FINAL DESIGN
CALCULATION PACKAGE
ON-SITE DISPOSAL FACILITY
REVISION OF OSDF PHASE V
PROJECT NUMBER 20105

United States Department of Energy
Fernald Environmental Management Project
Fernald, Ohio

prepared by

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Under

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7.3 CELL 8 IMPACTED RUNOFF CATCHMENT REQUIREMENTS

COMPUTATION COVER SHEET

SUBJECT OF COMPUTATIONS CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

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ADDENDUM TO SECTION 7.2
(ADDED TO REVISION 1 PACKAGE)

The calculation package presented in Section 7.2 was prepared to establish minimum cell storage requirements for containment of impacted runoff during the filling of cells. The analyses shown in Section 7.2 are for the case where the maximum containment volume of the impacted runoff catchment area (IRCA) is limited by the minimum elevation of a rain flap installed along the intercell berm at the south edge of the IRCA. This case applies to the northernmost and interior on-site disposal facility (OSDF) cells (i.e., Cells 1 to 7). However, the southernmost OSDF cell (i.e., Cell 8) differs from the other cells in that: (i) Cell 8 has a slightly modified configuration as compared to Cells 1 to 7; (ii) Cell 8 is an end cell; and therefore, the maximum containment volume of the IRCA is limited by the minimum elevation of a rain flap installed along the Cell 8 perimeter; and (iii) the downstream cells are not available for management and containment of impacted runoff during closure of Cell 8, as was the case for prior OSDF cells, management and containment of impacted runoff is provided solely within Cell 8 until construction of the final cover system.

This addendum to Section 7.2 was prepared to verify the adequacy of the IRCA for the Cell based on the varying size of Cell 8 and to estimate the decreasing Cell 8 impacted runoff catchment area (IRCA) storage requirements as Cell 8 is progressively filled and capped during staged closure. Similar methods and input data to that used in Section 7.2 were used herein. This addendum is presented as Section 7.3 of the OSDF Final Design Calculation Package, and is entitled "Cell 8 Impacted Runoff Catchment Area Requirements". Section 7.3 is presented in Volume VII of the OSDF Final Design Calculation Package.

CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

EXECUTIVE SUMMARY

PURPOSE OF ANALYSES

The purpose of this calculation package is to demonstrate the adequacy of the Cell 8 impacted runoff catchment area (IRCA) design in providing the necessary impacted runoff storage capacity both before and during staged closure of the final cell (i.e., Cell 8). Furthermore, the package provides requirements for sizing the IRCA during final closure construction activities through use of a design chart to interpolate for cases where the capped cell area is between that of the stages of closure evaluated in this package. The flow capacity of channels discharging to the IRCA and the expected time for drawdown of impacted runoff within the IRCA are calculated to demonstrate that the design meets the required design criteria.

METHODS OF ANALYSES

The cases modeled in this package represent conditions expected to exist during the filling and staged closure of the final cell (i.e., Cell 8). Analyses are separated into three groups:

i.) evaluation of IRCA storage capacity;

ii.) evaluation of IRCA inlet channel capacity; and

iii.) evaluation of impacted runoff drawdown time.

It is important to note that non-impacted runoff is being defined as runoff from cap areas over which two lifts of compacted clay cap have been placed as a part of the final cover system. Non-impacted runoff will be diverted to the OSDF surface water management system and thus will not enter the IRCA. The term "capped" will be used to describe areas of the landfill that have received at least two lifts of compacted clay cap and where runoff has been diverted to the OSDF surface water management system, and "uncapped" will refer to areas of the landfill that discharge runoff to the IRCA.

IRCA Storage Capacity

The Cell 8 IRCA, prior to staged closure, is designed to contain the runoff from two cells (i.e., Cells 7 and 8). As shown in the construction drawings, the IRCA is designed to have a North/South dimension of 250 feet measured from the northern edge of the impacted material haul road into Cell 8 and an East/West dimension of 212 feet measured from the western side of the Cell 8 perimeter berm baseline. This geometry provides a similar IRCA plan area to those of

Cells 1 through 7 as presented in an earlier calculation package (Section 7.2, Required Cell Leachate Storage).

Three stages of IRCA filling during the staged closure are considered for evaluation. These stages and the runoff areas associated with these stages are shown in Figures 1 through 3. Figure 1 shows the IRCA geometry designed to contain the runoff for Stage I, when Cell 7 has received final cover, and approximately 30 percent of Cell 8 has received final cover. This geometry provides a smaller IRCA plan area than those of Cells 1 through 7 as presented in an earlier calculation package (Section 7.2, Required Cell Leachate Storage); however, it will be shown to provide adequate volume. The geometry of Stage I was chosen to provide a remaining impacted material placement capacity of approximately 100,000 cubic yards with an additional approximately 16,500 cubic yards of non-impacted material capacity to provide for surface water management within the cell.

Figure 2 shows an IRCA geometry designed to contain the runoff for Stage II, which provides for a remaining impacted material placement capacity of 30,000 cubic yards with up to an additional approximately 16,500 cubic yards of non-impacted material capacity to provide for surface water management within the cell. At this stage, approximately 60 percent of Cell 8 has received at least two lifts of compacted clay. Calculations showing the total impacted material remaining to be placed for Stages I and II are presented in Attachment A-4.

Figure 3 represents the case when the remaining impacted material has been placed in Cell 8 up to the estimated total impacted material capacity of Cell 8. However, at this point, the two lifts of compacted clay have not been placed, and therefore, runoff in this area is still impacted. Approximately 16,500 cubic yards of non-impacted material will be required to reach proposed final cover contouring layer grades. At this stage, approximately 90 percent of Cell 8 has received two lifts of compacted clay.

The IRCA is considered adequate if it complies with the design criteria used to evaluate the IRCAs for Cells 1 through 7 in Section 7.2, which requires the IRCA to provide storage capacity to handle the 25-year, 24-hour storm event with 0.5 ft of freeboard. Hydrologic and basin routing analyses are performed using methodologies presented in TR-20 [USDA-SCS, 1982] and TR-55 [USDA-SCS, 1986], as coded into the computer program HydroCAD™.

Channel Capacity

The required depths for channels discharging to the IRCA are evaluated for the "worst-case" scenario only (i.e., Channel B in Stage I on Figure 1). Channel B in Stage I represents the worst-case scenario in regards to the channel depth because it has the largest uncovered contributing area, resulting in the largest impacted runoff peak flow rate being routed through the channel. The channel is designed to convey peak flow rates from the 25-year, 24-hour storm event with minimum freeboard of 0.5 ft as established in the DCP [GeoSyntec, 2000]. Hydraulic analysis of this channel is performed using Manning's equation as coded into a computer spreadsheet.

Peak flow rate for the channel was taken from the HydroCAD™ output performed for the IRCA capacity calculations.

Drawdown Time

The amount of time expected for impacted runoff to drain from the IRCA after the completion of the 25-year, 24-hour storm event into the Cell 8 LCS is referred to; herein, as the drawdown time. The drawdown time is estimated for the three stages described earlier in this calculation package. The drawdown time estimated for these three stages is controlled by the fact that the flow rate is limited by the capacity of the enhanced permanent leachate transmission system (EPLTS) permanent lift station pumps. A simplified calculation was performed where the volume of the IRCA is discharged at the maximum allowable flow rate of the EPLTS permanent lift station pumps (i.e., 200 gpm).

RESULTS

Revised Phase V IRCAs and channels are designed for the 25-year, 24-hour storm event. The results are as follows:

IRCA Storage Capacity

- The Cell 8 IRCA design, prior to staged closure, provides containment for runoff from two cells (i.e., Cells 7 and 8) during the 25-year, 24 hour storm event with the required 0.5 ft of freeboard based on the Section 7.2 calculation package results.
- The calculated peak water elevation for the 25-year, 24-hour storm event allows more than 0.5 ft of freeboard from the minimum embankment crest elevation for the three staged closure cases analyzed.
- The results of the HydroCAD™ analysis of the IRCA storage capacity for the three staged closure stages analyzed are summarized in Table 8. The results show that the required IRCA storage capacity for each of the three stages analyzed for the staged closure are:

  Stage I = 62,247 ft^3;

  Stage II = 35,284 ft^3; and

  Stage III = 17,729 ft^3.

Channel Capacity

- Calculated freeboard corresponding to the peak flow rate for the inlet Channel B is greater than the minimum required freeboard of 0.5 ft.

- Calculated peak flow velocity for the unlined channel is 3.14 ft/s for Channel B in Stage I. Appropriate erosion control practices should be used by the contractor to minimize the potential for erosion.

Drawdown Time

- The estimated drawdown time for Stages I through III is limited by the capacity of the EPLTS. The EPLTS permanent lift station pumps provide a maximum allowable flow rate of 200 gpm, which results in the following approximate drawdown times:

  Stage I = 1.6 days;

  Stage II = 0.9 days; and

  Stage III = 0.5 days.

CONCLUSIONS

The purpose of this calculation package was to demonstrate the adequacy of the design in providing the necessary impacted runoff storage capacity both before and during the staged closure of the final cell (i.e., Cell 8) in the OSDF. Additionally, IRCA inlet channel capacity and IRCA drawdown time were calculated to show that the design meets the required design criteria. The following conclusions are made based on the calculations performed in this package:

- The Cell 8 IRCA design, prior to staged closure, provides adequate storage volume to contain the runoff for the 25-year, 24-hour storm event from two cells (i.e., Cells 7 and 8) based on the results from the Section 7.2 calculation package.

- The IRCAs for the three stages evaluated during staged closure provide adequate storage volume to contain the runoff for the 25-year, 24-hour storm event.

- A design chart has been prepared (Figure 4) to provide requirements for sizing the IRCA based on the uncapped area of the OSDF remaining where the capped cell area is between that of the closure stages evaluated herein.

- The temporary channels carrying the runoff into the IRCA provide adequate capacity; however, due to the flow velocities, appropriate erosion control practices should be implemented by the contractor.

- Calculation results show that the design meets the applicable design criteria; therefore, the design is considered acceptable.

CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

EXECUTIVE SUMMARY

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CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

CALCULATION PROCEDURES

INTRODUCTION AND PURPOSE

The purpose of this calculation package is to demonstrate the adequacy of the Cell 8 impacted runoff catchment area (IRCA) design in providing the necessary impacted runoff storage capacity both before and during staged closure of the final cell (i.e., Cell 8) for the on-site disposal facility (OSDF). Furthermore, the package provides requirements for sizing the IRCA during final closure construction activities through use of a design chart to interpolate for cases where the capped cell area is between that of the stages of closure evaluated in this package. Additionally, the flow capacity of channels discharging to the IRCA and the expected time for drawdown of impacted runoff within the IRCA are calculated to demonstrate that the design meets the required design criteria.

The calculations provided in this calculation package are based on the Preliminary Certified-for-Construction drawings developed as part of the Revised Phase V design. Although these drawings have been slightly modified in the Certified-for-Construction drawing package, the modifications to the drawings do not significantly influence Cell 8 staged closure grading, and therefore, do no influence the conclusions of this calculation package. Therefore, the calculations provided herein have not been modified to reflect the Certified-for-Construction drawings.

DESIGN SCENARIOS

The cases modeled in this package represent conditions expected to exist both before and during the staged closure of the final cell (i.e., Cell 8). Analyses are separated into three groups:

i.) evaluation of IRCA storage capacity;

ii.) evaluation of IRCA inlet channel capacity; and

iii.) evaluation of impacted runoff drawdown time.

It is important to note that the criteria defining non-impacted runoff has been established as runoff from cap areas over which two lifts of compacted clay cap have been placed as part of the final cover system. Non-impacted runoff will be diverted to the OSDF surface water management system and thus will not enter the IRCA. The term "capped" will be used to describe areas of the landfill that have received at least two lifts of compacted clay cap and

where runoff has been diverted to the OSDF surface water management system, and "uncapped" will refer to areas of the landfill that discharge runoff to the IRCA.

The Cell 8 IRCA, prior to staged closure, is designed to contain the runoff from two cells (i.e., Cells 7 and 8). As shown in the construction drawings, the IRCA is designed to have a North/South dimension of 250 feet measured from the northern edge of the impacted material haul road into Cell 8 and an East/West dimension of 212 feet measured from the western side of the Cell 8 perimeter berm baseline. This geometry provides a similar IRCA plan area to those of Cells 1 through 7 as presented in an earlier calculation package (Section 7.2, Required Cell Leachate Storage).

Three stages of IRCA filling during staged closure are considered for evaluation. These stages and the runoff areas associated with these stages are shown in Figures 1 through 3. Figure 1 shows the IRCA geometry designed to contain the runoff for Stage I, when Cell 7 has received final cover, and approximately 30 percent of Cell 8 has received final cover. This geometry provides a smaller IRCA plan area than those of Cells 1 through 7 as presented in an earlier calculation package (Section 7.2, Required Cell Leachate Storage); however, it will be shown to provide adequate volume. The geometry of Stage I was chosen to provide a remaining impacted material placement capacity of approximately 100,000 cubic yards with up to an additional approximately 16,5000 cubic yards of non-impacted soil capacity to provide for surface water management within the cell.

Figure 2 shows an IRCA geometry designed to contain the runoff for Stage II, which provides for a remaining impacted material placement capacity of 30,000 cubic yards with up to an additional approximately 16,500 cubic yards of non-impacted soil capacity to provide for surface water management within the cell. At this stage, approximately 60 percent of Cell 8 has received at least two lifts of compacted clay. Volume calculations estimating the capacity remaining for Stages I and II are presented in Attachment A-4.

Figure 3 represents the case when the remaining impacted material has been placed in Cell 8 up to the estimated total impacted material capacity of Cell 8. However, at this point, the two lifts of compacted clay have not been placed, and therefore, runoff in this area is still impacted. Approximately 16,500 cubic yards of non-impacted material will be required to reach proposed final cover contouring layer grades. At this stage, approximately 90 percent of Cell 8 has received two lifts of compacted clay.

IRCA Storage Capacity

The required IRCA storage capacity (estimated volume of impacted runoff), before staged closure, will be shown to be adequate for containing the volume of impacted runoff from two cells by comparing the design to the IRCA design for Cells 1 to 7. The required IRCA storage capacity will be calculated for the three stages discussed above. A comparison will be made to the actual IRCA storage capacity to show that adequate storage is provided for the IRCA geometries shown in Figures 1 through 3.

Channel Capacity

Channel capacity calculations will be performed for the most critical channel only (i.e., Channel B in Stage I) identified in Figure 1. The calculations will be performed for the geometry in Stage I, as this represents the stage with the largest uncapped area and consequently the greatest volume of runoff.

Drawdown Time

The amount of time expected for impacted runoff to drain from the IRCA after the completion of the 25-year, 24-hour storm event into the Cell 8 LCS is referred to herein as the drawdown time. An estimate of the drawdown time is made for the three stages represented in this calculation package. The estimate for the three stages is controlled by the fact that the flow rate will be limited by the allowable capacity of the enhanced permanent leachate transmission system (EPLTS) permanent lift station pumps. A simplified calculation was performed where the volume of the IRCA is discharged at the maximum allowable flowrate of the EPLTS permanent lift station pumps (i.e., 200 gpm).

METHODS OF ANALYSIS

IRCA Storage Capacity

Required IRCA storage capacity calculations are performed using methodologies presented in TR-20 [USDA-SCS, 1982] and TR-55 [USDA-SCS, 1986], as coded into the computer program HydroCAD™ [HydroCAD™, 1993]. HydroCAD™ breaks the units influencing the runoff into three types: (i) Subcatchments; (ii) Reaches; and (iii) Ponds. Different input parameters are required for each.

Certain input parameters are required for the overall analysis; these parameters include: (i) design storm event; and (ii) rainfall distribution.

The main input parameters needed for the Subcatchment subroutines include: (i) subcatchment runoff curve numbers; (ii) subcatchment areas; (iii) flow length and geometry; (iv) 2-year, 24-hour storm event; and (v) Manning's coefficient.

The main input parameters required for the Reach subroutines include: (i) channel geometry; and (ii) Manning's coefficient.

The main input parameters for the Pond subroutines include: (i) pond areas at various elevations; and (ii) properties of the outflow structures.

The values for these parameters used herein are presented in the Data Verification Section of this calculation package. Further discussion of the significance of these input parameters can be found in Section 12.4 of the Revised Final Design Calculation Package On-Site Disposal Facility entitled "OSDF-Phase IV-Surface Water Management Design".

Once the required storage capacity has been calculated for the three stages shown in the closure drawing, requirements will be provided for sizing the IRCA during the final closure construction through use of a design chart (Figure 4) to interpolate for cases where the capped area is between that of the stages analyzed in this package.

Channel Capacity

The adequacy for the hydraulic capacity of the inlet channels is evaluated in terms of an available freeboard for peak flow rates. The available freeboard is calculated as the difference between the available flow depth in the channel and the calculated peak flow depth.

The peak flow depth is calculated based on Manning's equation as coded into a computer spreadsheet. Manning's equation is as follows:

$$Q_{max} = \frac{1.49}{n} A R^{2/3} S_o^{1/2}$$

where: Q_{max} = peak flow rate (cfs);
n = Manning's roughness coefficient (dimensionless);
A = cross-sectional area of flow (ft^2);
R = hydraulic radius (ft) defined as R = A/P where P is wetted perimeter (ft);
and
S_o = longitudinal slope (rise/run).

Both A and P are functions of the peak flow depth; therefore, the equation can be used to solve for the peak flow depth.

The values for these parameters used herein are presented in the Data Verification Section of this calculation package.

Peak flow rates for Channel B of Stage I were used as inputs and were taken from the HydroCAD™ output performed for the IRCA storage capacity calculations. The minimum available flow depth is obtained directly from the construction drawings at the point that the channels flow into the IRCA.

Drawdown Time

As mentioned earlier, the drawdown time is the amount of time expected for impacted runoff associated with a 25-year, 24-hour storm event to drain from the IRCA into the Cell 8 LCS. The drawdown time may be evaluated using Darcy's Law as shown below:

$$\Delta t = \frac{\Delta V}{kiA}$$

where: Δt = incremental drawdown time (seconds);
ΔV = incremental volume change (ft^3);
k = permeability of the LCS drainage layer (ft/day);
i = hydraulic gradient (ft/ft); and
A = area perpendicular to flow (ft^2).

The drawdown time evaluated based on Darcy's Law, as noted above, is applicable to characterize liquid flow through the granular protective layer/LCS layer overlying the LCS corridor. This 'LCS corridor' drawdown time must be compared with the drawdown time associated with the allowable capacity of the EPLTS permanent lift station pumps, downstream of the LCS corridor. A simplified calculation may be performed where the volume of the IRCA is discharged at the maximum flowrate of the EPLTS permanent lift station pumps (i.e., 200 gpm). The equation below shows the formula used to calculate the 'EPLTS limited' drawdown time:

$$t = \frac{V}{Q}$$

where: t = drawdown time (days);
V = required IRCA storage capacity for a given stage (ft^3); and
Q = flow rate (gpm).

DESIGN CRITERIA

The calculations included in this package have been performed for the 25-year, 24-hour storm event as required by the Design Criteria Package (DCP) [GeoSyntec, 2000]. For the Fernald Environmental Management Project (FEMP) property, this event has a rainfall intensity of 4.7 in. [Parsons, 1995].

IRCA Storage Capacity

The Cell 8 IRCA, prior to staged closure, must be designed to contain impacted runoff from two cells during the 25-year, 24-hour storm event and shall provide at least 0.5 ft of freeboard from the minimum embankment crest elevation. The storage capacity of the IRCA will be calculated for each of the closure stages discussed and shall provide at least 0.5 ft of freeboard from the minimum embankment crest elevation.

Channel Capacity

The calculated freeboard of the channels must equal or exceed the minimum required freeboard of 0.5 ft as stated in the DCP [GeoSyntec, 2000]. The velocity of the flow within each channel will be calculated based on the assumption that the channels will be unlined. This velocity will be checked against a maximum suggested flow rate of 2.0 ft/sec for unlined channels as established in Section 7.2. If the computed flow velocity is larger than this criterion, appropriate erosion control practices will be required in the field.

Drawdown Time

The drawdown time will be calculated and the results will be reported.

REFERENCES

Applied Microcomputer Systems, *HydroCAD™ Stormwater Modeling System*, Version 3.10, Chocorua, NH, 1993.

GeoSyntec Consultants, *OSDF Final Design Criteria Package*, May 2000, Revision 1C, United States Department of Energy, Fernald Environmental Management Project, Fernald, Ohio, prepared by GeoSyntec Consultants, 2000.

Parsons, *2,000-Year Flood and Probable Maximum Flood Sitewide Flood Plain Determination*, CERCLA/RCRA Unit 2, Project Order 148, Fernald Environmental Management Project, Rev. A, Fairfield, OH, August 1995.

U.S. Department of Agriculture (USDA-SCS), *Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55)*, 2nd ed. Washington, D.C., Soil Conservation Service, 1986.

U.S. Department of Agriculture (USDA-SCS), *Technical Release Number 20 (TR-20)*, Soil Conservation Service, 1982.

CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

DATA VERIFICATION

INTRODUCTION

This section presents the selection of parameters used to perform analyses in the Calculation Results section of this calculation package. Many of these parameters have been established in earlier calculation packages; however, some are unique to this package and will be discussed in detail herein. The input parameters will be discussed in terms of the three main types of calculations being performed as part of this package.

INPUT PARAMETERS

IRCA Storage Capacity

As discussed in the Calculation Procedures section, the computer program HydroCAD™ was used to compute the required IRCA storage capacity. HydroCAD™ breaks the units influencing the runoff into three types: (i) Subcatchments; (ii) Reaches; and (iii) Ponds. Different input parameters are required for each.

Some of the input parameters are required for the overall analysis; these parameters include: (i) design storm event; and (ii) rainfall distribution. The design storm event in this analysis is the 25-year, 24-hour storm event, which has a rainfall intensity of 4.7 in. [Parsons, 1995]. The rainfall distribution for the Fernald Environmental Management Project (FEMP) property is Type II, and was established based on a chart that shows the rainfall distribution for different regions of the United States. The calculation package in Section 7.2 shows this chart.

The main input parameters needed for the Subcatchment subroutines include: (i) subcatchment runoff curve numbers; (ii) subcatchment areas; (iii) flow lengths and slopes; (iv) magnitude of precipitation from the 2-year, 24-hour storm event; and (v) Manning's coefficient. The runoff curve number for the entire OSDF was set as CN = 91 as established in Section 7.2 for a newly graded area of the soil type found at the OSDF. The subcatchment areas, flow lengths, and slopes of the flow paths were established from the construction drawings. The 2-year, 24-hour storm event has a rainfall magnitude of 2.55 in. [Parsons, 1995]. Manning's coefficient of roughness was set at 0.011 for the subcatchment areas as established in Section 7.2 for a smooth rolled surface. Tables 1 through 3 show the remaining inputs used by HydroCAD™ for the Subcatchment calculations for Stages I, II, and III.

The main input parameters required for the Reach subroutines include: (i) channel geometry; and (ii) Manning's coefficient. The channel geometry (i.e., channel side slopes, longitudinal slope, channel length, and inlet and outlet elevations) was established from the construction drawings.

Manning's coefficient was set as 0.018 as established in Section 7.2 for a straight unlined channel. However, due to the simplicity of the HydroCad models for Stages I through III, Reaches were not used. Nevertheless, the capacity of Channel B in Stage I, was verified in an Excel Spreadsheet using the flow rate input from HydroCad. Table 4 shows the geometric inputs used in HydroCAD™ for Channel B in Stage I.

The main input parameters for the Pond subroutines include: (i) pond areas for given elevations; and (ii) properties of the outflow structures. The pond areas were measured for various elevations using AutoCAD. Table 5 shows the areas measured, the cumulative storage volume, and the corresponding elevations for the IRCA in each of the three stages of the staged closure. No outflow structures were modeled in this analysis, which provides a conservative estimate of the storage capacity, since no outflow was allowed.

Additional discussion of the selection of the parameters can be found in the notes below Tables 1 through 5. The results of the analyses are presented in the Calculation Results section of this package.

Channel Capacity

As discussed in the Calculation Procedures section of this package, the peak depth of flow in Channel B during Stage I was verified. The minimum available flow depth was obtained directly from the construction drawings and is approximately 3 feet.

The parameters needed to compute the channel capacity using Manning's equation are as follows: (i) the peak flow rate, Q_{max} (cfs); (ii) Manning's coefficient, n (dimensionless); (iii) the cross-sectional area of flow, A (ft^2); (iv) the hydraulic radius, R (ft); and (v) the longitudinal slope of the channel, S_o (rise/run).

The peak flow rate for Channel B was obtained from the HydroCAD™ output performed for the IRCA storage capacity calculation for Stage I. The peak flow rate used in the analyses is 12.75 cfs.

The value used for the Manning's coefficient is 0.018. This is the same value that was used for the channels in the HydroCAD™ analysis discussed above.

The parameters A, R, and S_o are functions of the geometry of the channel and are established directly from the construction drawings. The values of the geometrical input parameters used for this calculation are shown in Table 4. The results of the analyses are presented in the Calculation Results section of this package.

Drawdown Time

As discussed in the Calculation Procedures section of this package, the 'LCS corridor' controlled drawdown time may be computed using Darcy's Law for incremental IRCA

elevations. The parameters needed for this analysis include: (i) incremental volume change, ΔV (ft); the permeability of the LCS drainage layer, k (ft/s); the hydraulic gradient, i (ft/ft); and the area perpendicular to flow, A (ft). The input values used for the drawdown analysis are shown below:

where: ΔV = varies (corresponds to the storage elevation in the IRCA according to HydroCAD™ output);

k = 0.0033 ft/s (minimum permeability of the LCS drainage and granular protective layer as required by the specifications);

i = varies (related to the storage elevation of the IRCA); and

A = 1336 ft^2 for Stage I; 1,246 ft^2 for Stage II; 340 ft^2 for Stage III.

The simplified calculation performed to provide an estimate of the drawdown times controlled by the allowable capacity of the EPLTS permanent lift station pumps requires the following input parameters: (i) volume of required IRCA storage capacity, V (ft^3); and (ii) the flow rate of the leachate, Q (gpm). The volume of required IRCA storage capacity was computed as a part of the IRCA storage capacity calculations in this calculation package. The volume of required IRCA storage capacity for the three stages is summarized in Table 6. The flow rate of the leachate is that of the EPLTS permanent lift station pumps, which has been established as 200 gpm.

REFERENCES

Parsons, *2,000-Year Flood and Probable Maximum Flood Sitewide Flood Plain Determination*, CERCLA/RCRA Unit 2, Project Order 148, Fernald Environmental Management Project, Rev. A, Fairfield, OH, August 1995.

CELL 8 IMPACTED RUNOFF CATCHMENT AREA REQUIREMENTS

CALCULATIONS

INTRODUCTION

This section presents calculations and results based on procedures and data presented in the Calculation Procedures and Data Verification sections of this calculation package. The calculations and results will be discussed for the three types of analyses performed as part of this package.

CALCULATIONS AND RESULTS

IRCA Storage Capacity

The IRCA is considered adequate if it complies with the design criteria used to evaluate the IRCAs for Cells 1 through 7 in Section 7.2, which requires the IRCA to provide storage capacity to handle the 25-year, 24-hour storm event with 0.5 ft of freeboard. Hydrologic and basin routing analyses are performed using methodologies presented in TR-20 [USDA-SCS, 1982] and TR-55 [USDA-SCS, 1986], as coded into the computer program HydroCAD™. The output from HydroCAD™ for the three stages of the staged closure can be found in Attachment A-1.

The Cell 8 IRCA, prior to staged closure, is of similar dimensions to the Cells 1 to 7 IRCA presented in an earlier calculation package (Section 7.2, Required Cell Leachate Storage). To verify that the Cell 8 IRCA would provide adequate containment, the area of Cells 7 and 8 contributing impacted runoff to the Cell 8 IRCA were compared to the area of two cells contributing impacted runoff to the other IRCAs as designed in the Section 7.2 calculation package. It is noted that the designed IRCA for Cells 1 to 7 is approximately 20 percent overdesigned (Section 7.2, Required Cell Leachate Storage). The area contributing runoff to the Cell 8 IRCA is approximately 13.6 acres. The area of two cells calculated in the Section 7.2 calculation package was 13.2 acres. Based on the similar dimensions of the IRCAs and the contributing impacted runoff areas, and the fact that the Cell 1 to 7 IRCA design is approximately 20 percent overdesigned, we conclude that the IRCA for Cell 8 is adequately sized.

This calculation provides requirements for sizing the IRCA during the final closure construction through use of a design chart (Figure 4) to interpolate for cases where the capped area is between that of the stages analyzed in this package.

The results of the IRCA Storage Capacity calculations are as follows:

- The calculated peak water elevation for the 25-year, 24-hour storm event allows more than 0.5 ft of freeboard from the minimum embankment crest elevation for the three staged closure cases analyzed.

- The results of the HydroCAD™ analyses of the IRCA storage capacity for the three stages analyzed are summarized in Table 6. The results show that the required IRCA storage capacity for each of the three stages analyzed for the staged closure are as follows:

  Stage I = 62,247 ft^3;

  Stage II = 35,284 ft^3; and

  Stage III = 17,729 ft^3.

Additionally, estimates of the volume of impacted material remaining to be placed were made for Stage I and Stage II. Calculations showing the total impacted material remaining to be placed for Stages I and II are presented in Attachment A-4. The results of these estimates are included in Table 6.

Channel Capacity

The channels are designed to safely convey peak flow rates from the 25-year, 24-hour storm event. Hydraulic analysis of Channel B in Stage I is performed using Manning's equation as coded into a computer spreadsheet. Attachment A-2 shows the detailed calculations for the channel. The results for the channel capacity are as follows:

- Calculated freeboards for the channel are greater than the minimum required freeboard of 0.5 ft.

- Calculated peak flow velocity for the unlined channels is 3.14 ft/s. Appropriate erosion control practices should be used by the contractor.

Drawdown Time

The amount of time expected for impacted runoff to drain from the IRCA after the completion of the 25-year, 24-hour storm event into the Cell 8 LCS is referred to herein as the drawdown time. An estimation of the drawdown time is made for the three stages represented in this calculation package. Analyses indicated that the estimated drawdown time for Stages I through III is limited by the capacity of the EPLTS. The EPLTS permanent lift station pumps provide a maximum flow rate of 200 gpm, which results in the following approximate drawdown times:

Stage I = 1.6 days;

Stage II = 0.9 days; and

Stage III = 0.5 days.

CONCLUSIONS

The purpose of this calculation package is to demonstrate the adequacy of the design in providing the necessary impacted runoff storage capacity both before and during staged closure of the final cell (i.e., Cell 8) in the OSDF. Additionally, IRCA inlet channel capacity and IRCA drawdown time are calculated to show that the design meets the required design criteria. The following conclusions are made based on the calculations performed in this package:

- The IRCA for Cell 8, prior to staged closure, will provide adequate containment volume for impacted runoff from the 25-year, 24-hour storm event from two cells (i.e., Cells 7 and 8) based on the Section 7.2 calculation package.
- The IRCAs for the three closure stages provide adequate storage volume to contain the runoff for the 25-year, 24-hour storm event.
- A design chart has been created (Figure 4) to offer guidance in sizing the IRCA based on the uncapped area of the OSDF between that of the stages analyzed in the calculation package.
- The temporary channels carrying the runoff into the IRCA provide adequate capacity; however, due to the flow velocities, appropriate erosion control practices should be used by the contractor.
- Calculation results show that the design meets the applicable design criteria; therefore, the design is considered acceptable.

REFERENCES

Applied Microcomputer Systems, *HydroCAD™ Stormwater Modeling System*, Version 3.10, Chocorua, NH, 1993.

GeoSyntec Consultants, *OSDF Final Design Criteria Package*, May 2000, Revision 1C, United States Department of Energy, Fernald Environmental Management Project, Fernald, Ohio, prepared by GeoSyntec Consultants, 2000.

U.S. Department of Agriculture (USDA-SCS), *Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55)*, 2nd ed. Washington, D.C., Soil Conservation Service, 1986.

U.S. Department of Agriculture (USDA-SCS), *Technical Release Number 20 (TR-20)*, Soil Conservation Service, 1982.

TABLES

Written by: Tamara E. Zettler TEZ Date: 1/21/2004 Reviewed by: KSD Date: 1/21/04

Client: Fluor Fernald, Inc. Project: OSDF Revised Phase V Project No.: GO3211 Task No.: 06

Table 1 - Input parameters describing the geometry used in the HydroCAD Subcatchment calculations for Stage I

		Sheet Flow 1[1]		Sheet Flow 2[1]		Shallow Concentrated Flow 1		Shallow Concentrated Flow 2		Shallow Concentrated Flow 3		Channel Flow				
Subcatchment Label	Area (acre)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Long. Slope (ft/ft)	Flow Depth (ft)	Left Slope (H:V)	Right Slope (H:V)
A	2.02	100	0.24	-	-	26	0.24	57	0.26	128	0.03	-	-	-	-	-
B	1.92	100	0.28	-	-	38	0.28	229	0.03	-	-	245	0.007	0.5	1.5:1	33:1
C	0.29	78	0.33	22	0.03	96	0.03	-	-	-	-	-	-	-	-	-
Pond	0.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: (1) Sheet Flow is restricted to a conservative value of 100 ft.

Table 2 - Input parameters describing the geometry used in the HydroCAD Subcatchment calculations for Stage II

		Sheet Flow 1[1]		Sheet Flow 2[1]		Shallow Concentrated Flow 1		Shallow Concentrated Flow 2		Shallow Concentrated Flow 3		Shallow Concentrated Flow 4		Channel Flow				
Subcatchment Label	Area (acre)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Long. Slope (ft/ft)	Flow Depth (ft)	Left Slope (H:V)	Right Slope (H:V)
A	1.4	79	0.25	21	0.27	50	0.27	13	0.26	59	0.03	15	0.27	-	-	-	-	-
B	0.62	91	0.33	9	0.03	138	0.03	-	-	-	-	-	-	174	0.006	0.5	1.5:1	33:1
C	0.075	45	0.33	51	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Pond	0.546	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: (1) Sheet Flow is restricted to a conservative value of 100 ft.

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Written by: Tamara E. Zettler TEZ Date: 1/21/2004 Reviewed by: KRD Date: 1/21/04

Client: Fluor Fernald, Inc. Project: OSDF Revised Phase V Project No.: GO3211 Task No.: 06

Table 3 - Input parameters describing the geometry used in the HydroCAD Subcatchment calculations for Stage III

		Sheet Flow 1[1]		Shallow Concentrated Flow 1	
Subcatchment Label	Area (ft^2)	Flow Length (ft)	Slope (ft/ft)	Flow Length (ft)	Slope (ft/ft)
A	0.981	100	0.26	34	0.26
Pond	0.331	-	-	-	-

Notes: (1) Sheet Flow is restricted to a conservative value of 100 ft.

Table 4 - Input parameters describing the geometry of the channel used to solve for the peak depth of flow within the channel

Channel Label	Longitudinal Slope (ft)	Bottom Width (ft)	Left Side Slope (H:V)	Right Side Slope (H:V)[3]
B	0.007	0	1.5:1	20:1

Notes:
(1) These inputs will be used to solve for the peak depth of flow, h, using an Excel spreadsheet.
(2) Values for the Area of Flow, A, and the Wetted Perimeter, P, are functions of the above parameters and the peak depth of flow, h.
(3) A 20H:1V slope was assumed to model a conservative scenario should the slope of the staged closure grades be modified based on available waste quantities during closure.

Table 5 - Areas and Cumulative Volume of the IRCA taken at various elevations for three stages of the closure sequence used in HydroCAD calculations

Stage I			Stage II			Stage III		
Elevation (ft)	Area (ft^2)	Cumulative Volume (cy)	Elevation (ft)	Area (ft^2)	Cumulative Volume (cy)	Elevation (ft)	Area (ft^2)	Cumulative Volume (cy)
586	1,534	0	586	1,534	0	586	566	0
587	6,703	156	587	6,548	153	587	2,396	55
588	11,132	487	588	10,971	478	588	4,704	187
589	16,127	987	589	15,960	976	589	7,579	415
590	18,823	1,629	590	18,652	1,617	590	9,714	734
591	21,325	2,373	591	21,148	2,352	591	11,979	1,136
592	23,964	3,212	592	23,782	3,185	592	14,418	1,625

Notes:
(1) The areas and volumes were computed using AutoCAD.
(2) HydroCAD uses the areas and elevations to establish the IRCA storage volume.

Table 6 - Results of IRCA Analysis

Stage	Uncapped Area (acres)	Volume of IRCA Required (acre-ft)	Volume of IRCA Required (ft^3)	Volume Provided By Design[1] (acre-ft)	Volume Provided By Design[1] (ft^3)	Peak Elevation during 25-Year Storm (ft)	IRCA Containment Elevation[2] (ft)	Volume Available for Impacted Material[3] (cy)
I	4.78	1.429	62,247	1.995	86,902	590.9	592.3	100,000
II	2.64	0.810	35,284	1.972	85,900	589.5	592.3	30,000
III	1.31	0.407	17,729	1.007	43,865	589.8	592.3	0

Notes:
(1) The reported volume was calculated assuming that the IRCA Containment Elevation was 592 ft which is 0.3 ft less than the actual containment elevation.
(2) The reported elevation corresponds to 0.5 ft of freeboard.
(3) Volumes of Impacted Material are estimates for information purposes only, the contractor should perform a detailed quantity calculation should exact quantities be required. The computations can be found in Attachment A-4.

FIGURES

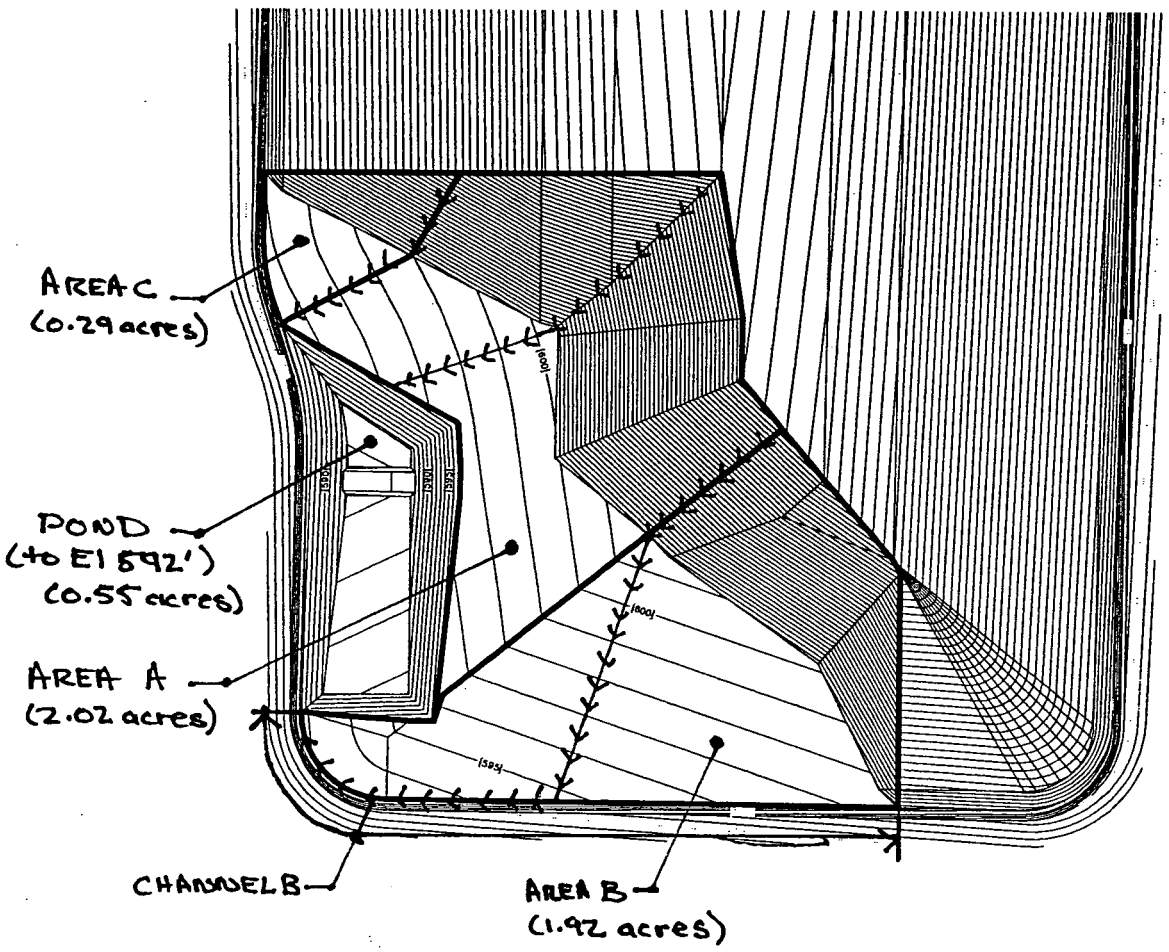


Figure 1 – Stage I (Not to Scale)

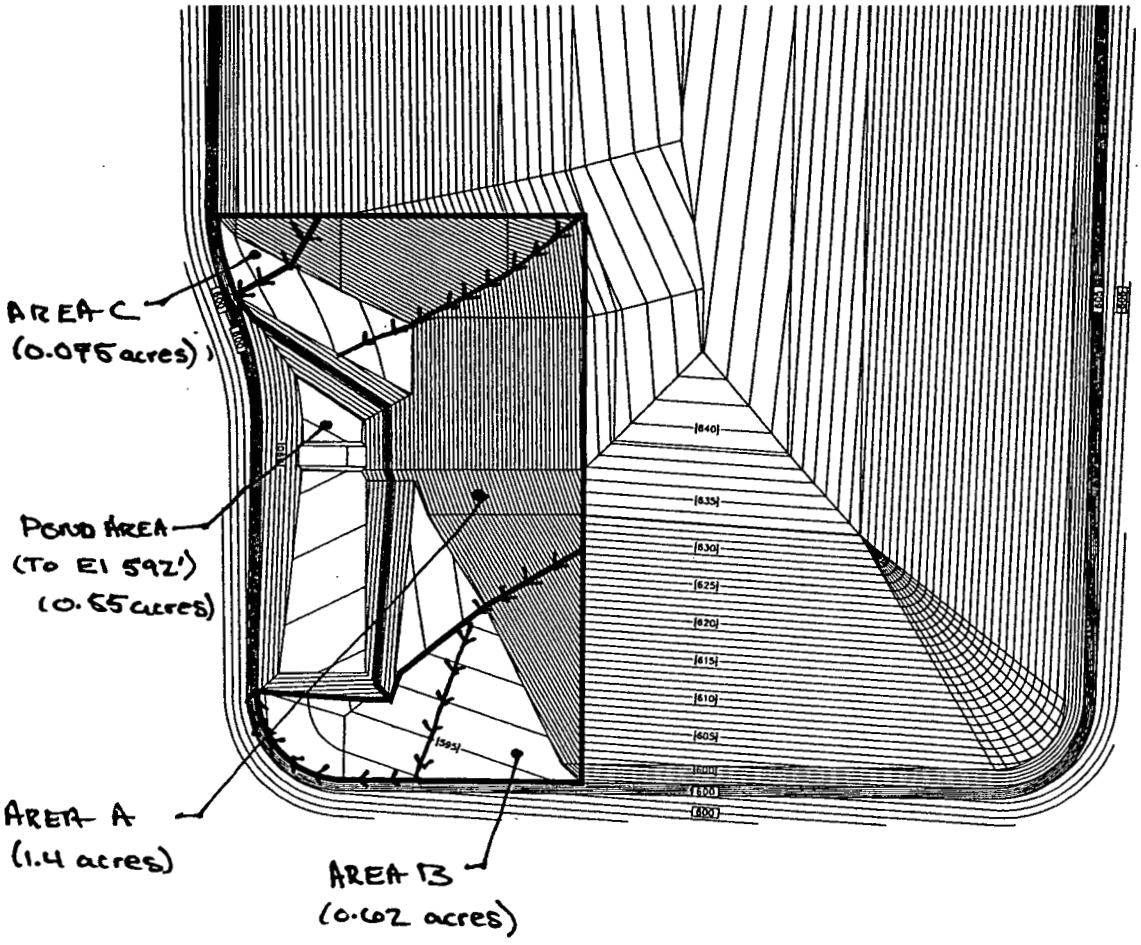


Figure 2 – Stage II (Not to Scale)

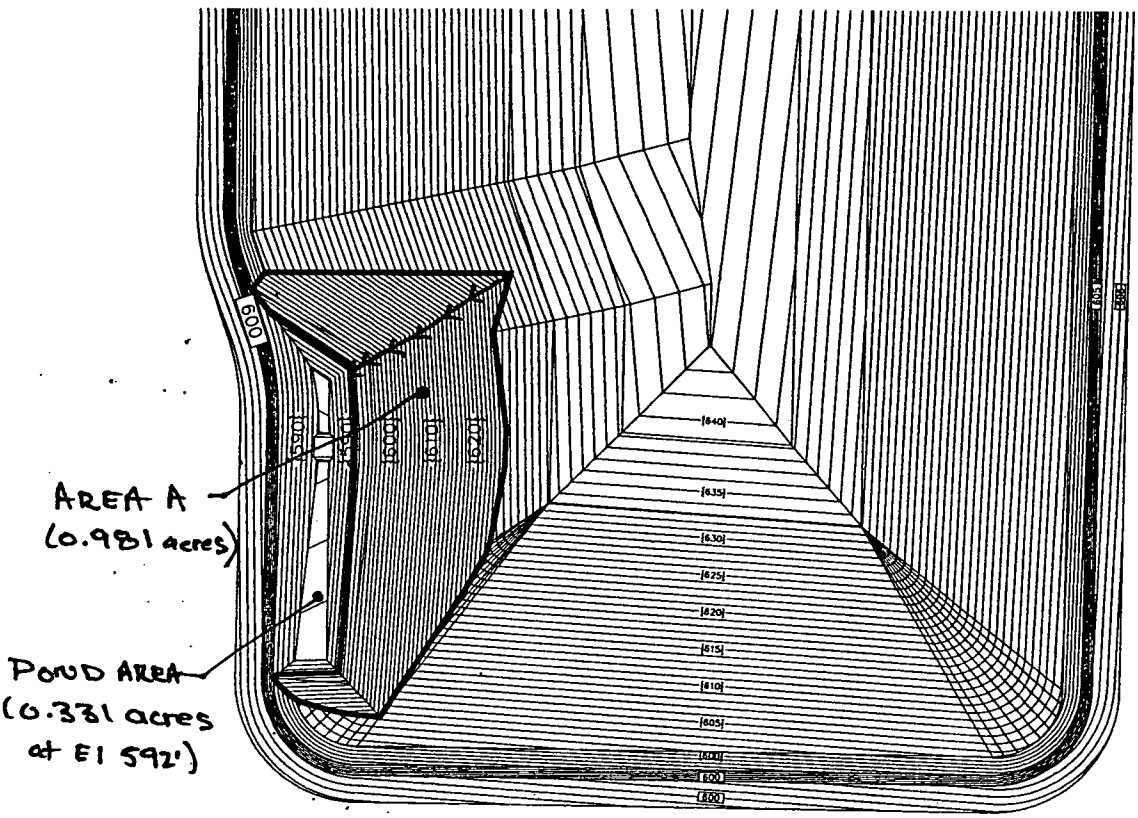
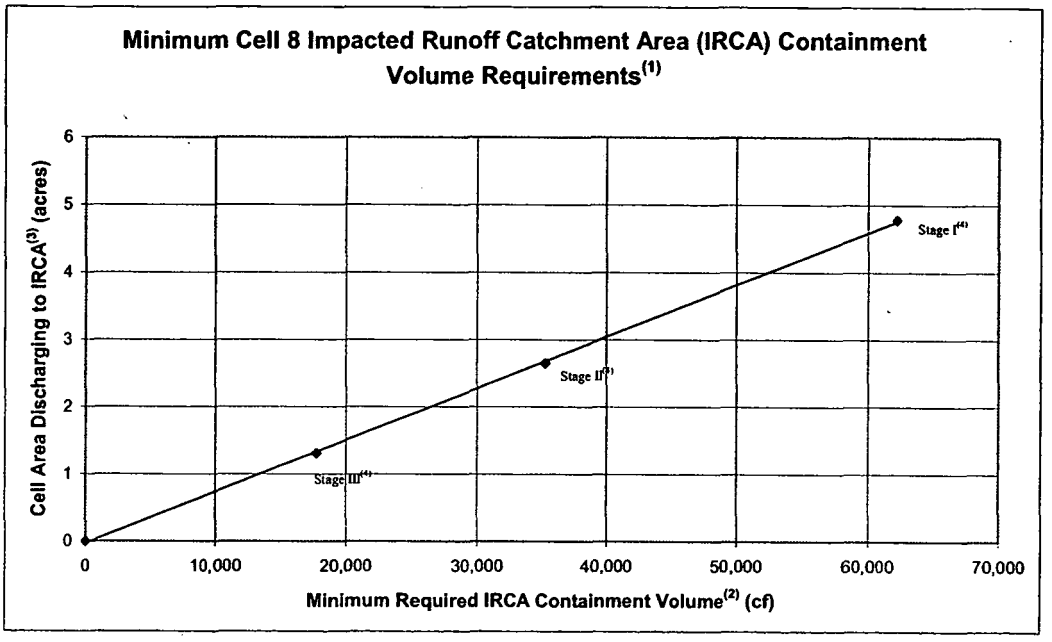


Figure 3 – Stage III (Not to Scale)



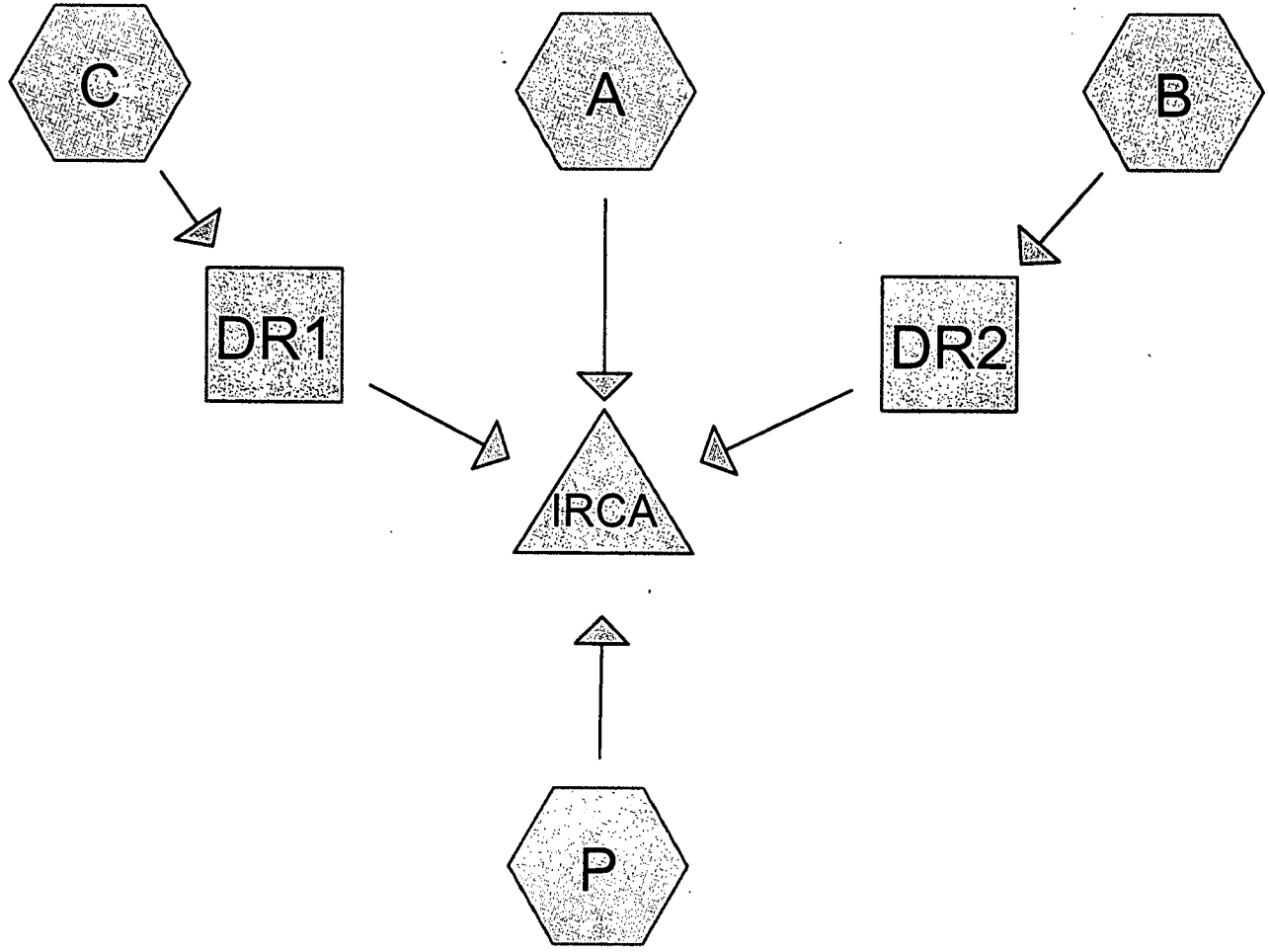
Notes: (1) Minimum required IRCA containment volumes correspond to estimated runoff from cell area discharging to IRCA as computed using HydroCAD.
(2) Minimum required IRCA containment volumes do not include freeboard.
(3) Cell area discharging to IRCA includes area of IRCA.
(4) Stages shown are as indicated on construction drawings.

