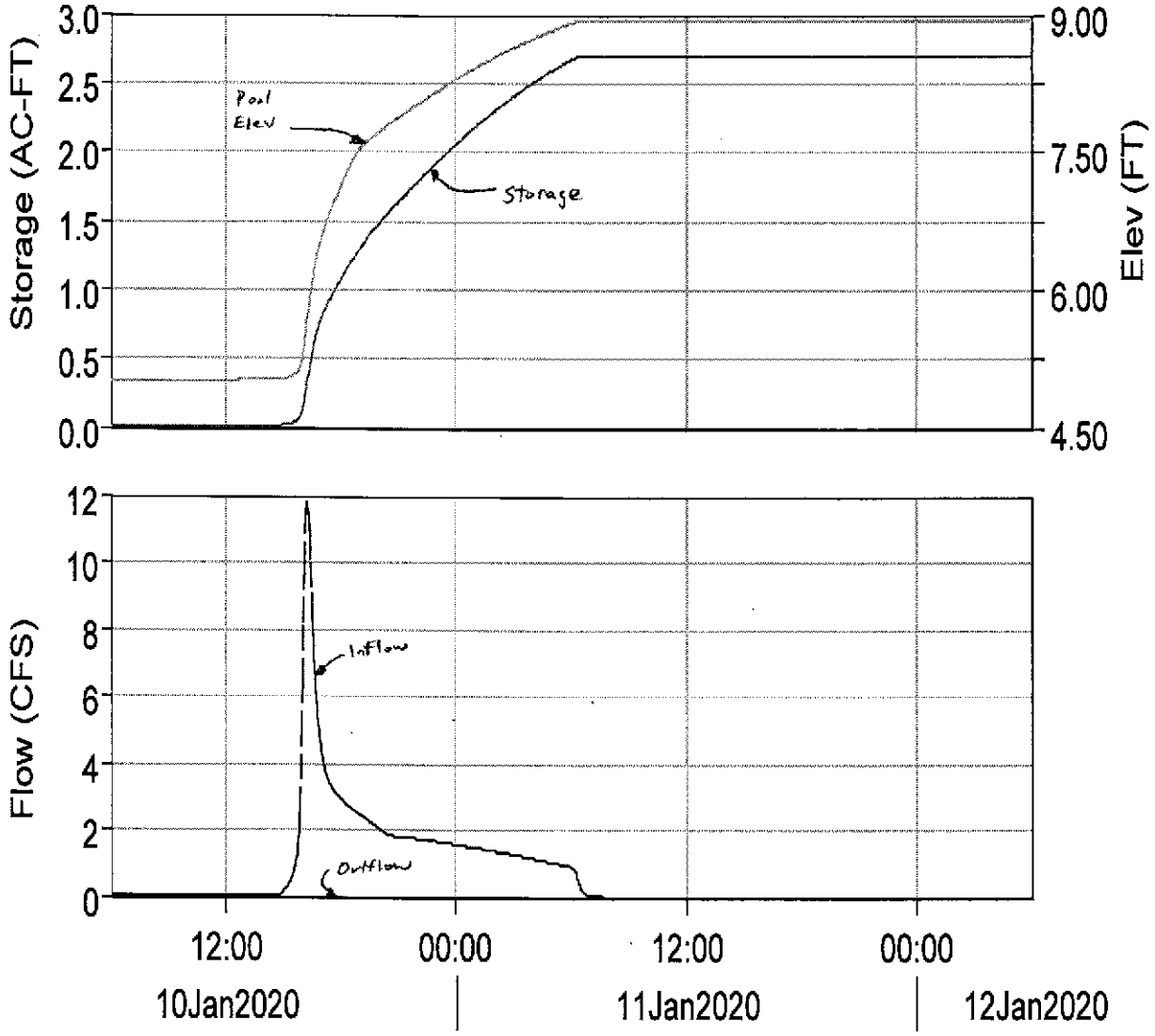
# of pages: 18

52.5406.1003

Attachment 2

HEC-HMS Output

Reservoir "Wetland" Results for Run "Run1 - Ex 100.24"



------ Run:Run1 - Ex 100.24 Element:WETLAND Result:Storage

— · — · Run:Run1 - Ex 100.24 Element:WETLAND Result:Pool Elevation

——— Run:Run1 - Ex 100.24 Element:WETLAND Result:Outflow

— — — Run:Run1 - Ex 100.24 Element:WETLAND Result:Combined Inflow

REV 2

Project: Oakley
Simulation Run: Run1 - Ex 100.24 Reservoir: Wetland

Start of Run: 10Jan2020, 06:00 Basin Model: Basin 1 - Existin
End of Run: 12Jan2020, 06:00 Meteorologic Model: Storm1 - 10
Compute Time: 22Jun2010, 08:13:54 Control Specifications: Control

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	06:00	0.0000	0.000	5.00	0.0000
10Jan2020	06:03	0.0001	0.000	5.00	0.0000
10Jan2020	06:06	0.0004	0.000	5.00	0.0000
10Jan2020	06:09	0.0011	0.000	5.00	0.0000
10Jan2020	06:12	0.0022	0.000	5.00	0.0000
10Jan2020	06:15	0.0037	0.000	5.00	0.0000
10Jan2020	06:18	0.0055	0.000	5.00	0.0000
10Jan2020	06:21	0.0074	0.000	5.00	0.0000
10Jan2020	06:24	0.0092	0.000	5.00	0.0000
10Jan2020	06:27	0.0108	0.000	5.00	0.0000
10Jan2020	06:30	0.0122	0.000	5.00	0.0000
10Jan2020	06:33	0.0133	0.000	5.00	0.0000
10Jan2020	06:36	0.0142	0.000	5.00	0.0000
10Jan2020	06:39	0.0148	0.000	5.00	0.0000
10Jan2020	06:42	0.0153	0.000	5.00	0.0000
10Jan2020	06:45	0.0157	0.000	5.00	0.0000
10Jan2020	06:48	0.0161	0.001	5.00	0.0000
10Jan2020	06:51	0.0163	0.001	5.00	0.0000
10Jan2020	06:54	0.0165	0.001	5.00	0.0000
10Jan2020	06:57	0.0166	0.001	5.00	0.0000
10Jan2020	07:00	0.0167	0.001	5.00	0.0000
10Jan2020	07:03	0.0168	0.001	5.00	0.0000
10Jan2020	07:06	0.0169	0.001	5.00	0.0000
10Jan2020	07:09	0.0170	0.001	5.00	0.0000
10Jan2020	07:12	0.0171	0.001	5.00	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	07:15	0.0172	0.001	5.00	0.0000
10Jan2020	07:18	0.0173	0.001	5.00	0.0000
10Jan2020	07:21	0.0173	0.001	5.00	0.0000
10Jan2020	07:24	0.0173	0.001	5.00	0.0000
10Jan2020	07:27	0.0174	0.001	5.00	0.0000
10Jan2020	07:30	0.0174	0.002	5.00	0.0000
10Jan2020	07:33	0.0174	0.002	5.00	0.0000
10Jan2020	07:36	0.0174	0.002	5.00	0.0000
10Jan2020	07:39	0.0174	0.002	5.00	0.0000
10Jan2020	07:42	0.0173	0.002	5.00	0.0000
10Jan2020	07:45	0.0173	0.002	5.00	0.0000
10Jan2020	07:48	0.0173	0.002	5.00	0.0000
10Jan2020	07:51	0.0173	0.002	5.00	0.0000
10Jan2020	07:54	0.0173	0.002	5.00	0.0000
10Jan2020	07:57	0.0173	0.002	5.00	0.0000
10Jan2020	08:00	0.0173	0.002	5.00	0.0000
10Jan2020	08:03	0.0173	0.002	5.00	0.0000
10Jan2020	08:06	0.0173	0.002	5.00	0.0000
10Jan2020	08:09	0.0174	0.002	5.00	0.0000
10Jan2020	08:12	0.0174	0.003	5.01	0.0000
10Jan2020	08:15	0.0175	0.003	5.01	0.0000
10Jan2020	08:18	0.0175	0.003	5.01	0.0000
10Jan2020	08:21	0.0176	0.003	5.01	0.0000
10Jan2020	08:24	0.0176	0.003	5.01	0.0000
10Jan2020	08:27	0.0177	0.003	5.01	0.0000
10Jan2020	08:30	0.0178	0.003	5.01	0.0000
10Jan2020	08:33	0.0179	0.003	5.01	0.0000
10Jan2020	08:36	0.0181	0.003	5.01	0.0000
10Jan2020	08:39	0.0182	0.003	5.01	0.0000
10Jan2020	08:42	0.0183	0.003	5.01	0.0000
10Jan2020	08:45	0.0184	0.003	5.01	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	08:48	0.0185	0.003	5.01	0.0000
10Jan2020	08:51	0.0186	0.004	5.01	0.0000
10Jan2020	08:54	0.0187	0.004	5.01	0.0000
10Jan2020	08:57	0.0189	0.004	5.01	0.0000
10Jan2020	09:00	0.0190	0.004	5.01	0.0000
10Jan2020	09:03	0.0191	0.004	5.01	0.0000
10Jan2020	09:06	0.0193	0.004	5.01	0.0000
10Jan2020	09:09	0.0194	0.004	5.01	0.0000
10Jan2020	09:12	0.0196	0.004	5.01	0.0000
10Jan2020	09:15	0.0197	0.004	5.01	0.0000
10Jan2020	09:18	0.0199	0.004	5.01	0.0000
10Jan2020	09:21	0.0201	0.004	5.01	0.0000
10Jan2020	09:24	0.0202	0.004	5.01	0.0000
10Jan2020	09:27	0.0204	0.004	5.01	0.0000
10Jan2020	09:30	0.0205	0.005	5.01	0.0000
10Jan2020	09:33	0.0207	0.005	5.01	0.0000
10Jan2020	09:36	0.0209	0.005	5.01	0.0000
10Jan2020	09:39	0.0210	0.005	5.01	0.0000
10Jan2020	09:42	0.0212	0.005	5.01	0.0000
10Jan2020	09:45	0.0213	0.005	5.01	0.0000
10Jan2020	09:48	0.0214	0.005	5.01	0.0000
10Jan2020	09:51	0.0215	0.005	5.01	0.0000
10Jan2020	09:54	0.0217	0.005	5.01	0.0000
10Jan2020	09:57	0.0218	0.005	5.01	0.0000
10Jan2020	10:00	0.0219	0.005	5.01	0.0000
10Jan2020	10:03	0.0221	0.006	5.01	0.0000
10Jan2020	10:06	0.0222	0.006	5.01	0.0000
10Jan2020	10:09	0.0224	0.006	5.01	0.0000
10Jan2020	10:12	0.0225	0.006	5.01	0.0000
10Jan2020	10:15	0.0226	0.006	5.01	0.0000
10Jan2020	10:18	0.0228	0.006	5.01	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	10:21	0.0229	0.006	5.01	0.0000
10Jan2020	10:24	0.0230	0.006	5.01	0.0000
10Jan2020	10:27	0.0231	0.006	5.01	0.0000
10Jan2020	10:30	0.0231	0.006	5.01	0.0000
10Jan2020	10:33	0.0232	0.006	5.01	0.0000
10Jan2020	10:36	0.0232	0.007	5.01	0.0000
10Jan2020	10:39	0.0233	0.007	5.01	0.0000
10Jan2020	10:42	0.0233	0.007	5.01	0.0000
10Jan2020	10:45	0.0233	0.007	5.01	0.0000
10Jan2020	10:48	0.0234	0.007	5.01	0.0000
10Jan2020	10:51	0.0235	0.007	5.01	0.0000
10Jan2020	10:54	0.0236	0.007	5.01	0.0000
10Jan2020	10:57	0.0237	0.007	5.01	0.0000
10Jan2020	11:00	0.0238	0.007	5.01	0.0000
10Jan2020	11:03	0.0239	0.007	5.01	0.0000
10Jan2020	11:06	0.0240	0.008	5.01	0.0000
10Jan2020	11:09	0.0240	0.008	5.02	0.0000
10Jan2020	11:12	0.0241	0.008	5.02	0.0000
10Jan2020	11:15	0.0241	0.008	5.02	0.0000
10Jan2020	11:18	0.0241	0.008	5.02	0.0000
10Jan2020	11:21	0.0241	0.008	5.02	0.0000
10Jan2020	11:24	0.0241	0.008	5.02	0.0000
10Jan2020	11:27	0.0242	0.008	5.02	0.0000
10Jan2020	11:30	0.0242	0.008	5.02	0.0000
10Jan2020	11:33	0.0243	0.008	5.02	0.0000
10Jan2020	11:36	0.0243	0.009	5.02	0.0000
10Jan2020	11:39	0.0244	0.009	5.02	0.0000
10Jan2020	11:42	0.0245	0.009	5.02	0.0000
10Jan2020	11:45	0.0245	0.009	5.02	0.0000
10Jan2020	11:48	0.0246	0.009	5.02	0.0000
10Jan2020	11:51	0.0247	0.009	5.02	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	11:54	0.0248	0.009	5.02	0.0000
10Jan2020	11:57	0.0249	0.009	5.02	0.0000
10Jan2020	12:00	0.0250	0.009	5.02	0.0000
10Jan2020	12:03	0.0251	0.009	5.02	0.0000
10Jan2020	12:06	0.0251	0.010	5.02	0.0000
10Jan2020	12:09	0.0252	0.010	5.02	0.0000
10Jan2020	12:12	0.0252	0.010	5.02	0.0000
10Jan2020	12:15	0.0253	0.010	5.02	0.0000
10Jan2020	12:18	0.0254	0.010	5.02	0.0000
10Jan2020	12:21	0.0256	0.010	5.02	0.0000
10Jan2020	12:24	0.0259	0.010	5.02	0.0000
10Jan2020	12:27	0.0263	0.010	5.02	0.0000
10Jan2020	12:30	0.0267	0.010	5.02	0.0000
10Jan2020	12:33	0.0271	0.011	5.02	0.0000
10Jan2020	12:36	0.0275	0.011	5.02	0.0000
10Jan2020	12:39	0.0280	0.011	5.02	0.0000
10Jan2020	12:42	0.0285	0.011	5.02	0.0000
10Jan2020	12:45	0.0290	0.011	5.02	0.0000
10Jan2020	12:48	0.0295	0.011	5.02	0.0000
10Jan2020	12:51	0.0300	0.011	5.02	0.0000
10Jan2020	12:54	0.0305	0.011	5.02	0.0000
10Jan2020	12:57	0.0310	0.011	5.02	0.0000
10Jan2020	13:00	0.0315	0.012	5.02	0.0000
10Jan2020	13:03	0.0320	0.012	5.02	0.0000
10Jan2020	13:06	0.0326	0.012	5.02	0.0000
10Jan2020	13:09	0.0331	0.012	5.02	0.0000
10Jan2020	13:12	0.0336	0.012	5.02	0.0000
10Jan2020	13:15	0.0341	0.012	5.02	0.0000
10Jan2020	13:18	0.0345	0.012	5.02	0.0000
10Jan2020	13:21	0.0349	0.013	5.02	0.0000
10Jan2020	13:24	0.0352	0.013	5.03	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	13:27	0.0355	0.013	5.03	0.0000
10Jan2020	13:30	0.0358	0.013	5.03	0.0000
10Jan2020	13:33	0.0360	0.013	5.03	0.0000
10Jan2020	13:36	0.0363	0.013	5.03	0.0000
10Jan2020	13:39	0.0365	0.013	5.03	0.0000
10Jan2020	13:42	0.0367	0.014	5.03	0.0000
10Jan2020	13:45	0.0369	0.014	5.03	0.0000
10Jan2020	13:48	0.0371	0.014	5.03	0.0000
10Jan2020	13:51	0.0373	0.014	5.03	0.0000
10Jan2020	13:54	0.0374	0.014	5.03	0.0000
10Jan2020	13:57	0.0376	0.014	5.03	0.0000
10Jan2020	14:00	0.0378	0.015	5.03	0.0000
10Jan2020	14:03	0.0380	0.015	5.03	0.0000
10Jan2020	14:06	0.0382	0.015	5.03	0.0000
10Jan2020	14:09	0.0384	0.015	5.03	0.0000
10Jan2020	14:12	0.0388	0.015	5.03	0.0000
10Jan2020	14:15	0.0392	0.015	5.03	0.0000
10Jan2020	14:18	0.0399	0.015	5.03	0.0000
10Jan2020	14:21	0.0407	0.016	5.03	0.0000
10Jan2020	14:24	0.0418	0.016	5.03	0.0000
10Jan2020	14:27	0.0430	0.016	5.03	0.0000
10Jan2020	14:30	0.0445	0.016	5.03	0.0000
10Jan2020	14:33	0.0462	0.016	5.03	0.0000
10Jan2020	14:36	0.0483	0.017	5.03	0.0000
10Jan2020	14:39	0.0513	0.017	5.03	0.0000
10Jan2020	14:42	0.0560	0.017	5.03	0.0000
10Jan2020	14:45	0.0634	0.017	5.03	0.0000
10Jan2020	14:48	0.0745	0.018	5.03	0.0000
10Jan2020	14:51	0.0900	0.018	5.04	0.0000
10Jan2020	14:54	0.1101	0.018	5.04	0.0000
10Jan2020	14:57	0.1351	0.019	5.04	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	15:00	0.1650	0.019	5.04	0.0000
10Jan2020	15:03	0.1996	0.020	5.04	0.0000
10Jan2020	15:06	0.2385	0.021	5.04	0.0000
10Jan2020	15:09	0.2819	0.022	5.04	0.0000
10Jan2020	15:12	0.3300	0.023	5.05	0.0000
10Jan2020	15:15	0.3831	0.025	5.05	0.0000
10Jan2020	15:18	0.4418	0.027	5.05	0.0000
10Jan2020	15:21	0.5063	0.029	5.06	0.0000
10Jan2020	15:24	0.5771	0.031	5.06	0.0000
10Jan2020	15:27	0.6542	0.033	5.07	0.0000
10Jan2020	15:30	0.7381	0.036	5.07	0.0000
10Jan2020	15:33	0.8313	0.039	5.08	0.0000
10Jan2020	15:36	0.9409	0.043	5.09	0.0000
10Jan2020	15:39	1.0805	0.047	5.09	0.0000
10Jan2020	15:42	1.2711	0.052	5.10	0.0000
10Jan2020	15:45	1.5412	0.058	5.11	0.0000
10Jan2020	15:48	1.9399	0.065	5.13	0.0000
10Jan2020	15:51	2.5519	0.074	5.15	0.0000
10Jan2020	15:54	3.4727	0.087	5.17	0.0000
10Jan2020	15:57	4.7619	0.104	5.21	0.0000
10Jan2020	16:00	6.3932	0.127	5.25	0.0000
10Jan2020	16:03	8.1882	0.157	5.31	0.0000
10Jan2020	16:06	9.8475	0.194	5.38	0.0000
10Jan2020	16:09	11.0883	0.238	5.47	0.0000
10Jan2020	16:12	11.7521	0.285	5.56	0.0000
10Jan2020	16:15	11.8419	0.333	5.66	0.0000
10Jan2020	16:18	11.4779	0.382	5.75	0.0000
10Jan2020	16:21	10.8064	0.428	5.85	0.0000
10Jan2020	16:24	9.9691	0.471	5.93	0.0000
10Jan2020	16:27	9.1061	0.510	6.01	0.0000
10Jan2020	16:30	8.3194	0.546	6.08	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	16:33	7.6513	0.579	6.14	0.0000
10Jan2020	16:36	7.0873	0.610	6.20	0.0000
10Jan2020	16:39	6.5866	0.638	6.26	0.0000
10Jan2020	16:42	6.1289	0.664	6.31	0.0000
10Jan2020	16:45	5.7169	0.689	6.36	0.0000
10Jan2020	16:48	5.3553	0.711	6.41	0.0000
10Jan2020	16:51	5.0424	0.733	6.45	0.0000
10Jan2020	16:54	4.7729	0.753	6.49	0.0000
10Jan2020	16:57	4.5421	0.772	6.53	0.0000
10Jan2020	17:00	4.3445	0.791	6.56	0.0000
10Jan2020	17:03	4.1730	0.808	6.60	0.0000
10Jan2020	17:06	4.0212	0.825	6.63	0.0000
10Jan2020	17:09	3.8854	0.842	6.66	0.0000
10Jan2020	17:12	3.7648	0.857	6.69	0.0000
10Jan2020	17:15	3.6592	0.873	6.72	0.0000
10Jan2020	17:18	3.5667	0.888	6.75	0.0000
10Jan2020	17:21	3.4851	0.902	6.78	0.0000
10Jan2020	17:24	3.4126	0.917	6.81	0.0000
10Jan2020	17:27	3.3475	0.930	6.84	0.0000
10Jan2020	17:30	3.2888	0.944	6.87	0.0000
10Jan2020	17:33	3.2360	0.958	6.89	0.0000
10Jan2020	17:36	3.1892	0.971	6.92	0.0000
10Jan2020	17:39	3.1484	0.984	6.94	0.0000
10Jan2020	17:42	3.1128	0.997	6.97	0.0000
10Jan2020	17:45	3.0807	1.010	7.00	0.0000
10Jan2020	17:48	3.0508	1.022	7.02	0.0000
10Jan2020	17:51	3.0218	1.035	7.05	0.0000
10Jan2020	17:54	2.9927	1.047	7.07	0.0000
10Jan2020	17:57	2.9631	1.060	7.09	0.0000
10Jan2020	18:00	2.9326	1.072	7.12	0.0000
10Jan2020	18:03	2.9015	1.084	7.14	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	18:06	2.8703	1.096	7.17	0.0000
10Jan2020	18:09	2.8396	1.108	7.19	0.0000
10Jan2020	18:12	2.8102	1.119	7.21	0.0000
10Jan2020	18:15	2.7825	1.131	7.23	0.0000
10Jan2020	18:18	2.7574	1.142	7.26	0.0000
10Jan2020	18:21	2.7349	1.154	7.28	0.0000
10Jan2020	18:24	2.7140	1.165	7.30	0.0000
10Jan2020	18:27	2.6931	1.176	7.32	0.0000
10Jan2020	18:30	2.6711	1.187	7.35	0.0000
10Jan2020	18:33	2.6485	1.198	7.37	0.0000
10Jan2020	18:36	2.6258	1.209	7.39	0.0000
10Jan2020	18:39	2.6034	1.220	7.41	0.0000
10Jan2020	18:42	2.5819	1.231	7.43	0.0000
10Jan2020	18:45	2.5613	1.241	7.45	0.0000
10Jan2020	18:48	2.5416	1.252	7.47	0.0000
10Jan2020	18:51	2.5222	1.262	7.49	0.0000
10Jan2020	18:54	2.5034	1.273	7.51	0.0000
10Jan2020	18:57	2.4849	1.283	7.52	0.0000
10Jan2020	19:00	2.4658	1.293	7.53	0.0000
10Jan2020	19:03	2.4461	1.303	7.54	0.0000
10Jan2020	19:06	2.4260	1.313	7.55	0.0000
10Jan2020	19:09	2.4061	1.323	7.56	0.0000
10Jan2020	19:12	2.3861	1.333	7.57	0.0000
10Jan2020	19:15	2.3654	1.343	7.58	0.0000
10Jan2020	19:18	2.3444	1.353	7.59	0.0000
10Jan2020	19:21	2.3237	1.362	7.60	0.0000
10Jan2020	19:24	2.3027	1.372	7.61	0.0000
10Jan2020	19:27	2.2819	1.381	7.62	0.0000
10Jan2020	19:30	2.2614	1.391	7.63	0.0000
10Jan2020	19:33	2.2420	1.400	7.63	0.0000
10Jan2020	19:36	2.2225	1.409	7.64	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	19:39	2.2014	1.419	7.65	0.0000
10Jan2020	19:42	2.1782	1.428	7.66	0.0000
10Jan2020	19:45	2.1533	1.437	7.67	0.0000
10Jan2020	19:48	2.1276	1.445	7.68	0.0000
10Jan2020	19:51	2.1026	1.454	7.69	0.0000
10Jan2020	19:54	2.0789	1.463	7.70	0.0000
10Jan2020	19:57	2.0565	1.471	7.71	0.0000
10Jan2020	20:00	2.0351	1.480	7.71	0.0000
10Jan2020	20:03	2.0129	1.488	7.72	0.0000
10Jan2020	20:06	1.9900	1.496	7.73	0.0000
10Jan2020	20:09	1.9669	1.505	7.74	0.0000
10Jan2020	20:12	1.9440	1.513	7.75	0.0000
10Jan2020	20:15	1.9233	1.521	7.76	0.0000
10Jan2020	20:18	1.9050	1.529	7.76	0.0000
10Jan2020	20:21	1.8881	1.536	7.77	0.0000
10Jan2020	20:24	1.8727	1.544	7.78	0.0000
10Jan2020	20:27	1.8590	1.552	7.79	0.0000
10Jan2020	20:30	1.8472	1.560	7.79	0.0000
10Jan2020	20:33	1.8374	1.567	7.80	0.0000
10Jan2020	20:36	1.8288	1.575	7.81	0.0000
10Jan2020	20:39	1.8216	1.582	7.82	0.0000
10Jan2020	20:42	1.8165	1.590	7.82	0.0000
10Jan2020	20:45	1.8132	1.597	7.83	0.0000
10Jan2020	20:48	1.8112	1.605	7.84	0.0000
10Jan2020	20:51	1.8102	1.612	7.85	0.0000
10Jan2020	20:54	1.8092	1.620	7.85	0.0000
10Jan2020	20:57	1.8073	1.627	7.86	0.0000
10Jan2020	21:00	1.8044	1.635	7.87	0.0000
10Jan2020	21:03	1.7995	1.642	7.88	0.0000
10Jan2020	21:06	1.7936	1.650	7.88	0.0000
10Jan2020	21:09	1.7887	1.657	7.89	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	21:12	1.7848	1.664	7.90	0.0000
10Jan2020	21:15	1.7819	1.672	7.91	0.0000
10Jan2020	21:18	1.7796	1.679	7.91	0.0000
10Jan2020	21:21	1.7765	1.686	7.92	0.0000
10Jan2020	21:24	1.7722	1.694	7.93	0.0000
10Jan2020	21:27	1.7681	1.701	7.94	0.0000
10Jan2020	21:30	1.7639	1.708	7.94	0.0000
10Jan2020	21:33	1.7606	1.716	7.95	0.0000
10Jan2020	21:36	1.7578	1.723	7.96	0.0000
10Jan2020	21:39	1.7546	1.730	7.96	0.0000
10Jan2020	21:42	1.7510	1.737	7.97	0.0000
10Jan2020	21:45	1.7465	1.745	7.98	0.0000
10Jan2020	21:48	1.7422	1.752	7.99	0.0000
10Jan2020	21:51	1.7392	1.759	7.99	0.0000
10Jan2020	21:54	1.7368	1.766	8.00	0.0000
10Jan2020	21:57	1.7337	1.773	8.01	0.0000
10Jan2020	22:00	1.7303	1.781	8.01	0.0000
10Jan2020	22:03	1.7256	1.788	8.02	0.0000
10Jan2020	22:06	1.7205	1.795	8.03	0.0000
10Jan2020	22:09	1.7164	1.802	8.04	0.0000
10Jan2020	22:12	1.7127	1.809	8.04	0.0000
10Jan2020	22:15	1.7098	1.816	8.05	0.0000
10Jan2020	22:18	1.7074	1.823	8.06	0.0000
10Jan2020	22:21	1.7041	1.830	8.06	0.0000
10Jan2020	22:24	1.6996	1.837	8.07	0.0000
10Jan2020	22:27	1.6944	1.844	8.08	0.0000
10Jan2020	22:30	1.6883	1.851	8.09	0.0000
10Jan2020	22:33	1.6823	1.858	8.09	0.0000
10Jan2020	22:36	1.6767	1.865	8.10	0.0000
10Jan2020	22:39	1.6716	1.872	8.11	0.0000
10Jan2020	22:42	1.6681	1.879	8.11	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	22:45	1.6659	1.886	8.12	0.0000
10Jan2020	22:48	1.6646	1.893	8.13	0.0000
10Jan2020	22:51	1.6639	1.900	8.13	0.0000
10Jan2020	22:54	1.6630	1.906	8.14	0.0000
10Jan2020	22:57	1.6609	1.913	8.15	0.0000
10Jan2020	23:00	1.6576	1.920	8.15	0.0000
10Jan2020	23:03	1.6521	1.927	8.16	0.0000
10Jan2020	23:06	1.6454	1.934	8.17	0.0000
10Jan2020	23:09	1.6396	1.941	8.17	0.0000
10Jan2020	23:12	1.6348	1.947	8.18	0.0000
10Jan2020	23:15	1.6310	1.954	8.19	0.0000
10Jan2020	23:18	1.6279	1.961	8.19	0.0000
10Jan2020	23:21	1.6238	1.968	8.20	0.0000
10Jan2020	23:24	1.6186	1.974	8.21	0.0000
10Jan2020	23:27	1.6135	1.981	8.21	0.0000
10Jan2020	23:30	1.6082	1.988	8.22	0.0000
10Jan2020	23:33	1.6039	1.994	8.23	0.0000
10Jan2020	23:36	1.6002	2.001	8.23	0.0000
10Jan2020	23:39	1.5960	2.007	8.24	0.0000
10Jan2020	23:42	1.5913	2.014	8.25	0.0000
10Jan2020	23:45	1.5858	2.021	8.25	0.0000
10Jan2020	23:48	1.5806	2.027	8.26	0.0000
10Jan2020	23:51	1.5767	2.034	8.27	0.0000
10Jan2020	23:54	1.5733	2.040	8.27	0.0000
10Jan2020	23:57	1.5692	2.047	8.28	0.0000
11Jan2020	00:00	1.5649	2.053	8.29	0.0000
11Jan2020	00:03	1.5593	2.060	8.29	0.0000
11Jan2020	00:06	1.5532	2.066	8.30	0.0000
11Jan2020	00:09	1.5481	2.072	8.31	0.0000
11Jan2020	00:12	1.5435	2.079	8.31	0.0000
11Jan2020	00:15	1.5397	2.085	8.32	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	00:18	1.5365	2.092	8.33	0.0000
11Jan2020	00:21	1.5323	2.098	8.33	0.0000
11Jan2020	00:24	1.5269	2.104	8.34	0.0000
11Jan2020	00:27	1.5208	2.111	8.34	0.0000
11Jan2020	00:30	1.5137	2.117	8.35	0.0000
11Jan2020	00:33	1.5067	2.123	8.36	0.0000
11Jan2020	00:36	1.5002	2.129	8.36	0.0000
11Jan2020	00:39	1.4942	2.135	8.37	0.0000
11Jan2020	00:42	1.4899	2.142	8.38	0.0000
11Jan2020	00:45	1.4869	2.148	8.38	0.0000
11Jan2020	00:48	1.4848	2.154	8.39	0.0000
11Jan2020	00:51	1.4835	2.160	8.39	0.0000
11Jan2020	00:54	1.4818	2.166	8.40	0.0000
11Jan2020	00:57	1.4790	2.172	8.41	0.0000
11Jan2020	01:00	1.4749	2.178	8.41	0.0000
11Jan2020	01:03	1.4685	2.184	8.42	0.0000
11Jan2020	01:06	1.4609	2.190	8.42	0.0000
11Jan2020	01:09	1.4543	2.197	8.43	0.0000
11Jan2020	01:12	1.4487	2.203	8.44	0.0000
11Jan2020	01:15	1.4441	2.208	8.44	0.0000
11Jan2020	01:18	1.4402	2.214	8.45	0.0000
11Jan2020	01:21	1.4354	2.220	8.45	0.0000
11Jan2020	01:24	1.4294	2.226	8.46	0.0000
11Jan2020	01:27	1.4227	2.232	8.47	0.0000
11Jan2020	01:30	1.4151	2.238	8.47	0.0000
11Jan2020	01:33	1.4076	2.244	8.48	0.0000
11Jan2020	01:36	1.4006	2.250	8.48	0.0000
11Jan2020	01:39	1.3942	2.255	8.49	0.0000
11Jan2020	01:42	1.3895	2.261	8.49	0.0000
11Jan2020	01:45	1.3861	2.267	8.50	0.0000
11Jan2020	01:48	1.3837	2.273	8.51	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	01:51	1.3821	2.278	8.51	0.0000
11Jan2020	01:54	1.3801	2.284	8.52	0.0000
11Jan2020	01:57	1.3769	2.290	8.52	0.0000
11Jan2020	02:00	1.3726	2.295	8.53	0.0000
11Jan2020	02:03	1.3658	2.301	8.53	0.0000
11Jan2020	02:06	1.3578	2.307	8.54	0.0000
11Jan2020	02:09	1.3509	2.312	8.55	0.0000
11Jan2020	02:12	1.3449	2.318	8.55	0.0000
11Jan2020	02:15	1.3400	2.323	8.56	0.0000
11Jan2020	02:18	1.3359	2.329	8.56	0.0000
11Jan2020	02:21	1.3307	2.335	8.57	0.0000
11Jan2020	02:24	1.3244	2.340	8.57	0.0000
11Jan2020	02:27	1.3182	2.345	8.58	0.0000
11Jan2020	02:30	1.3118	2.351	8.58	0.0000
11Jan2020	02:33	1.3065	2.356	8.59	0.0000
11Jan2020	02:36	1.3017	2.362	8.59	0.0000
11Jan2020	02:39	1.2965	2.367	8.60	0.0000
11Jan2020	02:42	1.2908	2.372	8.61	0.0000
11Jan2020	02:45	1.2842	2.378	8.61	0.0000
11Jan2020	02:48	1.2779	2.383	8.62	0.0000
11Jan2020	02:51	1.2730	2.388	8.62	0.0000
11Jan2020	02:54	1.2687	2.394	8.63	0.0000
11Jan2020	02:57	1.2637	2.399	8.63	0.0000
11Jan2020	03:00	1.2584	2.404	8.64	0.0000
11Jan2020	03:03	1.2517	2.409	8.64	0.0000
11Jan2020	03:06	1.2446	2.414	8.65	0.0000
11Jan2020	03:09	1.2386	2.419	8.65	0.0000
11Jan2020	03:12	1.2330	2.425	8.66	0.0000
11Jan2020	03:15	1.2283	2.430	8.66	0.0000
11Jan2020	03:18	1.2242	2.435	8.67	0.0000
11Jan2020	03:21	1.2191	2.440	8.67	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	03:24	1.2127	2.445	8.68	0.0000
11Jan2020	03:27	1.2065	2.450	8.68	0.0000
11Jan2020	03:30	1.2000	2.455	8.69	0.0000
11Jan2020	03:33	1.1945	2.460	8.69	0.0000
11Jan2020	03:36	1.1897	2.465	8.70	0.0000
11Jan2020	03:39	1.1843	2.470	8.70	0.0000
11Jan2020	03:42	1.1784	2.474	8.71	0.0000
11Jan2020	03:45	1.1715	2.479	8.71	0.0000
11Jan2020	03:48	1.1650	2.484	8.72	0.0000
11Jan2020	03:51	1.1599	2.489	8.72	0.0000
11Jan2020	03:54	1.1554	2.494	8.73	0.0000
11Jan2020	03:57	1.1502	2.498	8.73	0.0000
11Jan2020	04:00	1.1446	2.503	8.74	0.0000
11Jan2020	04:03	1.1377	2.508	8.74	0.0000
11Jan2020	04:06	1.1304	2.513	8.75	0.0000
11Jan2020	04:09	1.1241	2.517	8.75	0.0000
11Jan2020	04:12	1.1183	2.522	8.75	0.0000
11Jan2020	04:15	1.1134	2.526	8.76	0.0000
11Jan2020	04:18	1.1091	2.531	8.76	0.0000
11Jan2020	04:21	1.1038	2.536	8.77	0.0000
11Jan2020	04:24	1.0972	2.540	8.77	0.0000
11Jan2020	04:27	1.0907	2.545	8.78	0.0000
11Jan2020	04:30	1.0840	2.549	8.78	0.0000
11Jan2020	04:33	1.0783	2.554	8.79	0.0000
11Jan2020	04:36	1.0732	2.558	8.79	0.0000
11Jan2020	04:39	1.0676	2.563	8.80	0.0000
11Jan2020	04:42	1.0615	2.567	8.80	0.0000
11Jan2020	04:45	1.0545	2.571	8.80	0.0000
11Jan2020	04:48	1.0477	2.576	8.81	0.0000
11Jan2020	04:51	1.0424	2.580	8.81	0.0000
11Jan2020	04:54	1.0377	2.584	8.82	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	04:57	1.0323	2.589	8.82	0.0000
11Jan2020	05:00	1.0265	2.593	8.83	0.0000
11Jan2020	05:03	1.0194	2.597	8.83	0.0000
11Jan2020	05:06	1.0118	2.601	8.83	0.0000
11Jan2020	05:09	1.0054	2.605	8.84	0.0000
11Jan2020	05:12	0.9994	2.610	8.84	0.0000
11Jan2020	05:15	0.9943	2.614	8.85	0.0000
11Jan2020	05:18	0.9898	2.618	8.85	0.0000
11Jan2020	05:21	0.9843	2.622	8.85	0.0000
11Jan2020	05:24	0.9775	2.626	8.86	0.0000
11Jan2020	05:27	0.9708	2.630	8.86	0.0000
11Jan2020	05:30	0.9639	2.634	8.87	0.0000
11Jan2020	05:33	0.9581	2.638	8.87	0.0000
11Jan2020	05:36	0.9528	2.642	8.87	0.0000
11Jan2020	05:39	0.9470	2.646	8.88	0.0000
11Jan2020	05:42	0.9407	2.650	8.88	0.0000
11Jan2020	05:45	0.9335	2.654	8.89	0.0000
11Jan2020	05:48	0.9266	2.657	8.89	0.0000
11Jan2020	05:51	0.9211	2.661	8.89	0.0000
11Jan2020	05:54	0.9162	2.665	8.90	0.0000
11Jan2020	05:57	0.9106	2.669	8.90	0.0000
11Jan2020	06:00	0.9047	2.673	8.91	0.0000
11Jan2020	06:03	0.8923	2.676	8.91	0.0000
11Jan2020	06:06	0.8686	2.680	8.91	0.0000
11Jan2020	06:09	0.8291	2.683	8.92	0.0000
11Jan2020	06:12	0.7672	2.687	8.92	0.0000
11Jan2020	06:15	0.6850	2.690	8.92	0.0000
11Jan2020	06:18	0.5919	2.692	8.93	0.0000
11Jan2020	06:21	0.4968	2.695	8.93	0.0000
11Jan2020	06:24	0.4063	2.696	8.93	0.0000
11Jan2020	06:27	0.3255	2.698	8.93	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	06:30	0.2556	2.699	8.93	0.0000
11Jan2020	06:33	0.2005	2.700	8.93	0.0000
11Jan2020	06:36	0.1586	2.701	8.93	0.0000
11Jan2020	06:39	0.1256	2.701	8.93	0.0000
11Jan2020	06:42	0.0996	2.702	8.93	0.0000
11Jan2020	06:45	0.0785	2.702	8.93	0.0000
11Jan2020	06:48	0.0617	2.703	8.94	0.0000
11Jan2020	06:51	0.0487	2.703	8.94	0.0000
11Jan2020	06:54	0.0383	2.703	8.94	0.0000
11Jan2020	06:57	0.0301	2.703	8.94	0.0000
11Jan2020	07:00	0.0236	2.703	8.94	0.0000
11Jan2020	07:03	0.0185	2.703	8.94	0.0000
11Jan2020	07:06	0.0144	2.703	8.94	0.0000
11Jan2020	07:09	0.0112	2.703	8.94	0.0000
11Jan2020	07:12	0.0086	2.703	8.94	0.0000
11Jan2020	07:15	0.0066	2.703	8.94	0.0000
11Jan2020	07:18	0.0050	2.704	8.94	0.0000
11Jan2020	07:21	0.0038	2.704	8.94	0.0000
11Jan2020	07:24	0.0028	2.704	8.94	0.0000
11Jan2020	07:27	0.0019	2.704	8.94	0.0000
11Jan2020	07:30	0.0012	2.704	8.94	0.0000
11Jan2020	07:33	0.0007	2.704	8.94	0.0000
11Jan2020	07:36	0.0004	2.704	8.94	0.0000
11Jan2020	07:39	0.0001	2.704	8.94	0.0000
11Jan2020	07:42	0.0000	2.704	8.94	0.0000
11Jan2020	07:45	0.0000	2.704	8.94	0.0000
11Jan2020	07:48	0.0000	2.704	8.94	0.0000
11Jan2020	07:51	0.0000	2.704	8.94	0.0000
11Jan2020	07:54	0.0000	2.704	8.94	0.0000
11Jan2020	07:57	0.0000	2.704	8.94	0.0000
11Jan2020	08:00	0.0000	2.704	8.94	0.0000