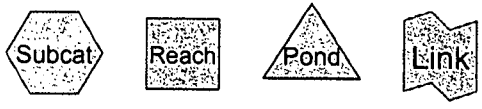
Figure 4 – Design Chart for Sizing IRCA

ATTACHMENT A-1

IRCA CAPACITY CALCULATIONS
HYDROCAD OUTPUT

STAGE I CALCULATION





Drainage Diagram for Cell 8_Stagel
Prepared by GeoSyntec Consultants 1/21/2004
HydroCAD® 6.00 s/n 000929 © 1986-2001 Applied Microcomputer Systems

JEZ 1/21/04 KD 1/21/04 35/73

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Time span=0.00-20.00 hrs, dt=0.01 hrs, 2001 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: Area A
Tc=1.5 min CN=91 Area=2.020 ac Runoff= 14.28 cfs 0.584 af

Subcatchment B: Area B
Tc=3.5 min CN=91 Area=1.920 ac Runoff= 12.75 cfs 0.555 af

Subcatchment C: Area C
Tc=1.3 min CN=91 Area=0.290 ac Runoff= 2.06 cfs 0.084 af

Subcatchment P: Pond Area
Tc=0.0 min CN=100 Area=0.550 ac Runoff= 4.40 cfs 0.205 af

Reach DR1: Dummy Reach
Inflow= 2.06 cfs 0.084 af
Outflow= 2.06 cfs 0.084 af

Reach DR2: Dummy Reach
Inflow= 12.75 cfs 0.555 af
Outflow= 12.75 cfs 0.555 af

Pond IRCA: Detention Pond
Peak Storage= 1.429 af Inflow= 32.09 cfs 1.429 af
Outflow= 0.00 cfs 0.000 af

Runoff Area = 4.780 ac Volume = 1.429 af Average Depth = 3.59"

JEZ 1/21/04 KSD 1/21/04

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Subcatchment A: Area A

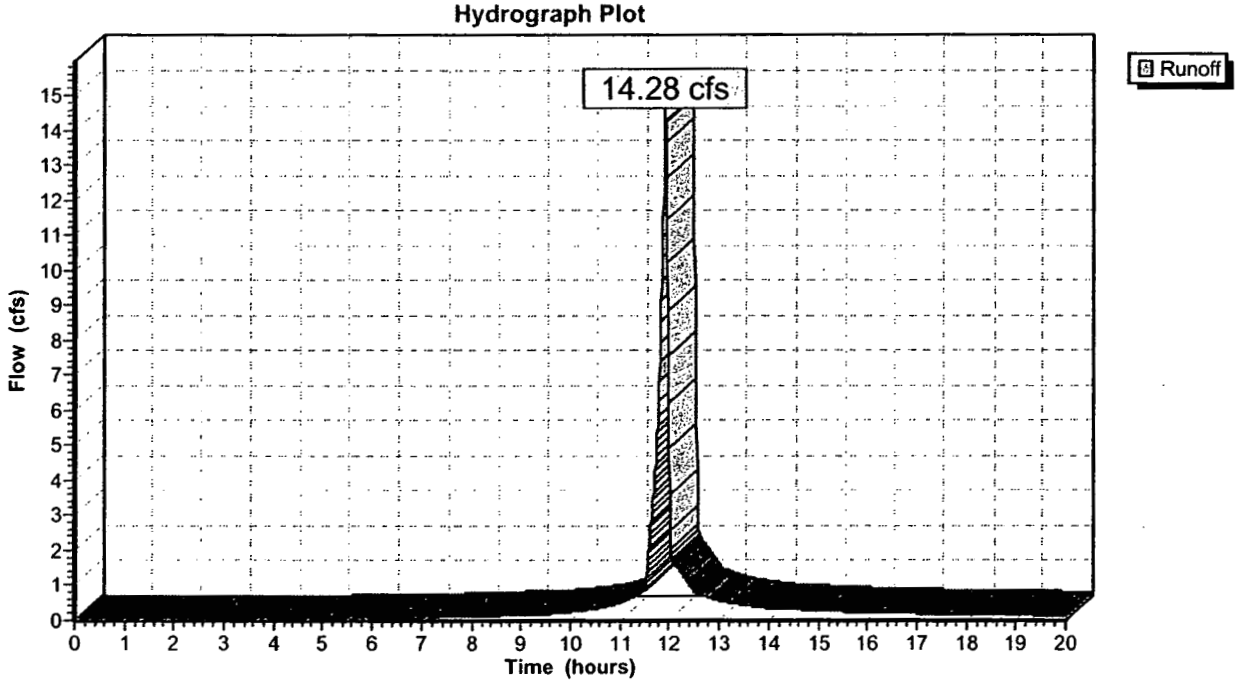
Runoff = 14.28 cfs @ 11.92 hrs, Volume= 0.584 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.020	91	Total Sideslope Area A

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	100	0.2400	3.3		**Sheet Flow, Segment A-1** Smooth surfaces n= 0.011 P2= 2.55"
0.1	26	0.2400	7.9		**Shallow Concentrated Flow, Segment A-2** Unpaved Kv= 16.1 fps
0.1	57	0.2600	8.2		**Shallow Concentrated Flow, Segment A-3** Unpaved Kv= 16.1 fps
0.8	128	0.0300	2.8		**Shallow Concentrated Flow, Segment A-4** Unpaved Kv= 16.1 fps
1.5	311	Total			

Subcatchment A: Area A



TEZ 1/21/04 KAD 1/21/04

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Subcatchment B: Area B

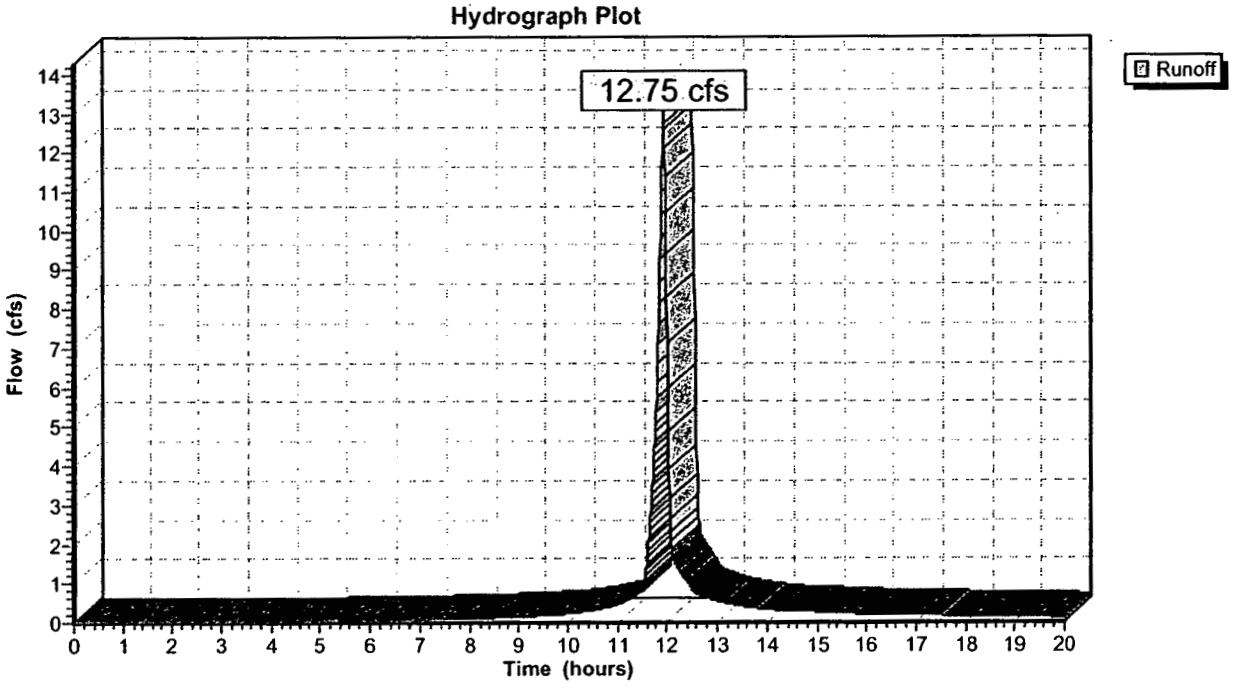
Runoff = 12.75 cfs @ 11.94 hrs, Volume= 0.555 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.920	91	Total Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	100	0.2800	3.5		**Sheet Flow, Segment B-1** Smooth surfaces n= 0.011 P2= 2.55"
0.1	38	0.2800	8.5		**Shallow Concentrated Flow, Segment B-3** Unpaved Kv= 16.1 fps
1.4	229	0.0300	2.8		**Shallow Concentrated Flow, Segment B-3** Unpaved Kv= 16.1 fps
1.5	245	0.0070	2.7	11.85	**Trap/Vee/Rect Channel Flow, Channel B** Bot.W=0.00' D=0.50' Z= 33.3 & 1.5 '/' n= 0.018
3.5	612	Total			

Subcatchment B: Area B



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Subcatchment C: Area C

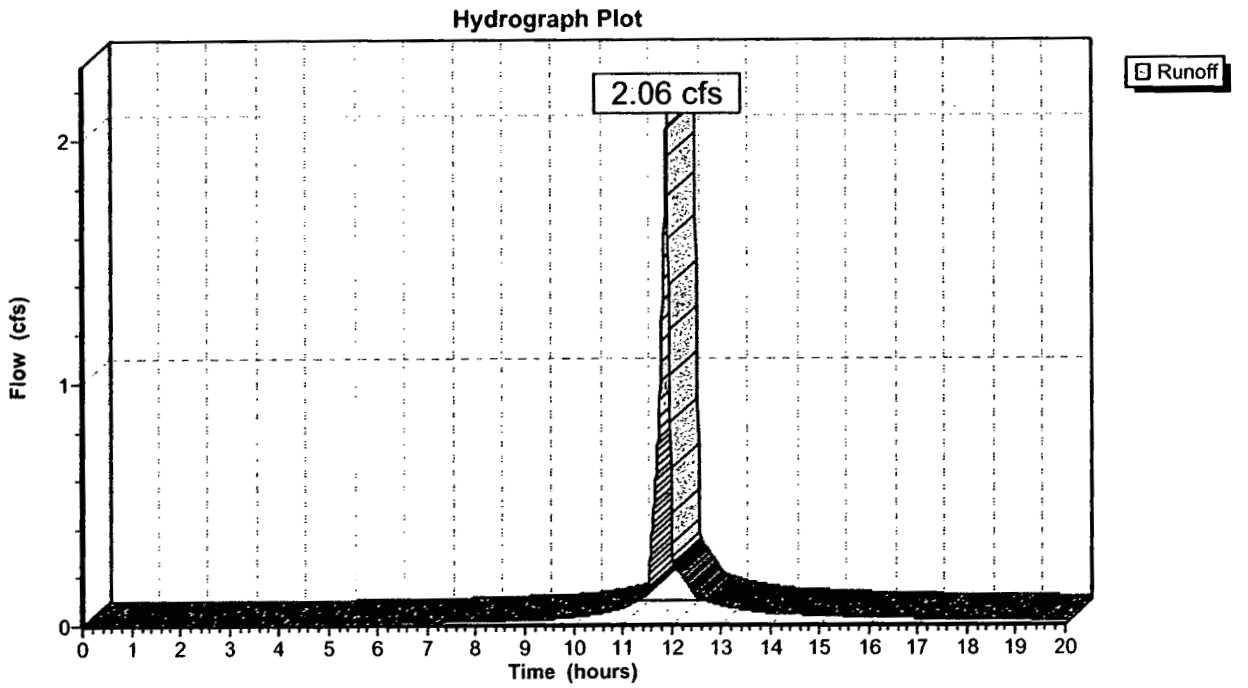
Runoff = 2.06 cfs @ 11.92 hrs, Volume= 0.084 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.290	91	Total Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	78	0.3300	3.6		**Sheet Flow, Segment C-1** Smooth surfaces n= 0.011 P2= 2.55"
0.3	22	0.0300	1.1		**Sheet Flow, Segment C-2** Smooth surfaces n= 0.011 P2= 2.55"
0.6	96	0.0300	2.8		**Shallow Concentrated Flow, Segment C-3** Unpaved Kv= 16.1 fps
1.3	196	Total			

Subcatchment C: Area C



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Subcatchment P: Pond Area

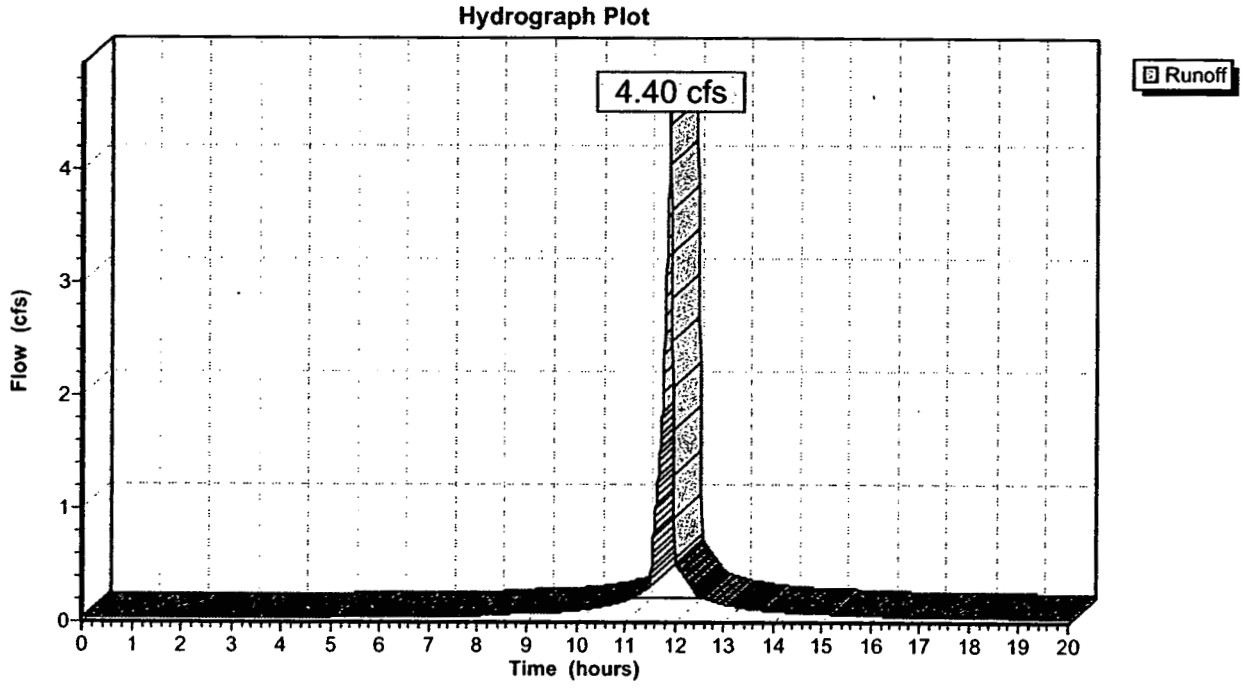
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 4.40 cfs @ 11.90 hrs, Volume= 0.205 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.550	100	Pond Area

Subcatchment P: Pond Area



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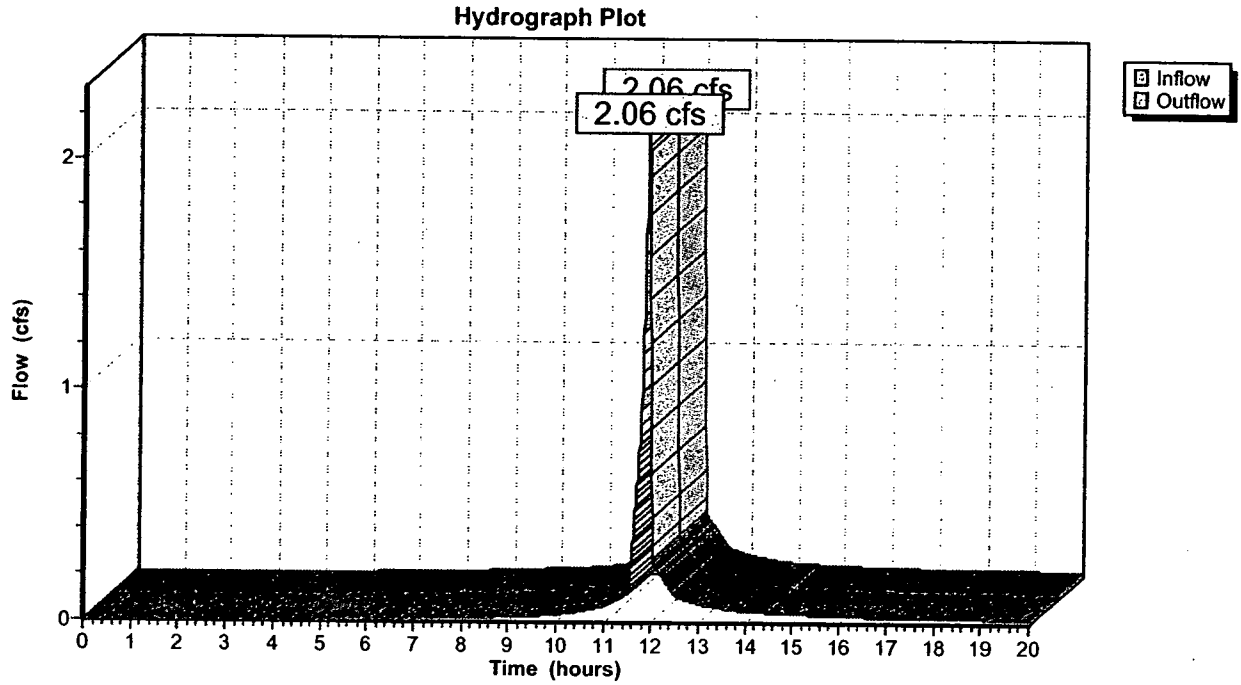
Reach DR1: Dummy Reach

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	2.06 cfs @	11.92 hrs,	Volume=	0.084 af
Outflow	=	2.06 cfs @	11.92 hrs,	Volume=	0.084 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Reach DR1: Dummy Reach



TEB 1/28/04 KDD 1/21/04 41/73 5316

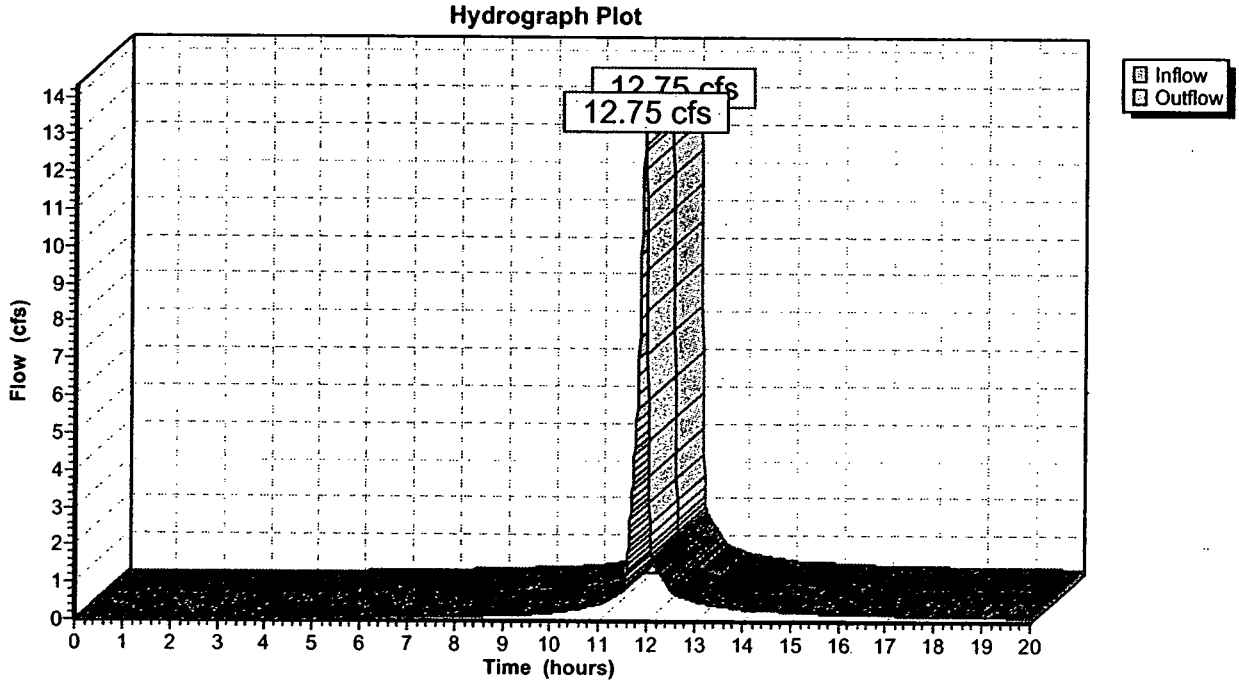
Reach DR2: Dummy Reach

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	12.75 cfs @ 11.94 hrs,	Volume=	0.555 af
Outflow	=	12.75 cfs @ 11.94 hrs,	Volume=	0.555 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Reach DR2: Dummy Reach



TE3 1/21/04 1/21/04 42-73 5316

Pond IRCA: Detention Pond

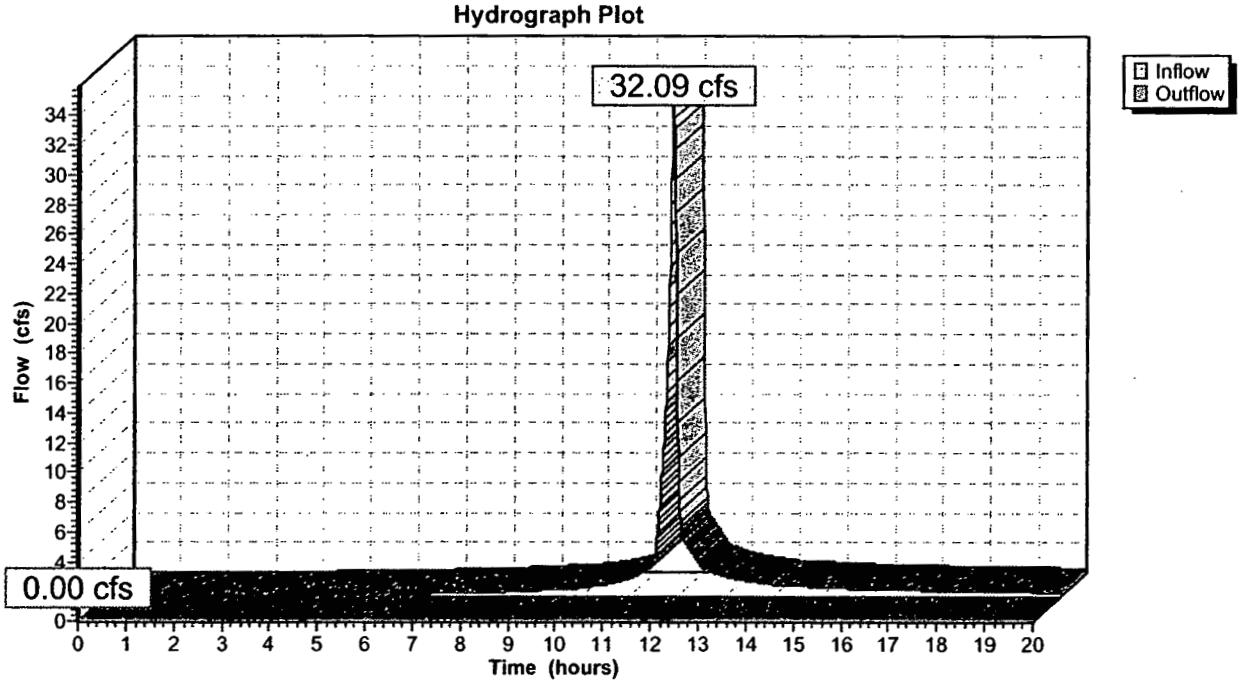
Inflow = 32.09 cfs @ 11.92 hrs, Volume= 1.429 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Peak Elev= 590.90' Storage= 1.429 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Prismatic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
586.00	0.035	0.000	0.000
587.00	0.154	0.095	0.095
588.00	0.256	0.205	0.300
589.00	0.370	0.313	0.612
590.00	0.432	0.401	1.013
591.00	0.490	0.461	1.475
592.00	0.550	0.520	1.995

Pond IRCA: Detention Pond



STAGE II CALCULATION

TEZ 1/21/04 KD 1/21/04

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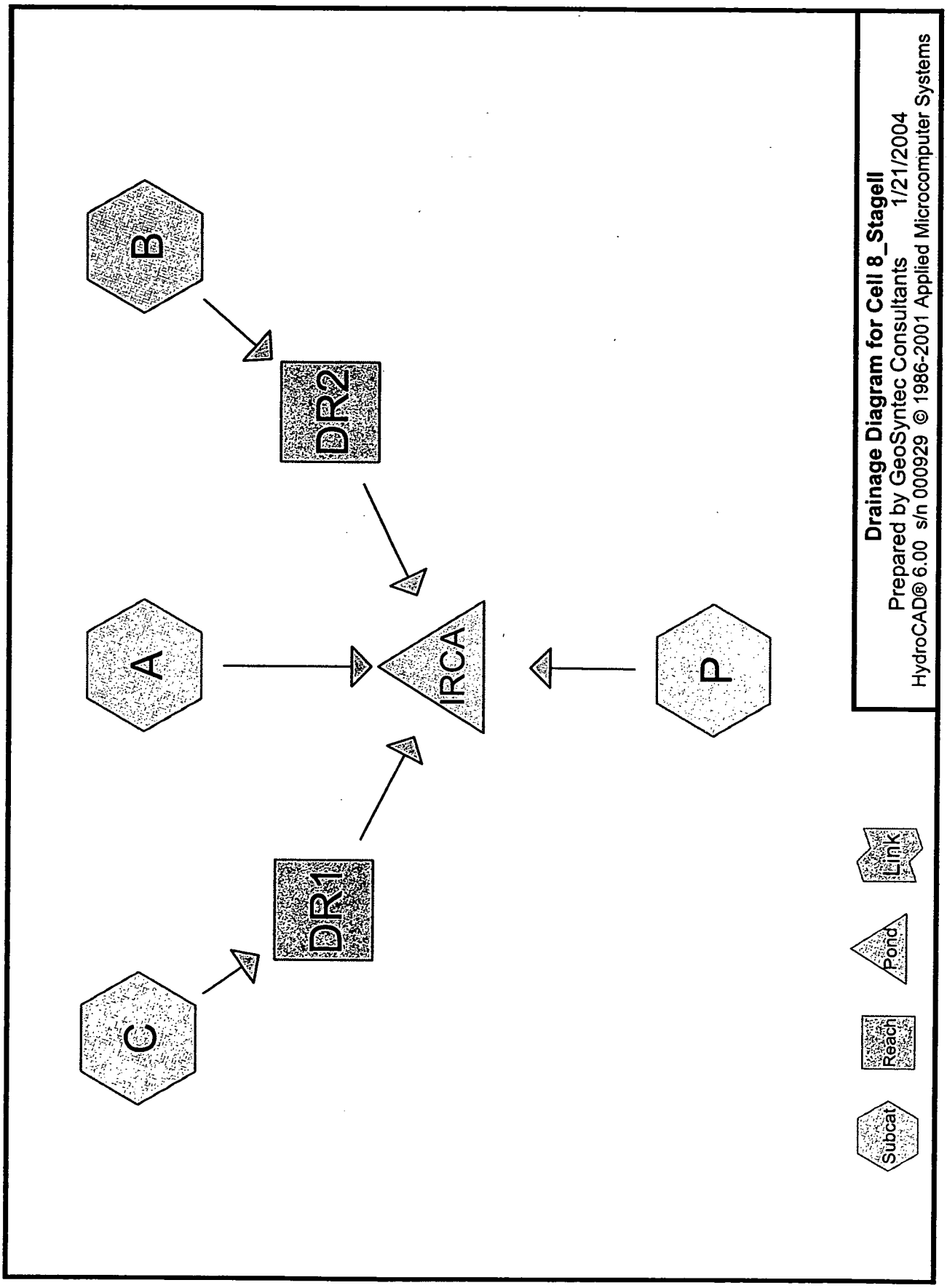

Drainage Diagram for Cell 8_Stagell
Prepared by GeoSyntec Consultants 1/21/2004
HydroCAD® 6.00 s/n 000929 © 1986-2001 Applied Microcomputer Systems

TEZ 1/21/04 KJD 1/21/04

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Time span=0.00-20.00 hrs, dt=0.01 hrs, 2001 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: Area A
Tc=1.0 min CN=91 Area=1.400 ac Runoff= 10.03 cfs 0.405 af

Subcatchment B: Area B
Tc=2.5 min CN=91 Area=0.620 ac Runoff= 4.25 cfs 0.179 af

Subcatchment C: Area C
Tc=0.9 min CN=91 Area=0.075 ac Runoff= 0.54 cfs 0.022 af

Subcatchment P: Pond Area
Tc=0.0 min CN=100 Area=0.546 ac Runoff= 4.37 cfs 0.204 af

Reach DR1: Dummy Reach
Inflow= 0.54 cfs 0.022 af
Outflow= 0.54 cfs 0.022 af

Reach DR2: Dummy Reach
Inflow= 4.25 cfs 0.179 af
Outflow= 4.25 cfs 0.179 af

Pond IRCA: Detention Pond
Peak Storage= 0.810 af Inflow= 18.62 cfs 0.810 af
Outflow= 0.00 cfs 0.000 af

Runoff Area = 2.641 ac Volume = 0.810 af Average Depth = 3.68"

7E3 1/21/04 KRD 1/21/04 46/73 5316

Subcatchment A: Area A

[49] Hint: Tc<2dt may require smaller dt

Runoff = 10.03 cfs @ 11.91 hrs, Volume= 0.405 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.400	91	Total Sideslope Area A

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	79	0.2500	3.2		**Sheet Flow, Segment A-1** Smooth surfaces n= 0.011 P2= 2.55"
0.1	21	0.2700	2.5		**Sheet Flow, Segment A-2** Smooth surfaces n= 0.011 P2= 2.55"
0.1	50	0.2700	8.4		**Shallow Concentrated Flow, Segment A-3** Unpaved Kv= 16.1 fps
0.0	13	0.2600	8.2		**Shallow Concentrated Flow, Segment A-4** Unpaved Kv= 16.1 fps
0.4	59	0.0300	2.8		**Shallow Concentrated Flow, Segment A-5** Unpaved Kv= 16.1 fps
0.0	15	0.2700	8.4		**Shallow Concentrated Flow, Segment A-6** Unpaved Kv= 16.1 fps
1.0	237	Total			

TEJ 1/21/04 KD 1/21/04

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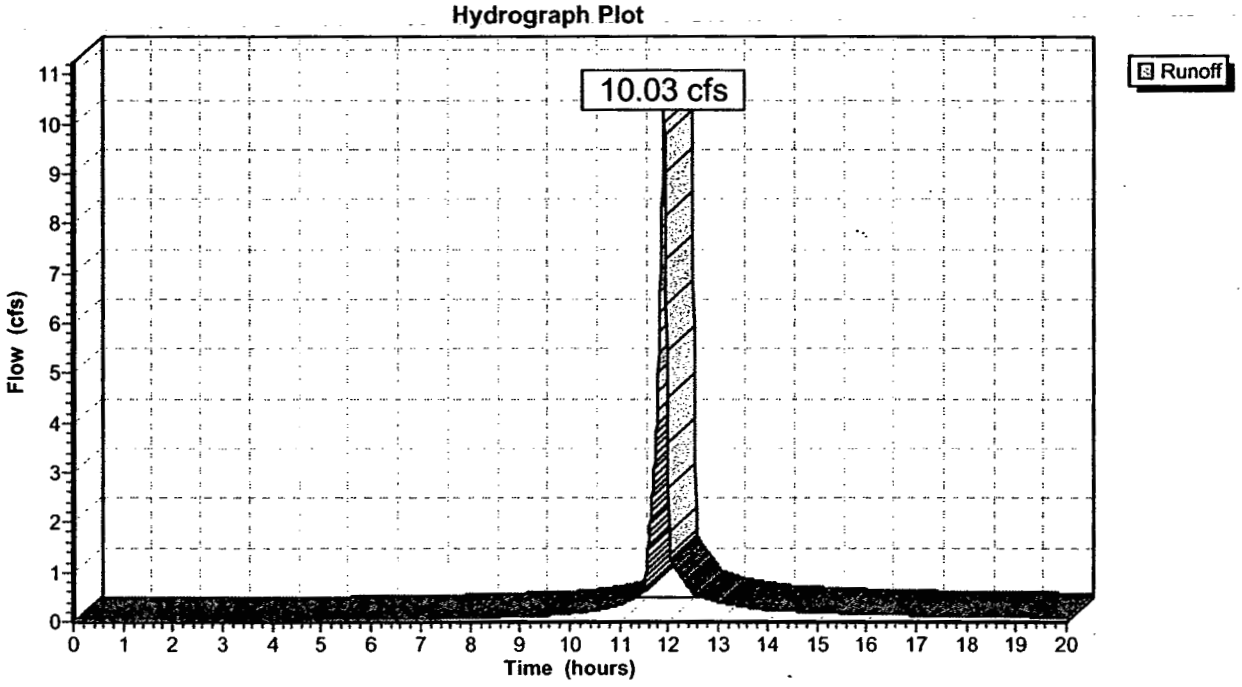
Subcatchment A: Area A



TEZ 1/21/04 KD 1/21/04 48/73

5316

Subcatchment B: Area B

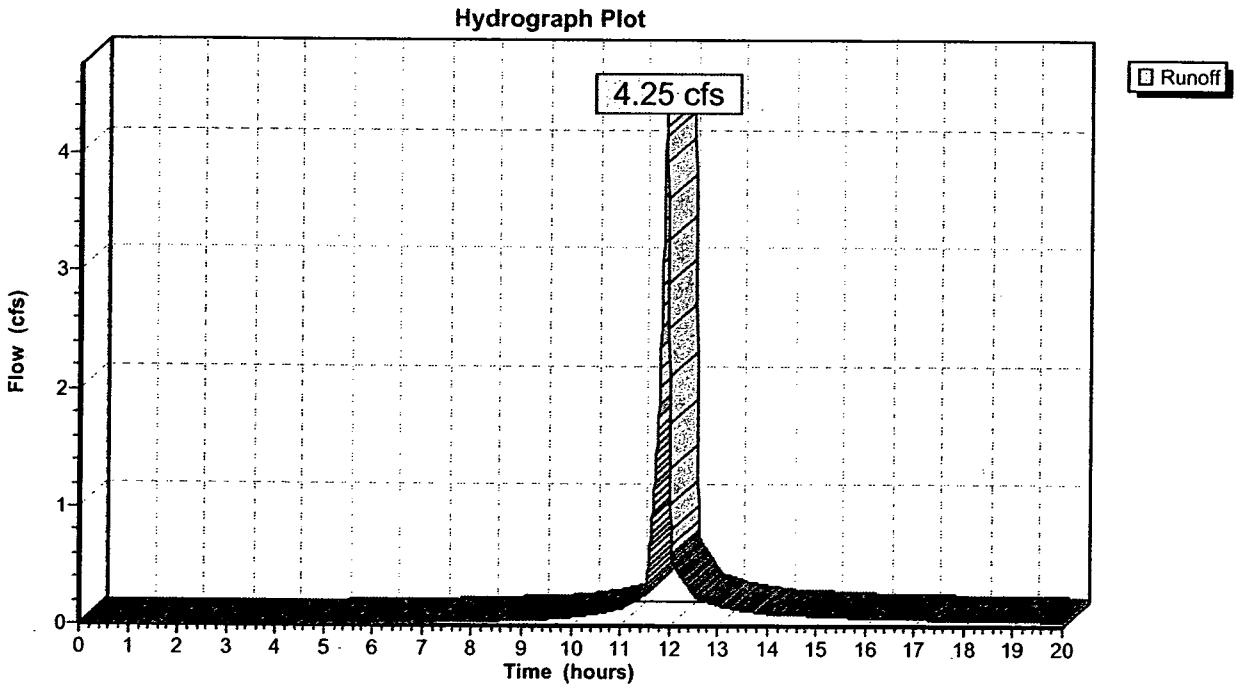
Runoff = 4.25 cfs @ 11.93 hrs, Volume= 0.179 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.620	91	Total Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	91	0.3300	3.7		**Sheet Flow, Segment B-1** Smooth surfaces n= 0.011 P2= 2.55"
0.2	9	0.0300	0.9		**Sheet Flow, Segment B-2** Smooth surfaces n= 0.011 P2= 2.55"
0.8	138	0.0300	2.8		**Shallow Concentrated Flow, Segment B-3** Unpaved Kv= 16.1 fps
1.1	174	0.0060	2.5	10.97	**Trap/Vee/Rect Channel Flow, Channel B** Bot.W=0.00' D=0.50' Z= 1.5 & 33.3 '/' n= 0.018
2.5	412	Total			

Subcatchment B: Area B



TEZ 1/21/04 KD 1/21/04

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Subcatchment C: Area C

[49] Hint: Tc<2dt may require smaller dt

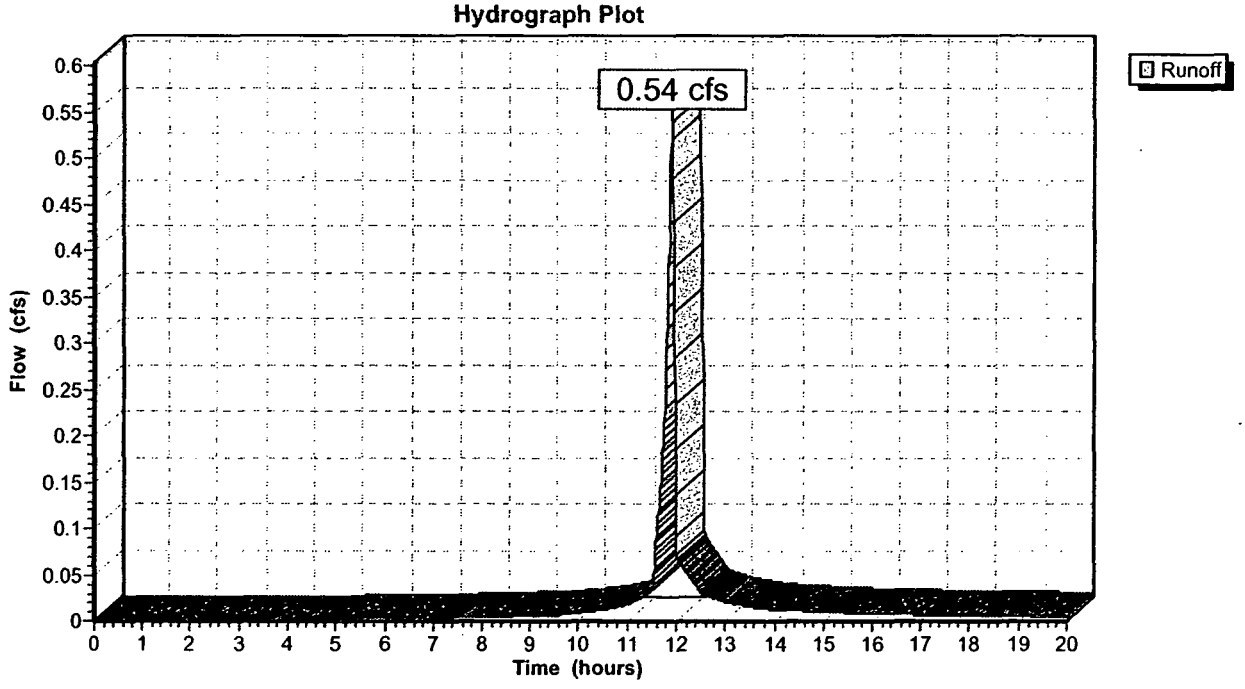
Runoff = 0.54 cfs @ 11.91 hrs, Volume= 0.022 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.075	91	Total Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	45	0.3300	3.2		**Sheet Flow, Segment C-1** Smooth surfaces n= 0.011 P2= 2.55"
0.7	51	0.0300	1.3		**Sheet Flow, Segment C-2** Smooth surfaces n= 0.011 P2= 2.55"
0.9	96	Total			

Subcatchment C: Area C



783 1/21/04 KJD 1/21/04 50 173

5316

Subcatchment P: Pond Area

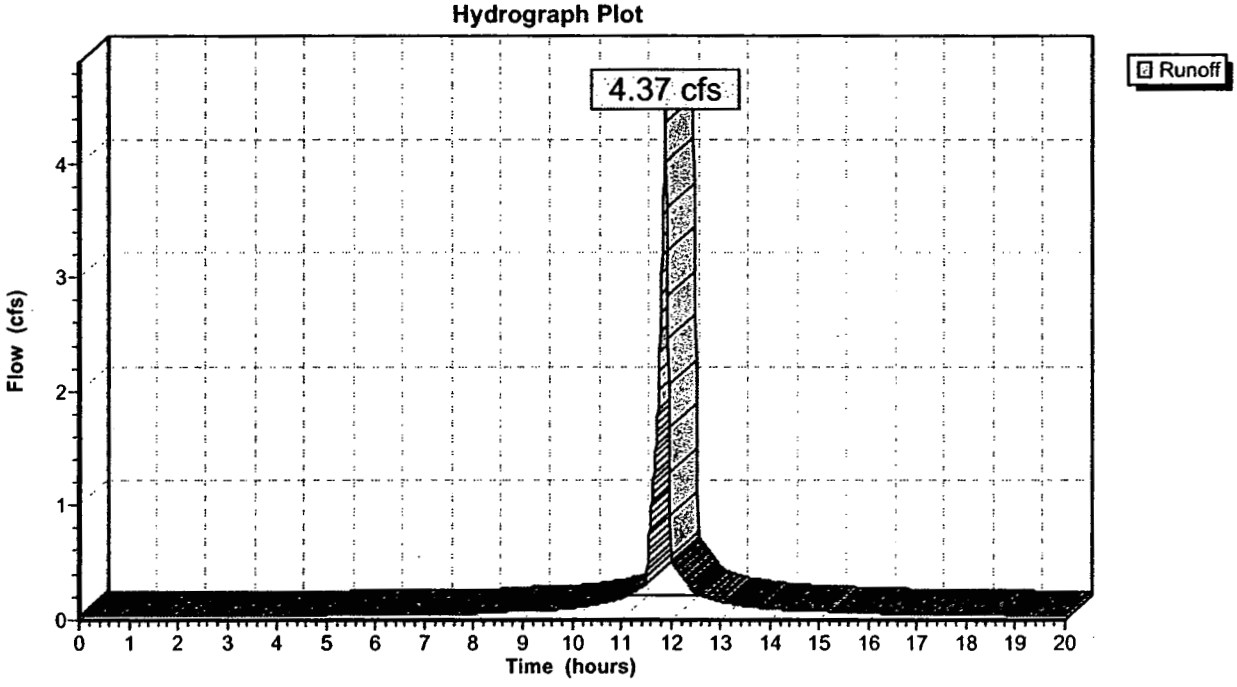
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 4.37 cfs @ 11.90 hrs, Volume= 0.204 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.546	100	Pond Area

Subcatchment P: Pond Area



TKZ 1/21/04 KJB 1/21/04

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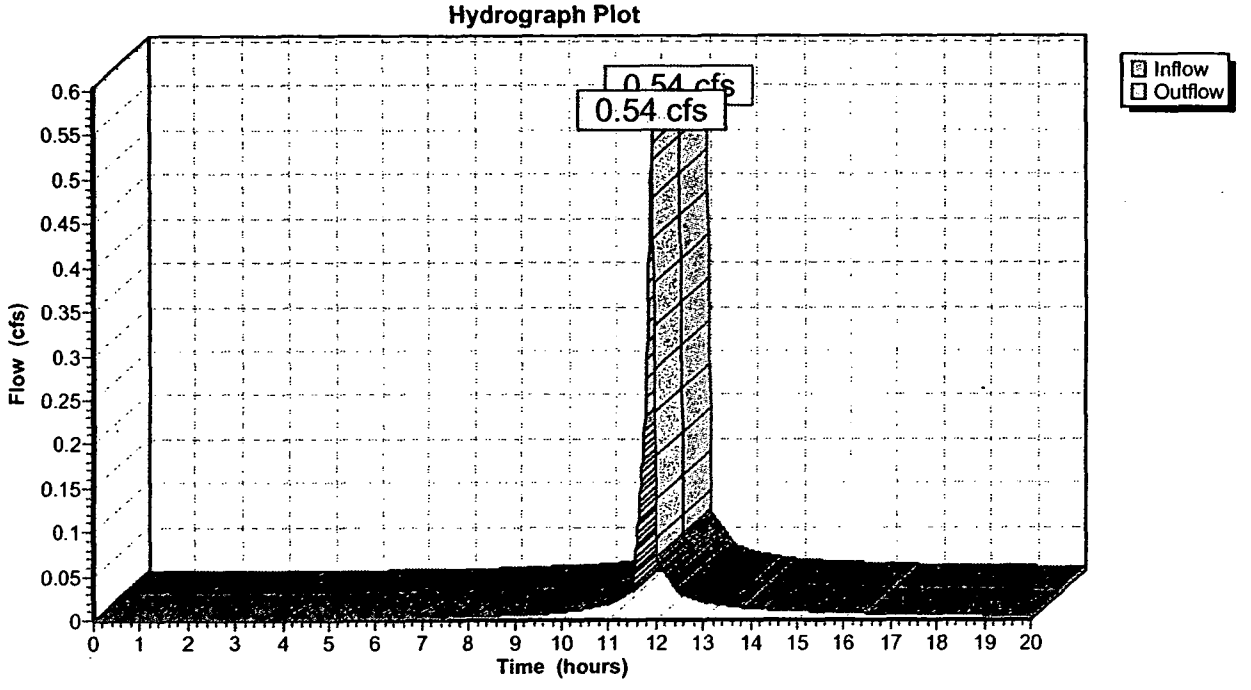
Reach DR1: Dummy Reach

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	0.54 cfs @	11.91 hrs, Volume=	0.022 af	
Outflow	=	0.54 cfs @	11.91 hrs, Volume=	0.022 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Reach DR1: Dummy Reach



TZ3 1/21/04 1/21/04 52/73

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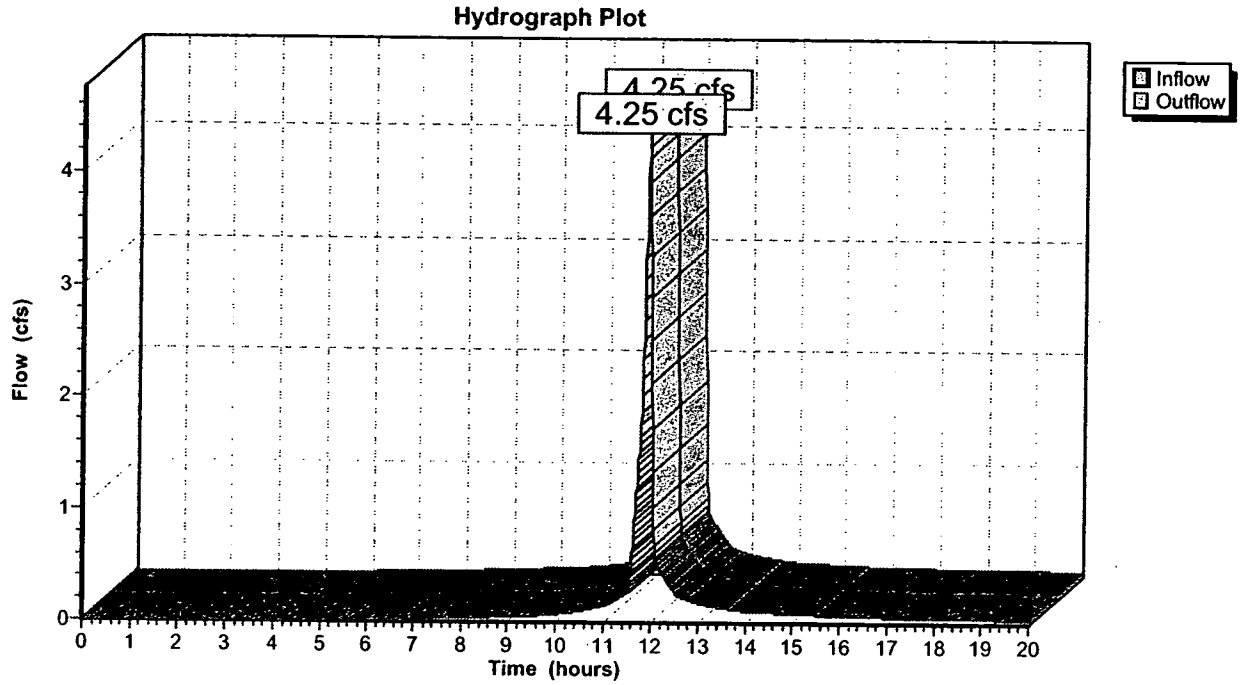
Reach DR2: Dummy Reach

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	4.25 cfs @	11.93 hrs,	Volume=	0.179 af
Outflow	=	4.25 cfs @	11.93 hrs,	Volume=	0.179 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Reach DR2: Dummy Reach



TEB 1/21/04 1/21/04

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Pond IRCA: Detention Pond

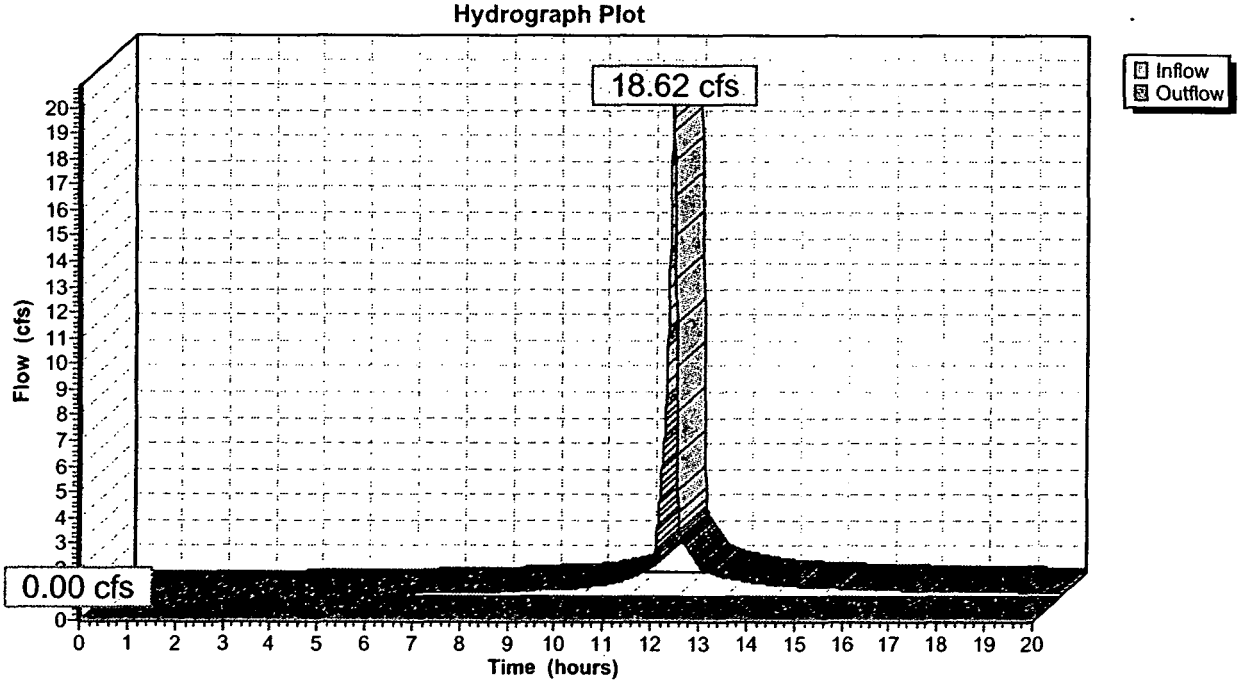
Inflow = 18.62 cfs @ 11.91 hrs, Volume= 0.810 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Peak Elev= 589.52' Storage= 0.810 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Prismatic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
586.00	0.035	0.000	0.000
587.00	0.150	0.093	0.093
588.00	0.252	0.201	0.294
589.00	0.366	0.309	0.603
590.00	0.428	0.397	1.000
591.00	0.485	0.456	1.456
592.00	0.546	0.515	1.972

Pond IRCA: Detention Pond

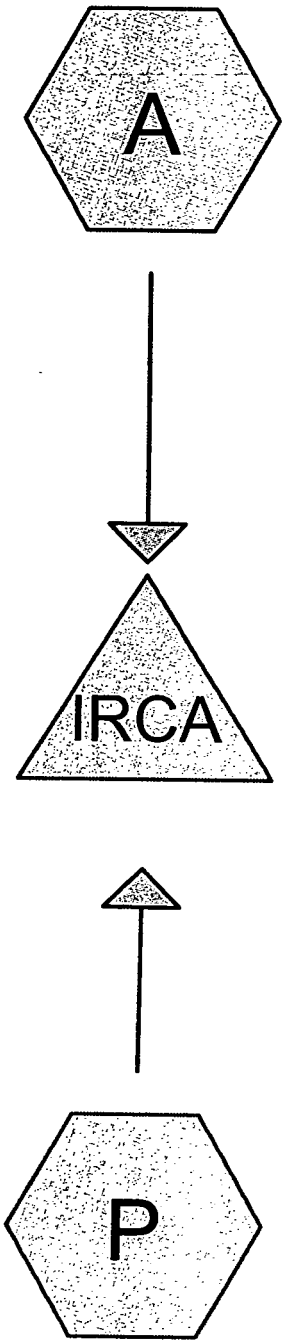


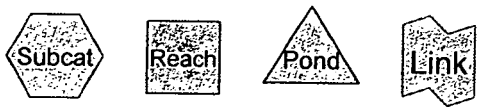
Written by: Tamara E. Zettler TEZ Date: 1/21/2004 Reviewed by: KD Date: 1/21/04

Client: Fluor Fernald, Inc. Project: OSDF Phase IV Project No.: GO1342 Task No.: 06

STAGE III CALCULATION

TEJ 1/21/04 KRD 1/21/04 5316 55173





Drainage Diagram for Cell8_StageIII
Prepared by GeoSyntec Consultants 1/21/2004
HydroCAD® 6.00 s/n 000929 © 1986-2001 Applied Microcomputer Systems

TEZ 1/21/04 KD 1/21/04 SCO 1-3

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CELL8_StageIII *Type II 24-hr Rainfall=4.70"*

Prepared by GeoSyntec Consultants Page 1

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Time span=0.00-20.00 hrs, dt=0.01 hrs, 2001 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: Area A

Tc=0.6 min CN=91 Area=0.981 ac Runoff= 7.11 cfs 0.284 af

Subcatchment P: Pond Area

Tc=0.0 min CN=100 Area=0.331 ac Runoff= 2.65 cfs 0.123 af

Pond IRCA: Detention Pond

Peak Storage= 0.407 af Inflow= 9.63 cfs 0.407 af
Outflow= 0.00 cfs 0.000 af

Runoff Area = 1.312 ac Volume = 0.407 af Average Depth = 3.73"

TEJ 1/21/04 KPD 1/21/04 57/73

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Subcatchment A: Area A

[49] Hint: Tc<2dt may require smaller dt

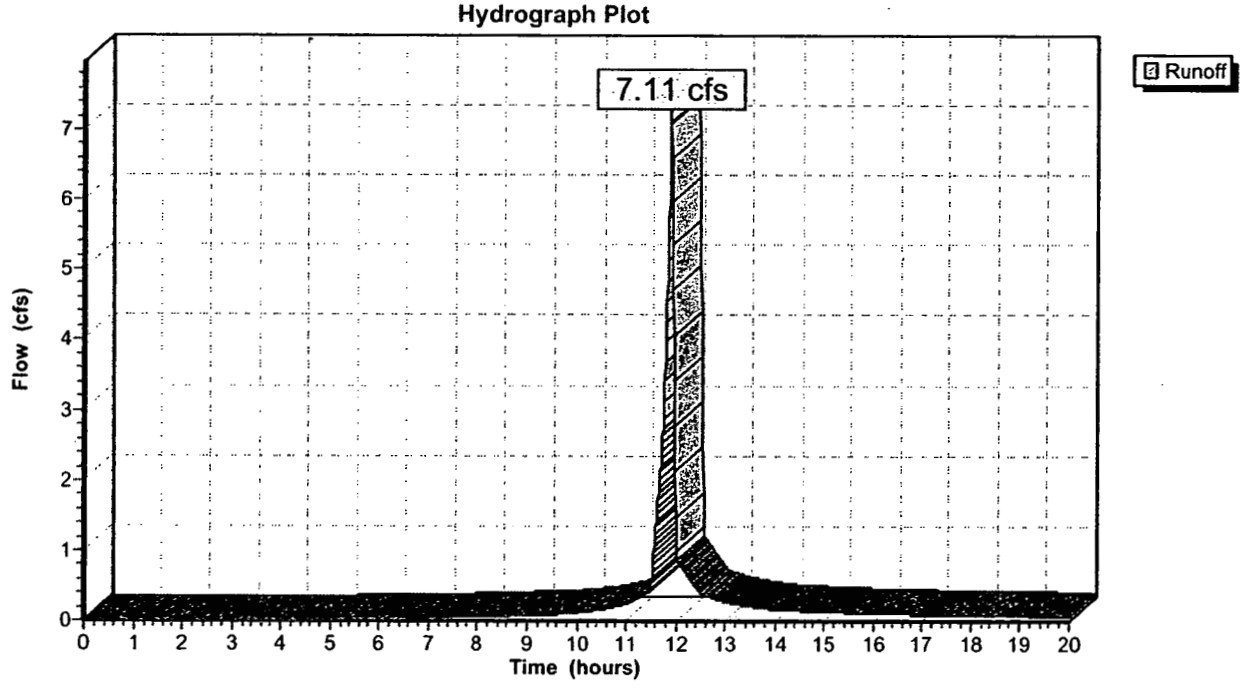
Runoff = 7.11 cfs @ 11.91 hrs, Volume= 0.284 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.981	91	Total Sideslope Area A

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	100	0.2600	3.4		**Sheet Flow, Segment A-1** Smooth surfaces n= 0.011 P2= 2.55"
0.1	34	0.2600	8.2		**Shallow Concentrated Flow, Segment A-2** Unpaved Kv= 16.1 fps
0.6	134	Total			

Subcatchment A: Area A



7E3 1/21/04 KD 1/21/04 58173

5.2.1.6

Subcatchment P: Pond Area

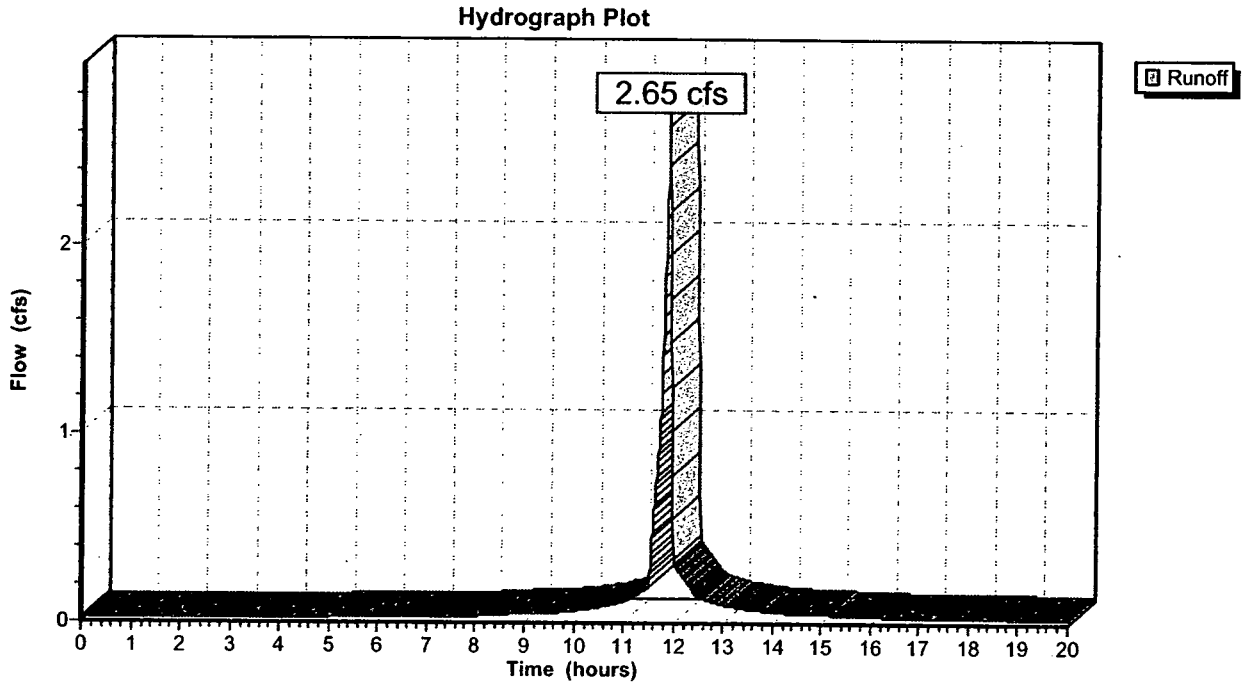
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 2.65 cfs @ 11.90 hrs, Volume= 0.123 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.331	100	Pond Area

Subcatchment P: Pond Area



7E3 1/21/04 1/21/04

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Pond IRCA: Detention Pond

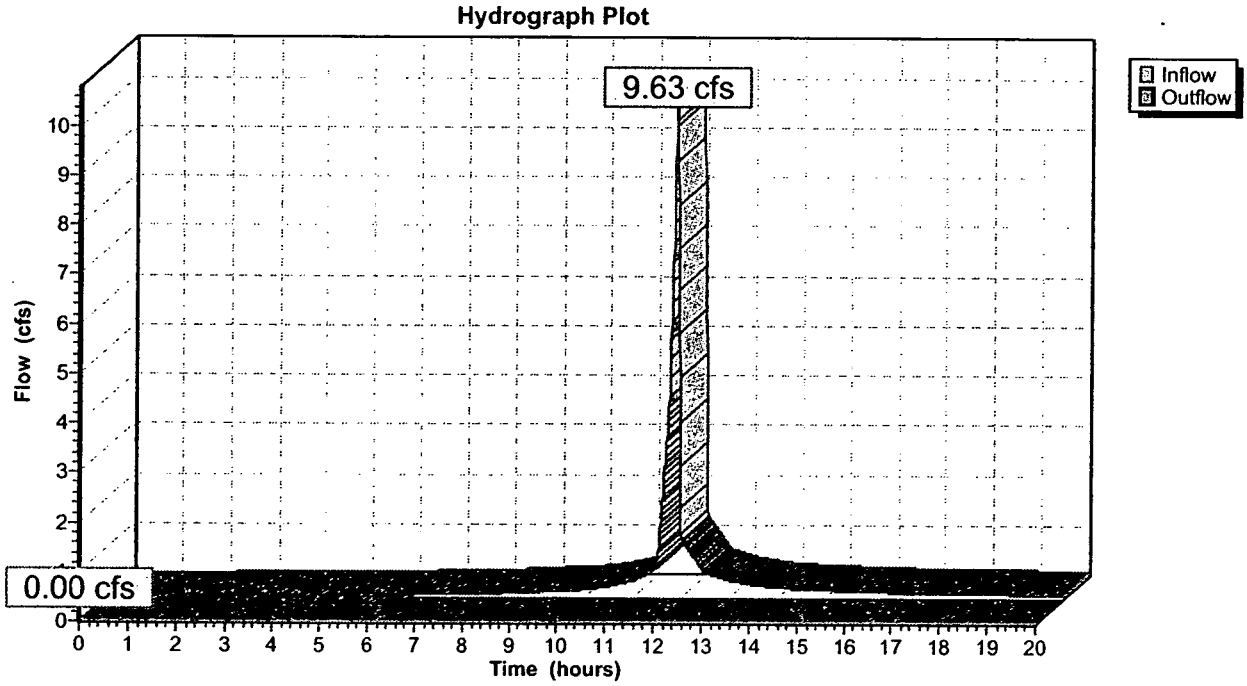
Inflow	=	9.63 cfs @	11.90 hrs,	Volume=	0.407 af
Outflow	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs

Peak Elev= 589.76' Storage= 0.407 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Prismatic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
586.00	0.013	0.000	0.000
587.00	0.055	0.034	0.034
588.00	0.108	0.081	0.116
589.00	0.174	0.141	0.256
590.00	0.223	0.198	0.455
591.00	0.275	0.249	0.704
592.00	0.331	0.303	1.007

Pond IRCA: Detention Pond



ATTACHMENT A-2

INLET CHANNEL SPREADSHEET

TEZ 1/21/04 KRD 1/21/04 61/73

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Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

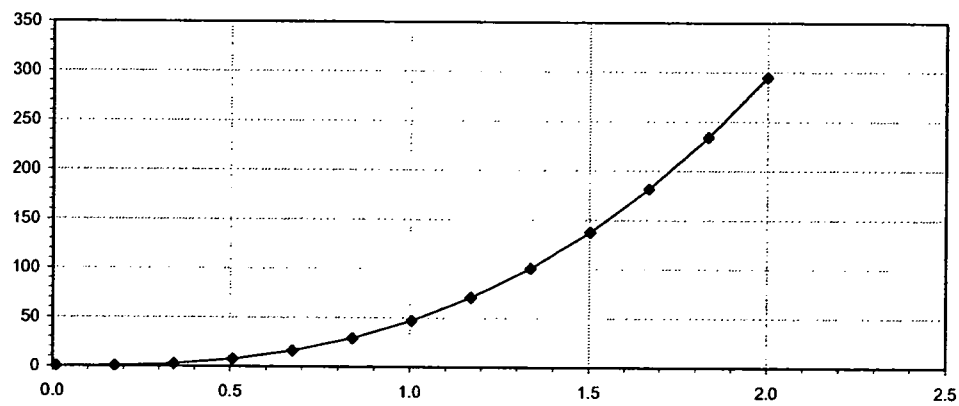
Project: Fernald OSDF Phase V

Ditch ID: **Southern Inlet to Pond at Cell 8 (Channel B - Stage I)**

Peak Discharge, Q_{max}=	12.75	cfs
Bottom Width, B =	0.00	ft
Left Side Slope, Z_1 =	1.50	horizontal :1 vertical
Right Side Slope, Z_2 =	20.00	horizontal :1 vertical
Manning's Roughness Coeff., n =	0.018	
Longitudinal Channel Slope, S_o =	0.0070	ft/ft

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.01	0.00	0.22	0.00	0.20	0.00	0.00	
0.18	0.33	3.84	0.09	1.35	0.45	0.04	
0.34	1.25	7.46	0.17	2.11	2.65	0.07	
0.51	2.77	11.08	0.25	2.75	7.61	0.11	
0.67	4.87	14.70	0.33	3.32	16.17	0.14	
0.84	7.57	18.32	0.41	3.84	29.08	0.18	
1.01	10.86	21.94	0.49	4.33	47.04	0.22	
1.17	14.74	25.56	0.58	4.80	70.69	0.25	
1.34	19.21	29.18	0.66	5.24	100.65	0.29	
1.50	24.27	32.80	0.74	5.67	137.49	0.32	
1.67	29.92	36.42	0.82	6.08	181.77	0.36	
1.83	36.16	40.04	0.90	6.47	234.04	0.39	
2.00	43.00	43.66	0.98	6.86	294.81	0.43	
0.620	4.13	13.53	0.31	3.14	12.97	0.13	DESIGN Q

Discharge versus Depth Relationship



JEZ 1/21/04 KJD 1/21/04

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Written by: Tamara E. Zettler Date: 1/21/2004 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase IV Project No.: GQ1342 Task No.: 06

ATTACHMENT A-3

IRCA DRAWDOWN CALCULATION

Written by: KRD ✓1/21/04 Date: 03/10/28 (YY MM DD) Reviewed by: TEZ Date: 04/01/21 (YY MM DD)

Client: FLOUR FEDERAL Project: OSDF PHASE V Project/Proposal No.: 6443211 Task No.: 06

STAGED CLOSURE - IMPACTED RUNOFF CATCHMENT AREA DRAWDOWN ESTIMATE.

- STAGE I

- ESTIMATED IMPACTED RUNOFF VOLUME = 1.429 acre-ft
  = 62,247 ft³

- DRAWDOWN THROUGH LCS CORRIDOR IS ESTIMATED USING DARCY'S LAW

(1) $Q = kiA$ $k = 0.1$ cm/sec = 0.0033 ft/sec (for LCS & GRANULAR PROTECTIVE LAYERS)

(2) $Q = \frac{dV}{dt} = \frac{\Delta V}{\Delta t}$ $i = 1$ (CONSERVATIVELY)
$A = 1336$ ft² (REFERENCE ATTACHED FIGURE FOR AREA) A-3 FIGURE 1 KRD 1/21/04

SOLVE FOR TIME...

(3) $\Delta t = \frac{\Delta V}{kiA}$

$$\Delta t = \frac{62,247 \text{ ft}^3}{(0.0033 \text{ ft/sec})(1)(1336 \text{ ft}^2)} = 14,118 \text{ sec}$$

$\Delta t = 3.92$ HOURS

- ESTIMATED FLOW RATE $Q = kiA$

$Q = (0.0033 \text{ ft/sec})(1)(1336 \text{ ft}^2)$

$Q = 4.408$ ft³/sec

$Q = 1980$ gpm

$Q > 200$ GPM → MAX. PUMP RATE OF EPLTS LIFT STATION PUMP.

∴ DRAWDOWN IS GOVERNED BY/LIMITED BY EPLTS LIFT STATION PUMP

Written by: KDD ✓1/21/04 Date: 03/10/28 (YY MM DD) Reviewed by: TZZ Date: 04/01/21 (YY MM DD)

Client: FLOWR FERRALD Project: OSDF PHASE V Project/Proposal No.: 693211 Task No.: 06

✓ STAGED CLOSURE – STAGE I DRAWDOWN TIME (CONT'D)

- TO SIMPLIFY DRAWDOWN TIME ESTIMATE, ASSUME THAT LEACHATE FLOW DOES NOT INFLUENCE DRAWDOWN

$Q = 200$ GPM

$V = 62{,}247\ FT^3$

$$t = \frac{V}{Q} = \frac{62{,}247\ FT^3 \left(\frac{7.481\ gal}{FT^3}\right)}{200\ GPM}$$

$t = 2328$ MIN

$$\boxed{t = 1.62 \text{ DAYS}}$$ ✓

Written by: KRD 1/21/04 Date: 03/10/28 (YY/MM/DD) Reviewed by: TEZ Date: 04/01/21 (YY/MM/DD)

Client: FLUOR FEDERAL Project: USDF PHASE V Project/Proposal No.: 693211 Task No.: 06

- STAGED CLOSURE - IMPACTED RUNOFF CATCHMENT AREA DRAWDOWN ESTIMATE - STAGE II

- SIMILAR TO STAGE I, STAGE II SIMILAR IN KRD 1/21/04 IMPACTED RUNOFF CATCHMENT AREA (IRCA) IS ~~THE SAME~~ SIZE (AND STORAGE CAPACITY) AND HAS THE LCS CORRIDOR EXPOSED. THEREFORE DRAWDOWN TIME WILL AGAIN BE GOVERNED BY THE EPLTS PUMP CAPACITY OF 200 GPM.

- ESTIMATED DRAWDOWN TIME ....

$Q = 200$ GPM

$V = 0.809$ ACRE·FT $= 35{,}240$ FT^3 ✓

$$t = \frac{V}{Q}$$

$$= \frac{35{,}240 \left(\frac{7.481 \text{ GAL}}{\text{FT}^3}\right)}{200 \text{ GPM}}$$

$t = 1318$ MIN (22.0 HR)

$t = 0.92$ DAYS ✓

✓ 1/21/04
KJD 03/10/28
G9 3211.06.

TEZ 04/01/21

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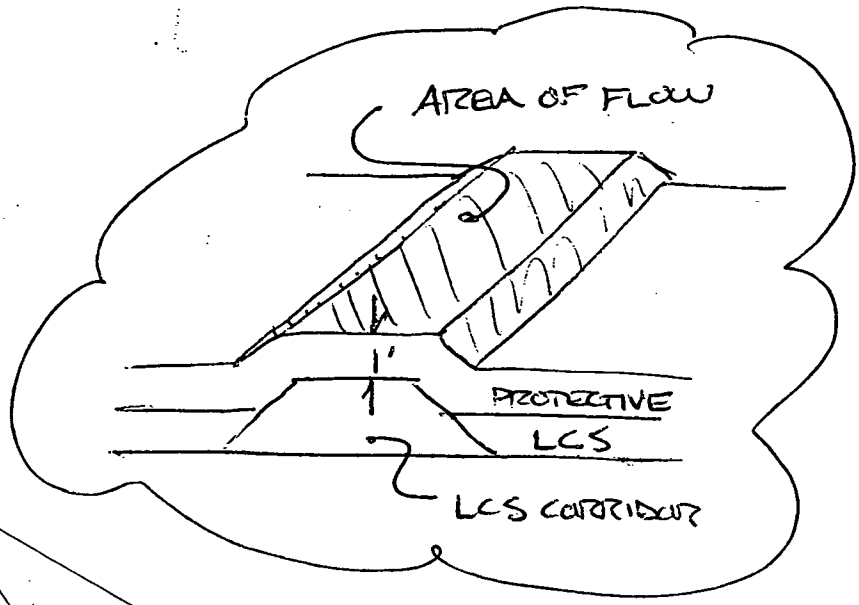

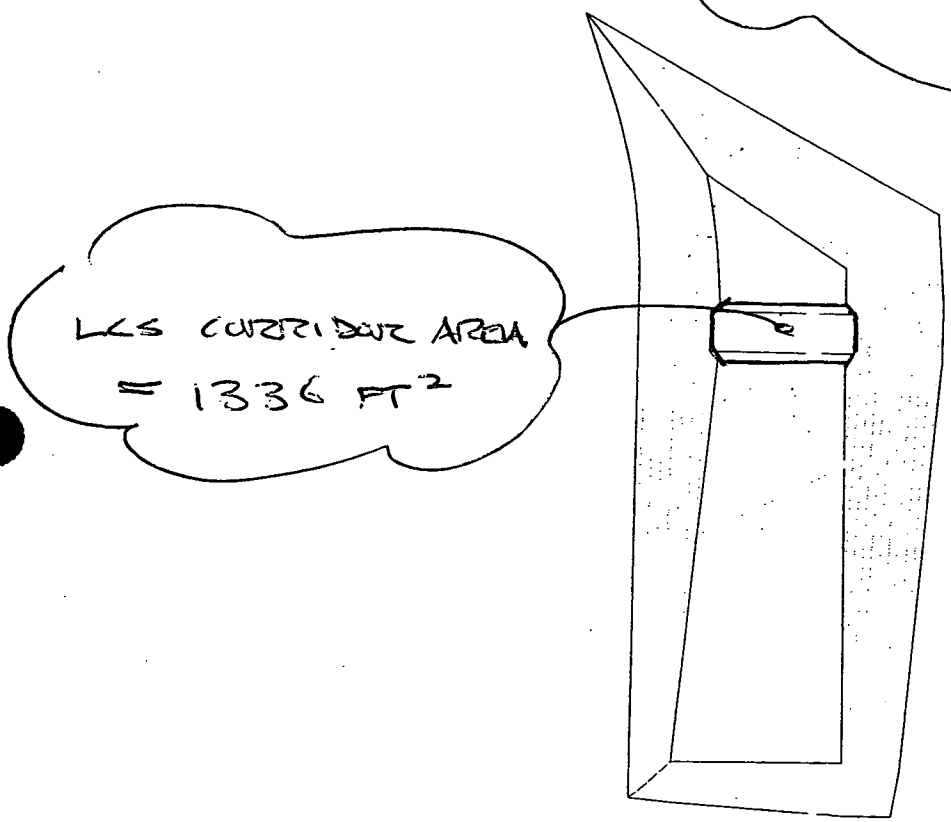

Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
CLOSURE	vol-008	lrca-3500cy	lrca-2000cy-fb				
				531	3510	2979 (F)	Composite

ATTACHMENT A-3
FIGURE 1

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KJD 1/21/04

STAGE I ~~AND II~~ CATCHMENT AREA

(NOTE: STAGE II CATCHMENT AREA VOLUME IS APPROXIMATELY THE SAME AS STAGE I, BUT SLIGHTLY SMALLER · KJD 1/21/04)

✓1/21/04

KJD 03/10/28 TEZ 04/01/21

GW 3211.06

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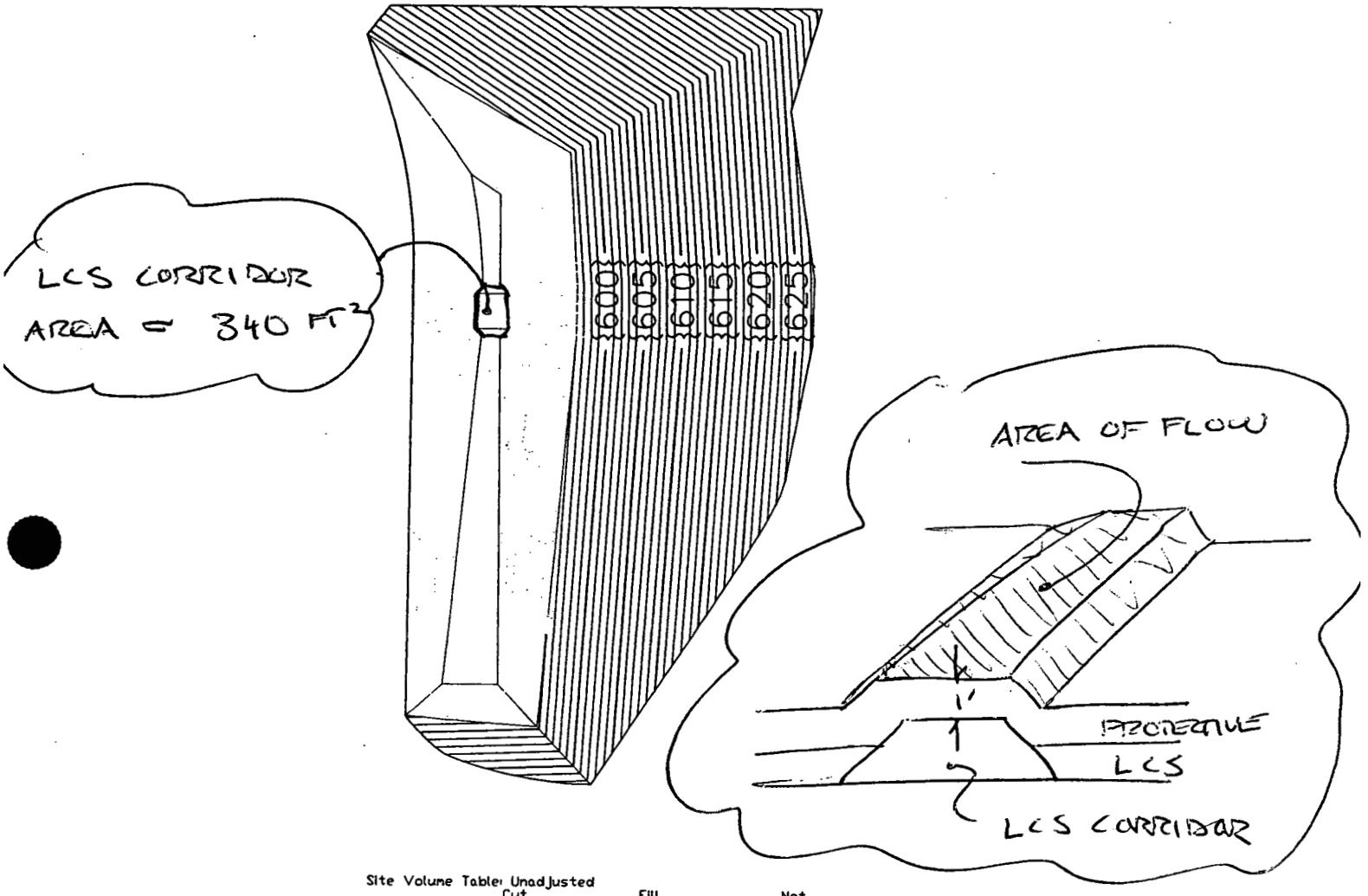


Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
CLOSURE	vol-006	lrca-1790cy	lrca-2000cy-fb	24122	1803	22319 (C)	Composite
	vol-007	lrca-1790cy	contouring-btm	0	16488	16488 (F)	Composite

STAGE III CATCHMENT AREA

ATTACHMENT A-3 - FIGURE 2

Written by: KJB 1/21/04 Date: 03/10/28 (YY MM DD) Reviewed by: TEZ Date: 04/01/21 (YY MM DD)

Client: FLOUR FERNALD Project: OSDF PHASE V Project/Proposal No.: 62321 Task No.: 06

- STAGED CLOSURE - IMPACTED RUNOFF CATCHMENT AREA DRAWDOWN ESTIMATE - STAGE III

- ESTIMATE DRAWDOWN TIME THROUGH LCS CORRIDOR

FROM $Q = kiA$ (1) $Q = \frac{dV}{dt} = \frac{\Delta V}{\Delta t}$ (2)

DERIVE $\Delta t = \frac{\Delta V}{kiA}$ $V = 0.407$ ACRE-FT $= 17{,}729$ FT3

$$\Delta t = \frac{17{,}729}{(0.0033\ \text{FT/SEC})(1)(340\ \text{SF})}$$

$\Delta t = 15{,}801$ sec $= 4.38$ HR

- ESTIMATE FLOW RATE THROUGH LCS

$Q = kiA = (0.0033\ \text{FT/SEC})(1)(340\ \text{SF})$

$Q = 1.12\ \text{FT}^3/\text{SEC}$

$Q = 503$ GPM

$Q > 200$ GPM (MAX EPLIS ~~PUMP~~ LIFT STATION PUMP RATE)

∴ THEREFORE DRAWDOWN IS GOVERNED BY EPLIS LIFT STATION PUMP.

- $Q = 200$ GPM

$V = 17{,}729\ \text{FT}^3$

$$t = V/Q = \frac{17{,}729\ \text{FT}^3 \left(\frac{7.481\ \text{GAL}}{\text{FT}^3}\right)}{200\ \text{GPM}}$$

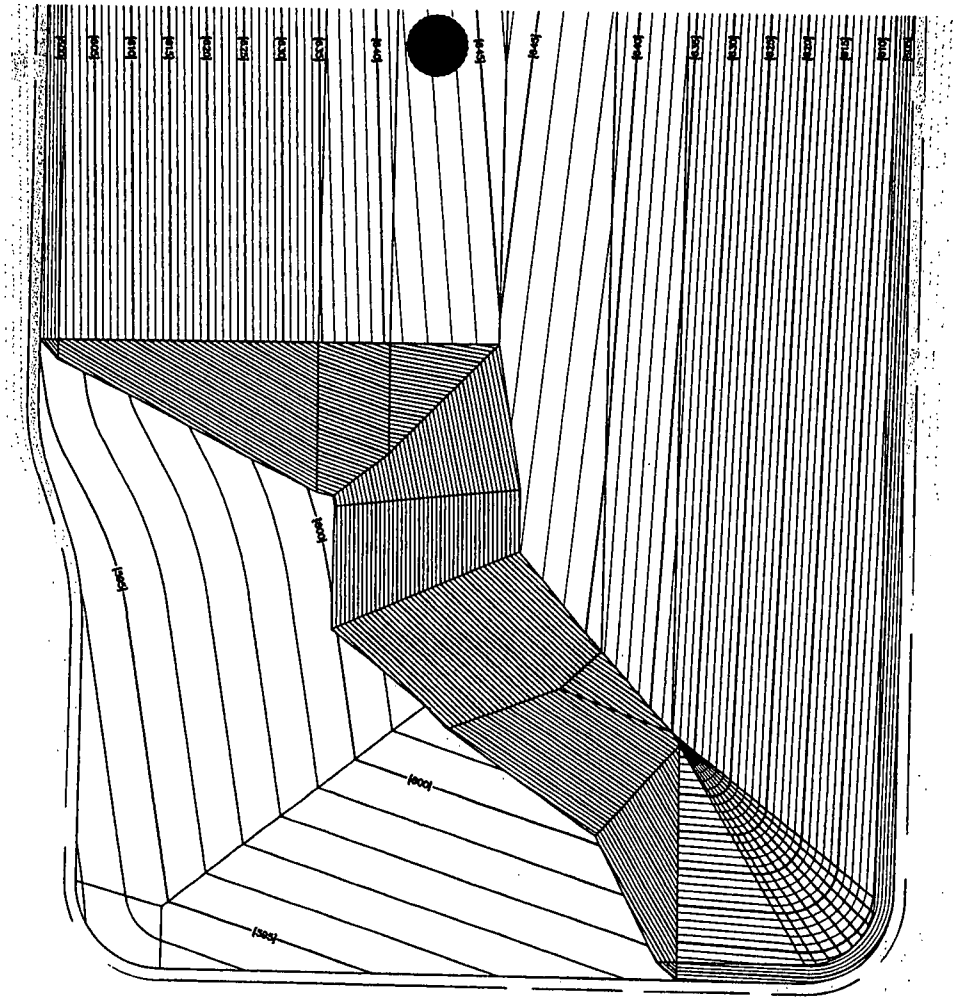
$t = 663$ MIN.

$t = 0.46$ DAYS

000072

ATTACHMENT A-4

STAGE I THROUGH III VOLUME ESTIMATES



Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
CLOSURE	vol-002	interim-btm	contouring-btm	0	111503	111503 (F)	Grid

+ IRCA VOLUME	3,510 CY	(A-4 FIGURE 3)
= GROSS VOLUME	115,013 CY	
− NON-IMPACTED FILL	16,488 CY	(A-4 FIGURE 4)
= NET IMPACTED MATERIAL CAPACITY	98,525 CY	⟹ ≃ 100,000 CY

STAGE I - VOLUME CALCULATION
(WITHOUT IMPACTED RUNOFF CATCHMENT AREA)

ATTACHMENT A-4 - FIGURE 1

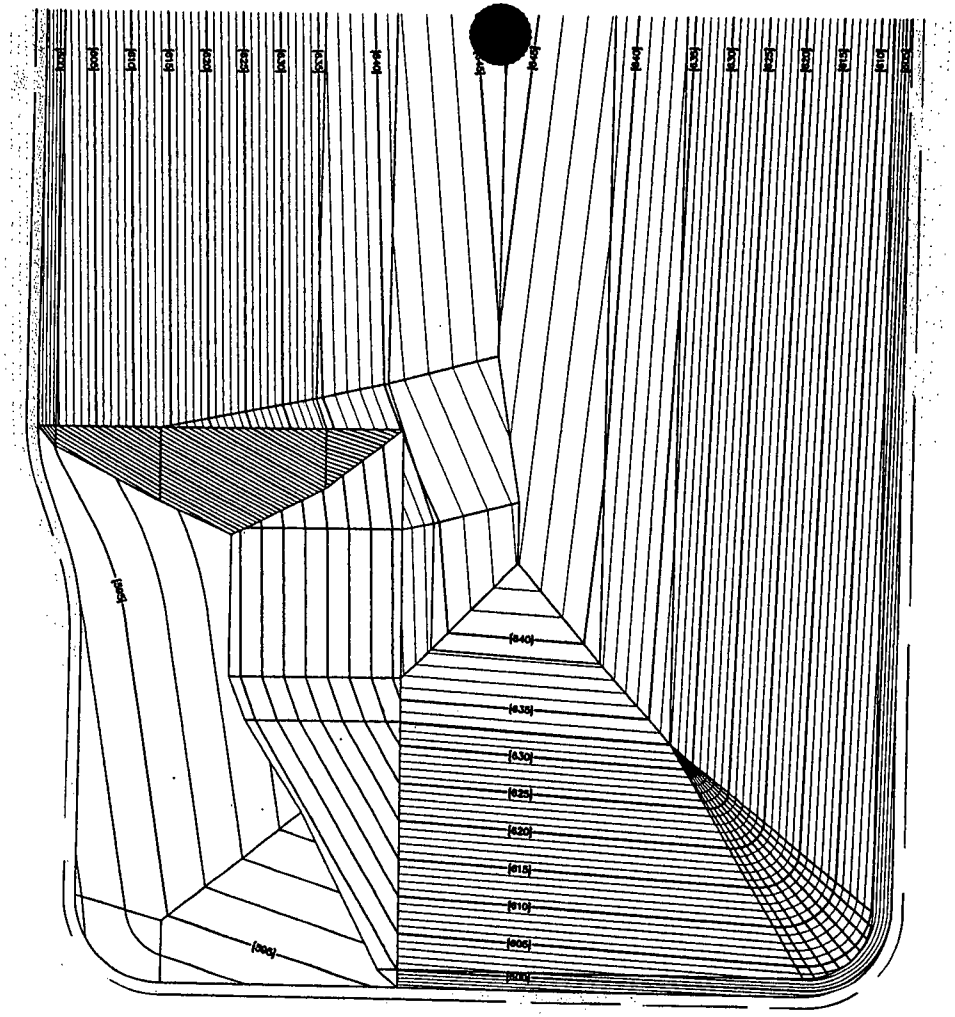
000074

JEB 1/21/04 KD 1/21/04

5316

70173

JEB 1/21/04 KRD 1/21/04



Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
CLOSURE	vol-003	Interim-btm-2	contouring-btm 0		42207	42207 (F)	Grid

+	IRCA VOLUME	3,510 CY ✓ (A-4, FIGURE 3)
=	GROSS VOLUME	45,717 CY ✓
−	NON-IMPACTED FILL	16,488 CY ✓ (A-4, FIGURE 4)
=	NET IMPACTED MATERIAL CAPACITY	29,229 CY ✓ → ≃ 30,000 CY ✓

STAGE II - VOLUME CALCULATION
(WITHOUT IMPACTED RUNOFF CATCHMENT AREA)

ATTACHMENT A-4 - FIGURE 11

000075

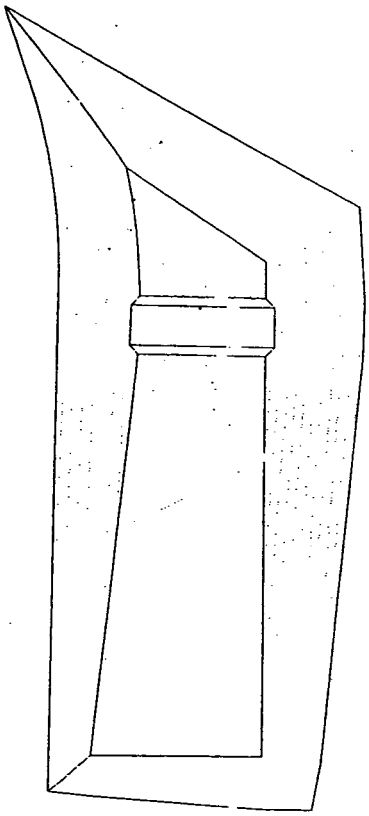
5316

1173

783 1/21/04 1/21/04

72/73

5316



Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
CLOSURE	vol-008	Irca-3500cy	Irca-2000cy-fb				
				531	3510	2979 (F)	Composite

STAGE I & II - IMPACTED RUNOFF CATCHMENT AREA

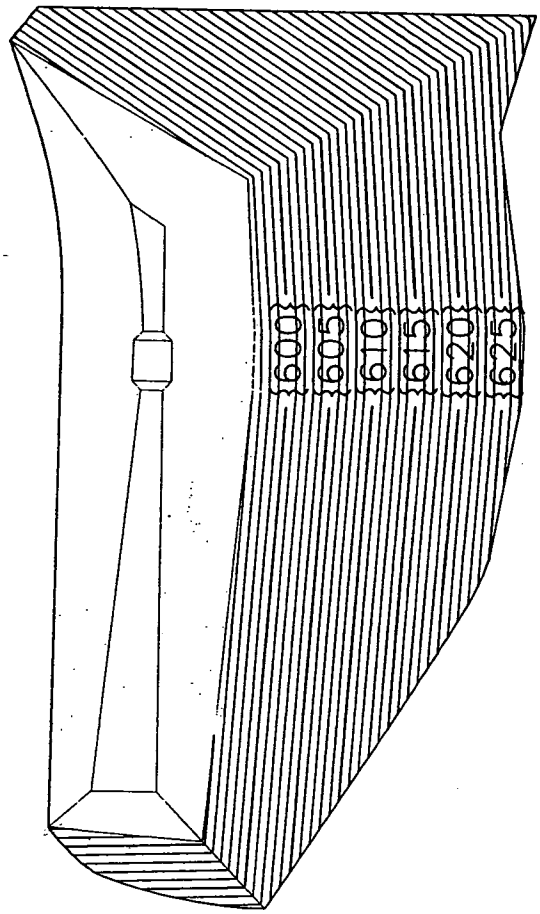
VOLUME 000076

ATTACHMENT A-4 - FIGURE 3

TEZ 11/21/04 1/21/04

73/73

5316



Site Volume Table: Unadjusted

	Site	Stratum	Surf1	Surf2	Cut cu.yds	Fill cu.yds	Net cu.yds	Method
IRCA →	CLOSURE	vol-006	irca-1790cy	irca-2000cy-fb	24122	1803	22319 (C)	Composite
* TOTAL →		vol-007	irca-1790cy	contouring-btm	0	16488	16488 (F)	Composite

STAGE III - VOLUME CALCULATION

ESTIMATED VOLUME TO REACH BOTTOM OF CONTOURING LAYER.