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Attachment 3

Reference 2

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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

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

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:

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

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 bankfull 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:

$$T_c = T_{t1} + T_{t2} + \ldots T_{tm} \qquad \text{[eq. 3-2]}$$

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

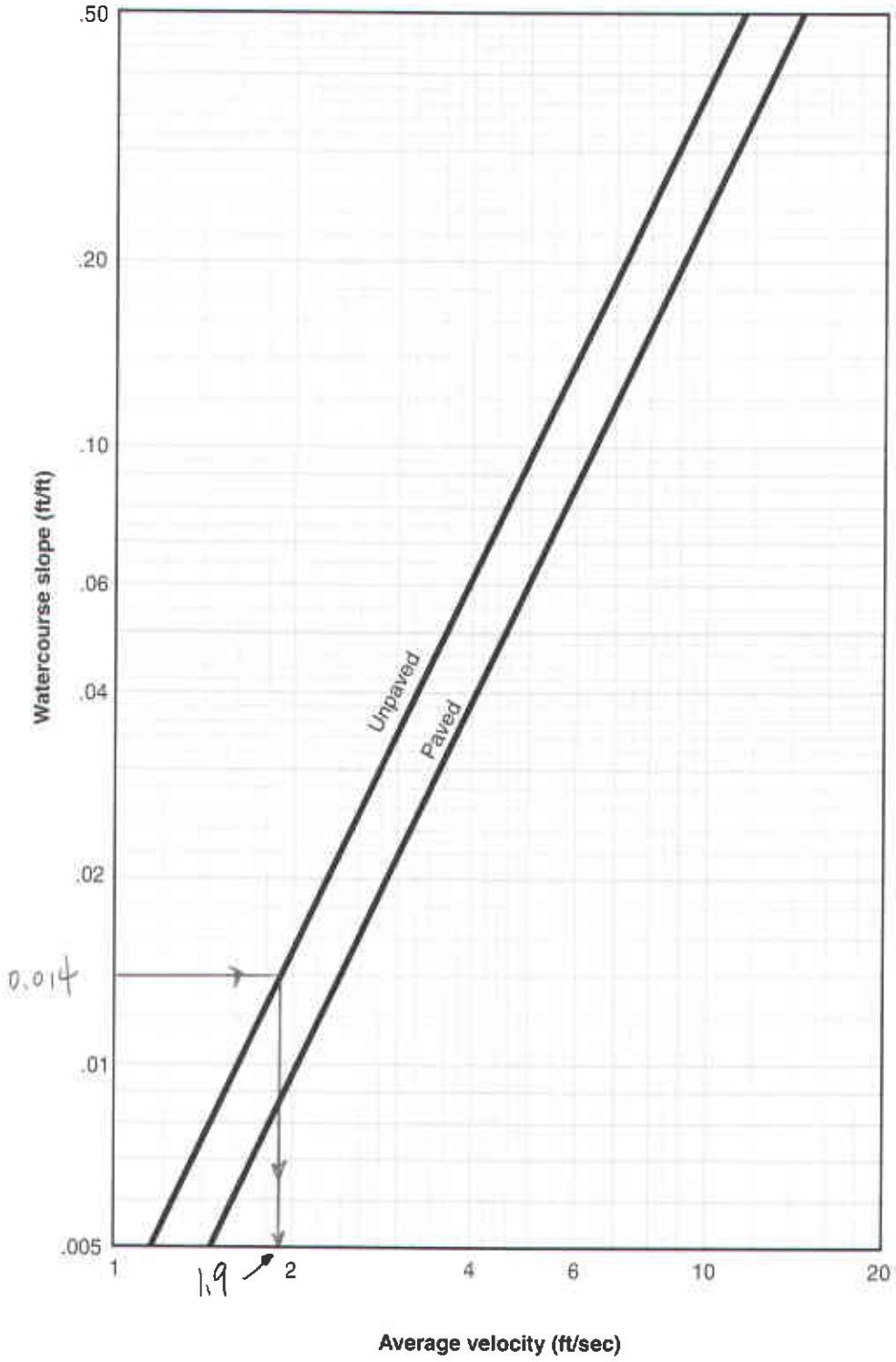
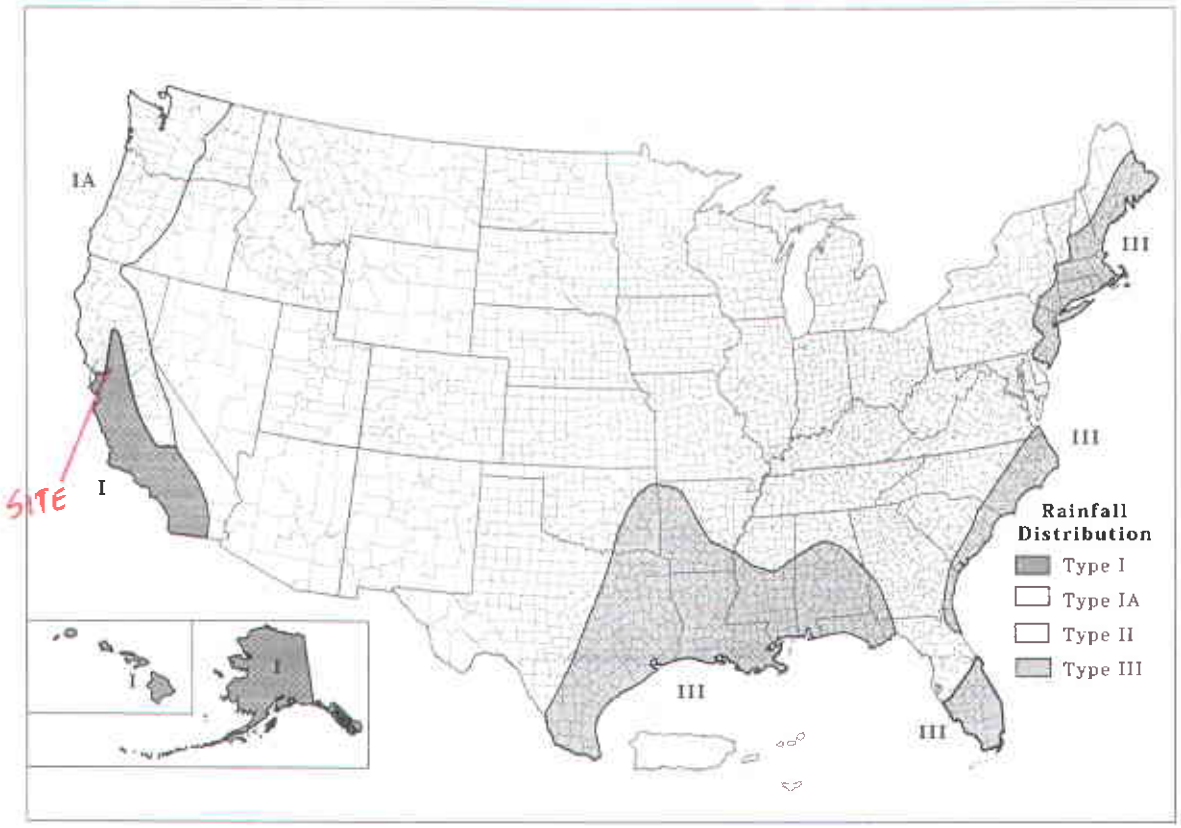


Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



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.

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52, 5406, 1003

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

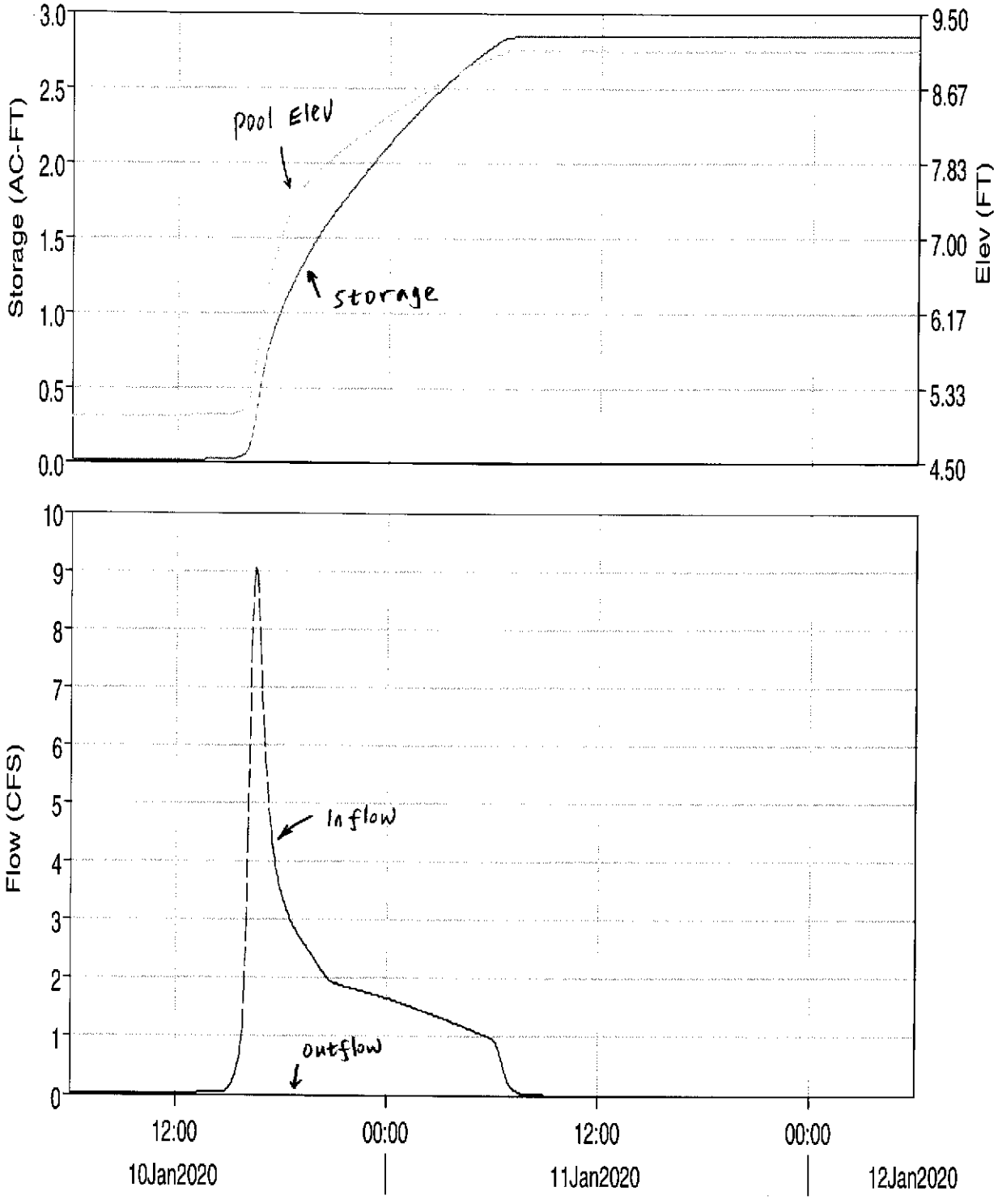
Laugenour

Percent of map unit: 3 percent

Data Source Information

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

Reservoir "Wetland" Results for Run "Run 1"