000077

ATTACHMENT A-4 - FIGURE 4

Section 7.4

7.4 LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

5316

SUBJECT OF COMPUTATIONS OSDF PHASE V, LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature GANESH GOPALAKRISHNAN — Date 1-23-04

Printed Name and Title: For Leslie M. Griffin, Engineer

Computations Checked by:

Signature Hollie N. Kinnecom — Date 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature — Date 1-23-04

Printed Name and Title: For Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature Rudolph Bonaparte — Date 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval

000079

Written By : RK Date: 12 -03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

ADDENDUM TO SECTION 7.1
(ADDED TO REVISION 1 PACKAGE)

The Calculation Package "Leachate Generation Rates" presented in Section 7.1 estimated leachate generation rates for different stages of the life of the Fernald On-Site Disposal Facility (OSDF). These rates were used to evaluate the performance of the leachate collection system (LCS), leak detection system (LDS), and leachate transfer system (LTS) in other Calculation Packages. The rates were calculated based on a cell 400 feet wide and 6.5 acres in size. This size cell applies to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). The southernmost OSDF cell (i.e., Cell 8) is sized differently from the other cells.

This addendum to Section 7.1 presents leachate generation rates for Cell 8. Similar methods and input data to that used in Section 7.1 were used herein. This addendum is presented as Section 7.4 of the OSDF Final Design Calculation Package, and is titled, "Leachate Generation Rates – Cell 8 Supplement". Section 7.4 is presented in Volume VII of the OSDF Final Design Calculation Package.

Written By : RK Date: 12 -03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Case 1B	1 of 19
Case 3D	11 of 19

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this analysis is to estimate leachate generation rates for different stages of the life of the Fernald On-Site Disposal Facility (OSDF) Cell 8. These rates will be used to evaluate the performance of the leachate collection system (LCS) and leak detection system (LDS).

METHOD OF ANALYSIS

The U.S. Environmental Protection Agency (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.07, was used to estimate leachate generation rates for Cell 8 of the OSDF.

CONCLUSIONS

Leachate Generation Rates for Cell 8

- Peak daily for active stage (i.e., 10 ft of waste) = 1754 gpad
- Peak daily for post-closure stage = 0.024 gpad

- Average annual for active stage (i.e., 10 ft of waste) = 1261 gpad
- Average annual for post-closure stage = 0.002 gpad

- Baseline design flow rate during active operations = 11,050 gpd
- Baseline design flow rate after closure = 0.15 gpd

Note that the above design flow rates do not account for large peak flows associated with the storm design basis flow rate or incremental flows that may occur from the consolidation of impacted materials. The storm design basis flow rate is addressed in Calculation Package "LTS Gravity Line Flow Capacity" and Calculation Package "LTS Pipe Hydrograph". The potential effects of

impacted material consolidation on the leachate generation rates are addressed in Appendix B of the Calculation Package "Leachate Generation Rates".

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this analysis is to estimate leachate generation rates for different stages of the life of the Fernald On-Site Disposal Facility (OSDF) Cell 8.

GENERAL DESCRIPTION OF CELL 8

The southernmost cell of the OSDF, Cell 8, is sized differently than the northernmost and interior cells (Cells 1 through 7). Cells 1 through 7 are approximately 700 feet long and 400 feet wide with a cell area of 6.5 acres. Cell 8 is designed approximately 650 feet long and 425 feet wide with a cell area of 6.3 acres.

LEACHATE GENERATION ANALYSIS

Generally, the analysis procedures presented in the Calculation Package "Leachate Generation Rates" are followed in these calculation packages. The U.S. Environmental Protection Agency (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.07 [Schroeder, et al., 1994a, b], is used to estimate leachate generation rates for Cell 8 of the OSDF.

Analyses were presented in the Calculation Package "Leachate Generation Rates" for three cases representing three different stages in the life of the OSDF. Based on these calculation results, it was determined that Case 1 is the critical case during active operation and Case 3 after closure of the OSDF. Therefore, leachate generation calculations for Cell 8 are performed for Cases 1 and 3 only in this calculation package.

The Calculation Package "Leachate Generation Rates" sub-classified Case 1 as 1A and 1B, and Case 3 as 3A, 3B, 3C, and 3D based on the different material types used to model certain layers in the

OSDF. Based on the analysis results presented in that Calculation Package, it was determined that Case 1B, and Case 3D (or 3C) are the critical cases that need to be considered for further analyses. Therefore, in this Calculation Package analyses are performed for Cases 1B (active condition) and 3D (post-closure condition).

REFERENCES

Schroeder, P.R., Lloyd, C.M., and Zappi, P.A. (1994a). "*The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3.*" U.S. Environmental Protection Agency, Office of the Research and Development, Washington D.C., Report No. EPA/600/R-94/168a, 83 p. (plus appendix).

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. (1994b). "*The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3.*" U.S. Environmental Protection Agency, Office of the Research and Development, Washington D.C., Report No. EPA/600/R-94/168b, 116 p.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT

HELP MODEL INPUT PARAMETERS

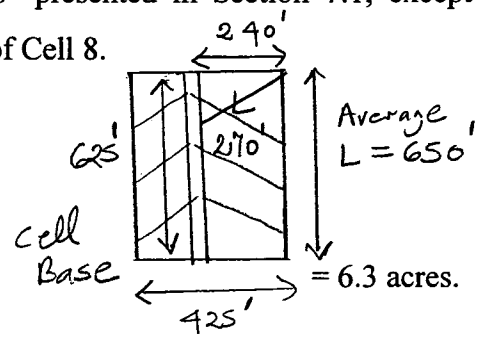
OBJECTIVE

To select values for the input parameters of HELP to model Cell 8 of the Fernald OSDF. Values are selected for Cases 1B and 3D for Cell 8. The following input parameters used for these cases are the same as the ones used in the Calculation Package "Leachate Generation Rates" presented in Section 7.1.

Weather Data Requirements

- Evaporation data
- Precipitation data
- Temperature data
- Solar radiation data

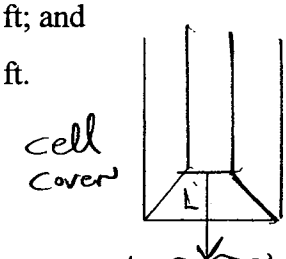
The following input parameters used for these cases are the same as the ones used in the Calculation Package "Leachate Generation Rates" presented in Section 7.1, except for the changes presented below to account for the new geometry of Cell 8.



625' @ 1%
240' @ 2%
270' @ 2.24%

Soil and Design data Requirements

- Landfill General Information
  - Cell area = 6.3 acres.
- Layer Data
  - Drainage path length for the LCS drainage layer = 270 ft; and
  - Drainage path length for the final cover = 480 ft.
- Runoff Curve Number
  - calculated by the program based on the new input parameters



L = 480' @ 13.4%

Written By : RK Date: 12 -03-03 Reviewed by: LMG Date: 12-09-03 5316

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE GENERATION RATES – CELL 8 SUPPLEMENT

COMPUTATION RESULTS

The leachate generation rates were estimated for Case 1 (active condition) and Case 3 (post-closure condition). The HELP program output files are included at the end of this Calculation Package as appendix A. The results for the HELP analyses are summarized in Table 1.

Calculation of Baseline Design Flow Rates for Cell 8

- Peak daily for active stage (i.e., 10 ft of waste) = 1754 gpad
- Peak daily for post-closure stage = 0.024 gpad

- Average annual for active stage (i.e., 10 ft of waste) = 1261 gpad
- Average annual for post-closure stage = 0.002 gpad

- Baseline design flow rate during active operations = 11,050 gpd
- Baseline design flow rate after closure = 0.15 gpd

Written By : RK Date: 12 -03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

Table 1. Summary of HELP Model Results

Case	Average Annual Totals (in)							Peak Daily Values (in)				
	P[1]	R[2]	E[3]	LD[4]	H_{avg}[5]	I[6]		P	R	LD	H_{avg} (H_{max}[7])	I
Case 1B	40.26	0	23.26	16.95	0.99	$6.0X10^{-5}$		4.7	0	0.0646	1.375 (2.497)	$2.4X10^{-7}$
Case 3D	40.34	4.76	27.50	$3.0X10^{-5}$	0	$2.5X10^{-6}$		13.0	8.29	$9.0X10^{-7}$	0 (0.005)	$5.5X10^{-9}$

Notes:

[1]P = Precipitation

[2]R = Runoff

[3]E = Evaporation

[4]LD = Lateral drainage in LCS drainage corridor

[5]H_{avg} = Average head above the primary geomembrane liner

[6]I = Infiltration through primary geomembrane liner

[7]H_{max} = Maximum head above the primary geomembrane liner

Appendix A

HELP Model Outputs

5316
1/19

CASE1B8

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     H:\PROJECTS\FERNALD\CELL8\CASE1B.D4
TEMPERATURE DATA FILE:       H:\PROJECTS\FERNALD\CELL8\CASE1B.D7
SOLAR RADIATION DATA FILE:   H:\PROJECTS\FERNALD\CELL8\CASE1B.D13
EVAPOTRANSPIRATION DATA:     H:\PROJECTS\FERNALD\CELL8\CASE1B.D11
SOIL AND DESIGN DATA FILE:   H:\PROJECTS\FERNALD\CELL8\CASE1B8.D10
OUTPUT DATA FILE:            H:\PROJECTS\FERNALD\CELL8\CASE1B8.OUT


TIME:  11: 0     DATE:  12/ 9/2003


******************************************************************************

     TITLE:  Fernald OSDF - Case 1B

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  31
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.5780 VOL/VOL
          FIELD CAPACITY             =      0.0760 VOL/VOL
          WILTING POINT              =      0.0250 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1790 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.410000002000E-02 CM/SEC