Run:Run 1 Element:WETLAND Result:Storage

Run:Run 1 Element:WETLAND Result:Pool Elevation

Run:Run 1 Element:WETLAND Result:Outflow

Run:Run 1 Element:WETLAND Result:Combined Inflow

Superseded by Rev 2

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
11Jan2020	09:12	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	09:18	0.0	2.8	9.1	0.0
11Jan2020	09:24	0.0	2.8	9.1	0.0
11Jan2020	09:30	0.0	2.8	9.1	0.0
11Jan2020	09:36	0.0	2.8	9.1	0.0
11Jan2020	09:42	0.0	2.8	9.1	0.0
11Jan2020	09:48	0.0	2.8	9.1	0.0
11Jan2020	09:54	0.0	2.8	9.1	0.0
11Jan2020	10:00	0.0	2.8	9.1	0.0
11Jan2020	10:06	0.0	2.8	9.1	0.0
11Jan2020	10:12	0.0	2.8	9.1	0.0
11Jan2020	10:18	0.0	2.8	9.1	0.0
11Jan2020	10:24	0.0	2.8	9.1	0.0
11Jan2020	10:30	0.0	2.8	9.1	0.0
11Jan2020	10:36	0.0	2.8	9.1	0.0
11Jan2020	10:42	0.0	2.8	9.1	0.0
11Jan2020	10:48	0.0	2.8	9.1	0.0
11Jan2020	10:54	0.0	2.8	9.1	0.0
11Jan2020	11:00	0.0	2.8	9.1	0.0
11Jan2020	11:06	0.0	2.8	9.1	0.0
11Jan2020	11:12	0.0	2.8	9.1	0.0
11Jan2020	11:18	0.0	2.8	9.1	0.0
11Jan2020	11:24	0.0	2.8	9.1	0.0
11Jan2020	11:30	0.0	2.8	9.1	0.0
11Jan2020	11:36	0.0	2.8	9.1	0.0
11Jan2020	11:42	0.0	2.8	9.1	0.0
11Jan2020	11:48	0.0	2.8	9.1	0.0
11Jan2020	11:54	0.0	2.8	9.1	0.0
11Jan2020	12:00	0.0	2.8	9.1	0.0
11Jan2020	12:06	0.0	2.8	9.1	0.0
11Jan2020	12:12	0.0	2.8	9.1	0.0
11Jan2020	12:18	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	12:24	0.0	2.8	9.1	0.0
11Jan2020	12:30	0.0	2.8	9.1	0.0
11Jan2020	12:36	0.0	2.8	9.1	0.0
11Jan2020	12:42	0.0	2.8	9.1	0.0
11Jan2020	12:48	0.0	2.8	9.1	0.0
11Jan2020	12:54	0.0	2.8	9.1	0.0
11Jan2020	13:00	0.0	2.8	9.1	0.0
11Jan2020	13:06	0.0	2.8	9.1	0.0
11Jan2020	13:12	0.0	2.8	9.1	0.0
11Jan2020	13:18	0.0	2.8	9.1	0.0
11Jan2020	13:24	0.0	2.8	9.1	0.0
11Jan2020	13:30	0.0	2.8	9.1	0.0
11Jan2020	13:36	0.0	2.8	9.1	0.0
11Jan2020	13:42	0.0	2.8	9.1	0.0
11Jan2020	13:48	0.0	2.8	9.1	0.0
11Jan2020	13:54	0.0	2.8	9.1	0.0
11Jan2020	14:00	0.0	2.8	9.1	0.0
11Jan2020	14:06	0.0	2.8	9.1	0.0
11Jan2020	14:12	0.0	2.8	9.1	0.0
11Jan2020	14:18	0.0	2.8	9.1	0.0
11Jan2020	14:24	0.0	2.8	9.1	0.0
11Jan2020	14:30	0.0	2.8	9.1	0.0
11Jan2020	14:36	0.0	2.8	9.1	0.0
11Jan2020	14:42	0.0	2.8	9.1	0.0
11Jan2020	14:48	0.0	2.8	9.1	0.0
11Jan2020	14:54	0.0	2.8	9.1	0.0
11Jan2020	15:00	0.0	2.8	9.1	0.0
11Jan2020	15:06	0.0	2.8	9.1	0.0
11Jan2020	15:12	0.0	2.8	9.1	0.0
11Jan2020	15:18	0.0	2.8	9.1	0.0
11Jan2020	15:24	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	15:30	0.0	2.8	9.1	0.0
11Jan2020	15:36	0.0	2.8	9.1	0.0
11Jan2020	15:42	0.0	2.8	9.1	0.0
11Jan2020	15:48	0.0	2.8	9.1	0.0
11Jan2020	15:54	0.0	2.8	9.1	0.0
11Jan2020	16:00	0.0	2.8	9.1	0.0
11Jan2020	16:06	0.0	2.8	9.1	0.0
11Jan2020	16:12	0.0	2.8	9.1	0.0
11Jan2020	16:18	0.0	2.8	9.1	0.0
11Jan2020	16:24	0.0	2.8	9.1	0.0
11Jan2020	16:30	0.0	2.8	9.1	0.0
11Jan2020	16:36	0.0	2.8	9.1	0.0
11Jan2020	16:42	0.0	2.8	9.1	0.0
11Jan2020	16:48	0.0	2.8	9.1	0.0
11Jan2020	16:54	0.0	2.8	9.1	0.0
11Jan2020	17:00	0.0	2.8	9.1	0.0
11Jan2020	17:06	0.0	2.8	9.1	0.0
11Jan2020	17:12	0.0	2.8	9.1	0.0
11Jan2020	17:18	0.0	2.8	9.1	0.0
11Jan2020	17:24	0.0	2.8	9.1	0.0
11Jan2020	17:30	0.0	2.8	9.1	0.0
11Jan2020	17:36	0.0	2.8	9.1	0.0
11Jan2020	17:42	0.0	2.8	9.1	0.0
11Jan2020	17:48	0.0	2.8	9.1	0.0
11Jan2020	17:54	0.0	2.8	9.1	0.0
11Jan2020	18:00	0.0	2.8	9.1	0.0
11Jan2020	18:06	0.0	2.8	9.1	0.0
11Jan2020	18:12	0.0	2.8	9.1	0.0
11Jan2020	18:18	0.0	2.8	9.1	0.0
11Jan2020	18:24	0.0	2.8	9.1	0.0
11Jan2020	18:30	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	18:36	0.0	2.8	9.1	0.0
11Jan2020	18:42	0.0	2.8	9.1	0.0
11Jan2020	18:48	0.0	2.8	9.1	0.0
11Jan2020	18:54	0.0	2.8	9.1	0.0
11Jan2020	19:00	0.0	2.8	9.1	0.0
11Jan2020	19:06	0.0	2.8	9.1	0.0
11Jan2020	19:12	0.0	2.8	9.1	0.0
11Jan2020	19:18	0.0	2.8	9.1	0.0
11Jan2020	19:24	0.0	2.8	9.1	0.0
11Jan2020	19:30	0.0	2.8	9.1	0.0
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
11Jan2020	20:00	0.0	2.8	9.1	0.0
11Jan2020	20:06	0.0	2.8	9.1	0.0
11Jan2020	20:12	0.0	2.8	9.1	0.0
11Jan2020	20:18	0.0	2.8	9.1	0.0
11Jan2020	20:24	0.0	2.8	9.1	0.0
11Jan2020	20:30	0.0	2.8	9.1	0.0
11Jan2020	20:36	0.0	2.8	9.1	0.0
11Jan2020	20:42	0.0	2.8	9.1	0.0
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
11Jan2020	21:18	0.0	2.8	9.1	0.0
11Jan2020	21:24	0.0	2.8	9.1	0.0
11Jan2020	21:30	0.0	2.8	9.1	0.0
11Jan2020	21:36	0.0	2.8	9.1	0.0

Attachment WSQ10-1
Correspondence from the Contra Costa County Flood Control and Water Conservation District

Jim McLucas

From: Nelson, Paul L. [nelsonpl@bv.com]
Sent: Wednesday, May 19, 2010 4:34 AM
To: Jim McLucas
Subject: 20100518 Contra Costa County Input on Flood Control Standards
Attachments: CCCo Isohyet Map-Low Color.pdf; 025yr-Low.pdf; 050yr-Low.pdf; 100yr-Low.pdf; 005yr-Low.pdf; 010yr-Low.pdf; Supplemental Detention Basin Design Guidelines.doc

Jim,
FYI
Regards,

Paul Nelson, PE
Black & Veatch
3550 Green Court
Ann Arbor, MI 48105
P: 734-622-8693
F: 734-622-8700

From: Kantola, Craig
Sent: Wednesday, May 19, 2010 7:24 AM
To: Nelson, Paul L.
Subject: FW: Flood Control Standards - Oakley, CA

Paul,
Received from Contra Costa County yesterday.
Craig

From: Jorge Hernandez [mailto:jhern@pw.cccounty.us]
Sent: Tuesday, May 18, 2010 8:37 PM
To: Kantola, Craig
Cc: Teri Rie; Tim Jensen
Subject: RE: Flood Control Standards - Oakley, CA

Mr. Kantola,

1. Per your request we are emailing a copy of our standard Isohyet map to determine the standard storm event.
2. For offsite conveyance of storm water runoff for an area less than 1-sqaure mile, the design storm event should be a 10-year event, however a detention/retention system should be able to store at the very least the 100-year design storm event.
3. See attached supplemental for suggested design of on-site facilities. Ultimately, the City will approve onsite facilities.
4. For the initial 100-year event, the assumption of an empty basin is acceptable, however a 10-year event after a recent 100-year occurrence should be analyzed. Additionally, the overland release of the basin should be directed north, per the current drainage pattern and not allowed to drain south to the existing inlet under the railroad crossing (bridge), which currently is outside of your parcel's drainage area and does not have the capacity to convey additional storm runoff.

If you have any additional question, you may contact me by either phone or email.

Thank you,

Jorge Hernandez
Staff Engineer

Contra Costa County
Flood Control
& Water Conservation District
255 Glacier Drive
Martinez, CA 94553-4897
Phone: (925) 313-2304
Fax: (925) 229-7955
A Division of the Public Works Department

From: Kantola, Craig [mailto:KantolaCA@bv.com]
Sent: Friday, May 14, 2010 10:21 AM
To: Jorge Hernandez
Subject: FW: Flood Control Standards - Oakley, CA

Jorge,
Good afternoon, I have left you a voice mail responding to your call from Wednesday. Any information you may be able to provide would be greatly appreciated. Please forward any design requirements for flood control in Contra Costa County that you think may be applicable for our project.
Thank you and have a nice weekend,
Craig Kantola
Black & Veatch Corporation
3550 Green Court, Ann Arbor, MI 48105
Ph: 734.622.8857 Fx: 734.622.8700

antola, Craig
esday, May 11, 2010 4:08 PM
rn@pw.cccounty.us'
Flood Control Standards - Oakley, CA

Mr. Hernandez,
Good afternoon, I am thanking you in advance for taking the time to read and consider the questions posed below as they relate to the flood water management standard in Contra Costa County (CCC). I understand you may have no knowledge of this site, however I believe that the questions I am asking are general in nature regarding CCC storm water management requirements.

Our firm Black & Veatch has been working on a proposed project in CCC which consists of proposed storm water management facilities. The California Energy Commission (CEC) has offered comments related to the storm facilities and I was hoping that you may be able to take a few moments to discuss the local requirements, as I am from Michigan and not familiar with CCC storm design standards.

If you could please read over the short list of questions below and let me know when you would be able to discuss over the phone it would be greatly appreciated. I would like to discuss this project with you tomorrow (Wednesday) afternoon if you are available, so we can proceed with responding to the CEC review comments.

- CEC has commented that the design rainfall events should be based on Oakley, which may be different than rainfall in Sacramento (which was the data set used for the initial CEC submittal). Does CCC have specific IDF curves for use in preparing storm water models for the region? The project site is located in Oakley. CEC has asked specifically that 10-year and 100-year rain events be analyzed based on the proposed site.

- Based on my understanding of reading the CCC website (http://www.co.contra-costa.ca.us/faq.aspx), since our project site has a drainage area of less than 1 square mile (see attached sketch), that the design storm event would be a 10-year event. Please confirm if this is correct, and if so are there design standards available for use in designing storm water facilities (ponds, swales, etc)?

- If the site design storm is 10-year per the note above, would there be an obligation to convey the 100-year storm event? The project facilities would be graded such that they would be above the 100-year floodplain elevation. What requirements, if any, does CCC have for conveying the 100-year event on a 10-year design site?

- The project site currently drains to an existing man-made basin / wetland in the NW site corner. CEC would like to see what happens when the 100-year storm hits assuming the wetland is already full from previous events. There currently is no outlet from the wetland/basin (it exists as a 'bowl'). In instances like this, does CCC have a typical standard for assuming a starting (normal) water level to base volumetric storage for design storm events? Locally, the expectation would be that the normal water level be determined by field survey and that would be the low elevation of the proposed volumetric storage for the design storm event.

In addition, I am including a snapshot of the site aerial view along with an overview sketch of the proposed site drainage.

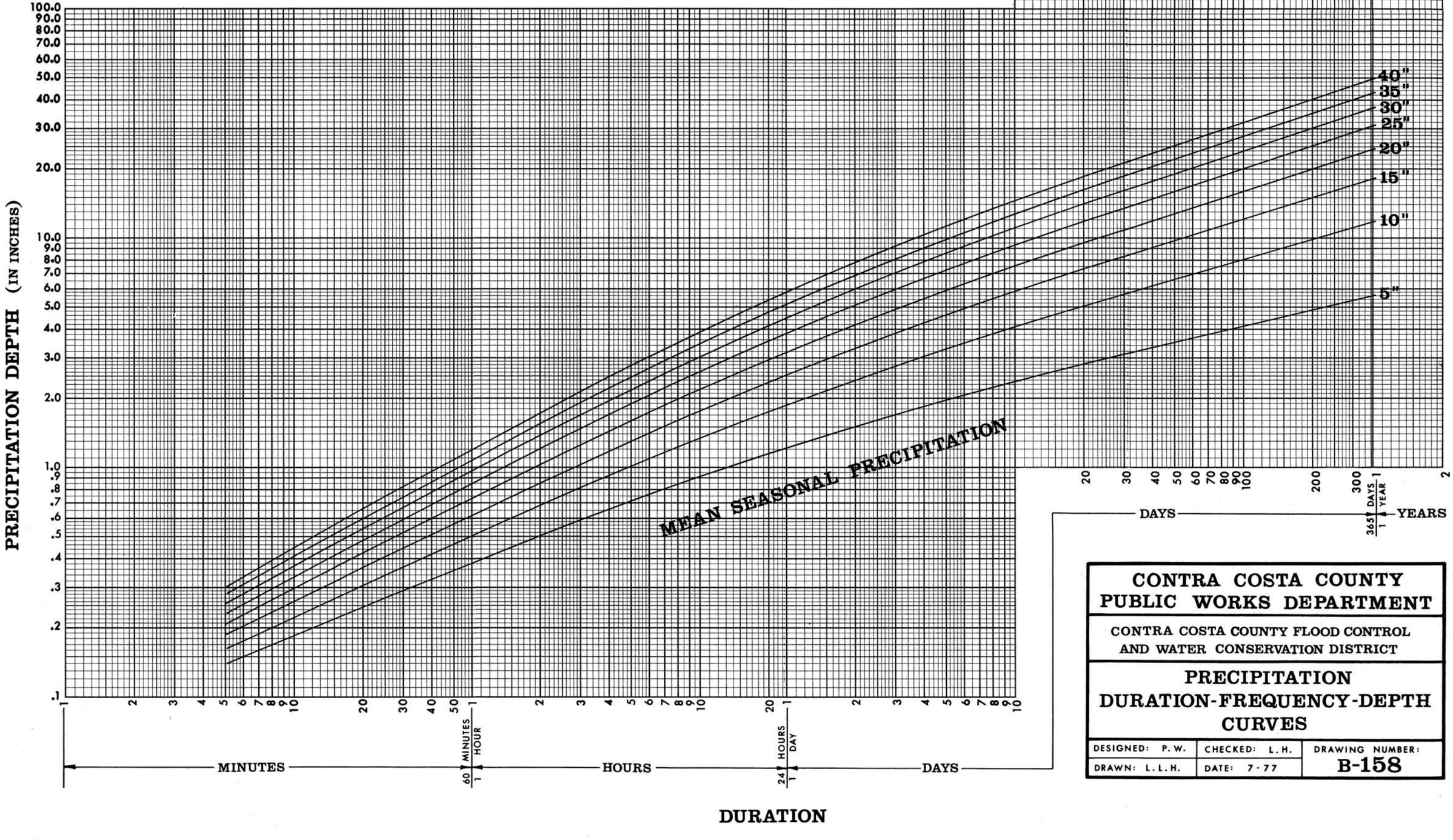
Bridgehead Rd

Any input or assistance you may be able to provide would be greatly appreciated.