                                LAYER  2
                                --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
```

CASE1B8

MATERIAL TEXTURE NUMBER 26

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4450	VOL/VOL
FIELD CAPACITY	=	0.3930	VOL/VOL
WILTING POINT	=	0.2770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3930	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000003000E-05	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0321	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	2.24	PERCENT
DRAINAGE LENGTH	=	270.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 6

5318
3/19

CASE1B8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	2.24	PERCENT
DRAINAGE LENGTH	=	270.0	FEET

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	36.25	INCHES
POROSITY	=	0.4290	VOL/VOL
FIELD CAPACITY	=	0.4200	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4290	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.819999997000E-07	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #31 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 425. FEET.

SCS RUNOFF CURVE NUMBER	=	96.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.725	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.936	INCHES

CASE1B8

LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.300	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	42.698	INCHES
TOTAL INITIAL WATER	=	42.698	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CINCINNATI OHIO

STATION LATITUDE	=	39.29	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	295	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR COVINGTON KENTUCKY

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.13	2.73	3.95	3.58	3.84	4.09
4.28	2.97	2.91	2.54	3.12	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CINCINNATI OHIO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CINCINNATI OHIO
AND STATION LATITUDE = 39.29 DEGREES

****

CASE1B8
AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.42	2.87	3.77	3.69	3.83	4.10
	4.42	2.86	2.79	2.35	3.22	2.94
STD. DEVIATIONS	1.59	1.34	1.48	1.54	1.84	2.18
	1.94	1.59	1.78	1.10	1.36	1.21
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.623	0.556	1.887	2.884	3.050	2.900
	3.205	2.290	1.874	1.653	1.373	0.965
STD. DEVIATIONS	0.271	0.310	0.589	0.753	0.960	1.012
	1.037	0.982	0.811	0.520	0.332	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	1.0769	1.2014	1.3951	1.7421	1.8831	1.7281
	1.6427	1.4718	1.3570	1.3201	1.1346	1.0017
STD. DEVIATIONS	0.6304	0.4926	0.4873	0.2934	0.2852	0.3783
	0.5000	0.5901	0.5836	0.5999	0.5661	0.5323
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

CASE1B8
AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.7389	0.9055	0.9573	1.2353	1.2922	1.2254
	1.1272	1.0099	0.9622	0.9058	0.8045	0.6874
STD. DEVIATIONS	0.4326	0.3732	0.3344	0.2080	0.1957	0.2682
	0.3431	0.4049	0.4138	0.4117	0.4014	0.3652

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.26	(5.552)	146142.4	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	23.260	(2.6639)	84432.33	57.774
LATERAL DRAINAGE COLLECTED FROM LAYER 3	16.95462	(3.94319)	61545.258	42.11322
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00006	(0.00002)	0.230	0.00016
AVERAGE HEAD ON TOP OF LAYER 4	0.988	(0.230)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00006	(0.00002)	0.220	0.00015
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 7	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.045	(3.1359)	164.55	0.113

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CASE1B8

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.70	17061.000
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.06463	234.60196
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00088
AVERAGE HEAD ON TOP OF LAYER 4	1.375	
MAXIMUM HEAD ON TOP OF LAYER 4	2.497	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	24.7 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00086
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 7	0.000	
MAXIMUM HEAD ON TOP OF LAYER 7	0.007	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	7.68	27876.4355

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5780
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0275

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	25.8107	0.2151
2	4.8788	0.4066
3	0.4190	0.0349

CASE1B8

4	0.0000	0.0000
5	0.1875	0.7500
6	0.3840	0.0320
7	0.0000	0.0000
8	15.5512	0.4290
SNOW WATER	0.000	

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CASE3D8

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0
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     H:\PROJECTS\FERNALD\CELL8\CASE3D.D4
TEMPERATURE DATA FILE:       H:\PROJECTS\FERNALD\CELL8\CASE3D.D7
SOLAR RADIATION DATA FILE:   H:\PROJECTS\FERNALD\CELL8\CASE3D.D13
EVAPOTRANSPIRATION DATA:     H:\PROJECTS\FERNALD\CELL8\CASE3D.D11
SOIL AND DESIGN DATA FILE:   H:\PROJECTS\FERNALD\CELL8\CASE3D8.D10
OUTPUT DATA FILE:            H:\PROJECTS\FERNALD\CELL8\CASE3D8.OUT


TIME:   9:13     DATE:  11/14/2003


******************************************************************************

     TITLE:  Fernald OSDF - Case 3D

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =      6.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2324 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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CASE3D8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	21.00	INCHES
POROSITY	=	0.4000	VOL/VOL
FIELD CAPACITY	=	0.3000	VOL/VOL
WILTING POINT	=	0.2000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2929	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-04	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1842	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	36.00	INCHES
POROSITY	=	0.3500	VOL/VOL
FIELD CAPACITY	=	0.0300	VOL/VOL
WILTING POINT	=	0.0100	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0300	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	100.000000000	CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0516	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	13.40	PERCENT
DRAINAGE LENGTH	=	480.0	FEET

LAYER 6

CASE3D8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.25	INCHES
POROSITY	=	0.4300	VOL/VOL
FIELD CAPACITY	=	0.4210	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.750000027000E-07	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 26

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4450	VOL/VOL
FIELD CAPACITY	=	0.3930	VOL/VOL
WILTING POINT	=	0.2770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3930	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000003000E-05	CM/SEC

LAYER 9

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 26

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4450	VOL/VOL
FIELD CAPACITY	=	0.3930	VOL/VOL
WILTING POINT	=	0.2770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3930	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000003000E-05	CM/SEC

LAYER 10

CASE3D8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 31

THICKNESS	=	408.00	INCHES
POROSITY	=	0.5780	VOL/VOL
FIELD CAPACITY	=	0.0760	VOL/VOL
WILTING POINT	=	0.0250	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0760	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.410000002000E-02	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 26

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4450	VOL/VOL
FIELD CAPACITY	=	0.3930	VOL/VOL
WILTING POINT	=	0.2770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3930	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000003000E-05	CM/SEC

LAYER 12

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	2.24	PERCENT
DRAINAGE LENGTH	=	270.0	FEET

LAYER 13

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 14

CASE3D8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 15

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000	CM/SEC
SLOPE	=	2.24	PERCENT
DRAINAGE LENGTH	=	270.0	FEET

LAYER 16

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 17

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	36.25	INCHES
POROSITY	=	0.4290	VOL/VOL
FIELD CAPACITY	=	0.4200	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4290	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.819999997000E-07	CM/SEC

CASE3D8

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 13.% AND A SLOPE LENGTH OF 480. FEET.

SCS RUNOFF CURVE NUMBER	=	80.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	8.162	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.099	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	5.088	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	82.440	INCHES
TOTAL INITIAL WATER	=	82.440	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM CINCINNATI OHIO

STATION LATITUDE	=	39.29	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	295	
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR COVINGTON KENTUCKY

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.13	2.73	3.95	3.58	3.84	4.09
4.28	2.97	2.91	2.54	3.12	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR CINCINNATI OHIO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

CASE3D8

28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CINCINNATI OHIO
AND STATION LATITUDE = 39.29 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.42	2.87	3.77	3.69	3.83	4.10
	4.51	2.86	2.79	2.35	3.22	2.94
STD. DEVIATIONS	1.59	1.34	1.48	1.54	1.84	2.18
	2.35	1.59	1.78	1.10	1.36	1.21
RUNOFF						
TOTALS	1.120	1.873	1.189	0.033	0.024	0.080
	0.150	0.025	0.035	0.017	0.043	0.166
STD. DEVIATIONS	1.338	1.405	1.738	0.086	0.068	0.164
	0.967	0.069	0.087	0.055	0.100	0.541
EVAPOTRANSPIRATION						
TOTALS	0.591	0.555	1.884	3.468	4.478	4.136
	4.253	3.158	2.015	1.243	0.969	0.748
STD. DEVIATIONS	0.208	0.278	0.564	0.622	1.155	1.495
	1.480	1.480	0.941	0.327	0.181	0.178
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.9216	0.6226	2.1673	1.0788	0.4276	0.1311
	0.1812	0.0645	0.0868	0.1554	0.7835	1.4636
STD. DEVIATIONS	1.0581	0.8350	1.1208	1.0338	0.6557	0.3135
	0.6182	0.1810	0.3058	0.3851	1.1062	1.0866
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 12						

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 14

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 15

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 17

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.1912	0.1416	0.4497	0.2313	0.0887	0.0281
	0.0376	0.0134	0.0186	0.0322	0.1680	0.3037
STD. DEVIATIONS	0.2195	0.1900	0.2326	0.2216	0.1361	0.0672
	0.1283	0.0376	0.0656	0.0799	0.2372	0.2255

DAILY AVERAGE HEAD ON TOP OF LAYER 13

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 16

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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CASE3D8

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.34	(5.640)	146443.7	100.00
RUNOFF	4.755	(2.9190)	17261.31	11.787
EVAPOTRANSPIRATION	27.497	(3.4243)	99812.54	68.158
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.08402	(3.22387)	29345.006	20.03843
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00003	(0.00001)	0.119	0.00008
AVERAGE HEAD ON TOP OF LAYER 6	0.142	(0.057)		
LATERAL DRAINAGE COLLECTED FROM LAYER 12	0.00003	(0.00001)	0.110	0.00008
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 13	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 15	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 17	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 16	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.007	(1.1694)	24.67	0.017

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	13.00	47190.000
RUNOFF	8.291	30097.5801
DRAINAGE COLLECTED FROM LAYER 5	0.74308	2697.38623
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000002	0.00892
AVERAGE HEAD ON TOP OF LAYER 6	4.779	

CASE3D8

MAXIMUM HEAD ON TOP OF LAYER 6	9.153	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	12.2 FEET	
DRAINAGE COLLECTED FROM LAYER 12	0.00000	0.00329
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 13	0.000	
MAXIMUM HEAD ON TOP OF LAYER 13	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 12 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 15	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 17	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 16	0.000	
MAXIMUM HEAD ON TOP OF LAYER 16	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 15 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	7.68	27876.4355

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3527
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1696

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	2.3608	0.3935
2	6.4221	0.3058
3	0.7817	0.1303
4	1.0800	0.0300

5	0.3844	0.0320
6	0.0000	0.0000
7	10.4275	0.4300
8	4.7160	0.3930
9	4.7160	0.3930
10	31.0080	0.0760
11	4.7160	0.3930
12	0.3840	0.0320
13	0.0000	0.0000
14	0.1875	0.7500
15	0.3840	0.0320
16	0.0000	0.0000
17	15.5512	0.4290
SNOW WATER	0.000	

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Section 8.4

8.4 MAXIMUM HEAD IN LCS – CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

5316

SUBJECT OF COMPUTATIONS OSDF PHASE V, MAXIMUM HEAD IN LCS – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature GANESH GOPALAKRISHNAN — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature Hollie N. Kinnecom — Date 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature Rudolph Bonaparte — Date 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval

000110

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

ADDENDUM TO SECTION 8.1
(ADDED TO REVISION 1 PACKAGE)

The Final Design Calculation Package "Leachate Collection System (LCS) Maximum Head in the LCS" presented in Section 8.1 evaluated the performance of the drainage layer and drainage corridor components of the LCS. Specifically the package estimated (i) average and maximum leachate head and liquid thickness for the drainage layer; and (ii) average and maximum leachate head and liquid thickness and flow capacity for the drainage corridor. The performance of the drainage layer and drainage corridor was evaluated using baseline design flow rates applicable to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). Baseline design flow rates for the southernmost OSDF cell (i.e., Cell 8) are presented in Section 7.4 and will be utilized in this package.

This addendum to Section 8.1 evaluated the performance of the drainage layer and drainage corridor for Cell 8. Similar methods and input data to that used in Section 8.1 were used herein. This addendum is presented as Section 8.4 of the OSDF Final Design Calculation Package, and is titled, "Leachate Collection System (LCS) Maximum Head in the LCS – Cell 8 Supplement". Section 8.4 is presented in Volume VII of the OSDF Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS) MAXIMUM HEAD IN LCS - CELL 8 SUPPLEMENT EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this analysis is to evaluate the performance of the drainage layer and the drainage corridor components of the leachate collection system (LCS) for Cell 8 of the Fernald On-site Disposal Facility (OSDF).

METHOD OF ANALYSIS

Drainage Layer: The maximum and average hydraulic head, and the maximum and average liquid thickness in the drainage layer were calculated using the USEPA HELP model and a closed-form analytical solution.

Drainage Corridor: The maximum and average hydraulic head, and maximum and average liquid thickness in the drainage corridor were calculated using a closed-form analytical solution. The flow capacity of the drainage corridor was calculated to verify its ability to convey leachate.

Calculations were performed for the active operation condition and for the post-closure (i.e., post-settlement) condition. Baseline design flow rates established in the "Leachate Generation Rates – Cell 8 Supplement" Calculation Package were utilized in the calculations. These flow rates do not account for large peak flows associated with the storm design basis flow rate.

CONCLUSIONS

ACTIVE OPERATION CONDITION:

Drainage Layer:

- maximum leachate head, h_{max} = 2.5 in. < 12 in. (O.K.)
- average leachate head, h_{avg} = 1.3 in.
- maximum liquid thickness, T_{max} = 2.5 in.
- average liquid thickness, T_{avg} = 1.3 in.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

Drainage Corridor:

- maximum leachate head, h_{max} = 3.3 in. < 12 in. (O.K.)
- average leachate head, h_{avg} = 1.9 in.
- maximum liquid thickness, T_{max} = 3.3 in.
- average liquid thickness, T_{avg} = 1.9 in.
- drainage corridor capacity, Q_{DC} = 23.6 gpm
- required flow capacity, Q_R = 7.7 gpm
- flow capacity factor of safety, Q_{DC}/Q_R = 3.1 (equal to target rate of 3, O.K.)

POST-CLOSURE CONDITION:

Drainage Layer:

- maximum leachate head, $h_{max} = 3.81 \times 10^{-5}$ in. < 12 in. (O.K.)
- average leachate head, $h_{avg} = 1.91 \times 10^{-5}$ in.
- maximum liquid thickness, $T_{max} = 3.81 \times 10^{-5}$ in.
- average liquid thickness, $T_{avg} = 1.91 \times 10^{-5}$ in.

Drainage Corridor:

- maximum leachate head, $h_{max} = 1.32 \times 10^{-4}$ in. < 12 in. (O.K.)
- average leachate head, $h_{avg} = 6.59 \times 10^{-5}$ in.
- maximum liquid thickness, $T_{max} = 1.32 \times 10^{-4}$ in.
- average liquid thickness, $T_{avg} = 6.59 \times 10^{-5}$ in.
- drainage corridor capacity, Q_{DC} = 9.42 gpm
- required flow capacity, $Q_R = 1.08 \times 10^{-4}$ gpm
- flow capacity factor of safety, $Q_{DC}/Q_R = 87.5 \times 10^{3}$ (much greater than target value of 10, O.K.)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
MAXIMUM HEAD IN LCS - CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to present the calculation procedures for the leachate collection system for Cell 8 of the OSDF. In particular, this package addresses the following analyses:

- drainage layer (average and maximum leachate head and liquid thickness); and
- drainage corridor (average and maximum leachate head and liquid thickness, and flow capacity).

METHODS OF ANALYSIS

This calculation package uses the same method of analysis as the one presented in Section 8.1, "Leachate Collection System (LCS) Maximum Head in LCS" in the Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
MAXIMUM HEAD IN LCS - CELL 8 SUPPLEMENT
DATA VERIFICATION

INTRODUCTION

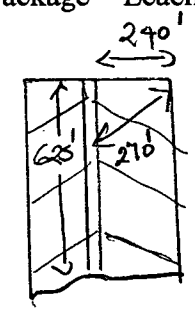
The purpose of this package is to present the data parameters needed to perform the calculations for the leachate collection system for Cell 8 of the OSDF. In particular, this package addresses the following analyses:

- drainage layer (average and maximum leachate head and liquid thickness); and
- drainage corridor (average and maximum leachate head and liquid thickness, and flow capacity).

In order to perform the analyses the data presented in the Calculation Package "Leachate Collection System (LCS) Maximum Head in LCS" is used, except that the slope lengths, cell area, and flow rates are revised based on the Calculation Package "Leachate Generation Rates – Cell 8 Supplement" as described in the following section.

ACTIVE OPERATION CONDITION:

cell Base



270' @ 2.24%
240' @ 2.0%
625' @ 1.0%

DRAINAGE LAYER

Leachate Head:

q_i = the maximum impingement rate of flow into the drainage layer = 0.0646 in. /day (peak daily value from HELP leachate generation analyses results; Case 1B) = 1.9×10^{-6} cm/sec

L = the length of the slope = 270 ft (3240 in.)

DRAINAGE CORRIDOR

Leachate Head: The impingement rate of flow into the drainage corridor is calculated by multiplying the impingement rate of flow into the drainage layer by (width of cell / width of drainage corridor). Therefore,

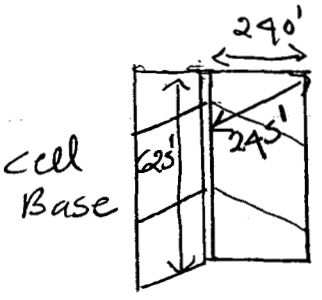
$q_{i\,dc}$ = (0.0646 in./day) x (425 ft/ 16 ft) = 1.716 in. /day (peak daily value) = 5.04×10^{-5} cm/sec

L = the length of the drainage corridor = 625 ft (7500 in.)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

POST-CLOSURE CONDITION:



625' @ 0.4%
240' @ 2.0%
245' @ 2.04%

DRAINAGE LAYER

Leachate Head:

q_i = the maximum impingement rate of flow into the drainage layer = 9.0×10^{-7} in. /day (peak daily value from HELP leachate generation analyses results; Case 3D) = 2.65×10^{-11} cm/sec

L = the length of the slope = 245 ft (2940 in.)

DRAINAGE CORRIDOR

Leachate Head: The impingement rate of flow into the drainage corridor is calculated by multiplying the impingement rate of flow into the drainage layer by (width of cell / width of drainage corridor) as shown in Figure 2. Therefore,

$q_{i\ dc}$ = (9.0×10^{-7} in./day) x (425 ft/ 16 ft) = 2.4×10^{-5} in. /day (peak daily value) = 7.06×10^{-10} cm/sec

L = the length of the drainage corridor = 625 ft (7500 in.)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
MAXIMUM HEAD IN LCS - CELL 8 SUPPLEMENT
CALCULATION RESULTS

Hand calculations were performed for the active condition case. A spreadsheet was used to repeat the calculations for the active case and perform calculations for post-closure case. These calculation results are presented in the following pages.

Written by: RK Date: 03/12/03 Reviewed by: LMG Date: 03/12/09

Client: Ebaur Fornald Project: OSDF - Revise Phase V Project/Proposal No.: GQ3211 Task No.: 06

DRAINAGE LAYER (ACTIVE OPERATION CONDITION)

LEACHATE HEAD

$$\lambda = \frac{q_i}{K \tan^2\beta} = \frac{1.9\times10^{-6}\ \text{cm/s}}{(0.1\ \text{cm/s})\tan^2(1.28^\circ)}$$

$$\lambda = 0.038$$

$$j = 1 - 0.12\exp\left[-\left[\log\left(\frac{8\lambda}{s}\right)^{\frac{5}{8}}\right]^2\right]$$

$$j = 1 - 0.12\exp\left[-\left[\log\left(\frac{8\times0.038}{s}\right)^{\frac{5}{8}}\right]^2\right]$$

$$j = 0.933$$

$$T_{max} = j\left[\frac{\sqrt{1+4\lambda}-1}{2}\cdot\frac{\tan\beta}{\cos\beta}\right]L$$

$$= (0.933)\left[\frac{\sqrt{1+(4)(0.933)}-1}{2}\cdot\frac{\tan(1.28^\circ)}{\cos(1.28^\circ)}\right]270\,ft$$

$$= 2.48''$$

$$h_{max} = T_{max}\cos\beta$$

$$= (2.48)\cos(1.28^\circ)$$

$$= 2.48'' < 12''\ \text{ok}$$

For $\lambda = 0.038$

$$\frac{T_{ave}}{T_{max}} = 0.54$$

$$T_{ave} = (0.54)(2.48) = 1.34''$$

Written by: RK Date: 03/12/03 (YY MM DD) Reviewed by: LMG Date: 03/12/09 (YY MM DD)

Client: Elmar Farnall Project: OSDF – RPV Project/Proposal No.: GQ 3211 Task No.: 06

$$h_{ave} = T_{ave} \cos\beta$$

$$= (1.34) \cos(1.28^\circ)$$

$$= 1.34''$$

$h_{max} = 2.5'' < 12''$ ← allowable head ok

$T_{max} = 2.5'' < 12''$ ← thickness of drainage layer ok

Written by: RK Date: 03/12/03 (YY/MM/DD) Reviewed by: LMG Date: 12/03/09 (YY/MM/DD)

Client: Elmer Fonald Project: 05JF-RPV Project/Proposal No.: GQ3211 Task No.: 06

DRAINAGE CORRIDOR (ACTIVE OPERATION CONDITION)

LEACHATE HEAD

$$q_i = 5.04 \times 10^{-5} \text{ cm/s}$$

$$\lambda = \frac{q_i}{k \tan^2\beta} = \frac{5.04 \times 10^{-5} \text{ cm/s}}{(10 \text{ cm/s})(\tan^2(0.573^\circ))}$$

$$\lambda = 0.050$$

$$j = 1 - 0.12 \exp\left[-\left[\log\left(\frac{8\lambda}{5}\right)^{\frac{5}{8}}\right]^2\right]$$

$$j = 0.924$$

$$T_{max} = j\left[\frac{\sqrt{1+4\lambda} - 1}{2} \frac{\tan\beta}{\cos\beta}\right] L$$

$$= (0.924)\left[\frac{\sqrt{1+(4)(0.050)} - 1}{2} \frac{\tan(0.573)}{\cos(0.573)}\right] \times 7500$$

$$= 3.34''$$

$$h_{max} = T_{max} \cos\beta$$

$$= (3.34)\cos(0.573)$$

$$= 3.34''$$

Written by: RKU Date: 03/12/03 Reviewed by: LMG Date: 03/12/09
Client: Fluor Fernald Project: OSDF-RPV Project/Proposal No.: GQ3211 Task No.: 06

For $\lambda = 0.050$

$$\frac{T_{ave}}{T_{max}} = 0.56$$

$$T_{ave} = (0.56)(3.34)$$
$$= 1.87''$$

$$h_{ave} = T_{ave} \cos\beta$$
$$= (1.87)\cos(0.573)$$
$$= 1.87''$$

$h_{max} = 3.34'' < 12''$ ← allowable head ok

$T_{max} = 3.34'' < 12''$ ← thickness of drainage corridor ok

Written by: RK Date: 03/12/03 (YY/MM/DD) Reviewed by: LMG Date: 03/12/09 (YY/MM/DD)

Client: Fluor Fernald Project: OSDF – RPV Project/Proposal No.: GQ3211 Task No.: 06

DRAINAGE CORRIDOR (ACTIVE OPERATION CONDITION)

FLOW CAPACITY

Flow capacity $Q_{DC} = kiA$

$= 1.49 \times 10^{-3}\ m^3/s$

(No change from section 8.1)

Required capacity $Q_R = q_i A_d$

$Q_R = [1.9 \times 10^{-6} \times 10^{-2}\ m/s][6.34\ acre \times 0.405\ \frac{ha}{acre} \times 10{,}000\ \frac{m^2}{ha}]$

$= [1.9 \times 10^{-8}\ m/s][2.57 \times 10^{4}\ m^2]$

$= 4.88 \times 10^{-4}\ m^3/s$

Ratio of drainage corridor capacity to required capacity

$\frac{Q_{DC}}{Q_R} = \frac{1.49 \times 10^{-3}}{4.88 \times 10^{-4}}$

$= 3.05 > 3$ o.k.

LCS Drainage Layer

Parameter	Active	Post-Closure
Drainage Path Length (ft)	270	245
Drainage Path Slope (%)	2.24	2.04
Slope Angle (rad)	0.02	0.02
Slope Angle (deg)	1.28	1.17
Thickness (in.)	12	12
Total Cell Width (ft)	425	425
Total Cell Length (ft)	650	650
Total Cell Area (acre)	6.34	6.34
k (cm/s)	0.1	0.1
qi, (in/day) [from HELP]	0.0646	0.0000009
qi, (cm/s)	1.90E-06	2.65E-11
λ [Giroud et al.]	0.038	0.000
j [Giroud et al.]	0.933	1.000
T_{max}/L	7.63E-04	1.30E-08
T_{max} (in.)	2.47	3.81E-05
h_{max} (in.)	2.47	3.81E-05
T_{ave}/T_{max}	0.54	0.5
T_{ave} (in.)	1.34	1.91E-05
h_{ave} (in.)	1.33	1.91E-05

LCS Drainage Corridor

Parameter	Active	Post-Closure
Drainage Path Length (ft)	625	625
Drainage Path Slope (%)	1.00	0.40
Slope Angle (rad)	0.01	0.00
Slope Angle (deg)	0.57	0.23
Thickness (in.)	12	12
Total Corridor Width (ft)	16	16
Total Corridor C/S Area (ft^2)	16	16
Total Corridor C/S Area (m^2)	1.49	1.49
Total Corridor Plan Area (acre)	0.23	0.23
k (cm/s)	10	10
qi, (in/day)	1.72	2.39E-05
qi, (cm/s)	5.04E-05	7.03E-10
λ [Giroud et al.]	0.050	0.000
j [Giroud et al.]	0.925	1.000
T_{max}/L	4.45E-04	1.76E-08
T_{max} (in.)	3.34	1.32E-04
h_{max} (in.)	3.34	1.32E-04
T_{ave}/T_{max}	0.56	0.5
T_{ave} (in.)	1.87	6.59E-05
h_{ave} (in.)	1.87	6.59E-05
Flow Capacity (m^3/s)	1.49E-03	5.95E-04
Required Capacity (m^3/s)	4.88E-04	6.80E-09
Factor of Safety (For Capacity)	3.05	8.75E+04

Section 8.5

8.5 LCS PIPE DESIGN – CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

5318

SUBJECT OF COMPUTATIONS OSDF PHASE V, LCS PIPE DESIGN – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature GANESH GOPALAKRISHNAN — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature Hollie N. Kinnecom — Date 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature Rudolph Bonaparte — Date 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval

000127

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

ADDENDUM TO SECTION 8.3
(ADDED TO REVISION 1 PACKAGE)

The Final Design Calculation Package "Leachate Collection System (LCS) LCS Pipe Design" presented in Section 8.3 evaluated the performance of the LCS collector pipe. The LCS pipe flow capacity was compared to the required capacity as part of the evaluation in that Calculation Package using baseline design flow rates applicable to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). Baseline design flow rates for the southernmost OSDF cell (i.e., Cell 8) are different from that of the other cells, and are presented in Section 7.4.

This addendum to Section 8.3 evaluated the performance of the LCS collector pipe for Cell 8 using the baseline flow rates for that cell. Similar methods and input data to that used in Section 8.3 were used herein. This addendum is presented as Section 8.5 of the OSDF Final Design Calculation Package, and is titled, "Leachate Collection System (LCS) LCS Pipe Design – Cell 8 Supplement". Section 8.5 is presented in Volume VII of the OSDF Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
LCS PIPE DESIGN - CELL 8 SUPPLEMENT
EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this analysis is to evaluate the performance of the LCS collector pipe for Cell 8 of the OSDF. The evaluation will be performed for both active operation and post-closure conditions.

METHOD OF ANALYSIS

The flow capacity, perforation size, and structural stability (wall crushing, wall buckling, and excessive ring deflection) were calculated for the LCS collector pipe in the Section 8.3, "Leachate Collection System (LCS) LCS Pipe Design" of the Final Design Calculation Package. The parameters used to calculate the perforation size and structural stability of the LCS collector pipe have not changed. However, the flow capacity of the LCS pipe is compared to the required flow capacity for Cell 8 in this Calculation Package.

CONCLUSIONS

- Pipe flow capacity for active operation condition, $Q_p = 196.4$ gpm
- Required flow capacity for active operation condition, $Q_{pr} = 7.7$ gpm
- Flow capacity factor of safety for active operation condition, $Q_p/Q_{pr} = 25 > 3$ (OK)
- Pipe flow capacity for post-closure condition, $Q_p = 124.2$ gpm
- Required flow capacity for post-closure condition, $Q_{pr} = 1.08 \times 10^{-4}$ gpm
- Flow capacity factor of safety for post-closure condition, $Q_p/Q_{pr} = 1.15 \times 10^{6} >> 10$ (OK)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
LCS PIPE DESIGN - CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to evaluate the factor of safety for flow capacity by comparing the new required flow capacity for Cell 8 with the LCS pipe flow capacity.

METHOD OF ANALYSIS

The required flow capacity for Cell 8 was evaluated in Section 8.4, "Leachate Collection System (LCS) Maximum Head in LCS – Cell 8 Supplement". The LCS pipe flow capacity was evaluated in Section 8.3 "Leachate Collection System (LCS) LCS Pipe Design" of the Final Design Calculation Package.

5316

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
LCS PIPE DESIGN - CELL 8 SUPPLEMENT
DATA VERIFICATION

Pipe flow capacity (Q_p) = 1.25×10^{-2} m^3/s (from Calculation Package "Leachate Collection System (LCS) LCS Pipe Design" – Section 8.3)

Required flow capacity (Q_{pr}) = 4.88×10^{-4} m^3/s (from Calculation Package "Leachate Collection System (LCS) Maximum Head in LCS – Cell 8 Supplement" – Section 8.4)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEACHATE COLLECTION SYSTEM (LCS)
LCS PIPE DESIGN - CELL 8 SUPPLEMENT
CALCULATION RESULTS

Hand calculations were performed for the active condition case. A spreadsheet was used to repeat the calculations for the active case and perform calculations for the post-closure case. These calculation results are presented in the following pages.

Written by: RJG Date: 03/12/03 (YY MM DD) Reviewed by: LMG Date: 03/12/09 (YY MM DD)

Client: Fluor Fernald Project: OSDF – RI PV Project/Proposal No.: GQ 3271 Task No.: 06

LCS PIPE FLOW CAPACITY (ACTIVE OPERATION)

LCS Pipe Flow capacity, $Q_p = 1.25 \times 10^{-2}\ m^3/s$

(no change from the previous calculation package) (section 8.3)

Required capacity $Q_{pr} = q_i A_d$

$$Q_{pr} = [1.9 \times 10^{-6} \times 10^{-2}\ m/s][6.34 \times 0.405 \times 10{,}000\ m^2]$$

$$= 4.88 \times 10^{-4}\ m^3/s$$

$$\frac{Q_p}{Q_{pr}} = \frac{1.25 \times 10^{-2}}{4.88 \times 10^{-4}}$$

$$= 25.4 > 3 \quad \text{O.K}$$

LCS Pipe

Parameter	Active	Post-Closure
Pipe Inner Diameter (in.)	5.421	5.421
Cross Section Area (in^2)	23.08	23.08
Cross Section Area (m^2)	1.49E-02	1.49E-02
Hydraulic Radius (in.)	1.36	1.36
Manning's Coefficient ($s/m^{0.33}$)	0.013	0.013
Drainage Path Slope (%)	1.00	0.40
Slope Angle (rad)	0.01	0.00
Slope Angle (deg)	0.57	0.23
Flow Capacity (m^3/s)	1.24E-02	7.84E-03
Required Capacity (m^3/s)	4.88E-04	6.80E-09
Factor of Safety (For Capacity)	25.41	1.15E+06

Section 9.6

9.6 MIGRATION THROUGH PRIMARY LINER – CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

5316

SUBJECT OF COMPUTATIONS OSDF PHASE V, MIGRATION THROUGH PRIMARY LINER – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: GANESH GOPALAKRISHNAN — Date: 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature: Hollie N. Kinnecom — Date: 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature: [illegible] — Date: 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

ADDENDUM TO SECTION 9.1
(ADDED TO REVISION 1 PACKAGE)

The Calculation Package "Leak Detection System (LDS) Migration through Primary Liner" presented in Section 9.1 summarized the analysis of leachate migration through the primary liner and into the LDS and discussed other potential sources of flow into the LDS for different stages of the life of the Fernald On-site Disposal Facility (OSDF). The leachate migration rates were calculated based on a cell 400 feet wide and 6.5 acres in size. This size cell applies to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). The southernmost OSDF cell (i.e., Cell 8) is sized differently from the other cells.

This addendum to Section 9.1 summarizes the analysis of leachate migration through the primary liner for Cell 8. Similar methods and input data to that used in Section 9.1 were used herein. This addendum is presented as Section 9.6 of the OSDF Final Design Calculation Package, and is titled, "Leak Detection System (LDS) Migration through Primary Liner – Cell 8 Supplement". Section 9.6 is presented in Volume VII of the OSDF Final Design Calculation Package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS) MIGRATION THROUGH PRIMARY LINER - CELL 8 SUPPLEMENT EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this package is to summarize the analysis of leachate migration through the primary liner and into the LDS for Cell 8 of the OSDF.

METHODS OF ANALYSIS

The infiltration rate of leachate through the primary liner into the LDS was estimated using the USEPA HELP model analysis performed in the "Leachate Generation Rates – Cell 8 Supplement" Calculation Package. The assumptions made to perform the leachate generation analysis were summarized in the "Leak Detection System (LDS) – Migration Through Primary Liner" Final Design Calculation Package. The updated results for Cell 8 of the OSDF are presented here.

CONCLUSIONS

Infiltration rates through the primary liner are as follows:

- Peak daily rate during active conditions = 6.5×10^{-3} gpad
- Average annual rate during active conditions = 4.5×10^{-3} gpad
- Average annual rate during post-closure conditions = 1.9×10^{-4} gpad

5316

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
MIGRATION THROUGH PRIMARY LINER - CELL 8
SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to present the calculation procedures for evaluating the migration of leachate through the primary liner.

METHOD OF ANALYSIS

Calculation procedures were the same as those presented in Section 9.1 "Leak Detection System (LDS) – Migration through Primary Liner" Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03 5316

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS) MIGRATION THROUGH PRIMARY LINER - CELL 8 SUPPLEMENT

DATA VERIFICATION

Leachate migration through primary liner analysis was performed as part of Section 7.4 "Leachate Generation Rates – Cell 8 Supplement" Final Design Calculation Package. The data required to perform this analysis is included in that package. A discussion on the variables that have the greatest effect on results, namely frequency and size of holes in the geomembrane components of the primary liner and quality of contact between the geomembrane and GCL components of the primary liner, was presented in Section 9.1 "Leak Detection System (LDS) – Migration through Primary Liner – Data Verification" Final Design Calculation Package. The discussion presented in that calculation package is applicable to the results presented in this calculation package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
MIGRATION THROUGH PRIMARY LINER - CELL 8
SUPPLEMENT
CALCULATION RESULTS

Infiltration rates through the primary liner are as follows:

- Peak daily rate during active conditions = 6.5×10^{-3} gpad
- Average annual rate during active conditions = 4.5×10^{-3} gpad
- Average annual rate during post-closure conditions = 1.9×10^{-4} gpad

Note, that peak daily rate for the post-closure stage cannot be calculated with certainty due to rounding errors by the HELP program, but is expected to be greater than 1.9×10^{-4} gpad.

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Client: Fluor Fernald Project: OSDF - RPV Project/Proposal No.: GQ3211 Task No.: 06

Infiltration rates through primary liner

Peak daily rate during active conditions

$= 2.4 \times 10^{-7}$ in/day [from HELP]

$= 6.5 \times 10^{-3}$ gpad

Average annual rate during active conditions

$= 6.0 \times 10^{-5}$ in/yr

$= 4.5 \times 10^{-3}$ gpad

Average annual rate during post-closure conditions

$= 2.5 \times 10^{-6}$ in/yr

$= 1.9 \times 10^{-4}$ gpad

Peak annual rate during post-closure conditions

$= 5.5 \times 10^{-9}$ in/d

$= 1.5 \times 10^{-4}$ gpad

000144

(less than the average → considered to be due to the rounding errors in HELP)

9.7 MAXIMUM HEAD IN LDS – CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

5318

SUBJECT OF COMPUTATIONS OSDF PHASE V, MAXIMUM HEAD IN LDS – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: GANESH GOPALAKRISHNAN — Date: 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature: Hollie N. Kinnecom — Date: 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature: for — Date: 1-23-04

Printed Name and Title: Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

Record of Revision (Number and initial all revisions)

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ADDENDUM TO SECTION 9.2
(ADDED TO REVISION 1 PACKAGE)

The Calculation Package "Leak Detection System (LDS) Maximum Head in LDS" presented in Section 9.2 evaluated the performance of the drainage layer and the drainage corridor components of the leak detection system (LDS) for different stages of the life of the Fernald On-site Disposal Facility (OSDF). The performance of the drainage layer and drainage corridor was evaluated using baseline design flow rates applicable to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). Baseline design flow rates for the southernmost OSDF cell (i.e., Cell 8) are presented in Section 7.4 and will be utilized in this package.

This addendum to Section 9.2 evaluated the performance of the drainage layer and drainage corridor for Cell 8. Similar methods and input data to that used in Section 9.2 were used herein. This addendum is presented as Section 9.7 of the OSDF Final Design Calculation Package, and is titled, "Leak Detection System (LDS) Maximum Head in LDS – Cell 8 Supplement". Section 9.7 is presented in Volume VII of the OSDF Final Design Calculation Package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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LEAK DETECTION SYSTEM (LDS)
MAXIMUM HEAD IN LDS - CELL 8 SUPPLEMENT
EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this package is to evaluate the performance of the drainage layer and the drainage corridor components of the leak detection system (LDS) for Cell 8 of the OSDF.

METHODS OF ANALYSIS

Drainage Layer: The maximum and average thickness of liquid in the LDS drainage layer were calculated using a closed-form analytical solution.

Drainage Corridor: The maximum and average hydraulic head and thickness of liquid in the drainage corridor were calculated using a closed-form analytical solution. The flow capacity of the drainage corridor was calculated using Darcy's equation to verify its ability to convey liquid with an adequate factor of safety.

Calculations were performed for the active operation condition and for the post-closure (i.e., post-settlement) condition. Baseline design flow rates established in the "Leachate Generation Rates – Cell 8 Supplement" Calculation Package were utilized in the calculations. These flow rates do not account for large peak flows associated with the storm design basis flow rate.

CONCLUSIONS

ACTIVE OPERATION CONDITION:

LDS Drainage Layer:

- maximum thickness of liquid, T_{max} = 0.021 in. < 12 in. (OK)
- average thickness of liquid, $T_{ave,w}$ = 1.9×10^{-4} in.

LDS Drainage Corridor:

- maximum leachate head, $h_{max} = 1.41 \times 10^{-5}$ in. < 12 in. (OK)
- average leachate head, $h_{avg} = 7.0 \times 10^{-6}$ in.
- maximum liquid thickness, $T_{max} = 1.41 \times 10^{-5}$ in.
- average liquid thickness, $T_{avg} = 7.0 \times 10^{-6}$ in.
- drainage corridor capacity, $Q_{DC} = 23.6$ gpm
- required flow capacity, $Q_R = 2.9 \times 10^{-5}$ gpm
- flow capacity factor of safety, $Q_{DC}/Q_R = 8.2 \times 10^5 >> 3$ (OK)

POST-CLOSURE CONDITION:

LDS Drainage Layer:

- maximum thickness of liquid, $T_{max} = 0.004$ in. < 12 in. (OK)
- average thickness of liquid, $T_{ave,w} = 2.62 \times 10^{-6}$ in.

LDS Drainage Corridor:

- maximum leachate head, $h_{max} = 2.4 \times 10^{-5}$ in. < 12 in. (OK)
- average leachate head, $h_{avg} = 1.2 \times 10^{-5}$ in.
- maximum liquid thickness, $T_{max} = 2.4 \times 10^{-5}$ in
- average liquid thickness, $T_{avg} = 1.2 \times 10^{-5}$ in.
- drainage corridor capacity, $Q_{DC} = 9.42$ gpm
- required flow capacity, $Q_R = 8.13 \times 10^{-7}$ gpm
- flow capacity factor of safety, $Q_{DC}/Q_R = 1.2 \times 10^7 >> 10$ (OK)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
MAXIMUM HEAD IN LDS - CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to present the calculation procedures for evaluating the maximum head in the LDS.

METHOD OF ANALYSIS

The calculation procedures are the same as those presented in Section 9.2 "Leak Detection System (LDS) Maximum Head in LDS" Final Design Calculation Package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)

MAXIMUM HEAD IN LDS - CELL 8 SUPPLEMENT

DATA VERIFICATION

INTRODUCTION

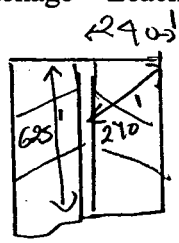
The purpose of this package is to present the data parameters needed to perform the calculations for the LDS for Cell 8 of the OSDF. In particular, this package addresses the following analyses:

- drainage layer (average and maximum liquid thickness); and
- drainage corridor (average and maximum leachate head and liquid thickness, and flow capacity).

In order to perform the analyses the data presented in the Calculation Package "Leachate Detection System (LDS) Maximum Head in LDS" is used, except that the slope lengths, cell area, and flow rates are revised based on the Calculation Package "Leachate Generation Rates – Cell 8 Supplement" as described in the following section.

ACTIVE OPERATION CONDITIONS:

Cell Base



240' @ 2%
270' @ 2.24%
625' @ 1%

Drainage Layer:

Q = leakage rate through a hole in the primary liner (assumes 1 hole per acre)

= 4.5×10^{-3} gpad (average annual daily infiltration calculated using the HELP model) X 1.0 acres

= 4.5×10^{-3} gpd

= 6.5×10^{-3} gpad (peak daily infiltration calculated using the HELP model) X 1.0 acres

= 6.5×10^{-3} gpd

L = the horizontal length of the slope = 270 ft (3240 in.)

Drainage Corridor:

The impingement rate of flow into the drainage corridor is calculated by multiplying the peak daily value from HELP for the drainage layer by a factor (width of cell / width of drainage corridor). Impingement rate is taken equal to the infiltration through the top liner (from HELP calculations performed as part of "Leachate Generation Rates – Cell 8 Supplement" Calculation Package).

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

q_i = the maximum impingement rate of flow into the drainage corridor

= (6.5×10^{-3} gpad or 2.4×10^{-7} in/d) x (425 ft / 16 ft)

= 6.4×10^{-6} in/d

L = the length of the drainage corridor = 625 ft (7500 in.)

POST-CLOSURE CONDITION:

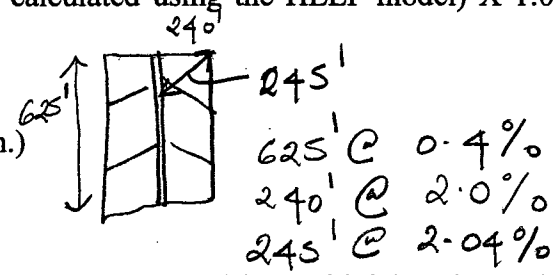
Drainage Layer:

Q = leakage rate through a hole in the primary liner (assumes 1 hole per acre)

= 1.9×10^{-4} gpad (average annual daily infiltration calculated using the HELP model) X 1.0 acres

= 1.9×10^{-4} gpd

L = the horizontal length of the slope = 245 ft (2940 in.)



Drainage Corridor:

The impingement rate of flow into the drainage corridor is calculated by multiplying the peak daily value from HELP for the drainage layer by a factor (width of cell / width of drainage corridor). Impingement rate is taken as equal to the infiltration through the top liner (from HELP calculations performed as part of "Leachate Generation Rates – Cell 8 Supplement" Calculation Package).

q_i = the maximum impingement rate of flow into the drainage corridor

= (1.9×10^{-4} gpad or 2.5×10^{-6} in/yr) x (425 ft / 16 ft)

= 6.6×10^{-5} in/yr

L = the length of the drainage corridor = 625 ft (7500 in.)

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)

MAXIMUM HEAD IN LDS - CELL 8 SUPPLEMENT (SEE VOLUME VIII)

CALCULATION RESULTS

Hand calculations were performed for the active condition case. A spread sheet was used to repeat the calculations for the active case and perform calculations for post-closure case. These calculation results are presented in the following pages.

Written by: RK Date: 03/12/03 (YY/MM/DD) Reviewed by: LM Cn Date: 03/12/09 (YY/MM/DD)

Client: Fluor Fernald Project: OSDF RPV Project/Proposal No.: GP3211 Task No.: 06

Drainage Layer

Active Condition:

$Q_{peak, Daily} = 6.5 \times 10^{-3}$ gpd (for 1 hole)

$Q_{Average, Annual} = 4.5 \times 10^{-3}$ gpd (for 1 hole)

Peak Daily ⇒

$$T_{max} = \sqrt{\frac{Q}{K}}$$

$$= \sqrt{\frac{(6.5 \times 10^{-3}\,gpd)\left(\frac{ft^3}{7.48\,gal}\right)\left[\frac{1}{24 \times 3600}\right]\frac{d}{s}}{(0.1\,cm/s)\left(\frac{ft}{30.48\,cm}\right)}}$$

$$= \sqrt{3.07 \times 10^{-6}}$$

$$= 1.75 \times 10^{-3}\,ft$$

$$= 0.021'' < 12''\ \text{o.k}$$

$$M = \frac{T_{max}}{L \sin\beta}$$

$$= \frac{1.75 \times 10^{-3}\,ft}{(270\,ft)\sin(1.28^\circ)}$$

$$= 2.90 \times 10^{-4}$$

Written by: RK Date: 03/12/03 (YY MM DD) Reviewed by: LMG Date: 03/12/09 (YY MM DD)

Client: Flour Fomld Project: OSDF-RPV Project/Proposal No.: GQ 3211 Task No.: 06

$$T_{ave,w} = \frac{3}{4} T_{max} = \frac{1 + \frac{3}{9}M}{\sqrt{1+\left(\frac{2}{M}\right)\left(1+\frac{M}{2}\right)}}$$

$$= 1.90 \times 10^{-4} \text{ in}$$

Drainage corridor

$$q_i = 6.4 \times 10^{-6} \text{ in/d}$$

$$\lambda = \frac{q_i}{k \tan^2\beta}$$

$$= \frac{6.4 \times 10^{-6} \frac{in}{d} \times \frac{2.54 \frac{cm}{in}}{2.4 \times 3600 \frac{s}{d}}}{(10 cm/s) \tan^2(0.573^\circ)}$$

$$= 1.88 \times 10^{-7}$$

$$j = 1 - 0.12 \exp\left[-\left[\log\left(\frac{8\lambda}{s}\right)^{\frac{s}{8}}\right]^2\right]$$

$$j = 1$$

$$T_{max} = j\left[\frac{\sqrt{1+4\lambda} - 1}{2} \frac{\tan\beta}{\cos\beta}\right] L$$

$$= (1)\left[\frac{\sqrt{1+(4)(1.88 \times 10^{-7})} - 1}{2} \frac{\tan(0.573)}{\cos(0.573)}\right] 625$$

Written by: RK Date: 03/12/03 (YY/MM/DD) Reviewed by: LMG Date: 03/12/09 (YY/MM/DD)

Client: Ebner Fernald Project: OSDF RPV Project/Proposal No.: GQ3211 Task No.: 06

$$T_{max} = 1.41 \times 10^{-5} \text{ in} < 12'' \quad \text{O.K}$$

$$h_{max} = T_{max} \cos\beta$$

$$= (1.41 \times 10^{-5}) \cos(0.573)$$

$$= 1.41 \times 10^{-5} \text{ in}$$

For $\lambda = 1.88 \times 10^{-7}$

$$\frac{T_{ave}}{T_{max}} = 0.5$$

$$T_{ave} = (0.5)(1.41 \times 10^{-5})$$

$$= 0.705 \times 10^{-5} \text{ in}$$

$$h_{ave} = T_{ave} \cos\beta$$

$$= (0.705 \times 10^{-5}) \cos(0.573^\circ)$$

$$= 0.705 \times 10^{-5} \text{ in} \quad //$$

Written by: RK Date: 03/12/03 Reviewed by: LMG Date: 03/12/09

Client: Fluor Fonald Project: 050F - RPV Project/Proposal No.: GQ 3211 Task No.: 06

Drainage corridor Flow Capacity

$$Q_{DC} = kiA$$

$$= (0.1\ m/s)(0.01)(1.49\ m^2)$$

$$= 1.49 \times 10^{-3}\ m^3/s \qquad [23.6\ gpm]$$

$$q_i = 6.5 \times 10^{-3}\ gpad$$

$$= 2.4 \times 10^{-7}\ in/d$$

Required capacity (Q_R)

$$Q_R = q_i A d$$

$$= \left[2.4 \times 10^{-7}\ in/d \times \frac{2.54}{100} \times \frac{1}{24 \times 3600}\right] m/s$$

$$\times \left[(6.4\ Acre) \times 0.405\ \frac{ha}{acre} \times 10{,}000\ \frac{m^2}{ha}\right]$$

$$= 7.06 \times 10^{-14}\ m/s \times 25920\ m^2$$

$$= 1.83 \times 10^{-9}\ m^3/s$$

$$\frac{Q_{DC}}{Q_R} = \frac{1.49 \times 10^{-3}}{1.83 \times 10^{-9}} = 8.1 \times 10^5 >> 3$$

O.K.

LDS Drainage Layer

Parameter	Active		Post-Closure	
	Daily Peak	Yearly Average	Daily Peak	Yearly Average
Drainage Path Length (ft)	270	270	245	245
Drainage Path Slope (%)	2.24	2.24	2.04	2.04
Slope Angle (rad)	0.02	0.02	0.02	0.02
Slope Angle (deg)	1.28	1.28	1.17	1.17
Thickness (in.)	12	12	12	12
Total Cell Width (ft)	425	425	425	425
Total Cell Length (ft)	650	650	650	650
Total Cell Area (acre)	6.34	6.34	6.34	6.34
k (cm/s)	0.1	0.1	0.1	0.1
qi, (in/day) [from HELP]	2.40E-07	1.64E-07	6.80E-09	6.80E-09
qi, (cm/s)	7.06E-12	4.82E-12	2.00E-13	2.00E-13
No of holes per acre	1	1	1	1
Q per hole, (ft3/s)	1.008E-08	6.890E-09	2.857E-10	2.857E-10
T_{max} (in.)	0.021	0.017	0.004	0.004
M	2.90E-04	2.40E-04	5.91E-05	5.91E-05
$T_{ave,w}$ (in.)	1.90E-04	9.30E-06	2.62E-06	2.62E-06

LDS Drainage Corridor

Parameter	Active	Post-Closure
Drainage Path Length (ft)	625	625
Drainage Path Slope (%)	1.00	0.40
Slope Angle (rad)	0.01	0.00
Slope Angle (deg)	0.57	0.23
Thickness (in.)	12	12
Total Corridor Width (ft)	16	16
Total Corridor C/S Area (ft^2)	16	16
Total Corridor C/S Area (m^2)	1.49	1.49
Total Corridor Plan Area (acre)	0.23	0.23
k (cm/s)	10	10
qi, (in/day)	6.38E-06	4.36E-06
qi, (cm/s)	1.87E-10	1.28E-10
λ [Giroud et al.]	1.874E-07	0.000
j [Giroud et al.]	1.000	1.000
T_{max}/L	1.87E-09	3.20E-09
T_{max} (in.)	1.41E-05	2.40E-05
h_{max} (in.)	1.41E-05	2.40E-05
T_{ave}/T_{max}	0.5	0.5
T_{ave} (in.)	7.03E-06	1.20E-05
h_{ave} (in.)	7.03E-06	1.20E-05
Flow Capacity (m^3/s)	1.49E-03	5.95E-04
Required Capacity (m^3/s)	1.81E-09	5.13E-11
Factor of Safety (For Capacity)	8.20E+05	1.16E+07

Section 9.8

9.8 TIME OF TRAVEL IN LDS – CELL 8 SUPPLEMENT

5316

COMPUTATION COVER SHEET

SUBJECT OF COMPUTATIONS OSDF PHASE V, TIME OF TRAVEL IN LDS – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: GANESH GOPALAKRISHNAN — Date: 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature: Hollie N. Kinnecom — Date: 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: R. Kulasingam — Date: 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature: [illegible] — Date: 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

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ADDENDUM TO SECTION 9.3
(ADDED TO REVISION 1 PACKAGE)

The Calculation Package "Leak Detection System (LDS) Time of Travel in LDS" presented in Section 9.3 estimated the maximum time of travel in the leak detection system (LDS) for different stages of the life of the Fernald On-site Disposal Facility (OSDF). The times of travel were calculated based on a cell 400 feet wide and 6.5 acres in size. This size cell applies to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). The southernmost OSDF cell (i.e., Cell 8) is sized differently from the other cells.

This addendum to Section 9.3 estimated the maximum time of travel in the leak detection system (LDS) for Cell 8. Similar methods and input data to that used in Section 9.3 were used herein. This addendum is presented as Section 9.8 of the OSDF Final Design Calculation Package, and is titled, "Leak Detection System (LDS) Time of Travel in LDS". Section 9.8 is presented in Volume VII of the OSDF Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
TIME OF TRAVEL IN LDS - CELL 8 SUPPLEMENT
EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this package is to estimate the maximum time of travel in the leak detection system (LDS) for Cell 8 of the OSDF. In accordance with the Design Criteria Package (DCP), REV1E, the maximum time of travel in the LDS should not exceed 20 days.

METHOD OF ANALYSIS

The maximum time of travel of liquids in the LDS is estimated for the active operation condition and the post-closure condition. Design grades and slopes are utilized for the active operation condition and post-settlement grades and slopes are utilized for the post-closure condition.

CONCLUSIONS

- time of travel for active operation condition = 17.6 days < 20 days (O.K.)
- time of travel for post-closure condition = 18.8 days < 20 days (O.K.)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
TIME OF TRAVEL IN LDS - CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to present the calculation procedures for the time of travel in the leak detection system (LDS). The LDS drainage corridor is the primary collector and the LDS pipe acts as a backup.

METHOD OF ANALYSIS

The calculation procedures are the same as those presented in Section 9.3, "Leachate Detection System (LDS) Time of Travel in LDS" of the Final Design Calculation Package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
TIME OF TRAVEL IN LDS - CELL 8 SUPPLEMENT
DATA VERIFICATION

INTRODUCTION

As described in the calculation procedures package, an analysis of the time of travel in the LDS will be performed.

In order to perform the analyses the data described in the Final Design Calculation Package "Leachate Detection System (LDS) Time of Travel in LDS" is used, except that the drainage path lengths are changed as described below to reflect the new geometry of Cell 8.

ACTIVE OPERATION CONDITION:

Time of Travel in the LDS Drainage Layer:
L_{DL} = length of flow in the LDS drainage layer = 270 ft

Time of Travel in the LDS Drainage Corridor:
L_{DC} = length of flow in the drainage corridor = 501.3 ft

Time of Travel in the LDS Collector Pipe:
L_{CP} = length of LDS collector pipe = 501.3 ft

Time of Travel in the LDS Pipe (Extending from outside the cell to Valve House 8 (VH-8)):
L_p = length of LDS pipe extending from outside the cell to VH-8 = 180 ft

POST-CLOSURE CONDITION:

Time of Travel in the LDS Drainage Layer:
L_{DL} = length of flow in the LDS = 245 ft

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

Time of Travel in the LDS Drainage Corridor:

L_{DC} = length of flow in the drainage corridor = 576 ft

Time of Travel in the LDS Collector Pipe:

L_{CP} = length of LDS collector pipe = 576 ft

Time of Travel in the LDS Pipe (Extending from outside the cell to Valve House 8 (VH-8)):

L_p = length of LDS pipe extending from outside the cell to VH-8 = 180 ft

5316

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
TIME OF TRAVEL IN LDS - CELL 8 SUPPLEMENT (SEE VOLUME VIII)
CALCULATION RESULTS

Written by: RK Date: 03/12/03 (YY/MM/DD) Reviewed by: LMG Date: 03/12/09 (YY/MM/DD)

Client: Elmer Fornald Project: OSDF – Revised Phase V Project/Proposal No.: GQ 3211 Task No.: 06

Time of Travel in LDS

ACTIVE CONDITION:

Time of travel in LDS drainage layer:

$$t_{DL} = \frac{L_{DL}\, n_{DL}}{k_{DL}\, i_{DL}}$$

$$= \frac{(270\,ft)(0.397)}{(0.1\,cm/s)\left(\frac{ft}{30.48\,cm}\right)(0.0224)} \times \frac{1}{3600}$$

$$= 405.15\ hr$$

Time of travel in LDS drainage corridor:

$$t_{DC} = \frac{L_{DC}\, n_{DC}}{k_{DC}\, i_{DC}}$$

$$= \frac{(501.3\,ft)(0.397)}{(10\,cm/s)\left(\frac{ft}{30.48}\right)(0.01)} \times \frac{1}{3600\,\frac{s}{hr}}$$

$$= 16.85\ hr$$

Time of travel in LDS collector pipe:

$$t_{cp} = \frac{L_{cp}\, n}{R_h^{0.66}\, i_{cp}^{0.5}}$$

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Client: Ebur Fernald Project: OSDF - Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

$$= \frac{\left[501.3\,ft \times \frac{12\,\frac{in}{ft} \times 2.54\,\frac{cm}{in}}{100\,\frac{cm}{m}}\right]\left(0.013\,\frac{s}{m^{0.33}}\right)}{(0.0345\,m)^{0.66}\,(0.010)^{0.5}}$$

$= 183.3$ secs

$= 0.05$ hr

Time of travel in LDS pipe extending outside of cell to VH-4.

$$t_p = \frac{L_p\, n}{R_h^{0.66}\, i_p^{0.5}}$$

$$= \frac{\left(180\,ft \times \frac{12 \times 2.54}{100}\,\frac{m}{ft}\right)\left(0.013\,\frac{s}{m^{0.33}}\right)}{(0.0345\,m)^{0.66}\,(0.040)^{0.5}}$$

$= 32.9$ secs

$= 9.1 \times 10^{-3}$ hr

$= 0.009$ hr

Total time of travel, t

$$= \mathrm{Max}\begin{bmatrix} 405.15 + 16.85 + 0.009, \\ 405.15 + 0.05 + 0.009 \end{bmatrix}$$

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Client: Fluor Fernald Project: OSDF - Revised Phase V Project/Proposal No.: GP3211 Task No.: 06

$= \text{Max}[422\ hr, 405\ hr]$

$= 422\ hr$

$= 17.6\ days < 20$ O.K

Written by: RK Date: 03/12/03 (YY MM DD) Reviewed by: LMG Date: 03/12/03 (YY MM DD)

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GR3211 Task No.: 06

Time of Travel in LDS

POST-CLOSURE CONDITION:

Time of travel in LDS drainage layer:

$$t_{DL} = \frac{L_{DL} n_{DL}}{k_{DL} i_{DL}}$$

$$= \frac{(245\ ft)(0.39\ y)}{(0.1\ cm/s)\left(\frac{ft}{30.48\ cm}\right)(0.0204)} \times \frac{1}{3600\left(\frac{s}{hr}\right)}$$

$$= 403.7\ hr$$

Time of travel in LDS drainage corridor:

$$t_{DC} = \frac{L_{DC} n_{DC}}{K_{DC} i_{DC}}$$

$$= \frac{(576\ ft)(0.39\ y)}{(10\ cm/s)\left(\frac{ft}{30.48\ cm}\right)(0.004)} \times \frac{1}{3600\left(\frac{s}{hr}\right)}$$

$$= 48.4\ hrs$$

Time of travel in LDS collector pipe:

$$t_{CP} = \frac{L_{CP}\, n}{R_h^{0.66}\, i_{CP}^{0.5}}$$

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Client: Fluor Fernald Project: OSDF - Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

$$= \frac{\left(576\,ft \times \frac{12 \times 2.54}{100}\,\frac{m}{ft}\right)\left(0.013\,\frac{s}{m^{0.33}}\right)}{(0.0345\,m)^{0.66}\,(0.004)^{0.5}}$$

$= 333$ Secs

$= 0.09$ hr

Time of travel in LDS pipe extending outside of cell to VH-4

$$t_p = \frac{L_p n}{R_h^{0.66} \cdot i_p^{0.5}}$$

$$= \frac{\left(180\,ft \times \frac{12 \times 2.54}{100}\,\frac{m}{ft}\right)\left(0.013\,\frac{s}{m^{0.33}}\right)}{(0.0345\,m)^{0.66}\,(0.040)^{0.5}}$$

$= 32.9$ secs

$= 9.1 \times 10^{-3}$ hr

$= 0.009$ hr

Total time of travel, t

$$= \text{Max}\left[\begin{array}{l} 403.7 + 48.4 + 0.009, \\ 403.7 + 0.09 + 0.009 \end{array}\right]$$

GEOSYNTEC CONSULTANTS

Written by: RK Date: 03/12/03 (YY MM DD) Reviewed by: LMG Date: 03/12/09 (YY MM DD)

Client: Ehrar Fernald Project: OSDF - Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

$= M_{asc}[452.1\ hr,\ 403.8\ hr]$

$= 452.1\ hr$

$= 18.8\ days < 20$ O.K.

Section 9.9

9.9 LDS PIPE DESIGN– CELL 8 SUPPLEMENT

COMPUTATION COVER SHEET

SUBJECT OF COMPUTATIONS OSDF PHASE V, LDS PIPE DESIGN – CELL 8 SUPPLEMENT

Computations By:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature GANESH GOPALAKRISHNAN — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Computations Checked by:

Signature Hollie N. Kinnecom — Date 1-23-04

Printed Name and Title: Hollie N. Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature R. Kulasingam — Date 1-23-04

Printed Name and Title: Ramachandran Kulasingam, Senior Staff Engineer

Approved by:
(PDP)

Signature — Date 1-23-04

Printed Name and Title: for Leslie M. Griffin, Engineer

Approved by:
(DTL/TETL)

Signature Rudolph Bonaparte — Date 23 Jan 04

Printed Name and Title: R. Bonaparte, Principal

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval

000177

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

ADDENDUM TO SECTION 9.4
(ADDED TO REVISION 1 PACKAGE)

The Final Design Calculation Package "Leak Detection System (LDS) LDS Pipe Design" presented in Section 9.4 evaluated the performance of the LDS collector pipe for the OSDF. The LDS pipe flow capacity was compared to the required capacity as part of the evaluation in that Calculation Package using the leakage rates applicable to the northernmost and interior OSDF cells (i.e., Cells 1 to 7). Leakage rates for the southernmost OSDF cell (i.e., Cell 8) are different from that of the other cells, and are presented in Section 7.4.

This addendum to Section 9.4 evaluated the performance of the LDS collector pipe for Cell 8 using the leakage rates for that cell. Similar methods and input data to that used in Section 9.4 were used herein. This addendum is presented as Section 9.9 of the OSDF Final Design Calculation Package, and is titled, "Leak Detection System (LDS) LDS Pipe Design – Cell 8 Supplement". Section 9.9 is presented in Volume VII of the OSDF Final Design Calculation Package.

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Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

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Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
LDS PIPE DESIGN - CELL 8 SUPPLEMENT
EXECUTIVE SUMMARY

PURPOSE OF ANALYSIS

The purpose of this analysis is to evaluate the performance of the LDS collector pipe for Cell 8 of the OSDF. The evaluation will be performed for both active operation and post-closure conditions.

METHOD OF ANALYSIS

The flow capacity, perforation size, and structural stability (wall crushing, wall buckling, and excessive ring deflection) were calculated for the LDS collector pipe in the Section 9.4, "Leak Detection System (LDS) LDS Pipe Design" of the Final Design Calculation Package. The parameters used to calculate the perforation size and structural stability of the LDS collector pipe have not changed. However, the flow capacity of the LDS pipe is compared to the required flow capacity for Cell 8 in this Calculation Package.

CONCLUSIONS

- pipe flow capacity for active operation condition, $Q_p = 198$ gpm
- required flow capacity for active operation condition, $Q_R = 2.9 \times 10^{-5}$ gpm
- flow capacity factor of safety for active operation condition, $Q_p/Q_{pr} = 6.84 \times 10^6 >> 3$ (OK)
- pipe flow capacity for post-closure condition, $Q_p = 124$ gpm
- required flow capacity for post-closure condition, $Q_R = 8.1 \times 10^{-7}$ gpm
- flow capacity factor of safety for post-closure condition, $Q_p/Q_{pr} = 1.5 \times 10^8 >> 10$ (OK)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
LDS PIPE DESIGN - CELL 8 SUPPLEMENT
CALCULATION PROCEDURES

INTRODUCTION

The purpose of this package is to evaluate the factor of safety for flow capacity by comparing the new required flow capacity for Cell 8 with the LDS pipe flow capacity.

METHOD OF ANALYSIS

The required flow capacity for Cell 8 was evaluated in Section 9.7 "Leak Detection System (LDS) Maximum Head in LDS – Cell 8 Supplement" of the Final Design Calculation Package. The LDS pipe flow capacity was evaluated Section 9.4 "Leak Detection System (LDS) LDS Pipe Design" of the Final Design Calculation Package.

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
LDS PIPE DESIGN - CELL 8 SUPPLEMENT
DATA VERIFICATION

Pipe flow capacity (Q_p) = 1.25×10^{-2} m^3/s (from Calculation Package "Leak Detection System (LDS) LDS Pipe Design" – Section 9.4)

Required flow capacity (Q_{pr}) = 1.83×10^{-9} m^3/s (from Calculation Package "Leak Detection System (LDS) Maximum Head in LDS" – Cell 8 Supplement" – Section 9.7)

Written By : RK Date: 12-03-03 Reviewed by: LMG Date: 12-09-03

Client: Fluor Fernald Project: OSDF – Revised Phase V Project/Proposal No.: GQ3211 Task No.: 06

LEAK DETECTION SYSTEM (LDS)
LDS PIPE DESIGN - CELL 8 SUPPLEMENT
CALCULATION RESULTS

Hand calculations were performed for the active condition case. A spread sheet was used to repeat the calculations for the active case and perform calculations for the post-closure case. These calculation results are presented in the following pages.

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Client: Flour Fernald Project: OSDF – RPV Project/Proposal No.: GQ 3211 Task No.: 06

LDS Pipe Design – ACTIVE CONDITION

LDS pipe flow capacity

$$Q_p = \frac{R_h^{0.66}\, i_p^{0.5}\, A_p}{n}$$

$$= \frac{(0.0345)^{0.66}(0.01)^{0.5}(1.5\times10^{-2})}{0.013}$$

$$= 1.25\times10^{-2}\ m^3/s \quad (198\ gpm)$$

same as before

Required capacity

$$Q_{pr} = q_i A_d$$

$$= \left(2.4\times10^{-7} \times \frac{2.54}{100} \times \frac{1}{24\times3600}\right)\left(6.4\times0.405\times10{,}000\right)$$

$$= 1.83\times10^{-9}\ m^3/s$$

$$\frac{Q_p}{Q_{pr}} = \frac{1.25\times10^{-2}}{1.83\times10^{-9}} = 6.8\times10^{6} >> 3 \quad \text{O.K.}$$

LDS Pipe

Parameter	Active	Post-Closure
Pipe Inner Diameter (in.)	5.421	5.421
Cross Section Area (in^2)	23.08	23.08
Cross Section Area (m^2)	1.49E-02	1.49E-02
Hydraulic Radius (in.)	1.36	1.36
Manning's Coefficient ($s/m^{0.33}$)	0.013	0.013
Drainage Path Slope (%)	1.00	0.40
Slope Angle (rad)	0.01	0.00
Slope Angle (deg)	0.57	0.23
Flow Capacity (m^3/s)	1.24E-02	7.84E-03
Required Capacity (m^3/s)	1.81E-09	5.13E-11
Factor of Safety (For Capacity)	6.84E+06	1.53E+08

Section 12.5

12.5 OSDF PHASE V, SURFACE-WATER MANAGEMENT SYSTEM DESIGN AND POST-CLOSURE HYDROLOGY

COMPUTATION COVER SHEET

5316

SUBJECT OF COMPUTATIONS OSDF PHASE V, SURFACE-WATER MANAGEMENT SYSTEM DESIGN AND POST-CLOSURE HYDROLOGY

Computations By:
(Cognizant Engineer)

Signature: Victoria S. Cheplak — Date: 1-21-04

Printed Name and Title: Victoria S. Cheplak, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: [signature] — Date: 1-21-04

Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Computations Checked by:

Signature: Hollie Kinnecom — Date: 1-21-04

Printed Name and Title: Hollie Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: Victoria S. Cheplak — Date: 1-21-04

Printed Name and Title: Victoria S. Cheplak, Senior Staff Engineer

Approved by:
(PDP)

Signature: [signature] — Date: 1-21-04

Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 1/22/04

Printed Name and Title: R. Bonaparte, Engineer of Record

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval
0	Submittal to FF/DOE/EPA	30 Jan 02	DBM	DGP	JFB
1	CFC Revision 1 Submittal to FF/DOE/EPA	23 Jan 04	VSC VSC	GG GG	RB

000187

OSDF PHASE V, SURFACE-WATER MANAGEMENT SYSTEM

DESIGN AND POST-CLOSURE HYDROLOGY

EXECUTIVE SUMMARY

PURPOSE OF ANALYSES

The purpose of this calculation package is to design the OSDF surface-water management (SWM) structures to be constructed as part of the revised Phase V development of the OSDF. These SWM structures are designed to satisfy the requirements of the Surface-Water Management and Erosion Control (SWMEC) Plan [GeoSyntec, 2002b] and the OSDF Design Criteria Package (DCP) [GeoSyntec, 2002a] and are shown on the Construction Drawings. These requirements include those applicable to the OSDF Construction/Filling period and the OSDF Post-Closure period (for permanent structures). Additionally, the adequacy of existing SWM structures is assessed where failure of these structures has the potential to impact the OSDF or where the development of the OSDF significantly impacts the runoff conveyed to these structures. Required modifications or additions to existing structures are incorporated into the Construction Drawings and this calculation package. Peak discharges from sedimentation basins are presented for post-closure conditions for use in future comparison of pre- and post-development runoff from watersheds in the FEMP to Paddy's Run, which is outside the scope of revised Phase V calculations. Lastly, hydrologic analyses are presented for post-closure conditions and a 2-year-24-hour storm event for use in an evaluation of sedimentation potential of permanent channels in the calculation "Sedimentation Evaluation of Permanent Drainage Channels for High Frequency Design Storms".

METHODS OF ANALYSES

For the purpose of hydrologic analyses and routing through sedimentation basins (basins), the total drainage area is divided into two parts and modeled as the East OSDF and the West OSDF Design Scenarios. Both the East OSDF and West OSDF Design Scenarios presented herein consider the actual conditions anticipated to exist when all eight cells have been constructed, lined, and capped. This represents the "worst case" conditions for the period of Phase V construction. Design Case "A" represents a temporary channel and culvert at the southwest end of Cell 6 constructed as part of the SWM system for Cell 6. Neither the channel nor the culvert is incorporated into either of the OSDF Design Scenarios. Design Case "B" represents a system of existing and new channels and culverts along the east and south side of the OSDF to correspond with the construction and filling of Cells 5, 6, and 7. Several channels are also incorporated into the East OSDF Scenario; however, two channels along the south side of the OSDF are distinct to this design case. Design Case "C" represents a system of existing and

new channels and culverts along the west side of the OSDF corresponding to the closing Cell 6. These channels and culverts are also modeled in the West OSDF Design Scenario.

For Phase V SWM structures (i.e., new structures), analyses are performed to design channels, culverts, and a sedimentation basin. Channels and culverts are designed to safely convey peak flow rates from the 25-year, 24-hour storm event. Additional analyses are performed for the selection of channel lining (channel bed stability) and required height of cover over culverts (structural stability). The sedimentation basin, OSDF Basin 2 is considered adequate if it complies with the design criteria for the 10-, 25-, and 100-year, 24-hour storm events, outlined in the DCP for construction, filling, and closure of the OSDF.

Analyses for 25-year channels along the East and West perimeters of the OSDF were previously performed as part of the OSDF Final Design Package [GeoSyntec, 1997c]. These channels have been constructed as part of Phases IV and V consistent the OSDF Final Design Package, or redesigned as part of the Phase V revisions; therefore, analyses are performed as part of this Calculation Package to re-assess the adequacy of these channels.

For existing SWM structures evaluated, analyses are performed to assess the adequacy of channels, culverts, and a sedimentation basin (basin). Channels and culverts are considered to be adequate if they have sufficient hydraulic capacity to convey peak flow rates from the 25-year, 24-hour storm event. The sedimentation basin, Borrow Area Basin, is considered adequate if it complies with the performance criteria for the 25-year, 24-hour storm event, outlined in the DCP for development and restoration of the Borrow Area.

Hydrologic and basin routing analyses are performed using methodologies presented in TR-20 [USDA-SCS, 1982] and TR-55 [USDA-SCS, 1986], as coded into the computer program HydroCAD™. Hydraulic analyses for channels are performed using Manning's equation as coded into a computer spreadsheet. Hydraulic analyses for culverts are performed using methodologies presented by USDOT [1985], as coded into the computer program CulvertMaster®.

CONCLUSIONS

All Phase V (i.e., new) channels, culverts, and OSDF Sedimentation Basin 2 are designed in accordance with the requirements of the SWMEC Plan [GeoSyntec, 2002b] and the DCP [GeoSyntec, 2002a], in particular as follows:

New Channels

- Calculated peak flow velocities for all grass-lined channels are less than the permissible flow velocity of 5.0 fps. One channel maintains flow velocities greater than 5.0 fps and will be riprap-lined.
- Calculated freeboards for channels equal or exceed the minimum required of 0.5 ft.

New Culverts

- Calculated headwater elevations at the inlet of culverts allow for 0.5 ft or greater freeboard.

- For all new culverts, cover provided at road crossings equal or exceed the minimum required thickness of cover for structural stability.

OSDF Sedimentation Basin 2

- The minimum available storage volume exceeds the calculated runoff volume (10-year, 24-hour storm event) and the calculated volume of 0.125 acre-ft/year per acre (disturbed upstream drainage area multiplied by the basin cleanout frequency).

- The calculated peak water elevation for the 25-year, 24-hour storm event is below the elevation of emergency spillway.

- The calculated peak water elevation for the 100-year, 24-hour storm event allows 1 ft of freeboard from the minimum embankment crest elevation.

Existing channels, culverts, and the Borrow Area Sedimentation Basin (with modifications shown in the Construction Drawings) have adequate capacity to convey applicable design storm events, in particular as follows:

Existing Channels

- Calculated freeboard for all channels equal or exceed the minimum required of 0.5 ft.

Existing Culverts

- Calculated headwater elevation at the upstream end of culverts allow for 0.5 ft or greater freeboard.

Borrow Area Sedimentation Basin

- The minimum available storage volume exceeds the calculated volume of 1,800 cubic ft per acre (total upstream drainage area multiplied by the basin cleanout frequency) within the drainage area that will be disturbed by construction during the designed life of the sediment basin.

- The calculated peak water elevation for the 25-year, 24-hour storm event allows more than 1 ft freeboard from the minimum embankment crest elevation.

The required cleanout frequency for basins is one year per cleanout.

OSDF PHASE V, SURFACE-WATER MANAGEMENT SYSTEM

DESIGN AND POST-CLOSURE HYDROLOGY

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OSDF PHASE V, SURFACE-WATER MANAGEMENT SYSTEM

DESIGN AND POST-CLOSURE HYDROLOGY

PROCEDURES

INTRODUCTION AND PURPOSE

The major elements of the OSDF Phase V revision project include construction of the liner systems for Cells 7 and 8, and capping of Cells 3, 4, 5, 6, 7, and 8. These and other construction elements are listed in Table A-1 along with their relationships to the design scenarios assumed herein. The layout of the surface-water management (SWM) system is shown on Construction Drawings.

The purpose of this Calculation Package is to evaluate the adequacy of OSDF SWM structures to be constructed as part of the revised Phase V development of the OSDF. Additionally, the adequacy of existing SWM structures is assessed. Required modifications or additions to existing structures are incorporated into the Construction Drawings and this Calculation Package.

Analyses for channels along the North, East, and West perimeters of the OSDF for the 25-year 24-hour storm event were previously performed as part of the OSDF Final Design Package [GeoSyntec, 1997c]. These channels have been constructed, or will be constructed as part of revised Phase V, consistent with the OSDF Final Design Package; therefore, analyses are performed as part of this Calculation Package to re-assess the adequacy of these channels with respect to as-built or new design conditions.

DESIGN CRITERIA

The revised OSDF Phase V SWM system is designed to satisfy the requirements of the Surface-Water Management and Erosion Control (SWMEC) Plan [GeoSyntec, 2002b] and the OSDF Design Criteria Package (DCP) [GeoSyntec, 2002a]. Applicable sections from the DCP

[GeoSyntec, 2002a] include Section 2.8, *Surface-Water Management*, which contains requirements for the OSDF runon/runoff structures and Section 2.10.2.4, *Surface-Water Management for Borrow Area* which contains requirements for the borrow area structures. These sections of the DCP are included as Attachment A-1.

The revised design of Phase V structures includes analyses for channels and culverts leading to the OSDF Sedimentation Basin 2. The channels and culverts are designed to safely convey peak flow rates from the 25-year, 24-hour design storm event. Additional analyses are performed for the selection of channel lining (i.e., channel bed stability), required height of cover over culverts (i.e., structural stability), and riprap design for inlet and outlet protection of culverts. The OSDF Basin 2 is considered adequate if it complies with the design criteria for the 10-, 25-, and 100-year, 24-hour design storm events, outlined in the DCP for construction, filling and closure of the OSDF.

The assessment of Phase V structures also includes analyses to assess the adequacy of channels and culverts leading to the Borrow Area Sedimentation Basin. Channels and culverts are considered to be adequate if they have sufficient hydraulic capacity to convey peak flow rates from the 25-year, 24-hour storm event. The Borrow Area Basin is considered adequate if it complies with the performance criteria for the 25-year, 24-hour storm event, outlined in the DCP for development and restoration of the Borrow Area.

Peak discharges from sedimentation basins are presented for post-closure conditions. These discharges are for use in future comparison of pre- and post-development runoff from watersheds in the FEMP to Paddy's Run, which is outside the scope of Phase V calculations. Also, hydrologic analyses are presented for post-closure conditions and a 2-year-24-hour storm event for use in an evaluation of sedimentation potential of permanent channels in the calculation "Sedimentation Evaluation of Permanent Drainage Channels for High Frequency Design Storms".

DESIGN SCENARIOS

The design of revised Phase V SWM structures, and assessment of hydraulic capacity for existing structures, is evaluated in this calculation package using two design scenarios, the East

OSDF and the West OSDF Design Scenarios. Both the East and West OSDF Design Scenarios presented herein consider the actual conditions anticipated to exist when all eight cells have been constructed, lined, and capped. This represents the "worst case" conditions for the period of Phase V construction. In addition, both East and West OSDF Design Scenarios have been analyzed assuming post-development conditions in order to assess potential sedimentation problems from high frequency design storms and to estimate peak discharges from sedimentation basins. Design Case "A" represents a system of existing and new channels and culverts at the southwest corner of Cell 6 constructed as part of the SWM system for Cell 6. Neither these channels nor these culverts are incorporated into either of the OSDF Design Scenarios. Design Case "B" represents a system of existing and new channels and culverts along the east and south side of the OSDF to correspond with the construction and filling of Cells 5, 6, and 7. Several channels are also incorporated into the East OSDF Scenario; however, two channels along the south side of the OSDF are distinct to this design case. Design Case "C" represents a system of existing and new channels and culverts along the west side of the OSDF corresponding to the closing Cell 6. These channels and culverts are also modeled in the West OSDF Design Scenario. The East and West OSDF Design Scenarios, and Design Cases "A", "B", and "C" are further described in Table A-1, and below.

East OSDF Design Scenarios

A schematic layout of the SWM system represented by the East OSDF Design Scenario is provided in Attachment A-2. The East OSDF Design Scenarios incorporate existing and new conditions, including the construction of Cell 7 and Cell 8 liner systems, the Cell 3, 4, 5, 6, 7, and 8 final cover systems, and the East run-off and runon channels which discharge to the Borrow Area Sedimentation Basin south of the OSDF. For this design scenario the Cell 1, 2, 3, 4, 5, and 6 final cover systems are considered vegetated, the Cell 7 and 8 final cover systems are considered to be non-vegetated, and no cells are receiving impacted material. For the post-development design scenario all final cover systems are considered fully vegetated.

All surface-water accounted for in the East OSDF Design Scenarios will flow to the Borrow Area Sedimentation Basin. The Borrow Area Basin has been modified to reflect the final

configuration of the Borrow Area Sedimentation Basin as presented in the *Borrow Area Management and Restoration Plan* [GeoSyntec, 2001].

West OSDF Design Scenarios

A schematic layout of the SWM system represented in the West OSDF Design Scenario is provided in Attachment A-2. The West OSDF Design Scenarios incorporate existing and new conditions, including the construction of Cell 7 and Cell 8 liner systems, the Cell 3, 4, 5, 6, 7, and 8 final cover systems, and the OSDF Sedimentation Basin 2. For this design scenario the Cell 3, 4, 5, and 6 final cover systems are considered to be vegetated, the Cell 7 and 8 final cover systems are considered non-vegetated, and no cells are receiving impacted material. For the post-development design scenario all final cover systems are considered to be fully vegetated. All surface-water accounted for in the West OSDF Design Scenario will flow to the OSDF Sedimentation Basin 2.

Design Case "A"

A schematic layout of the SWM system represented in Design Case "A" is provided in Attachment A-2. Design Case "A" incorporates temporary structures at the southwest end of the temporary termination for the Cell 6 liner system. Design Case "A" considers existing conditions in the construction laydown area to the south of the OSDF and includes runoff from the Cell 6 liner runout and areas south of the OSDF. None of these temporary structures are represented in either of the OSDF Design Scenarios.

Design Case "B"

A schematic layout of the SWM system represented in Design Case "B" is provided in Attachment A-2. Design Case "B" incorporates permanent structures associated with the runoff diversion channel along the East side of the OSDF and temporary structures associated with the temporary termination for the Cell 7 liner system. For this design scenario, the Cells 1 and 2 final cover systems are considered fully vegetated, Cells 3 and 4 final cover systems are considered non-vegetated, and Cells 5, 6, and 7 are receiving impacted material. The permanent structures that correspond to the East Runoff Diversion Channel are included in the East OSDF

Design Scenario, while the structures corresponding the temporary Cell 7 termination are not represented in either Design Scenario.

Design Case "C"

A schematic layout of the SWM system represented in Design Case "C" is provided in Attachment A-2. Design Case "C" incorporates permanent structures associated with the drainage channel and temporary runoff diversion berm along the West side of the OSDF, through Cell 6. For this design scenario, the Cells 3, 4 and 5 final cover systems are considered fully vegetated, and the Cell 6 final cover system is considered non-vegetated. These structures are all included in the West OSDF Design Scenario.

SOFTWARE

Hydrologic and Basin Routing Analyses

Surface-water runoff peak flow rates and other hydrologic and hydraulic information are estimated using the computer program HydroCAD™ [HydroCAD™, 2001]. This program uses hydrologic procedures presented in U.S. Soil Conservation Services' TR-20 [SCS, 1982] and TR-55 [SCS, 1986]. Hydrographs for individual subcatchments are routed through a user specified nodal network for each design scenario (see Attachment A-8), using standard hydrologic routing techniques. Runoff hydrographs from subcatchments are developed using input parameters which describe the storm event for which the calculation is being performed and characteristics of the subcatchment. Built-in subroutines allow the user to route the hydrographs through a sediment basin. The HydroCAD™ Technical Reference Manual is provided as Attachment A-3.

Channel Hydraulic Analyses

Hydraulic analyses for channels are performed using Manning's equation, as coded into a computer spreadsheet.

Culvert Hydraulic Analyses

Hydraulic analyses for culverts are performed using methodologies presented in USDOT [1985], as coded into the computer program CulvertMaster® [Haestad Methods, 2000]. Built-in subroutines allow the user to perform calculations for inlet and outlet control. The

CulvertMaster® User's Guide [Haestad Methods, 2000] Theory Section is provided as Attachment A-4.

HYDROLOGIC AND BASIN ROUTING ANALYSES

Hydrologic and basin routing analyses are performed using HydroCAD™ for 2-, 10-, 25-, and 100-year, 24-hour storm events. Input parameters are presented in the Data Verification section of this calculation package. HydroCAD™ output reports are presented in Attachment C-1 of the Calculation Section of this calculation package. Major input used in the HydroCAD™ subroutines includes parameters for subcatchments, reaches, and basins. These parameters are introduced and calculation methods described in the following sections.

Subcatchment Runoff

Rainfall Distribution

This parameter characterizes the assumed distribution of the design rainfall depth over a 24-hour duration and is selected based on the location of the Fernald site within the United States. Selection of this parameter is further described in the Data Verification section of this calculation package.

Rainfall Depth

This parameter is the total rainfall for a 24-hour design storm event. The design rainfall depths for return periods of 2, 10, 25, and 100 years are obtained as described in the Data Verification section of this calculation package.

Hydrologic Soil Groups (HSG)

This parameter classifies surficial soils at the site based on hydrologic characteristics, as presented in the Soil Surveys of Butler and Hamilton Counties, Ohio [USDA-SCS, 1980 and 1992]. The soil types and hydrologic soil groups found in the vicinity of the OSDF watershed are shown on a plan view of the OSDF area in Attachment A-5 [USDA-SCS, 1980 and 1992] and soil hydrologic data in Attachment A-6 [USDA-SCS, 1980 and 1992]. The soil names identified for the OSDF area and their respective HSG classification are summarized below.

SCS Map Label	Soil Name	Hydrologic Soil Group
FcA, FdA	Fincastle	C
Rda	Raub	C
RwB2	Russell	B
XeB, XeB2, XfA, XfB2	Xenia	B
MoE2	Miamian	C

An HSG classification of B/C is selected for the final cover system and for liner system runout areas. The final cover system and the liner system runout will be constructed using soil from the borrow area. Soil obtained from the borrow area includes B and C soils, with approximately 85% of the soil being classified as B.

Runoff Curve Numbers (CNs)

CNs are selected based on ground cover type, land use, cover condition, and HSG classification of site soils. A list of land use categories characterizing drainage areas for the Phase V SWM system is presented in the following table. This list is developed based on characterization of the ground cover and land use for anticipated runoff area conditions during and after Phase V construction. Land use categories are associated with TR-55 categories of land use and ground cover (See Attachment A-7 from [SCS, 1986]) and are presented in the following table:

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

	Construction Phase			Post-Development Phase		
Land Use Description	**TR-55 Land Use/ Ground Cover Category**	**HSG**	**CN**	**TR-55 Land Use/ Ground Cover Category**	**HSG**	**CN**
Non-vegetated final cover system and liner system runout	Newly graded areas	B	86	Not Applicable	-	-
		C	91		-	-
		B/C	89		-	-
Vegetated final cover system	Open space in poor condition - corresponds to less than 50% grass cover	B	79	Open space in fair condition - corresponds to between 50% to 75% grass cover	B	69
		C	86		C	79
		B/C	83		B/C	74
Runon Areas East of the OSDF, Runon Areas North of the Borrow Area	Pasture in fair condition	B	69	Pasture in fair condition	B	69
		C	79		C	79
Borrow Area Runoff, Runon to Borrow Area, Vegetated Borrow Area	Pasture in good condition	B	61	Pasture in good condition	B	61
		C	74		C	74
Areas Adjacent to the OSDF	Construction support (Farmsteads – buildings, lanes, driveways, and surrounding lot)	B	74	Grass in good condition - corresponds to over 75% grass cover	B	61
		C	82		C	74
Subgrade	Bare Soil	C	87	Not Applicable	-	-
Sedimentation basin (SB), direct runoff to SB, pavement	Impervious surfaces	-	98	Impervious surfaces	-	98

For areas indicated in the above table as having an HSG of "B/C", the CN was calculated based on a 1:1 ratio of B and C soils. A weighted CN for each subcatchment (CN_{S-i}) is calculated as a weighted average of CNs present within that subcatchment. The following equation is used, as coded into a spreadsheet:

$$CN_{S-i} = \sum_{i=1}^{n} P_i CN_i$$

Where, P_i is the percentage of total subcatchment area with CN_i.

Subcatchment Time of Concentration

The time of concentration for each subcatchment is calculated as the sum of the travel times for sheet, shallow concentrated, and channel flows, for a flow path from the most hydraulically distant location in the subcatchment to the outlet of the subcatchment. These calculations are performed within HydroCAD™ using specified input parameters for flow regimes. Methods and equations used for these calculations are presented in the HydroCAD™ Technical Reference Manual presented as Attachment A-3. Input parameters include the following:

- For sheet flow travel time: surface description or n = Manning's roughness coefficient (dimensionless); L = flow length (ft); P = 2-year; 24-hour rainfall depth (inches); and S = land slope (rise/run).
- For shallow concentrated flow travel time: surface description; L = flow length (ft); and S = land slope (rise/run).
- For channel flow travel time: L = flow length (feet); s = longitudinal slope (rise/run); n = Manning's roughness coefficient (dimensionless); D = flow depth (feet); W = bottom width (ft); and sideslopes (rise/run).

Manning's roughness coefficients (for sheet flow calculation referenced above) are selected based on a correlation of ground description to TR-55 surface descriptions [SCS, 1986], as shown in the following table:

Ground Description	TR-55 Surface Description	Manning's n for Sheet Flow
Non-vegetated final cover system, liner system runout, pavement and subgrade	Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Vegetated areas, construction support area, vegetated final cover system, runon area east of OSDF, runon area north of borrow area, borrow area runoff, and runon to borrow area	Grass: short grass prairie	0.15

A further description of input parameters for time of concentration computations is provided in the Data Verification section of this calculation.

Reaches

Hydrologic analyses, for estimation of peak flow rates and runoff volumes (for evaluation of SWM structures), are performed by routing the hydrographs for individual subcatchments through reaches. Reaches include channels and culverts, as described below.

Channels

For hydrologic analyses, channel parameters are input into HydroCAD™ based on information from the Construction Drawings. Channels consist of either "V" or trapezoidal-shaped sections, with either grass or riprap lining. Input parameters include: (i) bottom width (ft); (ii) sideslopes (rise/run); (iii) length (ft); (iv) longitudinal slope (rise/run); (v) Manning's roughness coefficient (dimensionless); and (vi) depth (ft). The adequacy of channels is assessed as described in a later section.

Culverts

For hydrologic analyses, culverts are input into HydroCAD™ as multiple 72-in. diameter pipes. Input parameters include: (i) length (ft); (ii) slope (rise/run); and (iii) Manning's

roughness coefficient (dimensionless). The culvert sizes selected in the computer model (i.e., multiple 72-in. dia. pipes) are fictitious values used solely for ease of computation. Design of culverts (i.e., selection of size and number of pipes) is performed using the computer program CulvertMaster® which uses peak flow rates obtained from hydrologic analyses and accepted methodologies described in a later section.

Sedimentation Basins

Surface-water runoff is routed through individual basins for the scenarios noted below.

- OSDF Basin 2: routed as part of the West OSDF Design Scenario.
- Existing Borrow Area Basin: routed as part of the East OSDF Design Scenario.

Routing through the basins is performed utilizing the Storage-Indication Method as coded into HydroCAD™. For the storage-indication method, the inflow runoff hydrograph at a basin and the stage-storage and stage-discharge relationships of the basin are utilized.

The stage-storage relationship of a basin is developed in HydroCAD™ using the Surface Area – Conic Volume Determination Method where cumulative storage is calculated based on areas within elevation contour lines from the outlet pipe invert elevation to the minimum embankment crest elevation.

The stage-discharge relationship of a basin is modeled in HydroCAD™ using the size and inlet elevations of the principal spillway riser and outlet pipes and the size, shape, and inlet elevation of the emergency spillway. Principal spillways consist of vertical riser and horizontal discharge pipes. Riser pipes are modeled as sharp-crested weirs in low flow conditions and as orifices in high flow conditions. Horizontal outlet pipes are modeled as culverts. Emergency spillways are modeled as broad-crested rectangular weirs. Also, the low-flow orifices (8-in. diameter) located at the bottom of the risers are neglected (conservatively) for this analysis. Additional information concerning development of stage-discharge relationships for these control structures is included in the HydroCAD™ Technical Reference Manual provided as Attachment A-3.

HYDRAULIC ANALYSES

The design of new SWM structures and assessment of existing SWM structures includes hydraulic analyses for channels, culverts, and basins. Peak flow rates and runoff values from HydroCAD™ output reports are utilized.

Channels

The hydraulic capacity of each new and existing channel is evaluated for conveyance of peak flow rates from the 25-year, 24-hour design storm event. In addition for new channels, analyses are performed to evaluate lining stability. For the purpose of these analyses, channels are divided into segments of relatively uniform cross-section and longitudinal slope.

Hydraulic Capacity

The adequacy for the hydraulic capacity of channels is evaluated in terms of an available freeboard for peak flow rates. The available freeboard is calculated as the difference between the minimum available flow depth in the channel and the calculated peak flow depth (peak flow depth). The peak flow depth is calculated based on Manning's equation as coded into a computer spreadsheet. Manning's equation is as follows:

$$Q = \frac{1.49}{n} A R^{2/3} S_0^{1/2}$$

Where, Q is the peak flow rate (cfs), n is Manning's roughness coefficient (dimensionless), A is cross-sectional area of flow (ft^2), R is hydraulic radius (ft) defined as R = A/P where P is wetted perimeter (ft), and S_o is longitudinal slope (rise/run). The minimum required freeboard (from the peak flow level to the level of overtopping of the channel sideslopes or nearby facility which would be adversely impacted if flooded) is 0.5 ft. The minimum available flow depth is obtained from the Construction Drawings.

Channel Lining

For each new channel, a peak flow velocity is calculated and compared to the permissible flow velocity for the selected channel lining. Permissible flow velocities for grass and riprap linings are <5 fps and <12 fps, respectively. Peak flow velocities are calculated based on Manning's equation, using a computer spreadsheet.

Sedimentation

For each permanent channel, hydrology results for post-closure conditions and the 2-year, 24-hour storm event are calculated for use in the Phase V calculation "Sedimentation Evaluation of Permanent Drainage Channels for High Frequency Design Storms".

Culverts

The hydraulic capacity of each new and existing culvert is evaluated for conveyance of peak flow rates from the 25-year, 24-hour design storm event. New culverts will be helically corrugated metal pipe (CMP). Existing culverts include CMP, reinforced concrete pipe (RCP), polyvinyl chloride (PVC), asphalted corrugated metal pipe (CMPA), and high density polyethylene (HDPE) pipes.

Hydraulic Capacity

The adequacy of culverts is evaluated for inlet and outlet control conditions in terms of headwater elevation, using the computer program CulvertMaster®. An allowable headwater elevation is calculated as the overtopping elevation of the channel sideslopes or road crossing or the minimum elevation of a nearby facility which might be adversely impacted if flooded minus 0.5 ft freeboard. The higher of the inlet or outlet headwater elevations is taken as the controlling headwater elevation.

The following input parameters are required: (i) material type and culvert shape; (ii) inlet configuration; (iii) number of culverts and diameter (ft); (iv) length (ft); (v) inlet and outlet invert

elevations (ft MSL); (vi) 25-year, 24-hour peak flow rate (cfs); (vii) tailwater elevation; and (viii) overtopping elevation. CulvertMaster® does not include all diameters and inlet configurations, therefore characteristics are selected within the CulvertMaster® program to best approximate those of the existing culvert. For the case of diameter, the closest diameter was used but no more than two inches larger than the existing diameter. For the case of inlet configuration, an inlet configuration with an entrance loss coefficient equal to that estimated for the actual inlet is selected. In cases where culverts discharge into well-defined channels, tailwater elevations will be assumed as the elevation of the normal flow depth in the downstream channel.

Outlet Protection

For each new temporary culvert, riprap outlet protection requirements are calculated to handle the 25-year, 24-hour storm event using a design chart from USDA-SCS [1987]. This design chart is presented in Attachment C-4B. For each new permanent culvert, outlet protection requirements are calculated to handle the 25-year 24-hour storm event using a design chart from the Ohio Department of Transportation [ODOT, 1992]. This design chart is presented in Attachment C-4B and is also presented in ODNR [1996]. Outlet protection is recommended in terms of downstream riprap length and average riprap particle size (d_{50}). For the purposes of designing outlet protection, the flow depth just downstream of the culvert is assumed as less than one half the diameter of the culvert (i.e., a minimum tailwater condition). Criteria for the selection of downstream riprap length and thickness are listed below.

- The downstream riprap length (at a culvert outlet) is based on the appropriate design chart, but at a minimum will be four times the culvert diameter (hereafter referred to as "minimum riprap length").
- If riprap is not required based on the appropriate design chart but the outlet velocity for the culvert is 5 fps or greater, the minimum riprap length is required.
- If riprap is not required based on the appropriate design chart and outlet velocity for the culvert is less than 5 fps, no outlet protection is required.

- If the direction of discharge (i.e., at culvert outlet) is not aligned with the longitudinal direction of the receiving channel, the minimum riprap length is required.
- Riprap thickness as described in DCP (GeoSyntec, 2002a).

Downstream channel peak flow depths are obtained from the results of hydrologic analyses. Outlet velocities are obtained from CulvertMaster® output reports. Where riprap is recommended for outlet protection, inlet protection is also recommended. The upstream length is two times the culvert diameter with a d_{50} equal to that for the outlet protection riprap.

Structural Stability

For each new culvert, structural stability is evaluated. For culverts crossing roads used by heavy construction vehicles (off-highway vehicle road) a Caterpillar D400E articulated truck (D400E) [Caterpillar, 1998] is selected as the design vehicle. For culverts crossing roads used only by highway vehicles (on-highway road), an HS-20 axle load is selected for design. The design axle load for off-highway vehicle roads of 95 kips is for a fully loaded truck and the combination of both rear axles. The design axle load for on-highway vehicle roads of 32 kips corresponds to an HS-20 loading [ACPA, 1998].

For CMP culverts, structural stability is evaluated using manufacturers guidelines [Contech, 1999 – See Table in Attachment A-9] for unpaved roads. In accordance with these guidelines, the minimum required cover for culvert diameters of 42 in. and less for off-highway and on-highway vehicle roads is 3.0 ft and 2.0 ft, respectively.

Sedimentation Basins

Existing and new basins are evaluated for handling runoff from applicable design storm events. A cleanout frequency of once per year is assumed consistent with the SWMEC Plan.

OSDF Sedimentation Basin 2 (See DCP Section 2.8 in Attachment A-1)

- The available minimum storage volume (below the principal spillway inlet elevation) should exceed the calculated runoff volume from the 10-year, 24-hour design storm event and the calculated volume of 0.125 acre-ft per year per acre (disturbed upstream

drainage area multiplied by the basin cleanout frequency). Total drainage area is conservatively used in place of disturbed upstream drainage area.

- The principal spillway should discharge runoff from the 25-year, 24-hour design storm event with no flow entering the emergency spillway.
- The principal and emergency spillways should discharge runoff from the 100-year, 24-hour design storm event, allowing for 1 ft of freeboard from the minimum embankment crest elevation.

Borrow Area Sedimentation Basin (See DCP Section 2.10.2.4 in Attachment A-1)

- The available minimum storage volume should exceed the calculated volume of 1,800 cf per acre (total upstream drainage area multiplied by the basin cleanout frequency) within the drainage area that will be disturbed by construction during the design life of the sediment basin.
- The principal spillway should discharge runoff from the 25-year, 24-hour design storm event, allowing for 1 ft of freeboard from the minimum embankment crest elevation.

In addition, both the OSDF Sedimentation Basin 2 and the Borrow Area Sedimentation Basin are evaluated to determine peak discharges for the post-development 25-year, 24 hour storm event. This analysis assumes that the basins remain unchanged after the closure of the OSDF. These peak discharges are for use in a future comparison of pre- and post-development runoff from watersheds in the FEMP to Paddy's Run, which is outside the scope of Phase V calculations.

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TABLE A-1

OSDF PHASE V CONSTRUCTION ELEMENTS AND DESIGN SCENARIOS

	East OSDF Construction Phase Design Scenario	West OSDF Construction Phase Design Scenario	East OSDF Post-Development Design Scenario	West OSDF Post-Development Design Scenario	Design Case "A"	Design Case "B"	Design Case "C"
Cell 1, 2, 3, 4, 5 Liner	Existing	Existing	Existing	Existing	Existing	Existing – Cells 1,2, 3, 4; New – Cell 5	Existing
Cell 6 Liner	Existing	Existing	Existing	Existing	New	New	Existing
Cell 7, 8 Liner	New	New	Existing	Existing	-	New – Cell 7	-
Cell 1, 2 Final Cover	Existing - Vegetated	Existing - Vegetated	Existing - Vegetated	Existing - Vegetated	Existing - Vegetated	Existing – Vegetated	Existing – Vegatated
Cell 3, 4, 5,6 Final Cover	New - Vegetated	New - Vegetated	Existing - Vegetated	Existing - Vegetated	New – Vegetated (Cells 3,4,5); Non Vegetated (Cell 6)	New – Non Vegetated (Cells 3,4)	New – Vegetated (Cells 3, 4, 5); Non Vegetated (Cell 6)
Cell 7,8 Final Cover	New – Non Vegetated	New – Non Vegetated	Existing - Vegetated	Existing - Vegetated	-	-	-
Borrow Area Sedimentation Basin	Existing – Final Configuration	-	Existing – Final Configuration	-	-	-	-
OSDF Sedimentation Basin 2	-	New	-	New	-	-	-
Existing Channels	Reaches 1, 2, 10BR, 12R, 13R, 14, 15, 16, 17	Reach 7DR, 8AR, 8CR, 16N	Reaches 1, 2, 10BR, 12R, 13R, 14, 15, 16, 17	Reach 7DR, 8AR, 8CR, 16N	Reaches 2, 7	Reaches 1, 11	-
Existing Culverts	Reaches 11, 31	Reaches 7CR, 8BR, 14, 15N	Reaches 11, 31	Reaches 7CR, 8BR, 14, 15N	Reaches 1, 3, 4	-	-
New Channels	Reaches 3, 4, 5, 6, 7R, 8R, 9R, 10AR, 18, 19, 20, 21, 22, 24, 26, 29, 30	Reaches 1, 2, 3, 4, 6, 7BR, 9AR, 9R, 10AR, 10R, 11AR	Reaches 3, 4, 5, 6, 7R, 8R, 9R, 10AR, 18, 19, 20, 21, 22, 24, 26, 29, 30	Reaches 1, 2, 3, 4, 6, 7BR, 9AR, 9R, 10AR, 10R, 11AR	Reaches 5, 6	Reaches 2, 3, 4, 5, 6A, 6B, 8, 9	Reaches 1, 2, 3, 4
New Culverts	Reaches 23, 25, 28	Reaches 5, 7AR, 9BR, 10BR, 11R, 13	Reaches 23, 25, 28	Reaches 5, 7AR, 9BR, 10BR, 11R, 13	Reach 8	Reach 7	Reach 5
Existing Culverts to be Replaced with New Culverts	Reach 27	Reach 12	Reach 27	Reach 12	-	-	-

ATTACHMENT A-1

DCP SECTIONS 2.8 AND 2.10

DCP SECTION 2.8
SURFACE-WATER MANAGEMENT

2.8 Surface-Water Management

2.8.1 Categories of Surface Water

Surface-water management for the OSDF must consider three categories of surface water:

- surface-water runon from outside the battery limit to within the battery limit;
- surface-water runoff, which includes all runoff from disturbed areas within the battery limit, except for wastewater explicitly identified below; and
- wastewater, which includes all waters that must be contained, collected, and conveyed to the biosurge lagoon or the FEMP former production area storm drainage control system.

Wastewater generated as a result of development of the OSDF area includes:

- leachate and runoff from impacted material within the OSDF; these wastewaters will be contained in the OSDF, allowed to percolate into the leachate collection system, and then conveyed by gravity through the leachate collection system pipe to the OSDF EPLTS (as discussed in Section 2.5 of this DCP). Surface-water collected in the OSDF cell catchment area may be conveyed to the FEMP former production area storm drainage control system or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA.
- runoff from impacted-material staging areas; these are self-contained units; liquid generated in these units will be conveyed to the FEMP former production area storm drainage control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA;
- runoff from impacted-material haul roads; this water will be contained, collected, and conveyed to the FEMP former production area storm drainage control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA; and
- perched ground water that seeps into excavations; this water will be contained, collected, and conveyed to the FEMP former production area storm drainage

control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA.

The remainder of this section of the DCP presents design criteria for management of stormwaters and wastewaters.

2.8.2 General Design Criteria

The functions of the surface-water management system are to: (i) route surface water to designated locations where it can be appropriately managed; (ii) protect the OSDF from damage caused by precipitation and surface-water runon and runoff; and (iii) discharge surface water to existing watercourses in accordance with applicable regulatory and DOE requirements.

The surface-water management system should perform in a manner that meets the project requirements for both temporary conditions (i.e., during construction, filling, and closure of the OSDF) and long-term conditions (i.e., after closure of the OSDF). The system should prevent surface-water runon to the OSDF and uncontrolled stormwater and wastewater runoff from the OSDF. Features of the permanent surface-water management system should be designed to require minimal monitoring and maintenance. The system should be integrated, to the extent possible, with existing topography, features, and facilities (design considerations).

2.8.3 Surface-Water Management During OSDF Construction/Filling/Closure

A. Design Criteria

- Temporary surface-water control structures for the OSDF will be designed for the 25-year, 24-hour storm event (ARAR: EPA 40 CFR §258.26 and OAC 3745-27-08(C)(6)(a) and (b)). For the FEMP property, this event has a rainfall intensity of 4.7 in. [Parsons, 1995a].

- Temporary surface-water control structures will be designed to minimize silting and scouring (ARAR: OAC 3745-27-08(C)(6)(c)).

- Temporary runon control measures should meet the following criteria (design considerations).

- Upgradient runon should be prevented from entering active working areas. Such runon should be diverted around work areas using berms, dikes, or channels as appropriate. This runon should not be allowed to mix with wastewater.

- Runon to temporary excavations should be prevented using berms, ditches, or other surface-water control features.

- Runon to impacted material stockpiles should be prevented using berms, ditches, or other surface-water control features.

- Prior to placement of impacted material into an OSDF cell, permanent runon controls must be in place. The requirements for permanent runon control are described in more detail in Section 2.8.4 of this DCP.

- Runoff from disturbed areas should be routed to the appropriate temporary sediment basin or managed using other appropriate erosion control practices. There must be no mixing of surface-water runoff and wastewaters (functional requirements).

- Temporary sediment basins will meet the following criteria of OEPA (ARAR: OAC 3745-27-08(C)(6)(d)):

  - the minimum acceptable basin storage will be established as the larger of the calculated runoff volume from a 10-year, 24-hour storm event, or, 0.125 acre-ft per year (for each acre) of upgradient disturbed area) multiplied by the scheduled frequency of basin cleanout (in years) ((6)(d)(i)); for the FEMP property, the 10-year, 24-hour storm event has a rainfall intensity of 4.1 in. [Parsons, 1995a];

  - the principal spillway will be capable of safely discharging the flow from a 10-year, 24-hour storm event; the inlet elevation of the emergency spillway will be designed to provide flood storage, with no flow entering the emergency spillway during a 25-year, 24-hour storm event, with allowance provided for the flow passed by the principal spillway during the event ((6)(d)(ii)); as previously noted, for the FEMP property, the 25-year, 24-hour storm event has a rainfall intensity of 4.7 in. [Parsons, 1995a];

- the combination of principal and emergency spillways should be capable of safely discharging the flow from a 100-year, 24-hour storm event; the basin embankment design should provide for no less than 1 ft of net freeboard when flow is at the design depth, after allowance for embankment settlement ((6)(d)(iii)); for the FEMP property, the 100-year, 24-hour storm event has a rainfall intensity of 5.6 in. [Parsons, 1995a];

- the basin will be constructed using a compacted soil liner, a geomembrane, or a combination thereof ((6)(d)(iv)); and

- sediment basins will be equipped with ring buoys and other safety/drowning equipment in accordance with USOSHA 1926.106.

- With respect to the last ARAR ((6)(d)(iv)), on 24 February 1992, the OEPA DSIWM issued the following guidance on the need for lining sediment basins:

  > *"The sole purpose of a liner in a sediment basin is water retention. Therefore, a design capable of ponding water, whether or not it contains a liner, will be acceptable to the Director. In areas with predominantly in-situ low permeability clay, a liner may be unnecessary (it would be wise to scarify and recompact the clay surface). The landfill engineer is responsible for meeting the "ponding" standard. In areas with more permeable soils a recompacted clay liner is necessary, but the QA/QC standards can be minimal and certainly do not need to follow the landfill liner standards."*

  The foregoing requirement is interpreted as allowing the development of unlined sediment basins in the low-permeability tills underlying the FEMP. To assure compliance with the intent of this guidance, the construction specifications for sediment basins associated with the OSDF should require scarification and recompaction of the till exposed in the sediment basin excavation, and overexcavation of any observed granular soil zones, followed by backfilling with till and recompaction (design consideration).

- Surface-water runoff from the FEMP watersheds to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

- Temporary channels for stormwater runoff should be designed to meet the following criteria (design considerations).
  - Channel lining:
    - peak flow velocity in riprap-lined channels should be less than 12 ft per second, unless it is demonstrated that greater velocities will not cause erosion or malfunction of the surface-water management feature; and
    - peak flow velocities in grass-lined channels should be less than 5 ft per second.
  - Channel sideslopes should be no steeper than 3 horizontal to 1 vertical.
  - Channel bottom widths may be zero.
  - The channel freeboard should be at least 0.5 ft under the design storm event.
  - Channels should be sloped at no less than 0.5 percent to prevent sediment buildup and clogging, unless it can be established by calculation that a lesser slope will not clog or build up sediment that will cause loss of flow capacity in the design storm event. Channel slopes should be no steeper than 5 percent unless it can be established by calculation that a steeper slope will not cause unacceptable erosion or other malfunction.
- Temporary culverts should be designed according to the following criteria (design considerations).
  - Culverts may be used in locations as needed and where cost-effective.
  - Channels should be protected from erosion using riprap or erosion mats for a length of at least two culvert diameters upstream and a width of at least three culvert diameters of the culvert inlet. The length and width, of riprap lining and average particle size downstream of the culvert outlet should meet criteria for permanent outlet protection provided in USDA-SCS, 1987.
  - Minimum thickness of riprap lining will be two times D_{50}, but not less than 6 in. and will be underlain by geotextile filters.
- Riprap will be designed according to the following criteria (design considerations).

- For channel lining, riprap should be sized to meet the following criteria [ODNR, 1996];

  - $D_{50} = 62.4 \text{ pcf} \times d \times S/4$
    where: D_{50} = theoretical spherical diameter of average stone size; d = peak flow depth for the design storm event (ft); and S = channel slope (rise/run).

- Riprap should meet the following particle size criteria [ODNR, 1996]:

  - $D_{max} = 1.5 \times D_{50}$
  - $D_{15} = 0.5 \text{ to } 0.75 \times D_{50}$
    where: D_{max} = theoretical spherical diameter of largest stone size; and D_{15} = theoretical spherical diameter of the stone size for which 15 percent of the material is smaller.