Thank you,
Craig Kantola, PE
Black & Veatch Corporation
3550 Green Court, Ann Arbor, MI 48105
Ph: 734.622.8857 Fx: 734.622.8700

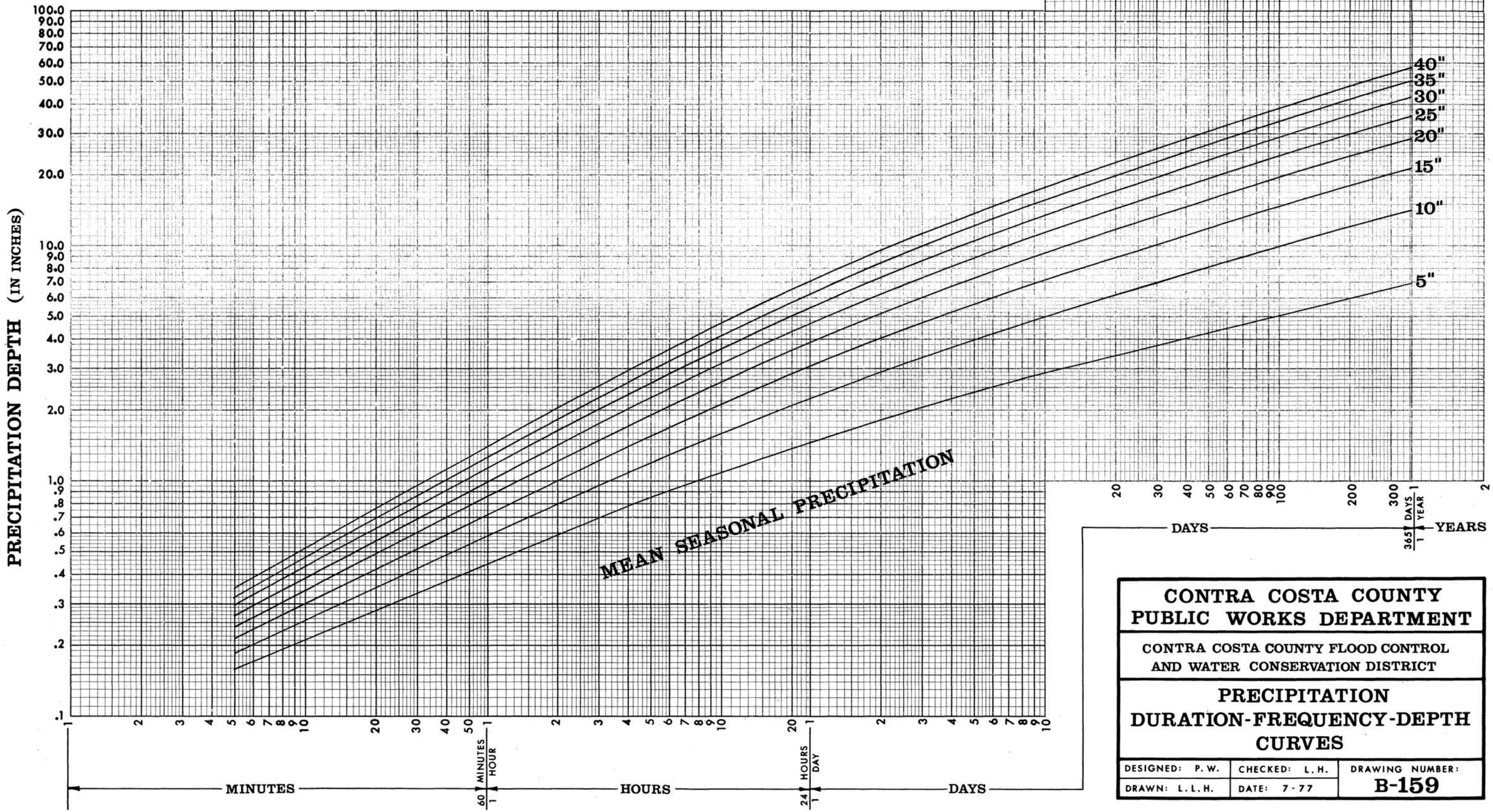
122°15′
122°00′
121°45′
38°00′
37°45′
Basic map reproduced by permission of the California State Automobile Association, copyright owner.
Pablo Bay
Suisun Bay
San Francisco Bay
Vallejo
Benicia
Crockett
Martinez
Pittsburg
Antioch
Oakley
Bethel Island
Concord
Pleasant Hill
Walnut Creek
Clayton
Brentwood
Knightsen
Byron
Richmond
El Cerrito
Albany
Berkeley
Emeryville
Oakland
Alameda
Piedmont
San Leandro
Castro Valley
Lafayette
Orinda
Moraga
Alamo
Danville
San Ramon
Dublin
Springtown
C O N T R A C O S T A
N
SCALE
MILES 0 1 2 3 4 5 MILES
KILOMETERS 0 1 2 3 4 5 6 7 8 KILOMETERS
ONE KILOMETER = ⅝ MILE
ISOHYETS SHOWN IN INCHES
ISOHYETS SHOWN IN MILLIMETERS
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

RECURRENCE INTERVAL
5 YEARS



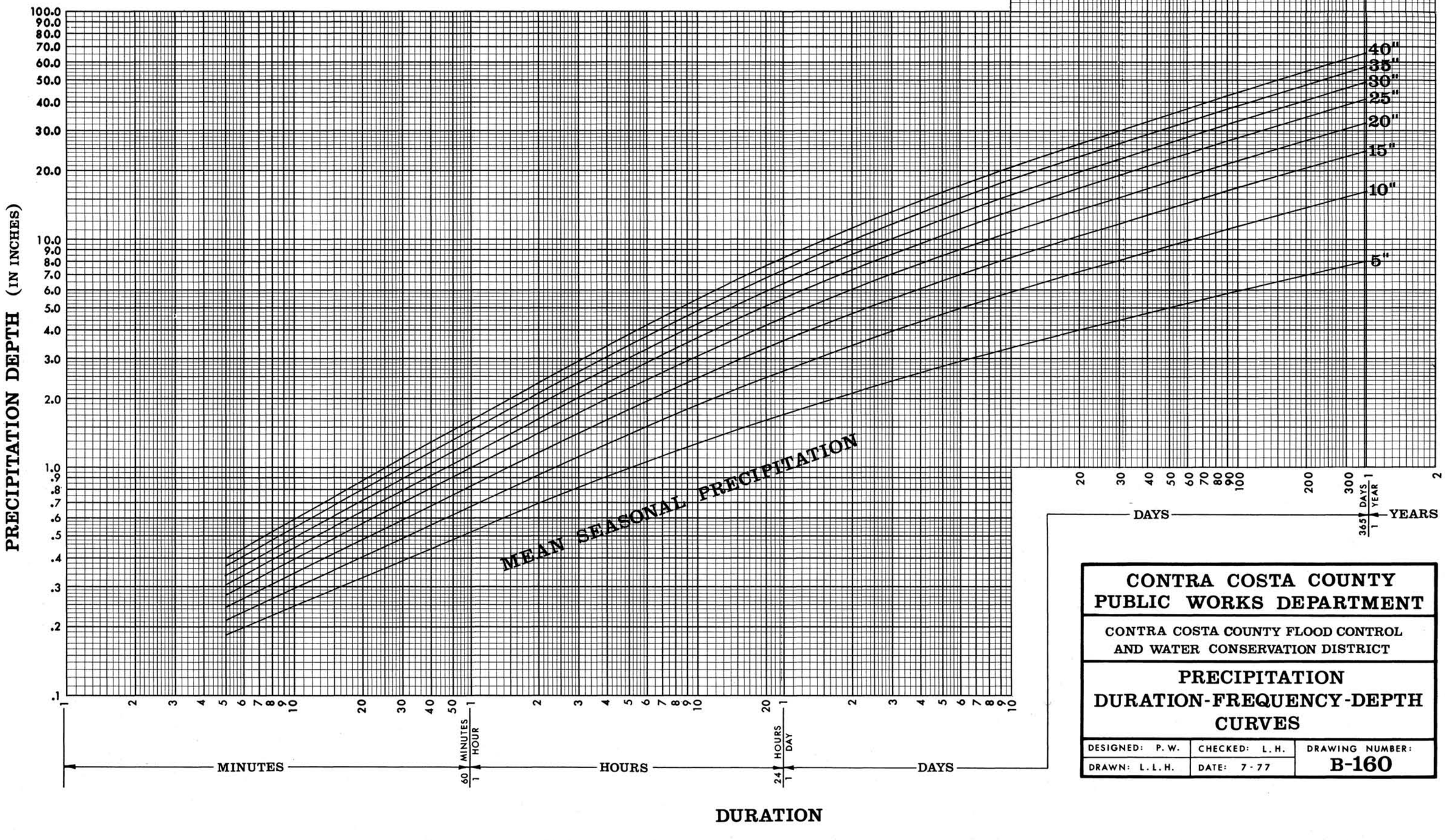
CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-158
DRAWN: L. L. H.	DATE: 7-77	

RECURRENCE INTERVAL
10 YEARS



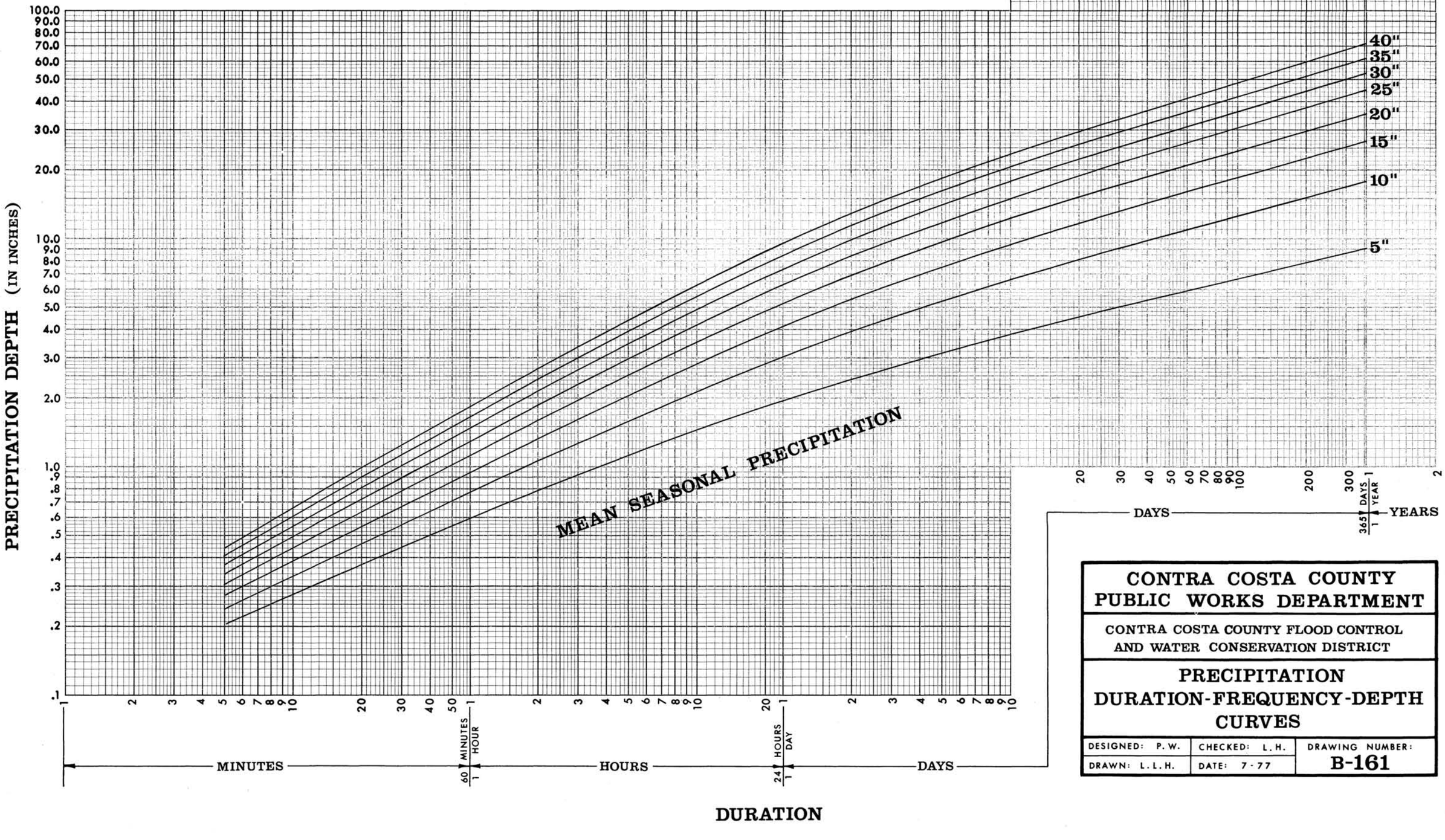
CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-159
DRAWN: L. L. H.	DATE: 7-77	

RECURRENCE INTERVAL
25 YEARS



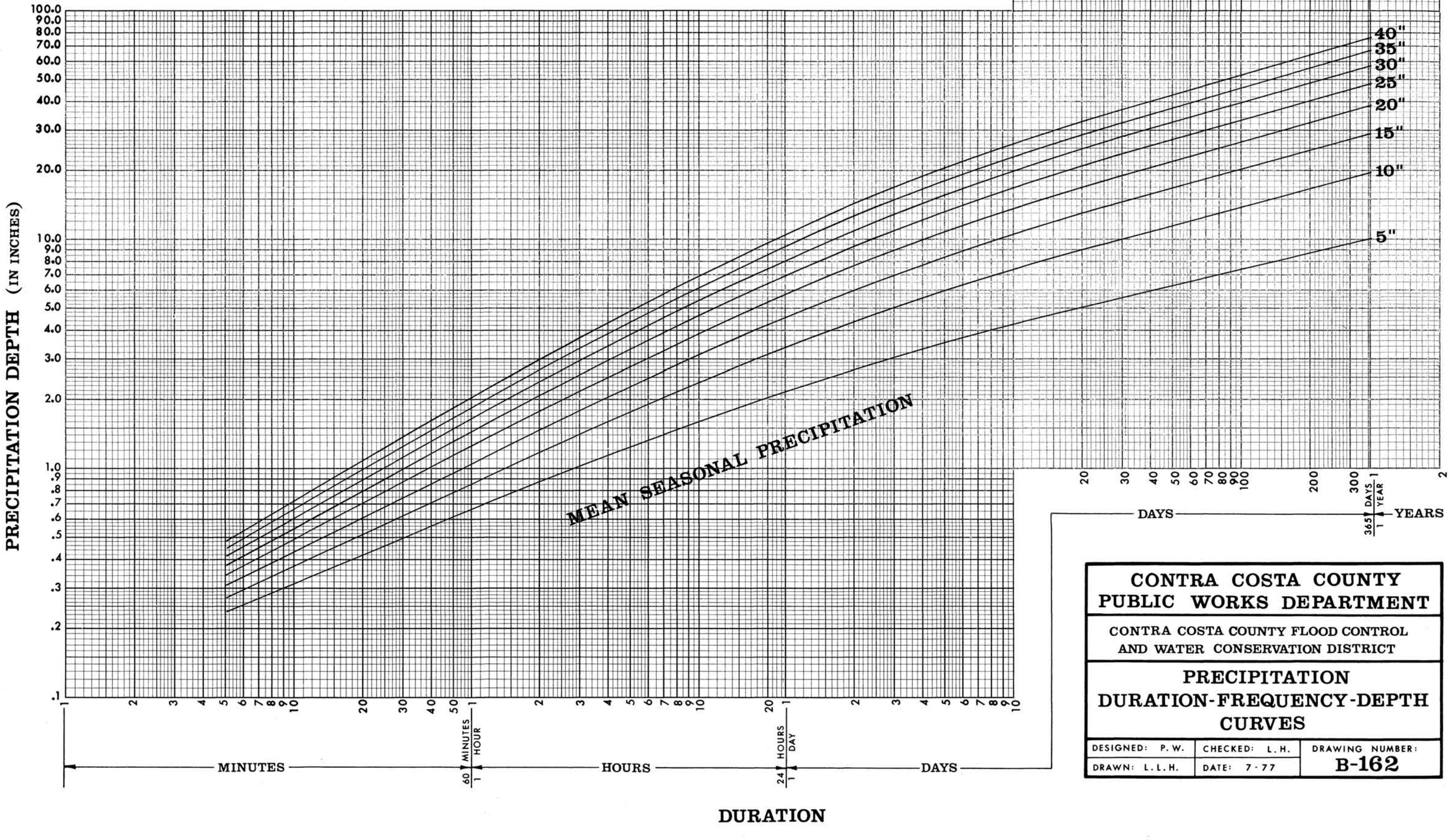
CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-160
DRAWN: L.L.H.	DATE: 7-77	

RECURRENCE INTERVAL
50 YEARS



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-161
DRAWN: L. L. H.	DATE: 7-77	

RECURRENCE INTERVAL
100 YEARS



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P.W.	CHECKED: L.H.	DRAWING NUMBER: B-162
DRAWN: L.L.H.	DATE: 7-77	

Draft

SUPPLEMENTAL DETENTION BASIN DESIGN GUIDELINES

By: Contra Costa County Flood Control and Water Conservation District

March 2, 2006

The ultimate design of a project that has a detention basin needs to show how the runoff is captured and conveyed to the basin. Obviously, if the flows cannot get into the inlets or cannot be contained in the pipes and reach the basin, the flows will not be mitigated.

Proposed contours should be examined to see if they indicate that overland flows (flows in the streets that the storm system cannot contain) will, in fact, get into the basin. If surface flows cannot enter the storm drain system, they will likely flow downstream and not be mitigated, or worse, cause flooding and storm damage.

CAPTURE OF RUNOFF

There are at least three approaches to capturing the runoff and ensuring it gets to the basin:

1. The entire system could be designed for the 100-year storm. The design and supporting calculations for the system would need to show that the inlets have capacity to capture the 100-year flows and that the storm drain can convey the flows to the basin with adequate freeboard to keep the flows from escaping the storm drain system and bypassing the detention basin.

2. The entire system could be designed for the 10-year storm and grading of the land and streets could be such that the overland flows are directed to the basin. The point of entry into the basin would need to be designed to capture the flows without erosion or damage to the basin or surrounding improvements.

3. The system could be designed for the 10-year storm and certain portions of it designed to capture and convey the 100-year storm flows. In this approach, the flows that cannot be captured at the inlets or contained in the 10-year storm system would be allowed to flow overland to the basin. Surface flows would be captured just upstream of a basin through a series of spaced inlets designed with consideration of bypass flows from one inlet being collected by the next inlet. Only a segment of the system would need to be designed to capture the higher flows and convey them to the basin.