- For channels, the minimum thickness of the riprap lining should be two times D_{50}, but not less than 6 in.

- Riprap used at channel transitions should extend upstream and downstream of the transition a distance of five times the downstream channel depth; the minimum extension should be 15 ft.

- Geotextile filters may be used to control piping and erosion beneath riprap in temporary facilities. Granular soils should be used for filters in permanent structures containing riprap, if required to prevent undermining of the riprap.

- Rock, grade control structures should be designed according to the following criteria (design considerations).

  - Rock, grade control structures may be used in temporary facilities. They should be designed in accordance with standard design procedures.

  - The minimum height of rock, grade control structures should be 1.5 ft and the minimum top width should be 2 ft.

- Temporary erosion control measures should include the items listed below (design considerations).

- Runoff from all disturbed areas should be routed to sediment basins, or managed using other appropriate sediment control practices, prior to discharge to natural watercourses, except for wastewaters which should be managed as described in Section 2.8.5 of this DCP.

- The size of any excavated or disturbed area should be as small as possible to minimize the potential for erosion (design consideration). Disturbed areas should be revegetated at the earliest possible time.

- Temporary erosion control may be achieved using geosynthetic materials, vegetation, crusting agents, check dams, straw bales, silt fences, or other appropriate structures.

- The use of erosion control materials should be minimized in impacted soils requiring OSDF disposal. Preference should be given to runon control, surface grading, and the selective use of erosion resistant impacted materials to control erosion of impacted areas.

- Maintenance and upkeep procedures for temporary erosion control features should be specified in the *Surface-Water Management and Erosion Control Plan.*

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to size the sediment basins for each contributory drainage area for each representative phase of the OSDF development. The calculations should be performed as described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.

- The size of the drainage control structures (e.g., channels) should be calculated for each contributory drainage area.

- The size of the sediment basin, including outlet structures, should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/Runoff routing and sediment basin sizing may be evaluated using the procedures described in USDA-SCS Technical Releases 20 and/or 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculations is the computer program "*HydroCAD™ Stormwater Modeling System*" [Applied Microcomputer Systems, 1993]. The above evaluations should be based on the information and guidance contained in USDA-SCS manuals [1985, 1986b, and 1988] and ODNR [1996].

Culverts should be sized in accordance with U.S. Federal Highway Administration guidelines [USDOT, 1985] and meet the structural design criteria contained in applicable design references such as the Concrete Pipe Design Manual [America Concrete Pipe Association, 1970].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

2.8.4 Surface-Water Management After OSDF Closure

A. Design Criteria

- Permanent runon control structures for the OSDF will be designed to limit interruption and damage (i.e., washout) of the OSDF in the 2,000-year, 24-hour storm event (design criterion for assumption of a DOE Performance Category 2 facility). For the FEMP property, this event has a rainfall intensity of 13.0 in. [Parsons, 1995a]. Runon should be controlled and diverted away from and around the OSDF using channels or diversion berms (design consideration).

- Permanent runoff control structures for the OSDF will be designed to limit interruption and damage (i.e., washout) of the OSDF in the 2,000-year, 24-hour storm event (design criterion for assumption of a DOE Performance Category 2 facility).

- Permanent runoff control measures should be designed according to the following criteria (design considerations).
  - Runoff from the 2,000-year, 24-hour storm event should be allowed to sheet flow to the toe of the OSDF final cover.
  - Runoff from the toe of the OSDF final cover should either sheet flow away from the facility or to a drainage channel beyond the toe.
  - Any drainage channels beyond the OSDF final cover system toe should outlet to existing drainage features at the battery limit. The location of the outlets should progress from north to south concurrent with the progressive development of the OSDF. The final outlet location for runoff from the eastern portions of the OSDF should be immediately south of the southern limit of the OSDF.
- Permanent drainage channels will be designed to meet the following criteria (design considerations).
  - The dimensions of the channel should accommodate both normal low flows and peak precipitation runoff flows.
  - The final grades of the channel should be no less than 0.5 percent to prevent sediment buildup and clogging, unless it can be established by calculation that a lesser slope will not clog or buildup sediment that will cause loss of flow capacity in the design storm event. Channel slopes should be no steeper than 5 percent unless it can be established by calculation that a steeper slope will not cause unacceptable erosion or other malfunction.
  - Peak flow velocity in the channel should not initiate channel gully erosion or scour.
  - Erosion potential should be minimized at channel transitions by utilizing smooth, rounded, and graded transitions wherever possible (preferred) and erosion control structures only when needed.
  - Flow velocity in the channel during high frequency (e.g., 2-year return frequency) and low-intensity (i.e., approximately 1 in. in 24 hours) storm

events should be large enough to limit sedimentation in the channels, to the extent possible.

- Channel sideslopes should be no steeper than 3 horizontal to 1 vertical.
- The freeboard in the drainage channel should be at least 0.5 ft during the design storm event.

- Permanent drop inlets and culverts may be used downgradient of the OSDF if necessary and if failure of the drop inlet and culvert would not result in damage to, or interruption of, the OSDF. Permanent drop inlets and culverts should be designed to meet the following criteria (design considerations).
  - Culverts beneath roads or access corridors where traffic is limited to highway vehicles should be designed for American Association of State Highway and Transportation Officials (AASHTO) HS-20 live loads and applicable dead loads.
  - Culverts beneath haul roads or access roads used for construction traffic should be designed for vehicle live loads and applicable dead loads.
  - Channels should be protected from erosion using riprap for a length of at least two culvert diameters upstream and a width of at least three culvert diameters upstream and downstream of the culvert inlet. The length and thickness of riprap lining and average particle size downstream of the culvert outlet should meet criteria for outlet protection provided in ODNR.
  - Permanent culverts should not be used upgradient of the OSDF.
- Riprap, if needed, should be designed as described in Section 2.8.3 of this DCP (design consideration).
- Riprap should consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone should be hard and angular and of a good quality, consistent with the UMTRA Technical Approach Document [DOE, 1989] (design consideration).

- Granular soils should be used as filters and bedding for permanent riprap features where necessary to prevent undermining of the riprap (design consideration).

- Rock grade control structures, if used, should be designed to meet the criteria listed in Section 2.8.3 of this DCP (design consideration).

- Surface-water runoff from watersheds in the FEMP to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to size the drainage channels for each contributory drainage area. For these areas where a permanent drainage channel is not needed, the amount of surface-water runoff should be calculated. The calculations that should be performed are described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.

- The size of the permanent drainage channel should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/runoff routing and sediment basin sizing may be evaluated using the procedures described in USDA-SCS Technical Releases 20 and 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculation is the computer program "*HydroCAD™ Stormwater Modeling System*" [Applied Microcomputer System, 1993]. The above evaluations should be based on information and guidance contained in USDA-SCS manuals [1985,1986b,1988].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

The erosion resistance of the permanent drainage channel at the north and east toes of the OSDF should be evaluated as follows:

- obtain the allowable tractive force on the channel vegetation and topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;

- establish the actual tractive force on the channel vegetation and the "effective" tractive force on the channel topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;

- determine the potential for erosion of the drainage channel by comparing the allowable tractive force on the topsoil to the "effective" actual tractive force on the topsoil; and

- evaluate the potential for the riprap portion of the channel lining to erode using the Safety Factors Method as described in the DOE Technical Approach Document [1989] and referenced documents.

2.8.5 Wastewater Management

Wastewaters that will be encountered in development of the OSDF were identified in Section 2.8.1 of this DCP. These wastewaters should be managed as follows.

- *Leachate* - Liquid that has percolated through, or been released from, the impacted material that has been disposed in the OSDF (functional requirement). Placement of impacted material in OSDF cells will be performed such that runoff from active and open portions of a cell resulting from the 25-year, 24-hour storm event can be managed within the cell (ARAR: EPA 40 CFR §258.26 and OAC 3745-27-08(C)(6)(a)). Leachate should be managed as described in Section 2.5 of this DCP.

- *Impacted Runoff* – Liquid that comes in contact with impacted material and runs off rather than percolating. Impacted runoff collected in the cell catchment areas may be conveyed as described in this Section. An OMTA will be constructed for the staging of impacted material for subsequent disposal in the

OSDF. To the extent possible, the. Runoff from these areas should drain to surface-water control structures within the former production area storm drainage control system (design consideration). Runoff from any staging area located within the OSDF battery limit should also be directed to the FEMP former production area storm drainage control system if possible, or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and OEPA/USEPA (design consideration). Additional discussion of the OMTA is presented in Section 2.11 of this DCP. Runoff from impacted material haul roads should be contained within the haul road boundary and allowed to flow by gravity to the FEMP former production area storm drainage control system, or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and USEPA/OEPA. Drainage control structure for impacted material haul roads should be designed for the 25-year, 24-hour storm event. (design consideration).

- *Perched Ground Water* - Perched ground water that enters the OSDF excavation should be collected in a toe drain, or other suitable sump, and pumped to the FEMP former production area storm drainage control system (including pumpage to the impacted-material haul road, where the water will be allowed to flow by gravity to the FEMP former production area storm drainage control system), or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and OEPA/USEPA (design consideration). The management of perched ground water that enters the borrow area excavation is not wastewater; management of this latter runoff is discussed in Section 2.10 of this DCP.

2.8.6 References

FEMP property data and information required to design the surface-water management system should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design these systems are given below.

American Concrete Pipe Association, "*Concrete Pipe Design Manual*", American Concrete Pipe Association, Arlington, VA, February, 1970.

Applied Microcomputer Systems, "*HydroCAD™ Stormwater Modeling System*", Version 3.10, Chocorua, NH, 1993.

Chow, V.T., *"Open-Channel Hydraulics"*, McGraw-Hill, Inc., 1959.

Department of Labor, OSHA Construction Standard, 29 CFR 1926.106 "*Working Over or Near Water.*"

Fernald Environmental Management Project, *"Fluor Daniel Fernald Safety Performance Requirements Manual"*, RM-0021.

Ohio Department of Natural Resources - Division of Soil and Water Conservation (ODNR), "*Rainwater and Land Development*", 2nd Edition, 1996.

Parsons, *"2,000-Year Flood and Probable Maximum Flood Sitewide Flood Plain Determination"*, CERCLA/RCRA Unit 2, Project Order 148, Fernald Environmental Management Project, Rev. A, Fairfield, OH, August 1995a.

Richardson, E.V., et al., "*Highways in the River Environment - Hydraulic and Environmental Design Considerations*, U.S. Department of Transportation, Available from Publications Office, Engineering Research Center, Colorado State University, Fort Collins, CO, 1975.

Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., *Stability Design of Grass-Lined Open Channels*", U.S. Department of Agriculture, Agriculture Research Service, Agriculture Handbook Number 667, 1987.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Computer Program for Project Formulation, Hydrology*", Technical Release 20 (TR20), U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1975.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*National Emergency Handbook, Section 4 - Hydrology*", U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1985.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Urban Hydrology for Small Watersheds*", Technical Release 55 (TR55), U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 2nd Edition, 1986a.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), *Engineering Field Manual for Conservation Practices*, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1986b.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Water Management and Sediment Control for Urbanizing Areas*", U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1987.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), *Ponds - Planning, Design Construction*, Agricultural Handbook Number 590, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., November 1988.

U.S. Department of Transportation (USDOT), "*Hydraulic Design of Highway Culverts*", Hydraulic Design Series No. 5, Federal Highway Administration, McLean, VA, September 1985.

U.S. Department of Energy (DOE), "*Technical Approach Document, Revision II*", Uranium Mill Tailings Remedial Action Project, December 1989.

2.9 Support Facilities and Utilities

2.9.1 General Design Criteria

The function of support elements and utilities is to provide support for, and enhance the performance of, the OSDF during construction, filling, closure, and post-closure care. As identified in Section 1.3 of this DCP, the support elements will include survey benchmarks, construction support area, equipment wash facility, materials storage areas, access control features, construction haul roads and leachate transmission system access corridor. Utilities will include electricity, water, and wastewater systems. Design criteria are presented separately in this section for each of these elements.

The support elements must provide adequate and reliable support for the activities that will be performed for the OSDF. Utilities must provide reliable service to the support elements for each type of utility. The support elements and utilities should be developed in a manner that is consistent with the requirements of applicable utility codes at the FEMP and with applicable health and safety requirements for the FEMP.

DCP SECTION 2.10
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American Association of State Highway and Transportation Officials (AASHTO), "*AASHTO Guide for Design of Pavement Structures*," Washington, D.C., 1992.

Portland Cement Association (PCA), "*Thickness Design for Concrete Highway and Street Pavement*", 1984.

State of Ohio, Department of Transportation (ODOT), "*Location and Design Manual, Volume I, Roadway Design*", Revision, October 1992, Columbus, OH, 1992.

State of Ohio, Department of Transportation (ODOT), "*Construction Materials Specifications*," Columbus, OH, January 1993.

Yang, H.H., "*Pavement Analysis and Design*", Prentice-Hall, Inc., New York, NY, 1993.

Yoder, E. and Witczack, M., "*Principles of Pavement Design*", John Wiley and Sons, Inc., New York, NY, 1975.

2.10 Borrow Area

2.10.1 General Design Criteria

The function of the borrow area is to provide soil for construction of the liner and final cover systems, and for other earthwork, related to construction, filling, and closure of the OSDF. This consists of soil borrow for construction of the compacted clay liner and cap, vegetative soil layer, compacted fill, and other earthwork associated with the project. The topsoil layer in the borrow area will be removed and stockpiled for later use unless it is determined to be impacted material, in which case it should be disposed of in the OSDF in accordance with the Impacted Material Placement Plan (IMP Plan). The borrow area for OSDF construction is located in the "East Field" area of the FEMP property. This borrow area will be developed over a period of time from 7 to 25 years (depending on the actual schedule for OSDF construction, filling, and closure), with a 10-year design life used for planning purposes. After the borrow area is restored, it should function with minimal maintenance.

The borrow area should be developed in a manner that results in efficient utilization of the available soils, results in efficient utilization of the natural topography of the borrow area to effectively control runon and runoff, provides soils with the engineering properties required for the OSDF earthwork components being constructed, and

minimizes the costs associated with the development and restoration of the area (design considerations). In addition to these requirements, the design of the borrow area should consider the requirements described below (design considerations).

- The borrow area should be laid out in a manner that provides easy ingress and egress.
- The area should be developed in a manner that requires minimal additional earthwork after borrow activities are complete to achieve the required restoration grades.
- The borrow area should be developed incrementally as soil is needed for construction of the OSDF.
- The size of disturbed borrow area should be minimized to the extent possible.
- Interim restoration should be performed progressively as excavation in each borrow area subarea is completed.
- Erosion and sediment controls should be implemented in the borrow area prior to excavation, during borrow activities, and in conjunction with restoration activities.

2.10.2 Specific Criteria

2.10.2.1 Location of Borrow Area

A. Design Criteria

- The borrow area should be located in an area having material quantities and types sufficient for OSDF construction, filling, and closure (design consideration).
- The borrow area should be located within the FEMP property and should not encroach on the transmission line, oil pipeline, or other easements (design consideration).

- The borrow area should not extend vertically into the gray till except as noted in the approved *Borrow Area Strategy Report* (Fluor Fernald, Inc. 2000). The reasons for this are: (i) the efficiency of the borrow area operation will be improved by limiting the depth of excavation; and (ii) by limiting the depth of excavation, the restored borrow grades will be flatter and restoration of the area will be more cost effective. The borrow area should be constructed with sufficient final slope to minimize erosion and support final restoration (design considerations).

- Within the above constraints, the borrow area should be as deep as possible to minimize the size of the area (design consideration).

B. Calculations

No formal calculation is required for the location of the borrow area. A review of past geotechnical investigations and the results of ongoing laboratory testing of borrow area soil samples collected in November 1995 should be conducted to assess the engineering properties of the material and to predict the suitability of the materials for use as compacted clay liner and cap materials, as well as other earthwork components of the OSDF, as listed in Section 2.10.1.

2.10.2.2Layout of Borrow Area

A. Design Criteria

- The borrow area should be laid out to facilitate surface-water management throughout the life of the borrow area (design consideration).

- The borrow area should be graded to promote surface-water runoff and prevent ponding of surface water (design consideration).

- The borrow area should be laid out to avoid interferences with roads, utility corridors, easements, etc. (design consideration).

- A soil contingency volume (equal to at least 15 percent of the required soil bank/unbulked volume based on the design estimate) should be provided in the borrow area for possible use in (design consideration):

- construction of an OSDF contingency cell if disposal volumes are larger than anticipated;
- backfilling to subgrade elevations beneath the footprint of the OSDF in the event that additional excavation of impacted material is necessary;
- constructing portions of the contouring layer of the cover system and the non-granular portion of the protective layer of the liner system with "non-impacted" soil; and
- providing material for "seasonal" closure between construction seasons in the event that suitable impacted soil is not available for this purpose.

- Intermediate borrow area slopes should be cut at a safe angle of repose for the material (design consideration).
- Permanent restored slopes within the borrow area should be no steeper than 5H:1V (design consideration).
- As may be required, design will comply with OSHA requirements, 29 CFR 1926 Subpart P-Excavations.

B. Calculations

A review of previous geotechnical field and laboratory test data, including brown till in-situ densities and moisture contents, standard Proctor compaction test results, and permeability test results should be made. The results of previous laboratory testing of borrow area soil should also be reviewed. The calculations described below should be undertaken in support of the design of the borrow area.

- The bank/unbulked volume of borrow soil required to build the earthwork components of the OSDF described in 2.10.1 should be calculated. The calculation should be conducted using the required compacted earthwork volume of on-site borrow material. This required compacted earthwork volume should be corrected to account for shrinkage/bulking of the borrow soil, the possible need for contingency volume, and the removal of the topsoil layer for stockpiling and later use as the topsoil layer in the OSDF final cover system.

- The bank/unbulked volume of available borrow soil, as calculated using computed-aided design (CAD) techniques, should be verified by hand calculation.

- The in-situ moisture content of the soil at the borrow area should be compared to the anticipated compaction moisture contents for the various earthwork components of the OSDF liner and final cover systems to assess the construction water demand and/or amount of soil drying required to moisture condition the borrow soils.

2.10.2.3Development of Borrow Area

A. Design Criteria

- The borrow area should be developed in a manner that produces consistent materials for construction of the OSDF and effectively utilizes the existing topography to control surface-water runoff and runon (design consideration).

- Requirements for processing of the borrow area soils should be identified during design. If possible, such processing should be performed in the borrow area or any temporary stockpile area. Such processing could include moisture conditioning, blending, screening, or admixture modification (design consideration).

- Prior to the start of construction in the borrow area, the following activities should be performed (design considerations):

  - establishment of temporary surface-water management and erosion and sediment controls for the borrow area, including sediment basins;

  - establishment of access controls for the borrow area (consistent with the requirements of Section 2.9.2.6 of the DCP); and

  - establishment of soil processing facilities (if any are needed).

- Prior to the start of borrow area development, topsoil in the area should be removed and stockpiled for later use for closure of the OSDF unless it is

determined to be impacted material, in which case it should be disposed in the OSDF in accordance with the IMP Plan (design consideration).

B. Calculations

No formal calculations are required for the development of the borrow area.

2.10.2.4 Surface-Water Management for Borrow Area

A. Design Criteria

- Temporary and permanent surface-water control structures for the borrow area with the exception of sediment basins, should be designed for the 25-year, 24-hour storm event (design consideration). Depending on the size of the contributory area, sediment basins should be designed for either the 10-year, 24-hour storm event, or the 25-year, 24-hour storm event [ODNR, 1996]. This criterion is discussed further later in this section of the DCP.

- Surface-water runoff from the FEMP watersheds to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

- Surface-water runoff should be managed so that, after restoration of the borrow area, the effects of erosion of the borrow area ground surface are minimal. Long-term erosion of the ground surface in the borrow area must not impact the OSDF (design considerations).

- Temporary runon control structures should be implemented to minimize runon from entering work areas. Such runon should be diverted around work areas using diversion dikes or channels as appropriate (design consideration).

- Temporary channels for surface-water runoff should be designed to meet the criteria presented in Section 2.8.3 of the DCP (design consideration).

- Permanent channels should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).

- Culverts should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).
- Riprap should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).
- Sediment basins should meet the following criteria [ODNR, 1996] (design considerations).
  - The minimum capacity of the sediment basin to the elevation of the crest of the pipe spillway should be 1,800 cubic ft for each acre within the drainage area that will be disturbed by construction during the design life of the sediment basin.
  - The capacity of the pipe spillway should be sufficient to pass the runoff from the 2-year, 24-hour storm event. For the FEMP property, this event has a rainfall intensity of 2.5 in. [Parsons, 1995a].
  - The combination of the principal and emergency spillways should be capable of safely discharging the flow from the 10-year, 24-hour storm event if the drainage area to the sediment basin is less than or equal to 20 acres, or the 25-year, 24-hour storm event if the drainage area to the sediment basin is greater than 20 acres.
  - Consideration should be given to using the permanent Fernald facility main entrance road as a containment dike for the surface-water runoff in lieu of an emergency spillway.
  - If an emergency spillway is implemented, a minimum freeboard of 1 ft measured from the peak water elevation in the emergency spillway to the top of the embankment, should be provided.
- Temporary erosion control measures should include those items described in Section 2.8.3 in the DCP (design consideration).

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to route the design storm through the borrow area for existing conditions and for construction conditions (i.e., during borrow activities), and to size sediment basins. The calculations should be performed as described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.
- The size of the sediment basin, including outlet structures, should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/runoff routing and sediment basin sizing should be evaluated using the procedures described in USDA-SCS Technical Release 20 and/or 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculations is the computer program "*HydroCAD™ Stormwater Modeling System*" [Applied Microcomputer Systems, 1993]. The above evaluations should be based on the information and guidance contained in USDA-SCS manuals [1985, 1986b, 1987, 1988].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

2.10.2.5Restoration

A. Design Criteria

The borrow area should be restored in accordance with the approved *Borrow Area Strategy Report* (Fluor Fernald, Inc., 2000) and *Borrow Area Management and Restoration Plan* (GeoSyntec, 2000) to a condition that requires minimal maintenance (functional requirement). The borrow area should be restored to a condition that is consistent with the geomorphological character of the area surrounding the FEMP (design consideration). The following criteria should be followed in preparing the restoration plan for the borrow area.

- Final grades should be selected that minimize long-term erosion in the area. The final grades should not result in erosion that is greater than the calculated erosion rate for stabilized slopes in the vicinity of the FEMP that have similar grades and similar soil types (design consideration).

- Surface-water runoff from the restored borrow area should be routed as indicated in Section 2.10.2.4 (design consideration).

- The restored borrow area should be revegetated with plant species that minimize erosion, that can be successfully established given the design final grades and soil types, and that are self-propagating in the expected conditions of the restored borrow area (design consideration).

- The design of the restoration plan should provide for progressive restoration of the borrow area, with commencement of restoration in an area as soon as borrow activities have been completed. To the extent possible, activities should not be performed in portions of the borrow area that have been restored (design consideration).

B. Calculations

No formal calculations are required for restoration of the borrow area. Procedures and materials for establishing permanent vegetation in the borrow area should be consistent with those procedures and materials selected for the OSDF final cover system (see Section 2.6 of this DCP).

2.10.3 References

FEMP property data and information required to design the borrow area should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design the borrow area are given in Section 2.8.6 of the DCP. Additional references are as follows:

Fluor Fernald, Inc. "*Borrow Area Strategy Report*", Revision O, Fernald, OH, April 2000.

GeoSyntec Consultants, Inc., "*Borrow Area Management and Restoration Plan*", Revision 1C, Atlanta, GA, April 2000.

ATTACHMENT A-2

LAYOUT OF DESIGN SCENARIO AND DESIGN CASE SWM SYSTEMS

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LEGEND

SUBCATCHMENT LABEL AND BOUNDARY

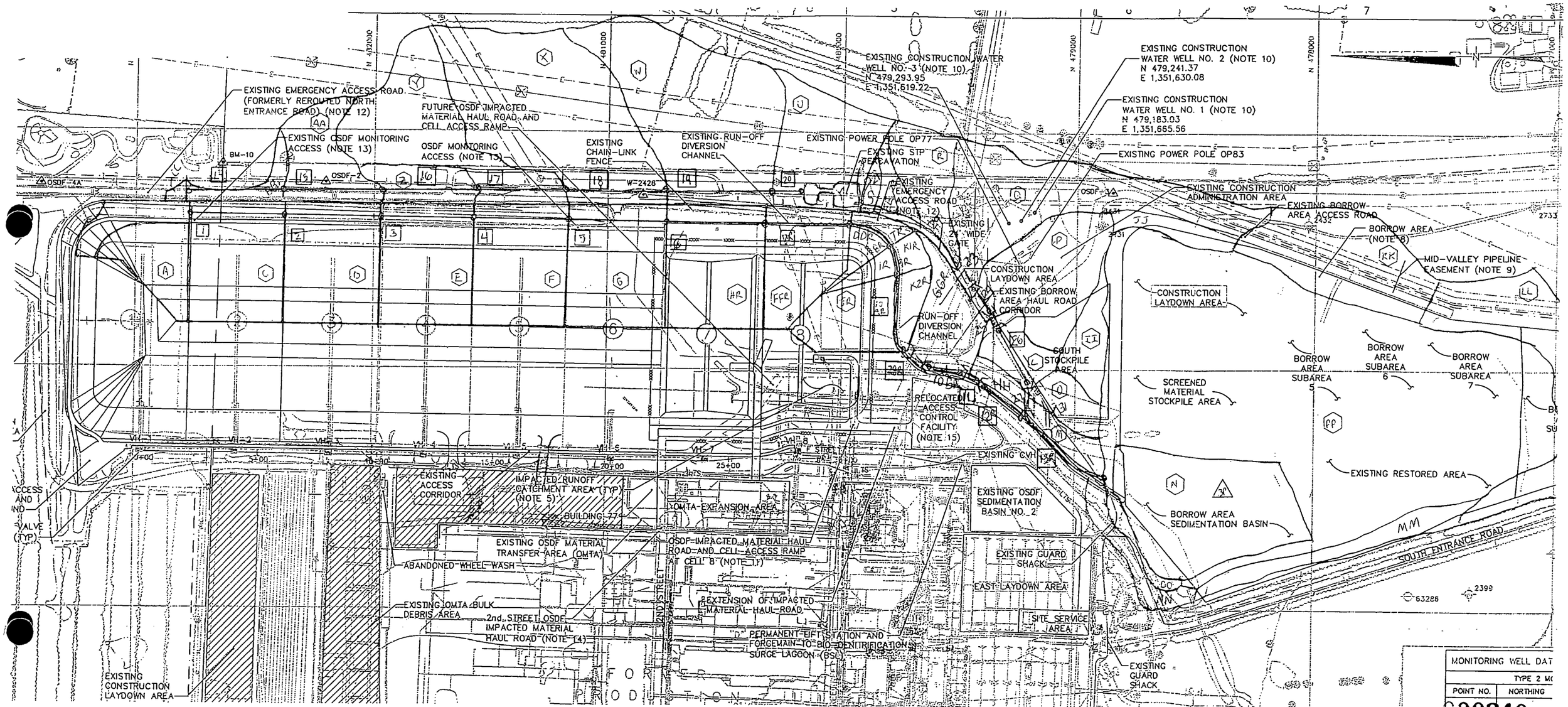
REACH ALIGNMENT AND LABEL

CULVERT

POND LABEL

PHASE V
EAST OSDF DESIGN SCENARIO
SCALE 1" = 400'

0 400'



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LEGEND

SUBCATCHMENT LABEL AND BOUNDARY

REACH ALIGNMENT AND LABEL

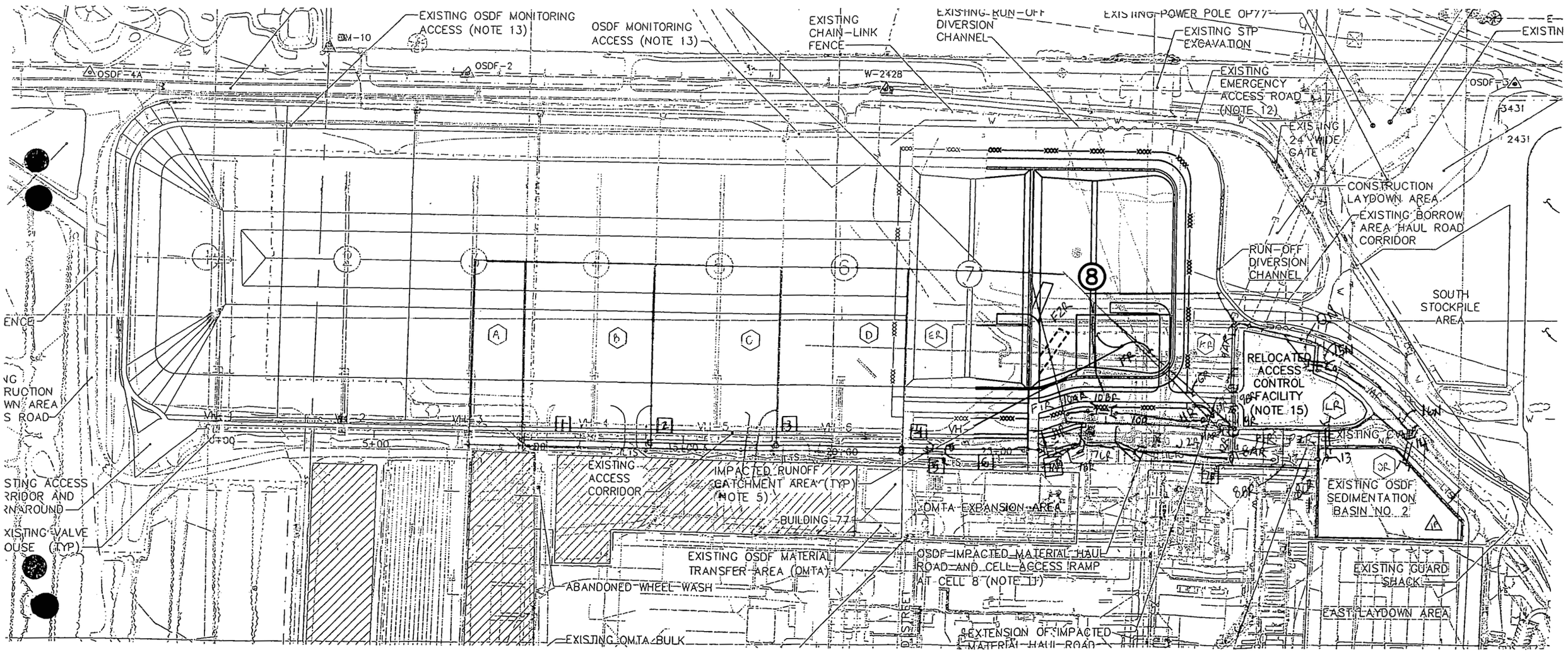
CULVERT

POND LABEL

PHASE V
WEST OSDF DESIGN SCENARIO
SCALE 1" = 300'

0 300'

N



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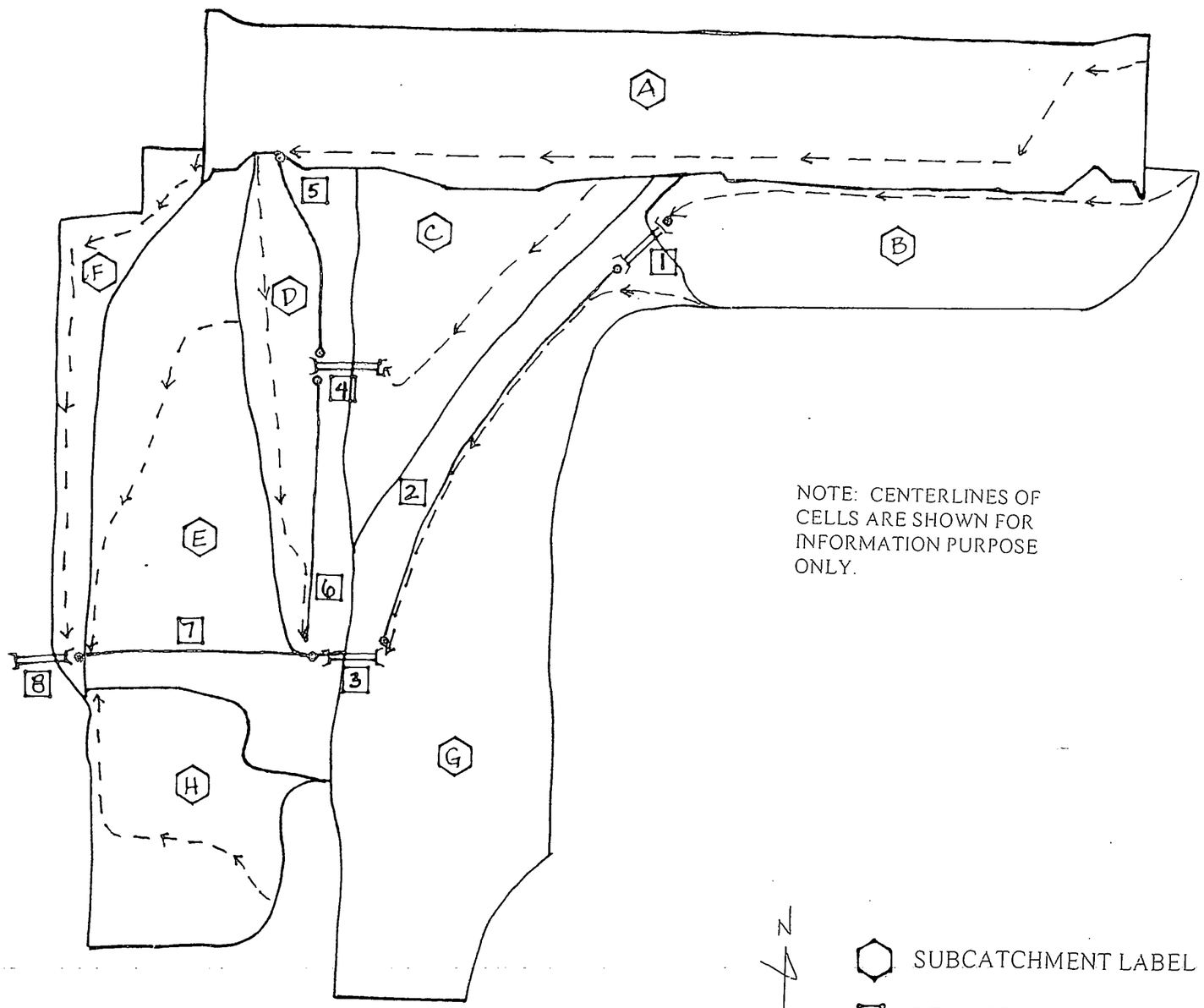

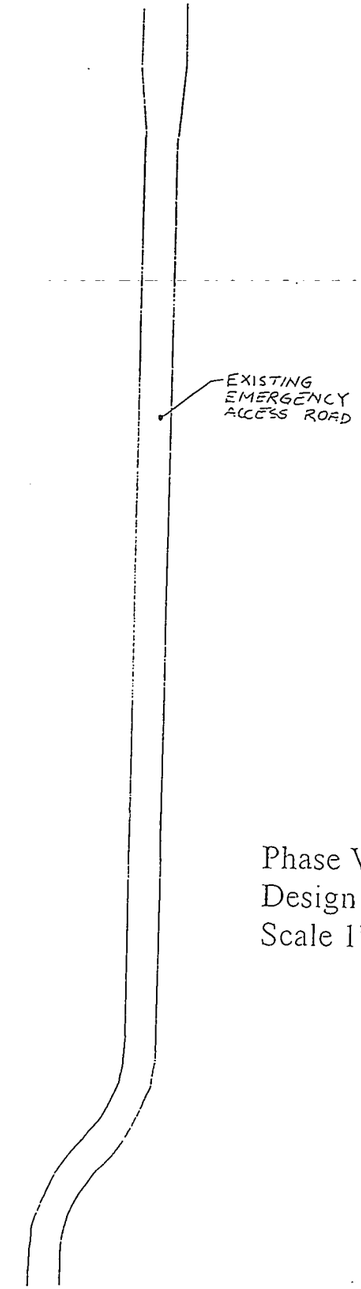

NOTE: CENTERLINES OF CELLS ARE SHOWN FOR INFORMATION PURPOSE ONLY.

Phase V
Design Case"A"
Scale 1" = 100'

LEGEND

N

SUBCATCHMENT LABEL
REACH LABEL
REACH ALIGNMENT
FLOW PATH
CULVERT
CENTERLINE OF CELL

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LEGEND

SUBCATCHMENT LABEL AND BOUNDARY

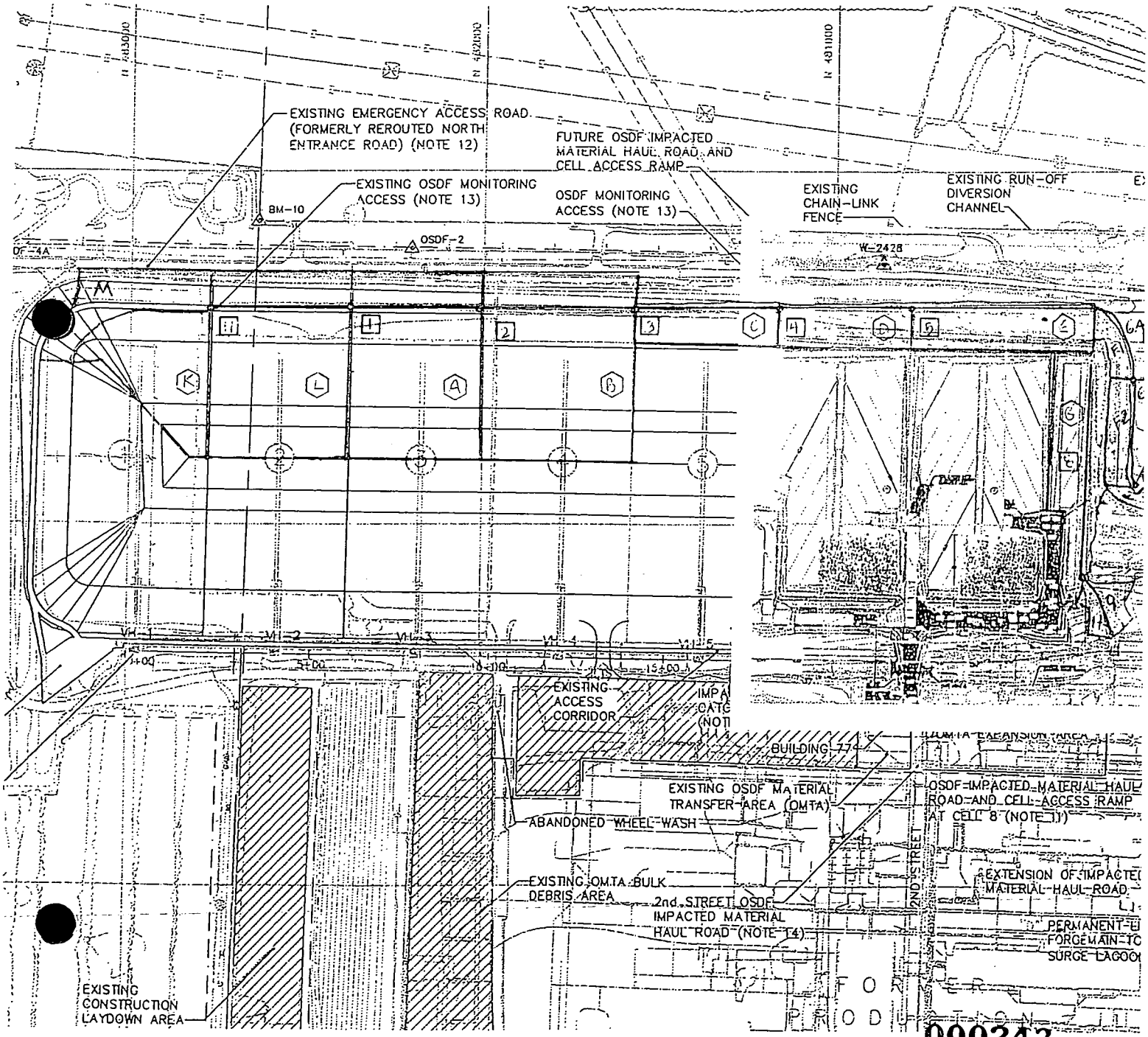
REACH ALIGNMENT AND LABEL

CULVERT

PHASE V
DESIGN CASE "B"
SCALE 1" = 400'

0 400

N



000243

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LEGEND

SUBCATCHMENT LABEL AND BOUNDARY

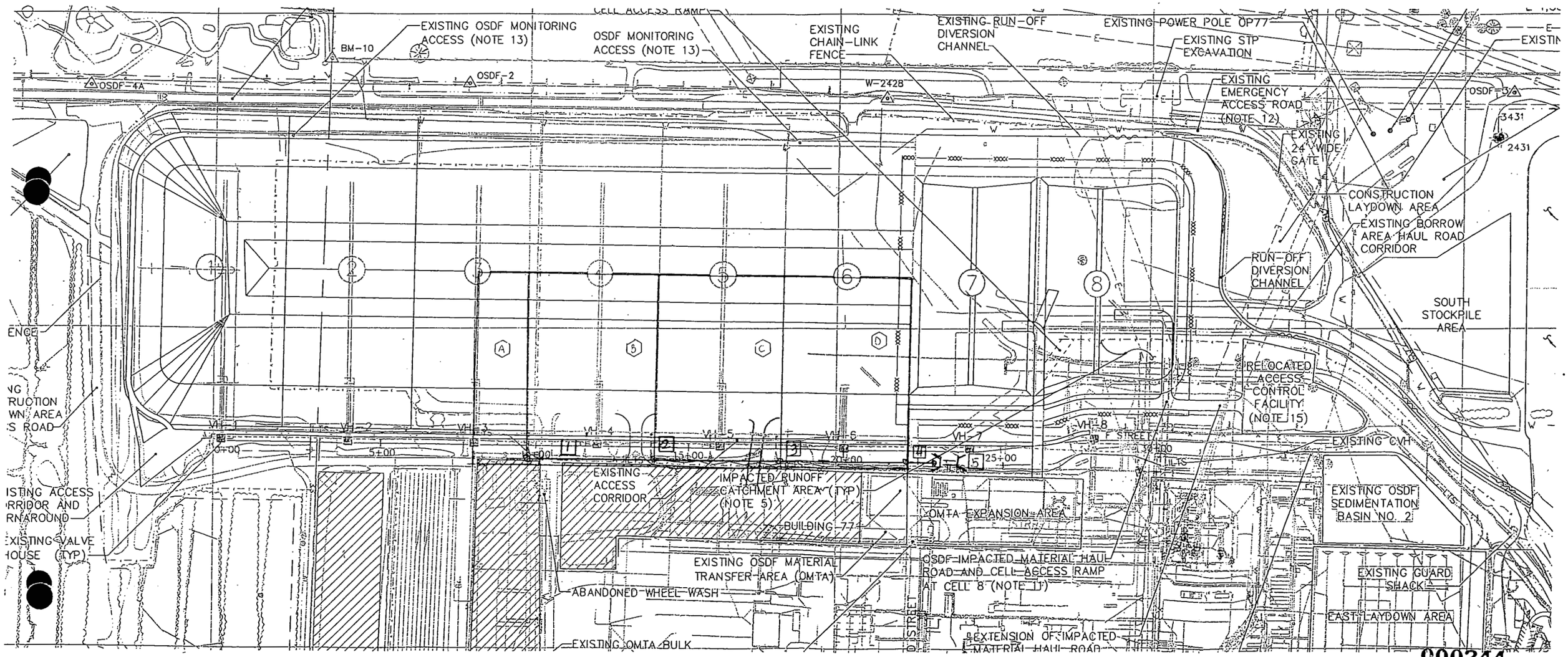
REACH ALIGNMENT AND LABEL

CULVERT

PHASE V
DESIGN CASE "C"
SCALE 1" = 300'

0 300'

N



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ATTACHMENT A-3

HydroCAD™ TECHNICAL REFERENCE MANUAL

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HydroCAD Technical Reference

Section 10 - Units of Measure

Most equations in this Manual are given in a universal format that may be directly evaluated in metric (SI) or English units. When evaluating these equations, care must be taken to use only *primary* units as listed in the following table.

	[illegible]	[illegible]	[illegible]
[illegible]	Seconds	Seconds	1
[illegible]	Meters	Feet	3.281
[illegible]	Square Meters	Square Feet	10.76
[illegible]	Cubic Meters	Cubic Feet	35.31
[illegible]	Meters per Second	Feet per Second	3.281
[illegible]	Cubic Meters per Second	Cubic Feet per Second	35.31
[illegible]	$\sqrt{Meters}$ / *Second*	$\sqrt{Feet}$ / *Second*	1.811

Some empirical equations were developed with specific units (such as inches in the SCS runoff equation), and cannot be readily expressed in a unit-less form. These equations are marked with the original units.

HydroCAD also supports many secondary units, such as acres and hectares, which are automatically converted to and from primary units as required. When evaluating equations by hand, be sure to use the appropriate primary units as listed above.

You can change the units for any project as described on page 21.

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What is Stormwater and why does it need to be modeled?

During a rainstorm, precipitation reaching the ground is dissipated by several mechanisms: some is lost to evaporation, some infiltrates into the ground, and the remainder appears as stormwater runoff. This runoff can cause a variety of undesirable effects, such as erosion and flooding. In order to prevent such damage, the runoff must be safely conveyed through suitable channels, pipes, streams, and rivers to a suitable point of disposal, and eventually to the sea. By determining the fate of the runoff and the way it will flow through these channels, it is possible to predict how, where, and when damage may occur. Steps can then be taken to reduce the chances of damage, such as enlarging a stream to prevent overflow of its banks, or detaining some of the runoff in a pond to reduce flooding downstream.

Why is there an increased need for stormwater modeling now?

Most new construction involves changes in the usage of the surrounding land. A new shopping center, for example, may remove a stand of trees and replace it with a paved parking lot and several buildings. Such a change in the ground cover has a dramatic effect on the runoff, greatly increasing its total volume and the rate of runoff. This directly increases the potential for erosion and flooding in all areas downstream of the new construction. To prevent such damage, the runoff must be predicted before construction so that suitable steps can be taken to handle the runoff in a safe and effective manner.

In the past, such analysis and design was often not performed. As a result, a significant amount of stormwater damage now occurs, ranging from minor flooding of local streams, to erosion of farmland, to flooding of major rivers. The resultant burden on many drainage systems and the increasing rate of construction means that all new construction and development should include a careful analysis of the effects on stormwater runoff. This not only reduces possible liability for stormwater damage, but is required by law in a growing number of states and towns.

How is stormwater modeled?

Stormwater modeling can be divided into two basic fields: Hydrology, which is the study of runoff and the factors that influence it, and Hydraulics, which is the study of water flow in the channels, pipes, streams, ponds, and rivers that convey it to the sea. In each field there are many techniques available for performing the required analysis. A qualified engineer must choose the best methods for each situation.

In the past, a number of simplified techniques have been employed for predicting runoff and its effects. With the advent of low-cost computers, it is now possible to use more sophisticated techniques to perform a more accurate and complete analysis in less time.

Different Approaches to Hydrology

There are many different approaches to stormwater modeling and drainage design. These techniques can be divided into two basic groups:

1) Steady-state (constant flow) methods, such as the Rational method as applied to storm sewer pipe networks.

2) Hydrograph generation and routing procedures designed to simulate the time-varying nature of actual runoff.

Although HydroCAD can be used for steady-state designs and does include the Rational method, it is designed primarily as a *hydrograph generation and routing* program. (See page 105 for a discussion of several related topics.)

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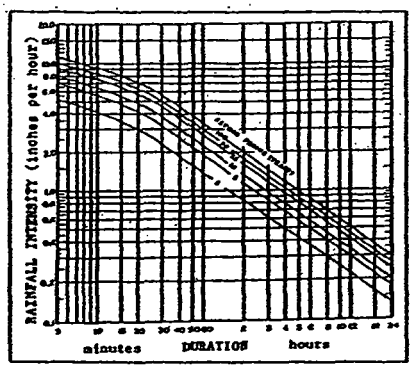
The Intensity-Duration-Frequency Relationship

Based on rainfall observations, IDF curves can be compiled for any location:



These curves indicate the relationship between the intensity (i) and duration (d) of a rainfall event with a given return period (T). They are typically used to determine the intensity of a specific design event.

Instead of return period, it is more accurate to think in terms of the exceedence probability (p), where p=1/T. Thus, a "25 year storm" actually designates a rainfall event which has a 4% chance of occurring in any given year.

The Rational Method for Predicting Runoff

The Rational method may be used to predict the peak runoff according to the formula:

$$Q = C \times i \times A$$

Q=Peak Runoff
C=Runoff Coefficient
i=Rainfall intensity
A=Area

(See page 61 for a discussion of rational method units.)

Although the rational method appears straightforward, it is totally dependent on the "correct" selection of C and i.

C is based on the soil, ground cover, and other factors.

i is obtained from the local IDF curve for a given return period and duration.

One of the major challenges of the rational method is choosing the *critical duration*. The duration must be just long enough for maximum runoff to occur. A longer duration will yield a lower intensity from the IDF curve, and thus a lower runoff.

For a single subcatchment, the critical duration is usually equal to the time-of-concentration. However, when several subcatchments are combined in a complete drainage system, *the critical duration can have any value between the shortest and longest Tc.*

The rational method is intended to determine only peak runoff. It does not yield accurate runoff volumes, and therefore should not be used when subsequent volume-sensitive routing calculations are required.[5]

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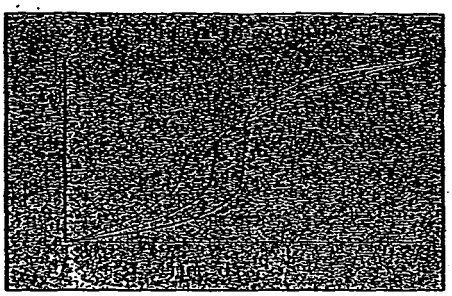
[5] If the Rational Method is selected for runoff calculations, HydroCAD generates a trapezoidal hydrograph for each subcatchment. This makes it possible to study the complex behavior that results from the combination of multiple subcatchments. Although HydroCAD is capable of routing the resultant hydrograph, such calculations exceed the intent and scope of the Rational Method and are best performed with other runoff techniques that provide more meaningful runoff volumes.

By studying the Weather Bureau's Rainfall Frequency Atlases, the Soil Conservation Service determined that virtually all rainfalls over the United States could be characterized by just four *dimensionless* rainfall distributions.* Each distribution is expressed as a *mass curve* indicating what *fraction* of the total 24-hour precipitation has fallen at any time.



These curves are *synthetic rainfall distributions*. They are intended as a tool for determining the behavior of a watershed under a wide range of conditions, and are not intended to represent an actual event.

Each curve is developed from the same depth-duration-frequency data used for IDF curves. Using 30 minute increments, the incremental rainfall is calculated for durations of 30 minutes to 24 hours. For example, the 30 minute depth is subtracted from the one hour depth, and the one hour depth from the 1½ hour depth. The largest 30 minute increment is placed at the middle of the hypothetical storm, which is 12 hours. The second largest 30-minute incremental depth is placed in the next 30 minutes, and the third largest in the previous 30 minutes. This process is repeated to develop the entire 24-hour curve.

- The most significant feature of the SCS storm distributions is that each curve contains depth information for events of *all* durations up to 24 hours.

- Furthermore, the SCS distributions give the cumulative rainfall at any point in time, thus making them suitable for volume-dependent routing calculations.

Although an actual event may be shorter than 24 hours, the same distribution is suitable for all events of 24 hour duration or *less*. Longer distributions are required only for very large watersheds where the overall travel time nears or exceeds 24 hours.

* While the SCS synthetic rainfalls are intended to cover most projects in the United States, some situations may require the use of a localized design storm, or even an actual rainfall distribution. HydroCAD contains a large library of such specialized storms, and additional custom storms are easily added.

The SCS Runoff Equation

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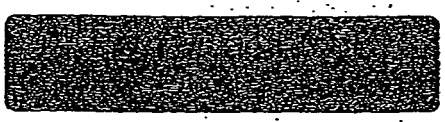
Studies by the SCS resulted in the following empirical relationship for runoff:



Q=Precipitation excess (runoff) [inches]
P=Cumulative precipitation [inches]
S=Potential maximum retention [inches]
CN=SCS Curve Number

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The SCS runoff equation predicts the *volume* of runoff resulting from a given precipitation depth. The key factor in this translation is the SCS Curve Number.

The Curve Number is based on the soil type, ground cover, and other factors. High curve numbers (up to 100) indicate complete runoff with little retention, and low numbers indicate high retention and reduced runoff. (See page 49 for further information.)

- One of the most common effects of land development is an increase in the Curve Number. The transition from woods to lawn, or lawn to pavement, is accompanied by a significant increase in the CN. A close study of the SCS runoff equation will reveal that even a modest increase in the curve number can produce a dramatic increase in the volume of runoff.

Determining the Time of Concentration

While the SCS runoff equation predicts the *volume* of runoff, it doesn't specify *when* the runoff will occur. To determine how the runoff is distributed over time, we must introduce a time-dependent factor. The *time-of-concentration*, or Tc, is commonly used.

The Tc is typically defined as *the time required for a particle of water to travel from the most hydrologically remote point in the watershed to the point of collection*. There are several methods available for calculating Tc, one of which is the Lag Method:

T_c=Time of concentration [hours]
L=Lag time [hours]
l=Hydraulic length of watershed [feet]
Y=Average land slope [percent]
S=Potential maximum retention [inches]
CN=Weighed Curve Number

Other methods in common use include:

- TR-55 Sheet Flow
- TR-55 Shallow Concentrated Flow
- Channel Flow (Based on the Manning's velocity)
- Upland Method (Described in NEH-4)

All of these techniques are provided by HydroCAD. This allows selection of the method(s) best suited to each situation. Other techniques may be employed by entering the resultant Tc directly into HydroCAD.

The SCS Dimensionless Unit Hydrograph

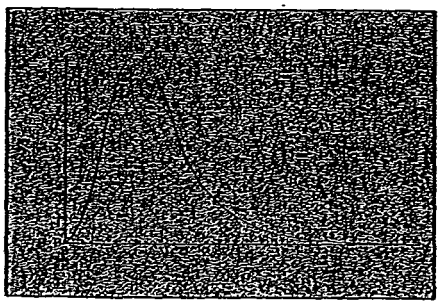
A unit hydrograph represents the runoff resulting from:

- One inch of precipitation excess,
- Generated uniformly over the watershed,
- At a uniform rate,
- For a duration D.

The hydrograph is made dimensionless by expressing:

- Ordinates as a fraction of the peak discharge q_p
- Time axis as a fraction of the time-to-peak T_p

By analyzing a large amount of measured data, the SCS developed an average dimensionless unit hydrograph:



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[redacted]

T_p=Time to peak
T_c=Time of concentration
D=Burst duration

This allows the burst duration D, and the overall duration of the UH, to be determined based solely on the time of concentration.

To dimension the ordinates of the UH, we can use the following relationship between the volume and peak of the UH:

[redacted]

q_p=Peak discharge [CFS]
484=Peak factor
A=Area [sq-miles]
Q=Precipitation excess (runoff) [inches]

This allows the ordinates of the UH to be dimensioned based on the precipitation excess (Q), as previously determined by the SCS runoff equation.

- The SCS Dimensionless Unit Hydrograph is significant in that it is applicable to an extremely wide range of conditions. Only a few locations require a different curve, such as the Delmarva[7] unit hydrograph, which has a peak factor of 284.

[7] The Delmarva UH was developed for the peninsula between Delaware, Maryland and Virginia for which it is named. It may also be used in other locations where the reduced peak factor of 284 is appropriate.

The unit hydrograph, when dimensioned, tells us what the runoff will be for a *single* burst of rainfall. To determine the runoff for the entire storm, we must perform a *convolution of the unit hydrograph with the precipitation excess*. This is simply a summation of many unit hydrographs, each of which represents one burst of runoff.

The process is as follows:

1) For the first burst (of duration D) we determine the precipitation excess and create a corresponding Unit Hydrograph.

2) For the next burst we determine the precipitation excess occurring *during* the interval D which is $\Delta Q=Q(t+D)-Q(t)$. We create the corresponding UH, translate it by the duration D, and add it to the previous result.

3) Step 2 is repeated for all durations D needed to compose the entire 24-hour storm.

The resulting hydrograph represents the runoff from the entire storm. This is the fundamental method used by TR-20 for predicting runoff. It is commonly referred to as the SCS Unit Hydrograph procedure (SCS-UH), or simply the Unit Hydrograph procedure.

Note that if T_c=7.5 minutes and D=1 minute, then a 24-hour storm will consist of 1440 bursts generating an equal number of unit hydrographs. If the UH consists of 100 coordinates, about 140,000 coordinates must be summed to produce the composite hydrograph! Obviously, such a technique is not practical to perform by hand.

TR-55 and the Tabular Method

Because of the enormous computational requirements of the unit hydrograph procedure, the SCS derived a simplified tabular method which it published in Technical Release 55 (TR-55).

The tabular method consists of a number of composite hydrographs produced with TR-20, which are then scaled and interpolated in order to approximate the results that would have been produced with TR-20 itself.

In order to keep the number of tables to a minimum, *average* values were used for several variables. The equations of TR-55 were then designed to reintroduce the dependencies on these parameters.

The two primary assumptions of TR-55 are a Curve Number of 75 and a runoff of 3 inches. TR-20 and TR-55 can be expected to deviate as these assumptions become invalid.

A number of other conditions also indicate the use of TR-20:

- T_c<1 hours or T_c>2 hours
- Drainage subareas differ by a factor of 5 or more
- The entire hydrograph is required for routing
- Accurate volumes are required for routing

The approximations of TR-55 are sufficient to cause the SCS to place the following warnings in the documentation:

> "This method (TR-55) approximates TR-20, a more detailed hydrograph procedure.... Use TR-20 if the watershed is very complex or a higher degree of accuracy is required."

This applies particularly to the design of detention basins, since they are very sensitive to changes in the inflow hydrograph. Again quoting from TR-55:

> "The procedure (TR-55) should not be used to perform final design if an error in storage of 25 percent cannot be tolerated.... More detailed hydrograph development and routing will often pay for itself through reduced construction costs."

When evaluating TR-55, keep in mind that it was developed primarily for manual use. When computers are available, the original TR-20/SCS-UH methodology would appear to be preferred.

HydroCAD, TR-20, TR-55 Comparison

The following table summarizes the technical similarities and differences between these three programs. Note that HydroCAD combines the most-used capabilities of TR-20 and TR-55, plus many other techniques and features not provided by either program.

	HydroCAD	TR-20	TR-55
[redacted]	SCS unit hydrograph procedure (unlimited points)	SCS unit hydrograph procedure (201 points)	Tabular method derived from TR-20
[redacted]	Extensive rainfall library plus user-defined storms	SCS type I, IA, II & III	SCS type I, IA, II & III
[redacted]	SCS or Delmarva U.H., plus user defined curves	SCS Unit Hydrograph or user defined curve	SCS Unit Hydrograph only
[redacted]	Automatic curve number lookup and weighting	Requires direct entry of composite curve number	Automatic curve number lookup and weighting
[redacted]	No restrictions	No restrictions	Reduced accuracy as CN differs from 75
[redacted]	All TR-55 methods plus common channel shapes, upland method, and CN method	Contains no Tc calculations: Requires direct entry of Tc	Calculates Tc for sheet, shallow concentrated, & channel flow
[redacted]	No restrictions	No restrictions	Limited to .1 to 2 hrs
[redacted]	1/10 minute or 1/600 hour	1/100 hour	Rounded to nearest step
[redacted]	None	None	Must not differ by more than factor of 5
[redacted]	Within 1% of TR-20	"The standard"	Within ±25% of TR-20
[redacted]	Storage-indication method with optional routing delay (translation)	Modified Att-Kin procedure	No routing, separate tables for travel times of 0 to 3 hours
[redacted]	Storage-indication method or coupled pond routing	Storage-indication	None, only estimates ponding effects
[redacted]	By plug flow method	not calculated	not calculated
[redacted]	Automatic calculation for simple and compound outlets	Must be entered directly, no calculations provided	n/a, no pond routing
[redacted]	Automatic calculation from pond surface areas, plus direct entry	Direct entry only	n/a, no pond routing
[redacted]	Automatic diversion of outflow from specified pond outlet(s)	Separate "Divert" procedure based on user-defined curve	n/a
[redacted]	Interactive, on-screen	none	none
[redacted]	Automatically calculated as required	"Batch mode" calculation of entire watershed	Manual initiation of each calculation
[redacted]	Full graphics to screen or printer	none	none
[redacted]	Automatic reports with headings, graphics, etc.	Manual	Manual
[redacted]	Automatic by job name	Manual	Manual

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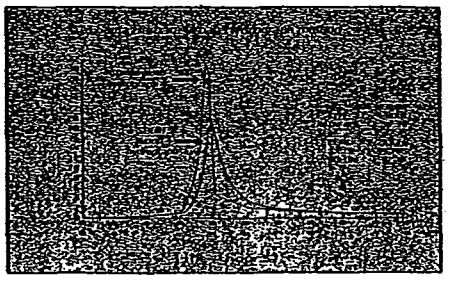
Another common runoff technique is the Santa Barbara Urban Hydrograph method or SBUH.[8] This technique is similar to the SCS-UH procedure in that it employs the same SCS curve numbers, runoff equation, and rainfall distributions. The difference is that rather than utilizing a Unit Hydrograph to generate the runoff hydrograph, the SBUH method generates an instantaneous hydrograph which is routed through an imaginary reservoir with a time delay equal to the subcatchment's time of concentration.



A significant feature of the SBUH method is that the calculations are relatively simple in comparison to the SCS-UH procedure. Although it is rarely advisable to perform either technique by hand, it is at least possible to compute the SBUH runoff manually, and it can be done quite readily with a basic spreadsheet program.

While the availability of the SCS-UH procedure would appear to eliminate the need for the SBUH method, some localities prefer the SBUH method for specific situations. HydroCAD provides both techniques, and the ease of switching from one method to another makes it a simple matter to provide the required analysis, and even to compare the results of different techniques.

[8] Note that the "UH" stands for *Urban* Hydrograph, not *Unit* Hydrograph. This is a common point of confusion regarding the SBUH method. In fact, the SBUH method does not employ a Unit Hydrograph at all.

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Section 12 - HydroCAD Fundamentals

Understanding HydroCAD

HydroCAD provides a number of techniques for the generation and routing of hydrographs. It also provides many other related calculations, such as time of concentration, weighted curve numbers, pond volumes, stage-discharge curves, etc. This broad range of capabilities allows a large number of studies to be performed entirely within HydroCAD.

HydroCAD is a *hydrograph routing model*. It is designed specifically to handle *time varying flows*, as required for pond design and other volume-sensitive calculations.

Certain calculations, such as channel backwater or pressurized pipe networks, are normally analyzed under *constant flow* conditions. These tasks may be best addressed by steady-state numerical techniques, and not by a hydrograph routing system such as HydroCAD. Some projects may require the use of HydroCAD to model the overall drainage system, combined with a steady-state analysis of specific components. This is an unavoidable consequence of the different methodologies.

Although HydroCAD's sequence of operations is very flexible, its power is most easily understood by viewing it in four phases.

Phase I - Construction of Routing Diagram

A diagram is constructed showing the functional components, or nodes, that make up the watershed. The diagram shows the location of each node and how water is routed from one node to another.

Phase II - Description of each Node

Each node is described in detail so that HydroCAD can calculate the outflow from each node once the inflow is known.

Phase III- Calculation of flow through each Node

Calculations occur automatically whenever a report is selected. Starting at the upstream end of the diagram and working downstream, HydroCAD calculates the outflow and other results for each node. Multiple inflows are summed automatically. A *minimal recalculation* feature automatically reuses the results of previous calculations where no changes have occurred.

Phase IV - Display and Examination of Results

Opening one or more report windows lets the user verify the behavior of the watershed. If any changes are required, the user may modify the watershed, causing the calculations and reports to e automatically updated.

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Determining the Curve Number

The curve number (CN) characterizes the type of soil and ground cover. A high CN (such as 98 for pavement) indicates minimum retention, while a low CN (such as 30 for certain wooded areas) indicates a large retention capability. For subcatchments with multiple CN values, HydroCAD calculates a composite CN by summing the products of each CN multiplied by its percentage of the total area.

HydroCAD includes a complete curve number lookup table based on data developed by the SCS (NRCS) and published in TR-55. This table is based partly on the Hydrologic Soil Group, which may be determined for any soil type by clicking Help on the lookup table screen. For further information see page 111 and NEH-4, which provides additional guidance on CN selection.