Where there are sags in the roads, the high flows would likely pond and slowly drain into inlets or drain over high points to the next downstream inlets. If so, the potential for ponded water to escape the road and flow overland could exist. Such sags need to be checked for inlet capacity and adequate and safe overland release to via downstream profile high points. The depth of water at the sag should be checked against local standards and adjacent improvements and structures (existing or proposed) to ensure that the depth of ponding is acceptable. If not, the design would need to be adjusted to reduce the depth of ponding.

INLET CAPACITY CALCULATIONS

The inlet capacity calculations must conform to U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 22 – "Urban Drainage Design Manual" (HEC 22). Inlet capacity calculations and inlet bypasses are built into some storm drain programs. Sag inlet capacity calculation methods are also included in HEC 22.

OVERLAND FLOW RELEASE

Per the Contra Costa County Flood Control and Water Conservation District's standard, detention basins are to have an emergency spillway to minimize the risk that the basin embankment will be compromised during higher than design flows or in the event the primary spillway does not work. The overland release of emergency spillway flows should be studied and impacts addressed.

The project should identify an overland release route, and Flood Control District shall approve of the concept. Overland release pertains to the conveyance of storm runoff to public roads or other major drainage facilities by overland routes if the site drainage system is inundated. Planning the overland release routes allows for understanding the impact of overwhelming flows and assists in making evacuation plans in case of flooding. The spillway, as well as overland release, should be designed for at least a 100-year storm event.

MB/cw
G:\GrpData\FldCtl\Standards\Det Basins\Supplemental Detention Basin Design Guidelines.doc

Attachment WSQ11-1
IMP Sizing for Plant Area
(Calculation 52.5406.1008)

BLACK & VEATCH
Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 19

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: IMP Sizing for Plant Area

Calculation No./File No.: 52.5406.1008

Verification Method: ☒ Check and Review ☐ Alternate Calculations

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 Oakley Generating project.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: _____ Version: _____

Standard B&V Application Used? ☐ Yes ☐ No
If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola	15 June 2010	PNielson	6/18/10	PNielson	18 June 2010

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. 1, "Grading & Drainage - Site Plan - Sheet 1"
   - 163994-SS-3201, Rev. 0, "Surfacing/Fencing/Roadway - Site Plan - Sheet 1"
   - 163994-SS-3050, Rev. 1, "Site Sections and Details"
   - 163994-SS-1002, Rev. 2, "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:

Four bioswales will be constructed within the plant area to collect and infiltrate stormwater.
Based on the Stormwater C.3 requirements (Ref 2), 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 #1-2	Trapezoidal	1,323	3 (h) to 1 (v)	2	26,460	43,659	13,042	10,806
Bioswale #3	Trapezoidal	187	3 (h) to 1 (v)	2	2,618	2,992	500	415
Bioswale #4	Trapezoidal	391	3 (h) to 1 (v)	2	7,820	12,903	7,598	6,296
Bioswale #5	Trapezoidal	385	3 (h) to 1 (v)	10 ft for first 265 ft long section; 8 ft for remaining 120 ft long section	10,105	16,714	9,910	8,211

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.

Four 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 and/or outlet control 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.

NRCS Soil Group

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.

BIOSWALE #3

BIOSWALE #1-2

BIOSWALE #5

POND

BIOSWALE #4

DRAINAGE AREA FOR EA. BIOSWALE (TYP)

ALL BACKCIRCLED CHANGES PER ECN-N-S-00XX

OPEN
05/27/10

Scale 1"=125'

page 5 of 19
Radback Energy
Oakley Project
Proj # 163994
File 52.5426.1008
By: C. Kawtola
Date: 6/15/10
Checked by: PLN
Date: 6/17/10

CONSERVATION EASEMENT

SLOPE TO MATCH BRIGEHEAD ROAD

BRIDGEHEAD ROAD

CL BIOSWALE

SLOPE

EDGE EL 17.0

SLOPE ROAD

EDGE EL 17.0

SEE NOTE 7 (TYP)

SEE NOTE 8

MATCHLINE E 6202810 – SEE DWG SS-3002 FOR CONTINUATION

N 2193000
N 2192750
N 2192500
N 2192250
N 2192000

E 6201500
E 6201750
E 6202000
E 6202250
E 6202500
E 6202750

ABBRE

APPRDX
ASPH
AVG
BND
BLDG
B/MH
BOC
BOD
BOP
BU
C
CB
CD
CHDPE
CL
CLR
CMH
CND
CONC
CO
CS
CW
DB
DBC
DET
DIA
DIP
DWG
DWP
EC
ECC
EF
EHH
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EMH
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FC
FDN
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GR
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8. TEMPORARY CONSTRUCTI

IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 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	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

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 "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.

Consequently,

$$\sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{matrix} DMA \\ Runoff \\ Factor \end{matrix} = (54{,}900 \times 1 + 65{,}113 \times 1 + 100{,}200 \times 0.6 + 198{,}264 \times 0.1 + 4{,}491 \times 0 + 68{,}200 \times 0.1)$$

$$= 206{,}779 \text{ ft}^2.$$

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:

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

$$= 206{,}779 \text{ x } 0.07 \text{ x } 0.901 = 13{,}041 \text{ ft}^2.$$

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

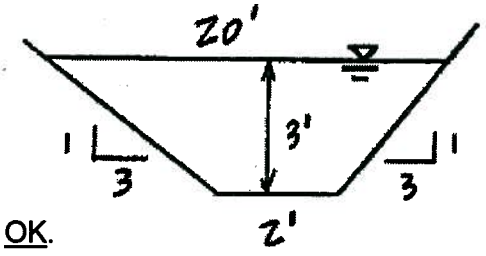
$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA \\ Square \\ Footage \end{pmatrix} \times \begin{pmatrix} DMA \\ Runoff \\ Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 206{,}779 \text{ x } 0.058 \text{ x } 0.901 = 10{,}806 \text{ ft}^3.$$

The proposed bioswale #1 is 1,323 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. Outlet structure OS-3 will be installed at the end of bioswale #1. See B&V Drawing SS-3001 (Attachment 1). The top of grate elevation of OS-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:

$20 \times 1{,}323 = 26{,}460\ ft^2 > 13{,}041\ ft^2$, OK.



The volume of bioswale #1 is:

$$\frac{2+20}{2} \times 3 \times 1{,}323 = 43{,}659\ ft^3 > 10{,}806\ ft^3,$$ OK.

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

Orifices starting approximately 9" above the bottom of the bioswale will be installed in the outlet control structure to discharge stormwater runoff from less intensive storm events to the wetland to maintain hydration of the wetland.

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

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OWNER	Radback Energy		COMP'D BY	C. Kantola
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PCN
TITLE	IMP Sizing		DATE	6/15/10
			PAGE	9 OF 19

Soil Type	IMP Name			
A	Bioswale #1-2			

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	54,900	Equipment / Roofs	1.00	54,900					
DMA-2	65,113	Asphalt Pavement	1.00	65,113					
DMA-3	100,200	Gravel Surfacing	0.60	60,120					
DMA-4	198,264	Landscape, Group A Soil	0.10	19,826					
DMA-5	4,491	Transformer Containment	0.00	0					
DMA-6	68,200	Open Graded Aggregates	0.10	6,820					
			Total:	206,779	0.070	0.901	13,042	26,460	IMP Area (ft^2)
					0.058	0.901	10,806	43,659	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: 25,711 ft^2 (0.59 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	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

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,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (3{,}873\text{x}1.0+2{,}086\text{x}1.0+19{,}752\text{x}0.1)$$

$$= 7{,}934 \text{ ft}^2.$$

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:

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

$= 7{,}934 \times 0.07 \times 0.901 = 500 \text{ ft}^2.$

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

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

$= 7{,}934 \times 0.058 \times 0.901 = 415 \text{ ft}^3.$

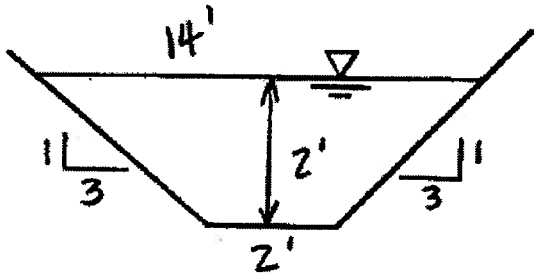
The proposed bioswale #3 is 187 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 11.0. Drop structure DS-1 will be installed at the end of bioswale #3. See B&V Drawing SS-3001. The top of grate elevation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

$14 \times 187 = 2{,}618 \text{ ft}^2 > 500 \text{ ft}^2$, OK.

The volume of bioswale #3 is:

$\frac{2+14}{2} \times 2 \times 187 = 2992 \text{ ft}^3 > 415 \text{ ft}^3$, OK.



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.

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OWNER	Radback Energy		COMP'D BY	C. Kantola
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PLN
TITLE	IMP Sizing		DATE	6/18/10
			PAGE	12 OF 19

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor
DMA-1	3,873	Equipment / Roofs	1.00	3,873
DMA-2	2,086	Asphalt Pavement	1.00	2,086
DMA-3	19,752	Landscape, Group A Soil	0.10	1,975
			Total:	7,934

Soil Type	IMP Name			
A	Bioswale #3			
IMP Sizing Factor	Rain Adjustment Factor	Minimum Area or Volume	Proposed Area or Volume	
0.070	0.901	500	2,618	IMP Area (ft^2)
0.058	0.901	415	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,

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

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

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.

Minimum Area and Minimum Volume of IMP

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

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

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

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

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

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

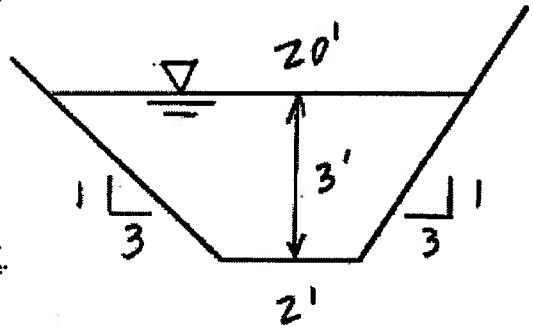
The proposed bioswale #4 is 391 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Outlet structure OS-4 will be installed at the end of bioswale #4. See B&V Drawing SS-3001. The top of grate elevation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

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

The volume of bioswale #4 is:

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



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

Orifices starting approximately 9" above the bottom of the bioswale will be installed in the outlet control structure to discharge stormwater runoff from less intensive storm events to the wetland to maintain hydration of the wetland.

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

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OWNER	Radback Energy		COMP'D BY	C. Kantola
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PCN
TITLE	IMP Sizing		DATE	6/17/10
			PAGE	15 OF 19

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

Soil Type	IMP Name			
A	Bioswale #4			
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: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 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.

Including Railroad yard PLW 6/17/10

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	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

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,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133 \text{ ft}^2.$$

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:

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

$$= 157{,}133 \times 0.07 \times 0.901 = 9{,}910 \text{ ft}^2.$$

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

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

$$= 157{,}133 \times 0.058 \times 0.901 = 8{,}211 \text{ ft}^3.$$

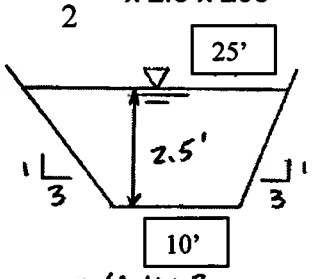
The proposed bioswale #5 is 385 feet long total. The bioswale cross section will be trapezoidal. Bottom width = 10 feet for the first 265 feet long section (Section 2 on SS-3001) and 8 feet for the remaining 120 feet long section (Section 2A on SS-3001). Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.0 for Section 2 and EL 11.0 for Section 2A. Outlet structure OS-5 will be installed at the end of bioswale #5. See B&V Drawing SS-3001. The top of grate elevation of OS-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:

$25 \times 265 + 29 \times 120 = 10{,}105 \text{ ft}^2 > 9{,}910 \text{ ft}^2$, OK.

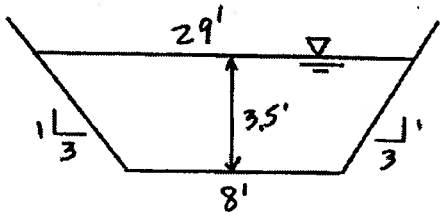
The volume of bioswale #5 is:

$$\frac{2+25}{2} \times 2.5 \times 265 + \frac{8+29}{2} \times 3.5 \times 120 = 16{,}714 \text{ ft}^3 > 8{,}211 \text{ ft}^3, \text{ OK}.$$



Section 2

DWG SS-3001



Section 2A

DWG SS-3001

An orifice will be installed in the outlet structure for bioswale #5 to discharge stormwater runoff from less intensive storm events to the wetland to allow the wetland continue to have water. See Dwg SS-3001 (Attachment 1).

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.

BLACK & VEATCH					
	OWNER	Radback Energy		COMP'D BY	C. Kantola
	PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010
	PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PLN
	TITLE	IMP Sizing		DATE	6/17/10
				PAGE	19 OF 19

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor
DMA-1	12,670	Equipment / Roofs	1.00	12,670
DMA-2	25,905	Asphalt Pavement	1.00	25,905
DMA-3	186,725	Gravel Surfacing	0.60	112,035
DMA-4	65,229	Landscape, Group A Soil	0.10	6,523
			Total:	157,133

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	9,910	10,105	**IMP Area (ft^2)**
0.058	0.901	8,211	16,714	**V_1 (ft^3)**
NA	0.901	NA	NA	**V_2 (ft^3)**
			Orifice Size:	NA

Radback Oakley Project

CAK 6/15/10

163994 File # 52.5406.1008

pgs 5

IMP Sizing for plant area

Attachment 1

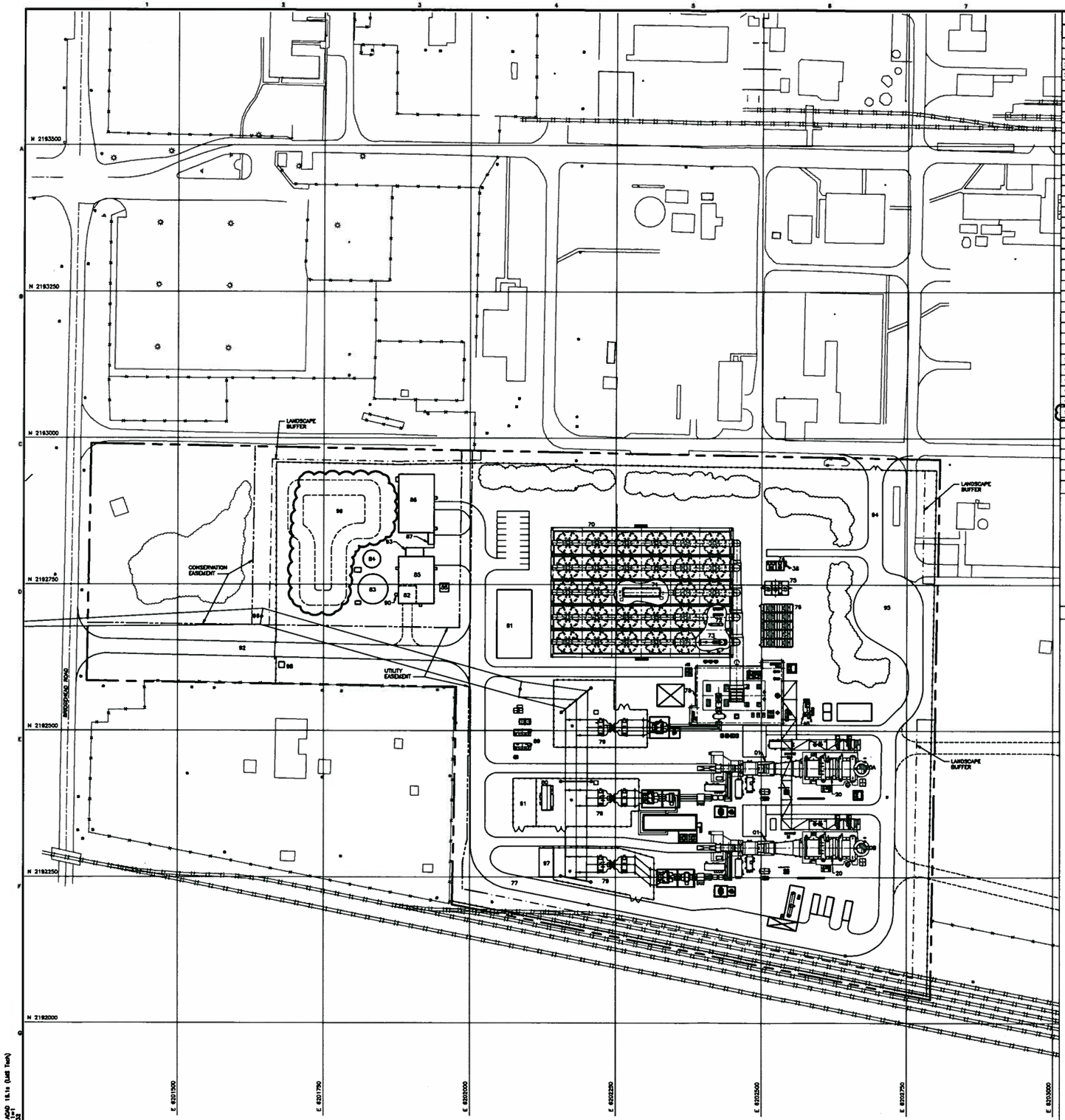
Black & Veatch Dwgs

SS-1002

-3001

-3201

-3050



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'	2192438.00	6202663.00	CL EXHAUST STACK
20B	HRSG EXHAUST STACK B	155'	2192300.00	6202663.00	CL EXHAUST STACK
38	SAFETY SHOWER EYEWASH STATION	--	--	--	--
48	AUXILIARY BOILER	50'	2192527.61	6202572.28	CL EXHAUST STACK
70	AIR COOLED CONDENSER (ACC)	124'	--	--	--
71	ACC ELECTRICAL ENCLOSURE	14'	--	--	--
72	CONDENSER AIR EXTRACTION SKIDS	8'	--	--	--
73	ACC CONDENSATE COLLECTION TANK	28'	--	--	--
74	WET SURFACE AIR COOLER CHEMICAL FEED SKIDS	8'	--	--	--
75	WET SURFACE AIR COOLER	23'	2192744.87	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	18'	--	--	--
87	LUBRICANT STORAGE SHED	10'	--	--	--
88	WASTE WATER LIFT STATION (IF REQUIRED)	--	--	--	--
89	GAS COMPRESSORS & GAS CONDITIONING	13'	--	--	--
90	DIESEL FIRE PUMP EXHAUST	18'	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	108'	--	--	--
97	OUTAGE MAINTENANCE TRAILERS AREA	--	--	--	--
98	GUARD HOUSE	--	--	--	--
99	STORM WATER POND	--	--	--	--

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 547", 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/08.

GENERAL LEGEND

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

ALL BACKCIRCLED CHANGES PER ECN-N-S-0004

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRAWN	DESIGNED	CHECKED	PROJECT ENGINEER	APPROVED
3	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAW	PLH	PLH	CAW
2	18/APR/08	ISSUED PER ECN-N-S-0003	MAW	PLH	PLH	PLH	CAW
1	30/MAR/08	ISSUED PER ECN-N-S-0001	MAW	PLH	PLH	PLH	CAW
0	13/MAR/08	ISSUED FOR PERMITTING	MAW	PLH	PLH	PLH	CAW

SCALE: 1" = 60'

LICENSED ENGINEER'S SEAL

BLACK & VEATCH CORPORATION

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
GENERAL ARRANGEMENT SITE

PROJECT 163994-SS-1002 | DRAWING NUMBER | REV 3

CODE | AREA

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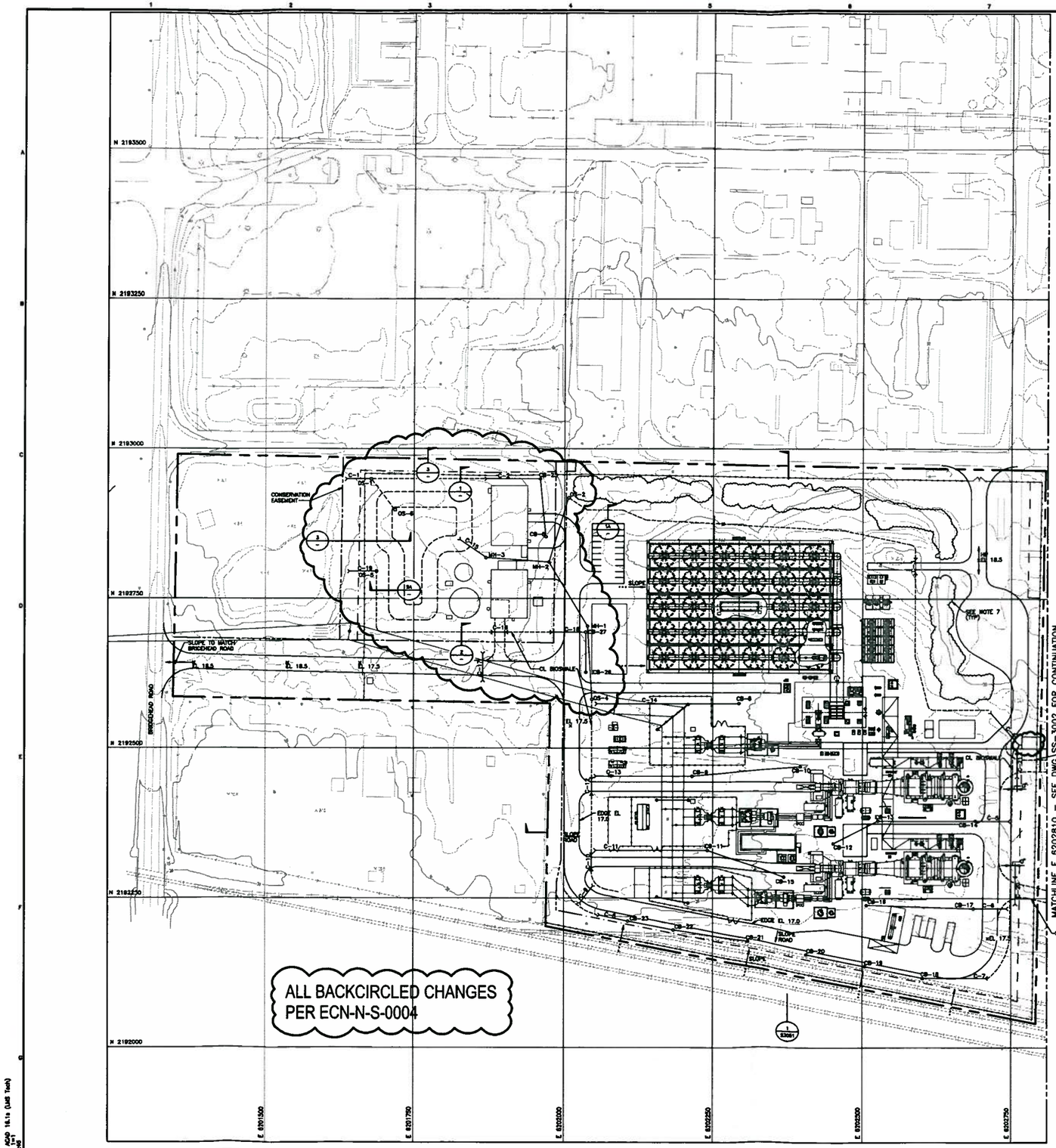

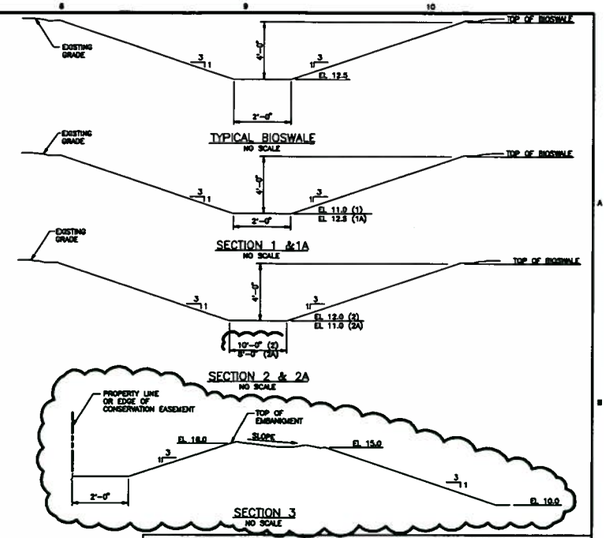

ABBREVIATIONS APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

APPROX	=	APPROXIMATE	LTR	=	LATER
ASPH	=	ASPHALT	MAX	=	MAXIMUM
AVG	=	AVERAGE	MH	=	MANHOLE
BEND	=	BEND	MIN	=	MINIMUM
BLDG	=	BUILDING	MJ	=	MECHANICAL JOINT
BOMH	=	BOTTOM OF MANHOLE ELEVATION	MSL	=	MEAN SEA LEVEL
BOP	=	BOTTOM OF CONDUIT ELEVATION	NO.	=	NUMBER
BOSB	=	BOTTOM OF DUCTBANK ELEVATION	NTS	=	NOT TO SCALE
BOP	=	BOTTOM OF PIPE ELEVATION	OD	=	OUTSIDE DIAMETER
BELL	=	BELL-UP	OWS	=	OIL WATER SEPARATOR
CULV	=	CULVERT	OMH	=	OILYWATER MANHOLE
CB	=	CATCH BASIN	PCF	=	POUNDS PER CUBIC FOOT
CABLE	=	CABLE SHEET	PH	=	PHASE
CMP	=	CORRUGATED HIGH DENSITY POLYETHYLENE PIPE	PI	=	POINT OF INTERSECTION
CL	=	CENTERLINE	PLCS	=	PLACES
CMU	=	CHEMICAL MANHOLE	PM	=	PLANT MANHOLE
CONC	=	CONCRETE	POT	=	POINT OF TANGENT
CONDT	=	CONDUIT	PT	=	PIPE TERMINATION
CONC	=	CONCRETE	PVC	=	POLYVINYL CHLORIDE PIPE
CY	=	CUBIC YARD	QTY	=	QUANTITY
CLDR	=	CLEAN OUT	R	=	RADIUS
CS	=	CARBON STEEL	RCP	=	REINFORCED CONCRETE PIPE
CWS	=	CIRCULATING WATER	RD	=	ROOF DRAIN
DUCTBANK	=	DUCTBANK	REV	=	REVISION
DBC	=	DIRECT BURIED CABLE	RGS	=	RIGID GALVANIZED STEEL
DET	=	DETAIL	RR	=	RAILROAD
DIA	=	DIAMETER	SECT	=	SECTION
DIP	=	DUCTILE IRON PIPE	SIM	=	SIMILAR
DWG	=	DRAWING	SLS	=	SANITARY LIFT STATION
DWP	=	DOUBLE WALL PIPE	SMH	=	SANITARY MANHOLE
EC	=	ELECTRICAL CONDUIT	STMH	=	STORM MANHOLE
EC	=	EXCENTRIC	STRL	=	STRUCTURAL
EF	=	EACH FACE	TC	=	TOP OF CONCRETE ELEVATION
EMH	=	ELECTRICAL MANHOLE	TG	=	TOP OF GRADE ELEVATION
EL	=	ELEVATION	TSH	=	TELEPHONE SERVICE HANDHOLE
EMH	=	ELECTRICAL MANHOLE	TMH	=	TOP OF MANHOLE ELEVATION
EW	=	EACH WAY	TP	=	TOP OF PAVEMENT ELEVATION
FC	=	FIELD CHECK	TPT	=	MECH PIPE TERMINAL POINT
FDN	=	FOUNDATION	TYP	=	TYPICAL
FF	=	FLAT FACE	UGL	=	UNDERGROUND LIGHTING CONDUIT
FRP	=	FIBERGLASS REINFORCED PIPE	UNO	=	UNLESS NOTED OTHERWISE
GR	=	GRADE	VERT	=	VERTICAL
HDM	=	HOT DRAIN MANHOLE	WGT	=	WEIGHT
HDPE	=	HIGH DENSITY POLYETHYLENE PIPE	WTR	=	WATER
HP	=	HIGH POINT	W	=	WITH
HYD	=	HYDRANT	W/O	=	WITHOUT
ID	=	INSIDE DIAMETER	WP	=	WORK POINT
INV	=	INVERT	XFMR	=	TRANSFORMER
JBX	=	JUNCTION BOX			
LF	=	LENGTH			
LP	=	LOW POINT			

LEGEND APPLICABLE TO ALL S3000 DRAWINGS

- NEW CULVERT
- CL BIOSWALE
- SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER (1 / S3000)
- FINISHED SPOT ELEVATIONS (× 328.5)
- SURVEY MONUMENT/CONTROL POINT (BM-1)
- EXISTING FENCE
- NEW SECURITY FENCE
- TEMPORARY CONSTRUCTION FENCE
- EROSION CONTROL METHOD (TR-1)
- NEW SLIDE GATE
- NEW SWING GATE
- EXISTING POWER POLE
- NEW CATCH BASIN (CB-101)
- NEW DROP STRUCTURE
- PROPERTY LINE
- BOUNDARY LINE
- EXISTING CONTOURS (128)
- 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 "Y 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE. ELEVATION = 11.188 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, DROP AND OUTLET 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.

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE MICRO FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRAWN	CHKD	APPD
1	18/JUN/10	ISSUED FOR PERMITTING	RJS/CHK	PJK/CHK	
0	16/APR/08	ISSUED FOR PERMITTING	MAN/PJK	PJK/CHK	

SCALE: 1"=80' (60' 30' 0 80' 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 _____ REG NO. _____
DATE _____

BLACK & VEATCH CORPORATION
ENGINEER PJK | DRAWN MAW
DESIGNED | CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
GRADING AND DRAINAGE - SITE PLAN - SHEET 1

PROJECT 163994 | DRAWING NUMBER SS-3001 | REV 1
CODE | AREA

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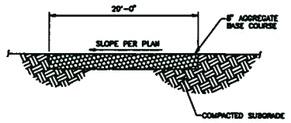
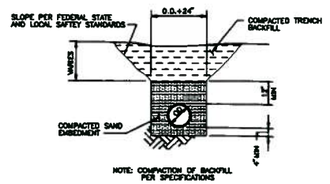


TYPICAL CONSTRUCTION LAYDOWN ROAD
NO SCALE



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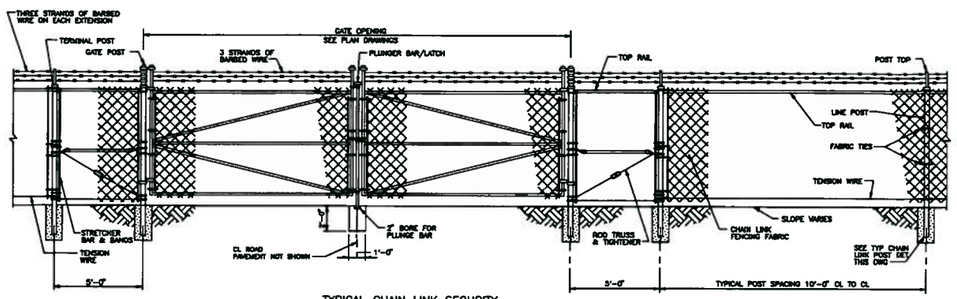

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
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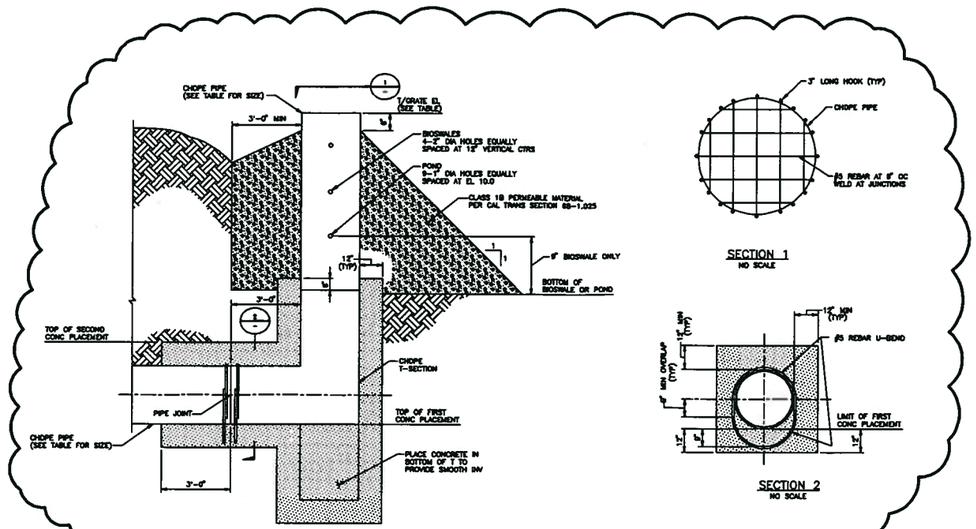

TYPICAL OUTLET STRUCTURE DETAIL
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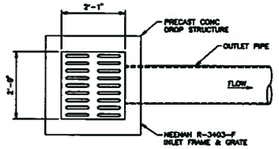
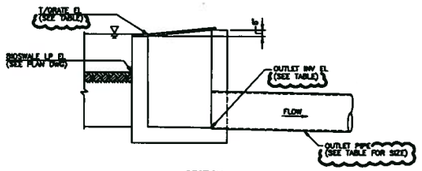


PLAN



SECTION

TYPICAL BIOSWALE DROP STRUCTURE DETAIL
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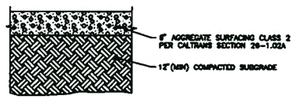
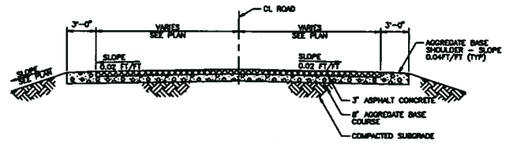
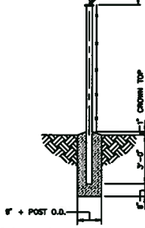


TYPICAL AGGREGATE SURFACING SECTION
NO SCALE

TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
NO SCALE



TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS-3201



TYPICAL SECURITY FENCE POST DETAIL
NO SCALE

CULVERT TABLE

CULVERT NO.	INLET INV ELEVATION	OUTLET INV ELEVATION	LENGTH	PIPE DIAMETER	PIPE MATERIAL	REMARKS
C-1	8.2	8.0	–	24"	–	
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	12.8	–	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	–	18"	–	
C-11	13.4	12.8	–	12"	–	
C-12	13.0	13.0	–	18"	–	
C-13	13.4	12.8	–	12"	–	
C-14	13.5	13.5	–	12"	–	
C-15	10.3	10.0	–	18"	–	
C-16	12.9	12.5	–	18"	–	
C-17	14.7	14.4	–	12"	–	
C-18	12.8	12.3	–	18"	–	
C-19	8.7	8.4	–	18"	–	
C-20	13.0	13.0	–	18"	–	
C-21	13.0	13.0	–	18"	–	

CATCH BASIN AND MAN HOLE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES NORTH	CENTERLINE COORDINATES EAST	TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION A INV EL	A DIA	B INV EL	B DIA	C INV EL	C DIA	D INV EL	D DIA	E INV EL	E DIA	F INV EL	F DIA	G INV EL	G DIA	H INV EL	H DIA	REMARKS
CB-6	–	–	18.0	12.3	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
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	–	–	13.8	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	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.8	12"	
CB-16	–	–	17.0	–	–	–	–	13.6	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	–	–	–	–	13.6	12"	–	–	–	–	–	–	13.6	12"	–	–	
CB-20	–	–	16.5	–	–	–	–	13.8	12"	–	–	–	–	–	–	–	–	–	–	
CB-21	–	–	16.5	–	–	–	–	–	–	–	–	–	–	–	–	13.8	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"	–	–	11.8	18"	–	–	
CB-26	–	–	16.0	13.2	18"	–	–	–	–	–	–	13.2	18"	–	–	–	–	–	–	
CB-27	–	–	16.5	–	–	–	–	–	–	–	–	12.4	18"	–	–	12.4	18"	–	–	
MH-1	–	–	16.5	–	–	–	–	–	–	–	–	12.9	18"	–	–	–	–	12.9	18"	
MH-2	–	–	17.0	–	–	11.2	18"	–	–	12.3	18"	–	–	–	–	11.0	18"	–	–	
MH-3	–	–	16.5	–	–	–	–	10.3	18"	–	–	–	–	–	–	–	–	10.3	18"	

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

DROP (DS) AND OUTLET (OS) STRUCTURE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES NORTH	CENTERLINE COORDINATES EAST	TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION A INV EL	A DIA	B INV EL	B DIA	C INV EL	C DIA	D INV EL	D DIA	E INV EL	E DIA	F INV EL	F DIA	G INV EL	G DIA	H INV EL	H DIA	REMARKS
OS-1	–	–	13.0	–	–	–	–	–	–	8.2	24"	–	–	–	–	–	–	8.2	24"	
OS-2	–	–	13.5	–	–	–	–	–	–	–	–	–	–	11.8	18"	–	–	–	–	
OS-3	NOT USED																			
OS-4	–	–	15.3	13.5	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-5	–	–	14.5	8.7	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-6	–	–	14.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.8	24"	

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

ALL BACKCIRCLED CHANGES PER ECN-N-S-0004

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

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRAWN	CHKD	DES	APP
1	10/JUN/10	ISSUED FOR PERMITTING	RJS	DAK	PLK	DVH
0	10/APR/09	ISSUED FOR PERMITTING	KAM	PLK	PLK	DVH

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

LICENSE EXPIRY DATE THE ORIGINAL SIGNATURE AND SEAL OF THE LICENSED ENGINEER APPEARS HEREON AND THIS IS A DULY REGISTERED AND LICENSED ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED _____ REG NO. _____
DATE _____

BLACK & VEATCH CORPORATION

ENGINEER	PLK	DRAWN	NMM
CHECKED		DATE	

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SITE
SECTIONS AND DETAILS

PROJECT	DRAWING NUMBER	REV
163994	SS-3050	1
CODE		
AREA		

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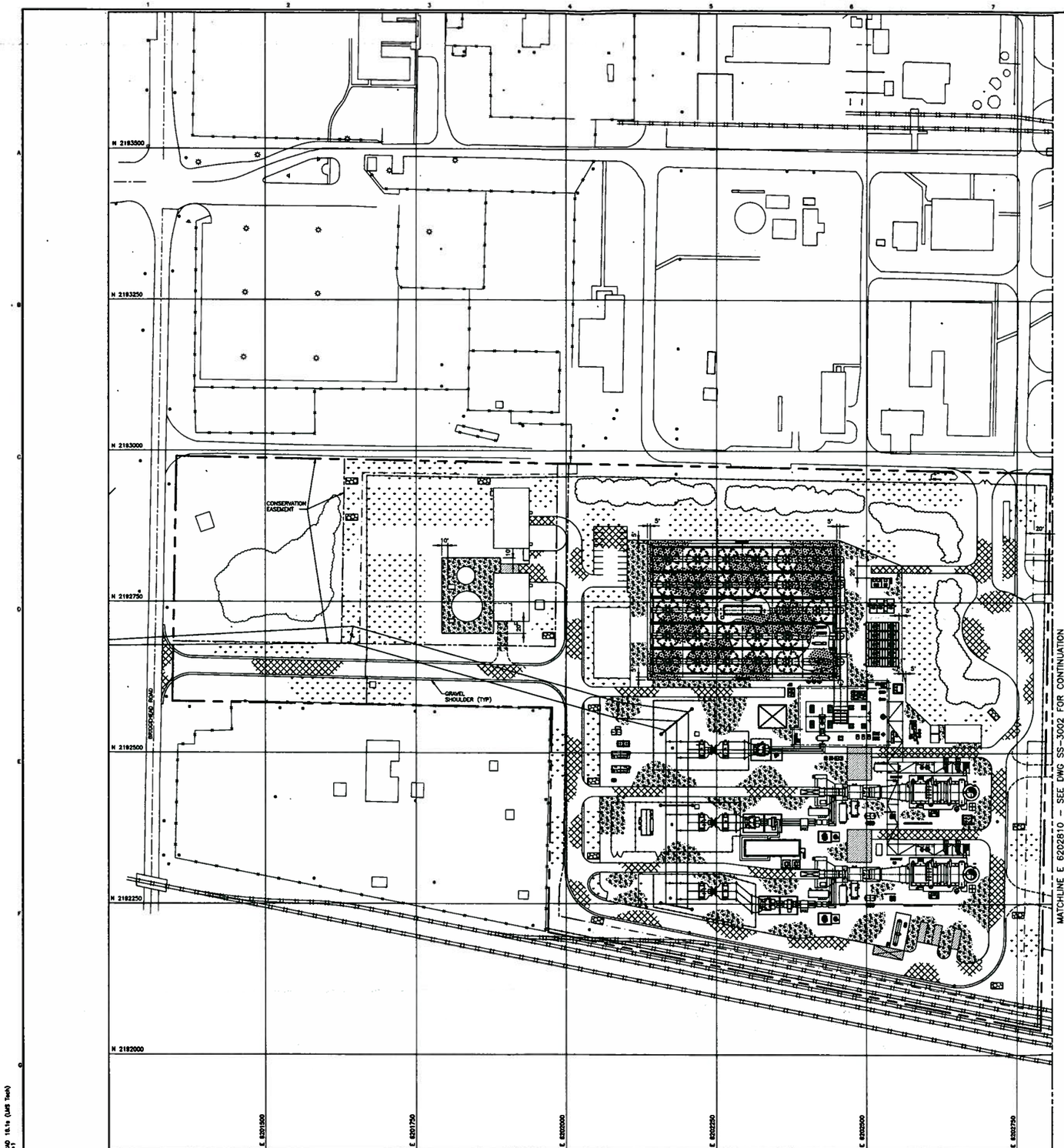
AUTHORITY 01
06/18/10 07:14:08



SITE SURFACING LEGEND

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

NOTES

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

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	ORIG	CHK	APP
0	16/APR/09	ISSUED FOR PERMITTING	MARTIN	PLASKIN	

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	MAP
CHECKED		DATE	

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SURFACING/FENCING/ROADWAY - SITE PLAN - SHEET 1

PROJECT 163994 | DRAWING NUMBER SS-3201 | REV 0
CODE
AREA

ACAD 16.1s (LMS Tech)
SPU37162 FI 1:1:20
DATA/DG/SS/SS-3201.DWG

CAK 6/15/10

pgs 5

Radback Oakley Project

163994 File # 52.5406.1008

IMP Sizing for plants area

Attachment 2

~~Black & Veatch Data~~

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

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

Equation 4-4

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

Equation 4-5

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

Equation 4-6

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

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

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

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

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

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*	*Soil Type:*	*IMP Name*			
					IMP Sizing factor	*Rain Adjust-ment Factor*	*Minimum Area or Volume*	*Proposed Area or Volume*	
			Total						*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:

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#163994 File # 52.5406.1008

IMP sizing for plant area

CAK 6/15/10

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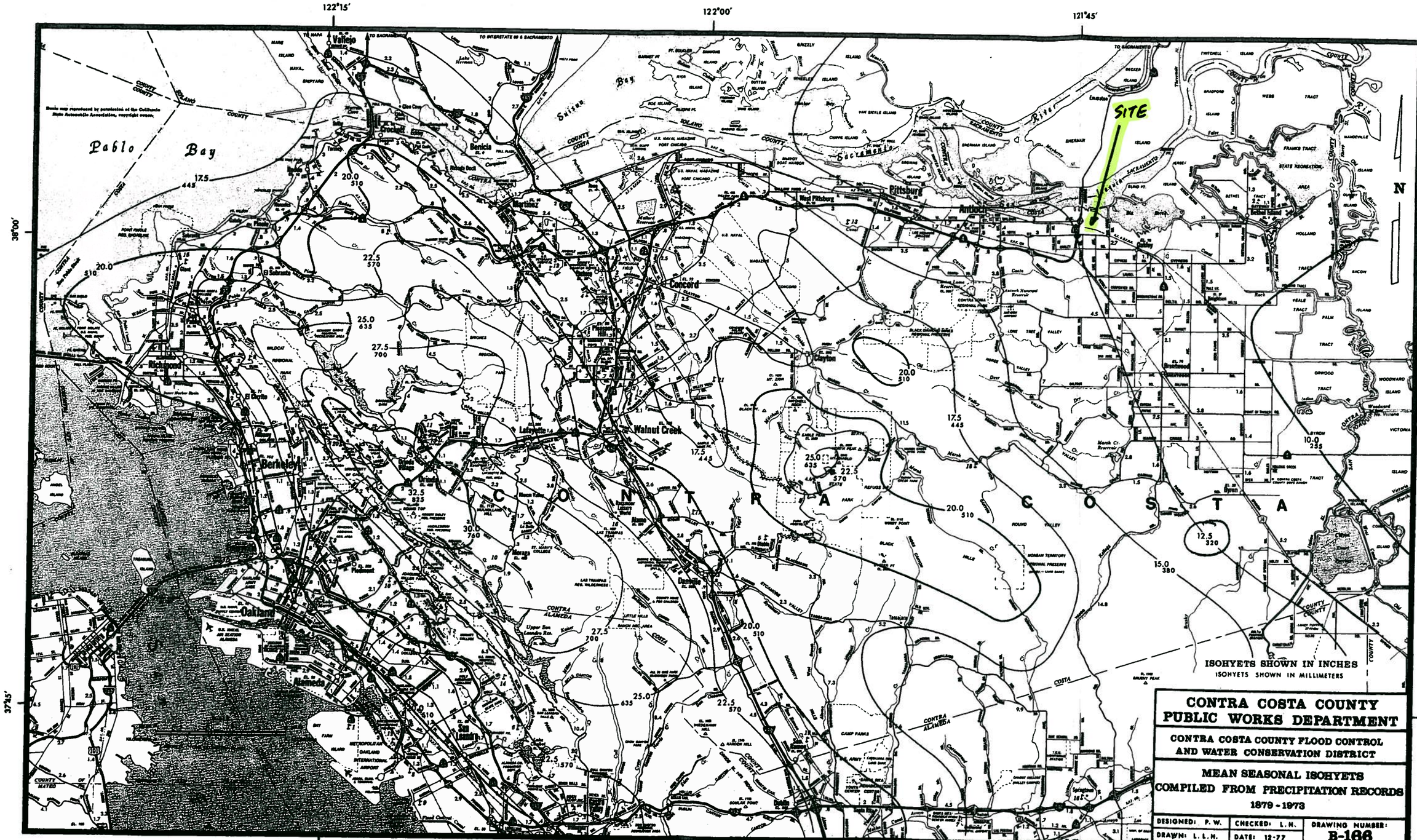
Attachment 3

Reference 3

Dwg 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:
DRAWN: L. L. H.	DATE: 12-77	B-166

Radback Oakley Project

CAK 6/15/10

163994 File # 52.5406.1008

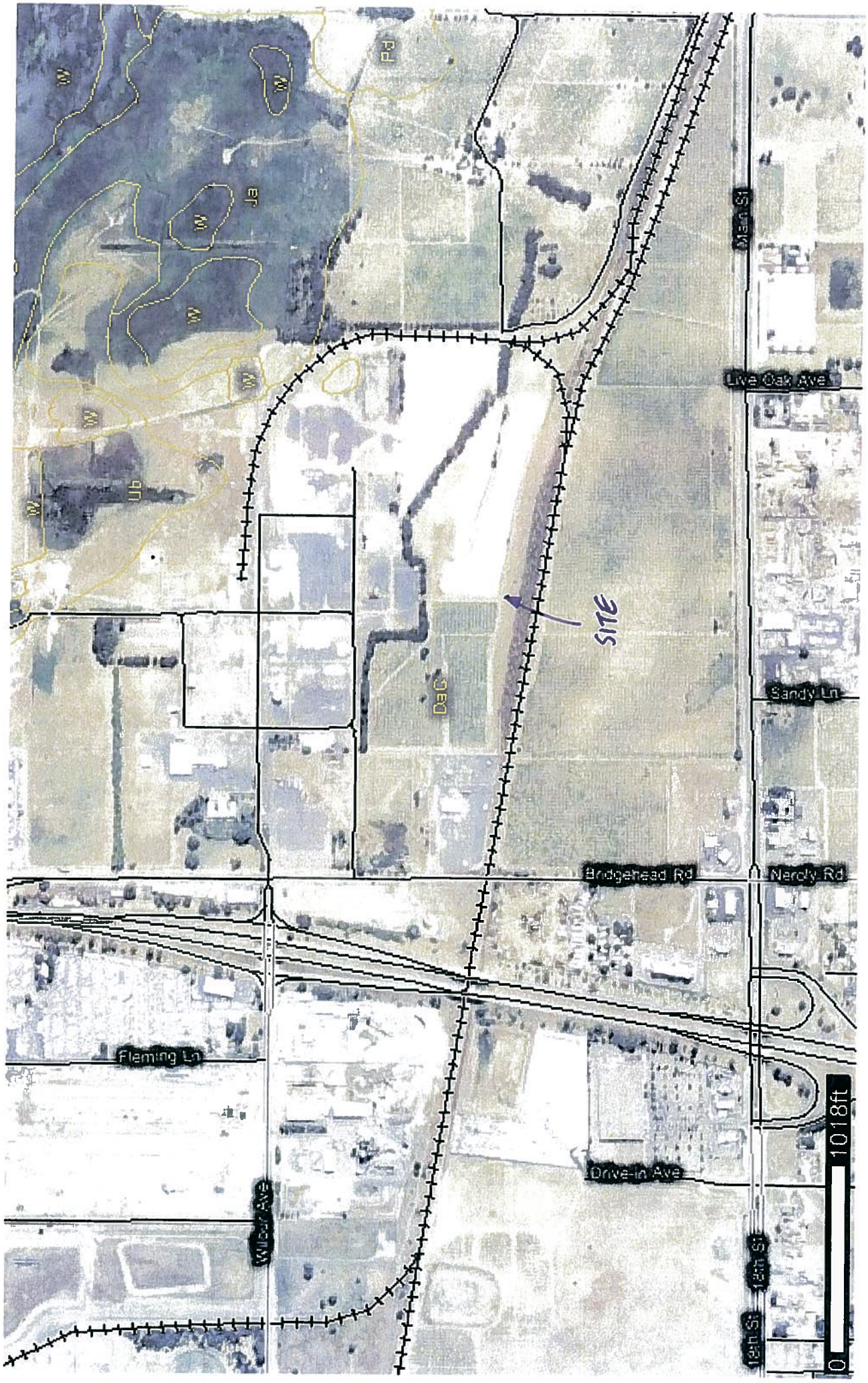
pgs 4

IMP sizing for plant area

Attachment 4

Reference 4

Select Pages



Main St
Live Oak Ave
Sandy Ln
Bridgehead Rd
Nerdy Rd
Fleming Ln
Drive-in Ave
Wilbur Ave
16th St
SITE
0
1018ft

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

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163994 File # 52.5406.1008

pgs 2

IMP Sizing for plant area

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 c siderably altered and the listed group classification no longer apply. In these circumstances, use the foll ing to determine HSG according to the texture of th new surface soil, provided that significant compacti 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, sil clay, or clay

Drainage and group D soils

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

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163994 File # 52.5406.1008

Pgs 3

IMP sizing for plant area

Attachment 6

E-Mail communication w/ 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

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

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 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

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 6/15/2010)

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*indicates change

DECLARATION OF SERVICE

I, Mary Finn, declare that on July 2, 2010, I served and filed copies of the Response to CEC Staff Workshop Queries 3 through 17. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: **[http://www.energy.ca.gov/sitingcases/contracosta/index.html].** The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(Check all that Apply)

For service to all other parties:

___ sent electronically to all email addresses on the Proof of Service list;

_____ by personal delivery;

___x__ by delivering on this date, for mailing with the United States Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses **NOT** marked "email preferred."

AND

For filing with the Energy Commission:

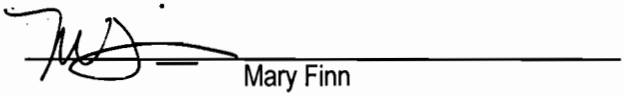
sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (preferred method);

OR

___x__ hand delivery 1 paper copy and 1 electronic copy, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 09-AFC-4
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.



Mary Finn