Curve Number Effects

The curve number is used to determine the fraction of the precipitation depth that will occur as runoff. This relationship is specified by the SCS runoff equation as shown on page 57.

Adjustments for Antecedent Moisture Condition

The antecedent moisture condition specifies the moisture level in the ground immediately prior to the storm. Three conditions are defined:

AMC I - Dry
AMC II - Normal
AMC III - Wet

It is common policy to use AMC II for most design work. Other values should be used only under special circumstances. AMC III is sometimes used to study extremely wet conditions, such as a spring storm falling on saturated ground. AMC III usually causes a dramatic increase in runoff, and is not normally used for design purposes.

The AMC works by adjusting the Curve Numbers in all subcatchments according to a predefined table as shown on page 116. In general terms, AMC I reduces all CN values while AMC III increases the values. AMC II uses the original values without adjustment.

The AMC is set for each project by selecting Settings|Calculation: Rainfall.

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Section 14 - Determining the Time of Concentration

One of the key elements required for any runoff calculation is the *Time of Concentration*, or T_c. The T_c is typically defined as the time required for runoff to travel from the most hydrologically distant point of the watershed to the point of collection.

The time of concentration is commonly determined by summing the travel time (T_t) for each consecutive *flow segment* along the subcatchment's hydraulic path. This process requires identification of the type of flow occurring in each segment, and application of the appropriate method for calculating the T_t. Although these segments will occur in a given physical order, the order in which they are used in the program has no effect on the total travel time.

HydroCAD provides a variety of techniques for calculating the T_t, plus other procedures (such as the Curve Number method) which are designed to directly determine the overall T_c. These procedures are discussed below. If necessary, the T_c or T_t may also be determined by other procedures and entered into HydroCAD directly.

☞ The determination of the time of concentration is one of the most widely discussed areas of hydrology. The actual method(s) used on any given project depends upon actual site conditions, regulatory requirements, and sound engineering judgement.

Curve Number Method

The Curve Number Method (see NEH-4 p.15-7) was developed to allow calculation of the overall T_c under a wide range of conditions. The method is designed for areas of 2000 acres or less. The calculation is quite simple, but requires a proper understanding of the input requirements:

$$T_c = \frac{L^{0.8}(S+1)^{0.7}}{1900\,Y^{0.5}} \qquad L = \frac{l^{0.8}(S+1)^{0.7}}{1900\,Y^{0.5}} \qquad S = \frac{1000}{CN} - 10$$

T_c=Time of concentration [hours]
L=Lag time [hours]
l=Hydraulic length of the watershed [feet]
Y=Average land slope [percent]
S=Potential maximum retention [inches]
CN=Weighted Curve Number (See page 111)

Note the use of the average *land* slope, as described below. (This is distinct from the slope of the hydraulic path, as used in most Tc calculations.) Although some care is required to determine this value, the Curve Number method has the advantage of using a small number of fairly objective parameters. This provides more consistent results than some other approaches.

Average Land Slope

The average land slope (or average watershed slope) is a critical factor in the use of the Curve Number method, as described above. A theoretical determination would require placing a grid over the subcatchment and averaging the slopes for all squares. Other techniques are available that have more modest data requirements, such as the following equation from Ponds-Planning, Design & Construction:

$$Y = \frac{C \times 100}{l}$$

Y=Average land slope [percent]
C=Total Contour length [feet] or [m]
l=Contour interval [feet] or [m]

C is obtained by adding the length of all contour lines within the subcatchment. The accuracy of this technique depends on having a sufficient number of contour lines within the subcatchment. Reducing the contour interval will generally increase the accuracy of the result.

TR-55 Sheet Flow Procedure

The Sheet Flow procedure is designed for flow over plane surfaces, as usually occurs in the headwaters of a stream. (See TR-55 p.3-3) The following equation is used for sheet flow:

$$T_t = \frac{0.007(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$$

T_t=Travel time [hours]
n=Manning's coefficient for sheet flow (See page 135)
L=Flow length [feet]
P_2=2-year, 24-hour rainfall [inches] (See map on page 121)
s=Land slope (along flow path) [ft/ft]

Determining the actual length of sheet flow is critical to this method. Although the technique was intended for lengths up to 300 feet, some agencies now recommend a maximum of 100 feet. In any case, the length should not extend past the point where there is evidence of concentrated flow on the ground. The length is also critical in that Sheet Flow is often a dominant factor in a subcatchment's total Tc.

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The Upland Method (see NEH-4 p.15-6) is designed for conditions that occur in the headwaters of a watershed, including overland flow, grassed waterways, paved areas, and through small upland gullies. Upland method is applicable to areas of 2000 acres or less. Although commonly published as a chart of velocity vs. slope for various surfaces, upland method is based on the following equation:

T_t=Travel time [hours]
L=Flow length [feet] or [m]
V=Average velocity [FPS] or [m/s]
K_v=Velocity factor [FPS] or [m/s] (See page 137)
s=Land slope (along flow path) [ft/ft] or [m/m]

Shallow Concentrated Flow

The TR-55 Shallow Concentrated Flow procedure (see TR-55 p.3-3) is of the same mathematical form as the Upland Method (above). The essential difference is that it utilizes only two surface types, *paved* and *unpaved*. (See page 137 for the corresponding K_v values for these surfaces.) Due to the similarity between Upland Method and Shallow Concentrated Flow, HydroCAD utilizes a single screen for both methods, and combines the K_v values from both methods into a single table.

Channel Flow

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The Channel Flow procedure (see TR-55 p.3-3) is commonly employed where surveyed cross sections are available, or anywhere the velocity can be reasonably determined by Manning's equation.

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T_t=Travel time [hours]
L=Flow length [feet] or [m]
V=Average velocity [fps] or [m/s]
n=Manning's coefficient (See table on page 128)
s=Channel slope [ft/ft] or [m/m]
r=Hydraulic radius [feet] or [m]
a=Cross-sectional flow area [sq-feet] or [m^2]
P_w=Wetted perimeter [feet] or [m]
1.486=English factor (use 1 for metric evaluation)

In addition to allowing direct entry of cross sectional area and wetted perimeter, HydroCAD can automatically calculate these parameters for rectangular, vee, trapezoidal, parabolic, and circular channels as described on page 138.

Other Tc Procedures

Other T_c procedures can be employed by entering the calculated value directly into HydroCAD. This can be used as the total T_c for a subcatchment, or combined with additional flow segments calculated by other means. One situation that calls for direct T_c entry is modeling the "runoff" on the surface of a pond. This requires the direct entry of a T_c of zero.[9]

[9] When used in combination with a Curve Number of 100, this will produce complete, instantaneous "runoff."

Section 15 - SCS Unit Hydrograph Procedure

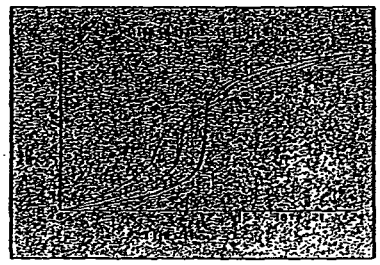
The US Department of Agriculture Soil Conservation Service[10] has developed a number of techniques for analyzing stormwater runoff. One of the most widely used is the SCS Unit Hydrograph procedure (SCS-UH). The SCS-UH procedure is a principal component of SCS/NRCS Technical Release 20, commonly known as TR-20.

The SCS-UH procedure is the primary runoff technique provided by HydroCAD. Although HydroCAD does not employ any of the actual code from TR-20, it is based on the same SCS-UH procedure and will produce essentially the same runoff results.

Due to the computational requirements of TR-20, the SCS produced a simplified, derivative tool in the form of the TR-55 Tabular method. The Tabular method is designed to approximate the results that would be obtained from TR-20, but uses various approximations that cause reduced accuracy in many situations. Because of this relationship, TR-20 will always provide equal or greater runoff accuracy, and is therefore preferable for most projects that call for the TR-55 Tabular method. (See page 43 for a detailed comparison of these techniques.)

Synthetic Rainfall Distributions

The SCS unit hydrograph procedure commonly utilizes a *synthetic rainfall distribution*. The SCS has developed several standard distributions that cover the entire U.S. These are commonly expressed as *mass curves*, as shown at right and discussed on page 117. When combined with national rainfall maps (starting on page 121), these distributions eliminate the need for local "IDF" curves as employed by the Rational method. In fact, the rainfall distributions contain the same information in a reduced form.



While the unit hydrograph procedure may initially appear more complex than the Rational method, it is actually easier to apply with a system such as HydroCAD. This is because the synthetic rainfall distributions encompass *all duration events* in a single calculation, while the Rational method requires a separate calculation for each duration.[11]

Custom rainfall distributions may also be used with the unit hydrograph procedure, but this is rarely necessary. It is not uncommon to confuse a local IDF curve with a rainfall distribution. An IDF curve is not only inapplicable to the unit hydrograph procedure, but it usually duplicates the information already contained in one of the rainfall distributions.

[10] Now the Natural Resources Conservation Service or NRCS.

[11] The SCS technique also provides accurate volume information for volume-sensitive studies such as ponds. In comparison, the Rational method is intended primarily for determining peak flows, and does not provide accurate volume information.

Data Requirements for the SCS-UH Procedure

The following data is required for the SCS unit hydrograph procedure as employed in both TR-20 and HydroCAD. Some of these items are provided for each individual subcatchment, while others apply to the entire watershed.

The curve number (CN) characterizes the type of soil and ground cover, as discussed on page 49.

The time of concentration (Tc) indicates the time required for all parts of the subcatchment to contribute to the runoff. (See page 51.)

The total storm rainfall (in inches) is determined for any specific location from U.S. Weather Bureau maps based on the desired return period (2, 5, 10, 25, 50, or 100 years). This is the total precipitation that will occur during the storm. Rainfall maps for the United States (reprinted from TR-55) begin on page 121.

The storm type is selected according to the geographic location and any special project requirements. For each storm, HydroCAD contains a mass curve indicating how the rainfall will be distributed over the total duration of the storm.

HydroCAD provides an extensive library of rainfall distributions, including the SCS 24-hour type I, IA, II, and III. (See page 117 for details.) The SCS rainfall data is in the form of second-order fitted equations, which guarantee a smooth runoff hydrograph free of "steps" or other irregularities. Specialized rainfall distributions are also provided for Florida, Illinois, and other areas, and custom rainfalls may be added if required.

Most storms include a default rainfall duration (such as 24 hours) which is employed for most studies. The duration may be changed for special applications, such as the Illinois Huff Distributions.

The unit hydrograph is a dimensionless curve that shows the runoff distribution resulting from one inch of precipitation excess occurring uniformly over the watershed during a specified duration. (See Hydrologic Analysis and Design p.399 for details.)

HydroCAD provides the standard SCS and Delmarva unit hydrographs (see TR-20 p.240) which have peak factors[12] of 484 and 284 respectively. Additional unit hydrographs may be defined if a different peak factor is required. (For details see the UH.txt file which is installed in the HydroCAD/Rainfall folder.)

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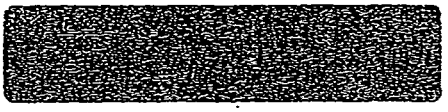
[12] The peak factor is a characteristic of the unit hydrograph curve, representing the peak-to-volume ratio of the curve. The peak factor does not appear directly in the SCS-UH runoff procedure, and can be changed only by using a different UH.

The runoff hydrograph is generated by performing a *convolution of the unit hydrograph with the rainfall excess*. (For details see NEH-4 p.16-2.) A brief description of the HydroCAD implementation follows:

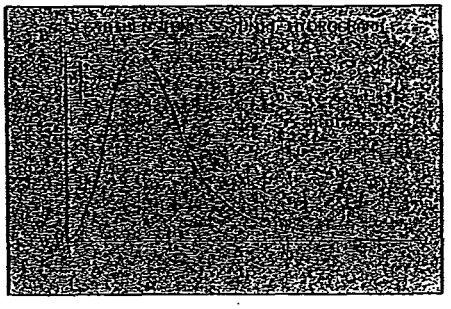
1) At any time during the storm, the cumulative precipitation (rainfall depth) can be determined from the selected rainfall distribution when multiplied by the total rainfall depth. The cumulative *precipitation excess* (runoff) can then be determined by the SCS runoff equation. (See TR-55 p.2-1 and NEH-4 p.10-5.)



Q=Precipitation excess (runoff) [inches]
P=Cumulative precipitation [inches]
S=Potential maximum retention [inches]
CN=Curve number

2) The storm is divided into a series of rainfall *bursts* of duration D=2/15 Tc. The precipitation excess occurring *during* any interval D at time t can be calculated by:

3) For each burst, the unit hydrograph defines how this volume of runoff will occur over time. The *volume* of the unit hydrograph is given by dQ (above). The *duration* of the unit hydrograph is related to Tc and D as shown. The result is that the *dimensionless* unit hydrograph has been dimensioned.



4) The runoff from the entire storm is determined by summing the hydrographs resulting from each rainfall burst.

1) The runoff hydrograph consists of a series of ordinates (CFS flows) at evenly spaced intervals "dt." Each ordinate specifies the *average flow* during the interval. As a result, if a narrow peak occurred within one interval, the hydrograph would indicate an average flow that might be significantly less than the instantaneous peak. This is likely to occur when T_c is less than 2dt, so HydroCAD displays an informative warning in these cases.

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When you encounter this situation, keep in mind that the instantaneous peak can exceed the average for a time no longer than dt, which is commonly 6 minutes or less. In practice, such a short instantaneous peak is usually attenuated to the average value by the storage characteristics of the first reach or pond. However, if a true instantaneous peak is required, the runoff interval (dt) may be reduced to approximately one-half the T_c.

2) TR-20 has no inherent limitations on the time of concentration. As T_c approaches 0, the runoff curve approaches the precipitation excess curve, which is the expected limiting case.[13] Similarly, for a very large T_c, the entire storm becomes a single rainfall "burst" and the runoff approaches the shape of the unit hydrograph.

3) When making comparisons to TR-55, note that the TR-55 tables were produced for a curve number of 75 and require a precipitation excess of at least 1.5 inches. As conditions deviate from these, an increasing difference of up to 25% can be expected.

4) Runoff hydrographs are generated for a specified *time span*, such as 10 to 20 hours. You must ensure that this span is suitable for the purposes of your analysis and the rainfall type being used. If you are primarily concerned with peak flows, you can reduce calculation time by using a shorter time span. However, for ponds and other volume-sensitive studies, make sure the time span begins at or before the earliest runoff, or this early volume won't be included in your calculations. HydroCAD will generate an automatic warning message if the span is not adequate to include the earliest inflow into a pond. Also keep in mind that the volumes displayed by HydroCAD include only the specified time span. By increasing the ending time to 25 hours or so, you'll get a complete picture of the storm.

5) As a safeguard, HydroCAD performs an automatic check of runoff peaks in relation to the time span. A warning message is displayed if the calculated time of the peak doesn't fall within the middle 90% of the time span. If this warning appears, you should examine the hydrograph and adjust the time span accordingly.[14]

- Although HydroCAD applies a number of tests to check the accuracy of your model, a visual examination of all hydrographs is *highly recommended*. This will help to detect erroneous input data and ensure meaningful results.

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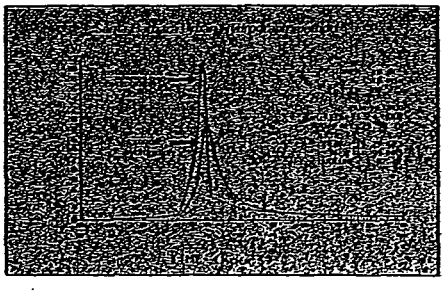
[13] If desired, the HydroCAD runoff procedure is specially designed to permit a Tc of zero. This can be used to model the instantaneous "runoff" from rain falling on the surface of a pond.

[14] This test is for the peak only. If the entire volume is required, you must still determine if the span is sufficient.

Section 16 - Santa Barbara Urban Hydrograph

The Santa Barbara Urban Hydrograph method (SBUH) was developed by the Santa Barbara County (California) Flood Control and Water Conservation District. The SBUH method has many similarities to the SCS Unit Hydrograph procedure discussed in the previous chapter. Both techniques employ the same SCS curve numbers, runoff equation, and rainfall distributions. However, the SBUH method does not utilize a unit hydrograph or the convolution process. Instead, an instantaneous hydrograph is generated and then routed through an imaginary reservoir with a time delay equal to the subcatchment's time of concentration.

This calculation is relatively simple in comparison to the SCS-UH procedure, and takes less time to perform. While the availability of the SCS-UH procedure might appear to eliminate the need for the SBUH method, some localities prefer the SBUH method for specific situations.



Runoff Procedure

There are two distinct steps involved in generating a runoff hydrograph by the SBUH method:

1) Compute the instantaneous hydrograph: The storm is divided into equal time increments (dt). At each increment, the SCS Runoff Equation (see page 57) is used to determine the precipitation excess. The difference between the successive values represents the instantaneous runoff at that point in time. A typical instantaneous hydrograph is represented by the dashed line in the above graph.

2) Compute the runoff hydrograph: The runoff hydrograph is obtained by routing the instantaneous hydrograph through an imaginary reservoir with a time delay equal to the time of concentration. The following equation is used to estimate the routed flow at each point in time:

Q_t=Runoff at time t [CFS]
i_t=Instantaneous runoff at time t [CFS]
dt=Calculation time increment [minutes]
T_c=Time of concentration [minutes]
w=Routing Coefficient

A typical runoff hydrograph is shown by a solid line in the graph above. Note the delay and reduction in the peak caused by the routing procedure.

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The Rational method may be used to generate runoff hydrographs. However, since Rational method was developed primarily for predicting peak flow, its use is not advised for volume-sensitive routing calculations.

The Rational method predicts the peak runoff according to the formula:

[illegible]

Q=Peak Runoff
C=Runoff Coefficient
I=Rainfall Intensity
A=Area

The equation can be evaluated using English or metric units, as long as proper dimensions are observed. For English use, it is traditional to employ inches-per-hour and acres for the intensity and area, respectively. Converting the units yields the following relationship, in which the factor of 1.01 is often omitted:

[illegible]

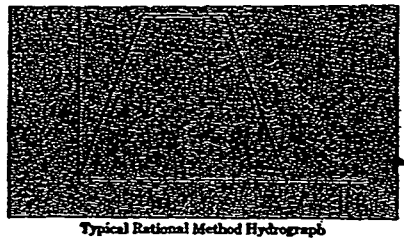
For metric use we can substitute mm/hr and hectares for the intensity and area, respectively. Converting the units yields the following relationship:

[illegible]

In order to generate a complete hydrograph (as required by HydroCAD), it is assumed that the runoff begins at the start of the storm and increases linearly to the peak value, which is sustained until the storm duration (D) has elapsed, and then decreases linearly to zero.

The rate at which the hydrograph rises and falls is based on the Tc and a rise/fall factor. For "standard" Rational method, the rise and fall factors are both one. That is, the rise and fall occur over the exact interval Tc. Variations of the Rational method (often called the Modified Rational method), may use different rise and fall factors, which can be set directly using Settings:Calculation.

Rational method runoff traditionally begins at zero hours, although it can start at whatever time is specified in the calculation settings. A typical rational method hydrograph is shown below.



Typical Rational Method Hydrograph

The user must choose the *critical duration* (and the corresponding intensity) that results in the maximum combined runoff at *each point of study*. Depending on the specific watershed, this may occur at any duration between the shortest and longest T_c. As the study progresses downstream, the critical duration generally increases, but some trial and error is required for an accurate determination. Note that as the duration is changed, all upstream subcatchments are properly recalculated for the new value. This is the correct procedure for applying the Rational method, despite frequent misuse of the method in which these values are held constant.

Since a hydrograph produced by the Rational method does not reflect the total storm runoff or the variation in intensity, it is not recommended for the design and analysis of detention ponds. It is strongly advised that the SCS-UH or SBUH runoff methodology be used when pond routing calculations will be performed.

Section 18 - Reach Routing Calculations

A reach is used to perform an *independent hydrograph routing* for an open channel or a pipe flowing under open-channel conditions. A channel or pipe can alternatively be modeled as a flow segment within a subcatchment, where its travel time will contribute to the Tc. The later approach is usually simpler, and may even be necessary in the case of a subcatchment that is draining along the entire length of the reach. However, for a long reach with a significant inflow at one end, a separate reach routing may be called for. This section details the procedures used to perform an independent reach routing.

The Routing Curves

Reach routing requires that the reach first be characterized by two curves: the end-area vs. depth, and the discharge vs. depth (stage-discharge). This information may be determined by one of three procedures:

1) The user may directly specify the end-area and discharge at any number of depths.

2) The user may enter the wetted perimeter at each depth, and Manning's equation (see Basic Hydraulics p.77) is used to determine the discharge as follows:

[illegible]

V=Average velocity of flow [feet/sec] or [m/s]
1.486=English factor (use 1.0 for metric)
R=Hydraulic radius [feet] or [m]
S=Slope of channel bottom [rise/run]
n=Manning's number (See table on page 128)

[illegible] Eq 18

A=Area of flow [sq-feet] or [m²]
P=Wetted perimeter [feet] or [m]
Q=Flow [CFS] or [m³/sec]

[illegible] Eq 19

[illegible] certain standard shapes (rectangular, vee, trapezoidal, parabolic channel, or a circular pipe), the user may provide the appropriate dimensions, and HydroCAD will determine the end area and discharge curves. These are calculated using the area and perimeter equations on page 138, and Manning's equation as shown above.

Reach Routing Limitations

Since the stage-discharge relationship is based solely on Manning's equation, it does *not* consider inlet or outlet conditions. It assumes that the Manning's flow, and not the inlet, outlet, or tailwater, is the controlling factor. If a complete analysis is desired for a pipe reach, including entrance losses, the reach should be modeled as a pond with a culvert outlet.

Reach Routing Methods

HydroCAD currently provides three techniques for reach routing, which are described in the remainder of this section.

- Storage-Indication Method (Stor-Ind)
- Storage-Indication plus translation (Stor-Ind+Trans)
- Simultaneous Method (Sim-Route)

Storage-Indication Method

The Storage-Indication method (Stor-Ind) is the basic reach routing technique provided by HydroCAD, and is based on the routing equations developed on page 85. The actual routing procedure is as follows.

1) The reach's stage-discharge relationship is calculated as described above.

2) The stage-storage relationship is determined from the reach cross-section multiplied by the length.

3) The stage-discharge and stage-storage curves are used to create a storage-indication curve.

4) Routing is performed using the specified time span and time increment. At each point in time, a storage-indication value is calculated based on the current inflow, plus the previous inflow, outflow, and volume in the reach.

5) The current storage-indication value and the storage-indication curve are used to determine the new elevation.

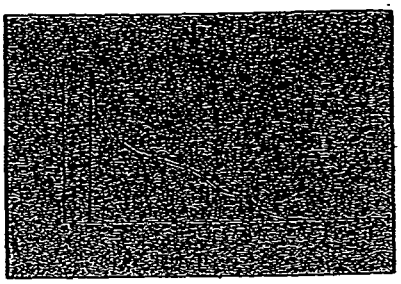
6) Using the new elevation, the stage-storage and stage-discharge curves are consulted to determine the new storage and discharge.

7) This process is repeated for all points in the inflow hydrograph.

In practice, the procedure may incorporate a number of other factors, such as a base flow or inflow loss. Any unusual conditions, such as the channel overtopping, will produce a specific warning message as listed on page 97.

000254

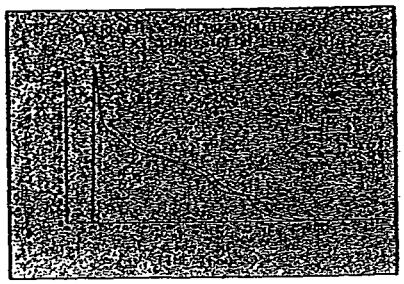
A reach will normally *attenuate and delay* the hydrograph that is routed through it. The extent of this transformation depends on many factors, including the reach dimensions, slope, and Manning's number. Short reaches (up to several hundred feet) often have a minimal effect on the routed hydrograph. For this reason they are frequently modeled as a flow segment within a subcatchment. This is the only option for some methods such as TR-55, which includes no reach routing procedures at all.



On the other hand, for long reaches with large cross-sections, low slopes and/or high Manning's numbers, the routing effect can be significant. The graph at right shows the effects of storage-indication routing through a 5500 foot long channel. Significant attenuation may also occur on shorter reaches if the inflow peak is of short duration.

Allowing for Travel Time

The storage-indication method, as described above, accounts for only the storage effects of the reach. Other techniques must be used to account for the kinematic effects of long reaches. HydroCAD provides the option of adding a time lag or *translation* to the normal storage-indication routing. Setting the reach routing method to "Stor-Ind+Trans" causes the storage-routed hydrograph to be further translated by the travel time, as defined on page 95. A close examination of the example at right reveals that the peak discharge no longer corresponds to a point on the inflow curve, but is translated by the prescribed amount.



Simultaneous Reach Routing

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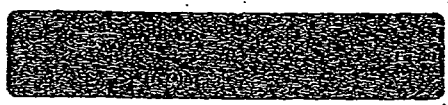
The Sim-Route reach routing procedure is provided for compatibility with simultaneous pond routing. Although this method does *not* currently allow reaches to respond to tailwater changes, it does allow the overall watershed to be analyzed in a simultaneous manner so that ponds may respond to tailwater effects as described on page 89.

Simultaneous reach routing is based on the basic equation for conservation of mass. (See Hydrologic Analysis and Design p.545.)



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I=Inflow rate
O=Outflow rate
Δt=Time increment (dt)
ΔS=Change in storage
S_1=Storage at start of time interval
S_2=Storage at end of time interval

The following procedure is used to perform the actual hydrograph routing:

1) Routing is performed using the specified time span and time increment, and begins with no water stored in the reach.

2) The new reach storage (S_2) is calculated using the above equation with the previous rates of inflow and outflow. (Using the previous value allows non-sequential flows, for which the current inflow is unknown.)

3) Using the new storage volume, a new flow depth is calculated based on the assumption of normal flow.

4) Using the new flow depth, a new discharge is calculated from Manning's equation or from the user-defined stage-discharge relationship.

5) Steps 2 through 4 are repeated at each time interval until the entire hydrograph has been developed.

Additional considerations apply to all simultaneous routing procedures as described on page 88.

Section 19 - Pond Storage Calculations

All pond routing techniques require basic information about the pond's stage-storage relationship. HydroCAD provides several options for obtaining this information:

1) Direct entry of *cumulative* (total) storage at various elevations.

2) Entry of *incremental* storage, that is, the volume of horizontal sections across the pond. These sections are summed by the program to produce the cumulative storage.

3) Entry of *surface areas* at various elevations, from which HydroCAD determines the incremental (and cumulative) storage at each elevation.

The third option is often the most convenient, since it uses readily available data, such as the surface area at each contour elevation.

Pond Shape

Knowing the pond's general shape allows an accurate determination of the storage volume and wetted area, based on the surface area specified at each stage. HydroCAD provides specific volume calculations for the following basic pond shapes:

Prismatic

Each stage is taken as a horizontal section of a prism. This provides accurate volumes for four-sided ponds when zero, one or two (opposing) sides of the pond are sloping, and the other sides are vertical. The traditional "average area" method accurately determines the volume of these shapes. (Since the aspect ratio of prismatic shapes is undefined, the wetted area cannot be determined, making this shape incompatible with exfiltration calculations. One of the other shapes should be selected when wetted area is required.)

Pyramidal

Each stage is taken as a horizontal section of a pyramid. This assumes four sides of equal length and slope, and includes any shape with horizontal cross-sections that are square and concentric, such as a square box.

Conic

Each stage is taken as a horizontal section of a cone. This assumes circular sections with equally sloping sides. This includes any shape with horizontal cross-sections that are circular and concentric, such as a vertical cone or cylinder.

Irregular

No assumptions are made concerning the shape. Instead, the area and perimeter are specified at each stage. This allows accurate determination of wetted area for a wide range of irregular shapes, including elongated shapes such as trenches or underground storage chambers.

Storage Volume Calculations

The following equations are used to calculate the pond volume, depending on the prevailing shape of the pond.

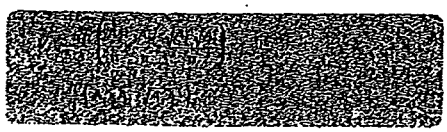
Prismatic volume determination (Average area method)

This technique assumes that the areas are horizontal planes through a *prism*.[15] The calculation involves taking the average of the area at the top and bottom of the section and multiplying by the thickness. Although this is a commonly used method for calculating volume, it should be noted that it is completely accurate only for prismatic sections.

V=Volume of section
h=Height of section
A_1=Area of bottom of section
A_2=Area of top of section

Conic or pyramidal volume determination (Frustum of a cone or pyramid)

Most real-world ponds are not prismatic. They may be more round than rectangular, and may have more than two sloping sides. For these situations, the volume may be more accurately determined by assuming that the areas are horizontal sections of a *cone or pyramid*.



V=Volume of section
h=Height of section
A_1=Area of bottom of section
A_2=Area of top of section

Irregular volume determination

For ponds with an irregular horizontal section, the actual shape is unknown, however an approximate volume can be calculated using the previous equation for sections of a cone or pyramid. This provides reasonable accuracy for natural ponds with equally sloping (or vertical) sides, or when small section heights are used.

000255

[15] A prismatic section must have four sides, with no more than two sloping sides, which must be opposite.

is reduced by gravel, sand, or other materials, the fraction of open space (voids) must be specified.

Open space is specified on the pond storage screen when "Set Open Space" is selected. This causes an additional column to appear in the stage-storage table.

When setting open space, a value must be provided at each defined stage, and applies to the storage between the current and *previous* line in the table. (Therefore the first open space value is not used in the calculation.) Setting the open space at each stage allows for ponds that are partially filled with gravel, filled with varying materials, or contain voids such as pipes or chambers.

> Note: Although the surface area could be reduced to account for gravel fill, this would yield incorrect wetted areas and exfiltration results. Hence the need to specify the open space separately.

Wetted Area Calculations

For some calculations (such as exfiltration) it may be necessary to determine the wetted area of the pond. Several methods are provided, depending on the shape of the pond. (Since prismatic shapes have an undefined aspect ratio, their wetted area cannot be determined. One of the following shapes should be selected when wetted area calculations are required.)

Wetted area for sections of a pyramid

The following equation is used to determine the wetted-area for a horizontal section (frustum) of a pyramid.

$$A = \sqrt{A_1 A_2} + \frac{(A_1 - A_2)^2}{3(A_1 + A_2 + \sqrt{A_1 A_2})} \qquad (4.22)$$

A=Wetted (side) area of section
h=Height of section
A_1=Area of bottom section
A_2=Area of top section

The following equation is used to determine the wetted-area for a horizontal section (frustum) of a cone. The results are accurate for all sections of cylinders and cones, making it suitable for most dry wells and natural ponds.

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$$A = \sqrt{A_1 A_2} + \frac{(A_1 - A_2)^2}{3(A_1 + A_2 + \sqrt{A_1 A_2})} \qquad (4.23)$$

A=Wetted (side) area of section
h=Height of section
A_1=Area of bottom section
A_2=Area of top section

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Wetted area for irregular sections

For ponds with irregular horizontal sections, it is possible to determine the wetted area by specifying the linear perimeter at each stage. Taking this distance as the circumference of a circle allows an equivalent radius and area to be determined. Substituting into the previous equation for the wetted area of a conic section yields a reasonable estimate of the wetted area:

$$A = \sqrt{P_1 P_2} + \frac{(P_1 - P_2)^2}{3(P_1 + P_2 + \sqrt{P_1 P_2})} \qquad (4.24)$$

A=Wetted (side) area of section
h=Height of section
P_1=Perimeter of bottom section
P_2=Perimeter of top section

Section 20 - Pond Hydraulics

This section details the hydraulic calculations used within HydroCAD. These equations are used to determine the discharge of each device under specific headwater and tailwater conditions. They are used primarily in determining the stage-discharge curve(s) for a pond. All equations determine the discharge Q, in CFS or m^3/sec.

Sharp-Crested Rectangular Weir

The basic equation for a sharp-crested weir is derived in Open Channel Hydraulics p.362.

$$Q = C L_e H^{3/2} \qquad (20.1)$$

C=Weir coefficient
L_e=Effective crest length
H=Head [above crest or invert elevation]

The effective crest length L_e may include an adjustment for the number of end contractions.

$$L_e = L - 0.1 n H \qquad (20.2)$$

L=Crest length
n=Number of end contractions (0, 1, or 2)

The weir coefficient C varies slightly based on the crest height and the resulting turbulence. The *English weir* coefficient is given by:

$$C = 3.27 + 0.40 \frac{H}{P} \qquad (20.3)$$

C=Weir coefficient [$\sqrt{feet}$/sec]
P=Crest height [above approach channel]

To obtain a metric weir coefficient, divide this value by 1.81 as described on page 31.

Broad-Crested Rectangular Weir

A broad-crested rectangular weir differs from a sharp-crested weir in that the weir coefficient may vary as an arbitrary function of head. (See Practical Hydraulics p.274.) This allows more accurate modeling of a wide range of real-world weirs.

$$Q = C L H^{3/2} \qquad (20.4)$$

C=Weir coefficient
L=Crest length
H=Head [above crest]

C varies with H by means of a lookup-table, which supplies the appropriate weir coefficient at specific heads. For intermediate heads, HydroCAD interpolates linearly between the given values. For heads that fall outside the given range, HydroCAD uses the first or last coefficient *without* extrapolation.

- For weirs with a sharp-edged crest, the coefficient lookup values can be supplied automatically by specifying the breadth of the crest. This causes the lookup table to be filled with coefficients as listed on page 130.
- Other crest profiles can be modeled by manually entering weir coefficients at appropriate heads. A table of various profiles is given on page 131.

V-Notch Weir

The basic equation for a v-notch weir is derived in Handbook of Hydraulics p.5-15:

$$Q = 2.5 \tan(\theta/2) H^{5/2} \qquad (20.5)$$

C=Weir coefficient
θ=Notch angle (between two sides, not from vertical)
H=Head [above apex of V]

The weir coefficient may be entered manually, or automatically calculated using the following equation:

$$C = 2.5 \tan(\theta/2) \qquad (20.6)$$

C=*English* weir coefficient [$\sqrt{feet}$/sec]

To obtain a metric weir coefficient, divide this value by 1.81 as described on page 31.

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The trapezoidal weir equation is a more general form of the v-notch weir. (Setting the crest length to zero yields the previous equation for a v-notch weir.)

[redacted]

C=Weir coefficient
θ=Notch angle (between two sides, not from vertical)
H=Head (above weir crest)
H_a=Head above imaginary apex of V
L=Length of horizontal crest (if any)

The weir coefficient may be entered manually, or automatically determined by Eq. 31 above.

Submerged Weirs

The preceding equations specify the discharge for various weirs under conditions of free discharge. If the tailwater of a weir exceeds the crest elevation, the crest becomes submerged, and the discharge is reduced according to the following equation from Handbook of Hydraulics p.5-18:

[redacted]

Q_f=Free discharge
Q_s=Submerged discharge
H_u=Upstream head above crest
H_d=Downstream head above crest
n=1.5 for rectangular weirs
n=2.5 for vee/trapezoidal weirs

Although this adjustment was derived specifically for sharp-crested weirs, it is also used to estimate the discharge for submerged broad-crested weirs.

For a rectangular opening in a vertical plane, the discharge under any head is derived from the discharge through a thin horizontal strip. (See Handbook of Hydraulics p.4-3.)

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[redacted]

C=Discharge coefficient (Default is .60)
L=Strip length (width of orifice)
g=Gravitational constant
Y=Head over center of strip
dY=Height of horizontal strip

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Integrating over the height of the orifice yields:

[redacted]

H=Head above invert elevation
M=Height of orifice

When the orifice is partially submerged (H<M) the term [H-M] becomes zero and this reduces to the weir equation:

[redacted]

The above equations apply to free-discharge conditions. When the tailwater exceeds the orifice invert, the discharge is the sum of two components:

1) The discharge for the portion of the orifice (if any) that lies above the tailwater elevation is given by the previous equations, with the head and height measured from the tailwater level rather than from the invert.

2) The portion of the orifice that lies *below* the tailwater is subject to a constant head differential, with the discharge given by the basic orifice equation:

[redacted]

tangular Orifice in a *Horizontal Plane*

For an orifice opening in a horizontal plane, the discharge is given by the basic orifice equation as derived in Handbook of Hydraulics p.4-3:

[redacted]

C=Discharge coefficient (default is .60)
a=Orifice area
h=Effective head
H=Headwater depth
TW=Tailwater depth

Under low-head conditions, you may also wish to consider the possibility of weir flow as described on page 77.

Circular Orifice

The discharge for a circular orifice is derived in Handbook of Hydraulics p.4-3:

[redacted]

C=Discharge coefficient (default is .60)
a=Submerged area
g=Gravitational constant
h=Effective head

Circular Vertical Orifice

For an opening in a *vertical plane*, the effective head is given by:

[redacted]

H=Headwater depth above invert
TW=Tailwater depth above invert
r=Radius

When partially submerged, the head adjustment closely approximates the weir discharge of an orifice. It also provides continuity between the fully and partially submerged conditions. For critical situations, the resulting discharge curve should be verified by independent means.

Circular Horizontal Orifice

For an orifice opening in a *horizontal plane*, the effective head is given by:

[redacted]

Under low-head conditions, you may also wish to consider the possibility of weir flow as described on page 77.

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The previous orifice equations for openings in a *vertical* plane are generally valid under all head conditions. No adjustment is required under low-head (partially submerged) conditions, since these equations reduce to the appropriate weir equation.

For orifice openings in a *horizontal* plane, the equations assume that the head is large in relation to the orifice size. This can lead to overestimating the discharge under low-head conditions. To ensure correct flow under all conditions, discharge can be automatically limited to that predicted by the weir equation:

$$Q = L \cdot H^{1.5} \cdot C$$

Q=Discharge [cfs]
L=Crest length (orifice perimeter) [feet]
H=Head [feet above invert elevation]

This will cause the weir equation to control at low heads, without affecting the high-head discharge predicted by the orifice equation. The result is useful for a range of real-world "orifices," such as the top of a standpipe.

- This adjustment is performed automatically whenever "Use weir flow at low heads" is selected for a horizontal orifice.

Modeling a Grate

A grate typically consists of several identical openings, each of which can be modeled as an orifice. The orifice dimensions are specified for each opening, and the discharge multiplier is used to specify the number of openings. (This technique may not be appropriate for *vertical* grates with circular or horizontal openings, since the openings are at different elevations and therefore not identical.)

When evaluating a culvert, HydroCAD checks multiple flow conditions in order to determine the prevailing control *at each elevation*. This is based on six types of culvert flow as identified in Culverts - Hydrology & Hydraulics page E-1. (Also see Standard Handbook for Civil Engineers p.21-18,19.)

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Type	Inlet	Outlet	Slope	Flow Type	Tailwater Dependent?	Type of Control
1a	Submerged	Submerged	Any	Pipe	Yes	Outlet
1b	Submerged	Free	Mild	Pipe	No	Outlet
1c	Submerged	Free	Any	Channel	No	Inlet (orifice)
2a	Free	TW>Yc	Mild	Channel	Yes	Outlet
2b	Free	TW<Yc	Mild	Channel	No	Outlet
2c	Free	TW<Yc	Steep	Channel	No	Inlet (weir)

TW=Tailwater, Yc=Critical Depth

For type 1b, assuming that the culvert is full along its entire length, the velocity is given by the following equation. (See Culverts - Hydrology & Hydraulics page D-11.)

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$$V = \sqrt{\frac{2gH - 2gL\left(\frac{n^2 C^2}{R}\right) - 2gK_e}{1 + 2gL\left(\frac{n^2 C^2}{R}\right)}}$$

V=Average velocity of flow
H=Headwater depth above inlet invert
D=Depth of flow (=culvert height)
S=Slope [rise/run]
L=Length
Ke=Entrance energy loss coefficient (See table on page 133)
g=Gravitational constant
n=Manning's number (See table on page 128)
C=2.22 for English, 1 for metric
R=Hydraulic radius
A=Cross-sectional flow area

Type 2b discharge is the same as type 1b except that the depth (D) is less than the culvert height. Under these conditions, open channel flow exists and backwater calculations must be performed to precisely determine the depth. To reduce calculation time, the depth is approximated by:

$$D = \frac{2}{3}H$$

Rather than directly determining whether type 1b or 2b flow exists, HydroCAD uses the lesser of this depth and the culvert height. This also ensures continuity between the two flow conditions, with the cross over occurring when the head is 4/3 of the culvert height.

Types 1a and 2a are similar to types 1b and 2b, except for the tailwater dependency. This is accommodated by setting D equal to the tailwater depth whenever this value exceeds the normal flow depth.

Types 1c and 2c operate under inlet control, and the discharge is determined with the orifice equations given previously. The orifice discharge coefficient is given by:

$$C_d = C_c \cdot \sqrt{2 \cdot K_e}$$

Cc=Contraction coefficient (default is .90)

Note that for Ke=.5 this yields Cd=.6, which is the default discharge coefficient for a sharp-edged orifice.

The final determination of culvert discharge is made by calculating the type 1a/2a, 1b/2b *and* 1c/2c flows as described above. The least of these values (a, b, and c) is then used as the final discharge for a given head.

NOTE: The approximations used for culvert discharge have generally been found to provide sufficient accuracy for most hydrograph routing purposes. However, it is strongly recommended that the resulting stage-discharge curve be verified using independent culvert data. If a significant discrepancy is found, the desired discharge data should be entered directly as a Special Outlet instead of using the built-in culvert equations.

Special Outlet Device

The special outlet device is designed to handle unusual stage-discharge relationships that can't be reproduced with standard devices. With HydroCAD's ability to model complex series-parallel devices (see page 84), there should be very few situations which actually require a special outlet.

A special outlet consists of user-defined stage-discharge curve. The first discharge value must always be zero and may occur at any desired elevation. Additional discharge values are specified at higher elevations as required to adequately represent the true shape of the desired curve. When choosing the elevations, keep in mind that HydroCAD performs a linear interpolation to determine the discharge at any required intermediate elevations.

If the last defined elevation is exceeded, HydroCAD can extrapolate from the last two values if desired. Otherwise, the final discharge value is used without extrapolation.

Exfiltration Calculations

Since exfiltration is incorporated into a pond's stage-discharge curve, it is classified as an "outlet device." Exfiltration is also distinct from an "inflow loss," in that it continues to occur even when there is no inflow.

To separate exfiltration from other "true" outflows, it is usually directed to the discarded outflow to prevent further routing. Although there are few standards as to how to determine exfiltration, HydroCAD provides two basic procedures that can be used to implement a wide range of design methods:

1) A constant exfiltration rate Q may be specified in CFS or m³/sec. This value may be applied whenever there is water in the pond, or only when the level exceeds the specified "invert elevation." This feature may be used to model a pump or other "outlet" that "turns on" at a given elevation. The invert may also be used to prevent exfiltration through (lower) impervious regions of the pond.

2) An exfiltration velocity V may be specified in FPM or mm/min. This is multiplied by the available exfiltration area at a given elevation to determine the final exfiltration rate.

$$Q_Y = V \cdot A_Y$$

Q_Y=Exfiltration at elevation Y
V=Exfiltration velocity
A_Y=Exfiltration area at elevation Y

The exfiltration area may be defined in two ways: (A) if all exfiltration is assumed to be downward (none through the sides of the pond), you may use the pond's *surface area*; (B) if exfiltration occurs through all exposed surfaces regardless of slope, you may use the pond's *wetted area*.

You may also elect to exclude the area of the pond that lies at or below the invert elevation. This option causes the discharge equation to be modified as follows:

$$Q_Y = V \cdot (A_Y - A_{INVERT})$$

A_{INVERT}=Exfiltration area at invert elevation

This causes exfiltration to occur only over the area of the pond that lies *above* the invert elevation, and is useful in preventing exfiltration through impervious (lower) regions of the pond.

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Using surface area vs. wetted area

For ponds with gentle side-slopes, the surface area and wetted area are almost identical, and the two methods will give similar results. In such cases, the surface area method is recommended for simplicity. By basing exfiltration on surface area, you are stating that all flow is essentially downward. Only horizontal areas (above any invert) are available for exfiltration. All vertical areas are excluded.

*you wish to allow exfiltration through vertical surfaces, such as the sides of a drywell, then you ust specify wetted area (See page 69 for details on wetted area calculations.) As always, it is your sponsibility to ensure that this computation is applicable to your particular situation.

Using a percolation rate

A measured percolation rate can be converted to an equivalent exfiltration velocity by the following equation. However, other factors must be considered to determine if this is a reasonable design value for a proposed exfiltration area. (For example, can a large pond be expected to perc for 24 hours at the same rate as a small test pit for over a much shorter period?)

V=Exfiltration velocity [FPM]
P=Perc Rate [Minutes per Inch]

Advanced techniques

While most cases will require just a single exfiltration device, it is also possible to use several exfiltration devices on a single pond. This could be used to model multistage exfiltration schemes, such as a drywell that overflows into a perforated pipe.

As with all pond designs, you should view and understand the stage-discharge plot to make sure the pond is exhibiting the behavior you expect. Do not rely solely on a review of the hydrograph where the pond's behavior is intertwined with the complexities of the inflow hydrograph.

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Section 21 - Pond Routing Calculations

Before routing through any pond, the storage vs. elevation (stage-storage) and the discharge vs. elevation (stage-discharge) relationships must be determined as described below.

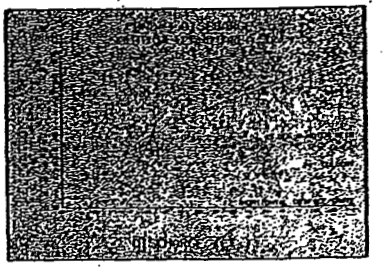
Stage-Storage Calculations

The cumulative stage-storage curve may be entered directly, or HydroCAD can sum incremental values to determine the cumulative storage. A third option is to enter surface areas at certain elevations and have HydroCAD calculate the storage. (These calculations are detailed on page 68.) In any case, a minimum of two storage points are required to permit interpolation for intermediate elevations. You should use as many points as necessary to accurately represent the true stage-storage curve for the pond. If the available storage space is less than 100%, or a storage multiplier is specified, the stage-storage curve is adjusted by these factors.

Stage-Discharge Calculations

The stage-discharge curve is automatically compiled based on the selected outlet devices. Each device is evaluated using the equations in the previous section. Each outlet also has a "discharge multiplier" which may be used for adjusting the normal rating curve or handling several identical devices.

The individual outlet devices are combined into one, two, or three stage-discharge curves based on the specified *device routing*. In the default configuration, all outlets are routed directly to the primary outflow, as shown in the sample stage-discharge curve at right. They are considered to be independent, *parallel* outlets whose flows are additive. The composite stage-discharge curve covers the same elevation range for which pond storage is defined, with the total discharge at each elevation determined by adding the discharge from each individual device.



If any devices are routed to a *secondary* or *discarded outflow*, additional stage-discharge curves are compiled using the same basic procedure. Each device is included in the stage-discharge curve to which it is routed. To perform the actual pond routing, a *total discharge curve* is obtained by adding individual curves. When routing is complete, the total outflow hydrograph is split into primary, secondary, and discarded outflows based on the ratio of the stage-discharge curves. This produces automatic split-flow, or "diversion." This is most commonly used when one or more outlets require separate routing, such as an emergency spillway or an exfiltration outflow.

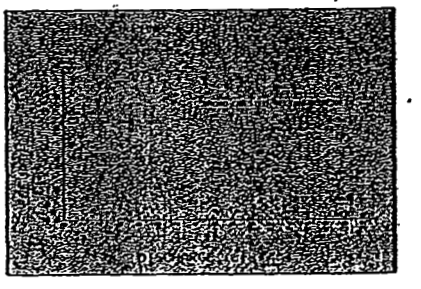
Compound Outlet Devices

More complex outlets can be modeled by placing standard devices in *series*. An orifice, for example, could be routed through a culvert. To calculate the discharge at each elevation, HydroCAD evaluates the standard flow through each device, and uses the lower (controlling) flow to build the stage-discharge curve. By making this comparison at each elevation step, different devices may control the outflow at different pond stages.[16]

Even more complex outlets can be modeled by utilizing simultaneous series/parallel device combinations. A standpipe is a common example of a compound outlet device. This could be modeled by a combination of standard devices as shown in the schematic representation at right.

Reading from the bottom up: Device 3 is a horizontal orifice representing the flow into the top of the riser. Device 2 is used to model one or more openings in the side of the riser. Devices 2 and 3 are summed together, and routed through the final outlet culvert, device 1.

This graph shows a typical stage-discharge curve for a pond with a compound outlet. A culvert is positioned with the inlet invert at 50 feet; however, no discharge occurs until the water level reaches an orifice 50.5 feet. (This example might represent an orifice plate used to reduce the flow through an existing culvert.) Above 50.5 feet, both devices are evaluated to determine which will control at each elevation. The resulting curve is labeled "pri" for primary.



This example also includes a broad-crested weir which is directed to the secondary discharge. This might represent an emergency spillway that is being routed separately from the culvert/orifice combination.

☞ When describing compound outlet devices, it is generally easiest to start with the *final* device (such as the culvert shown above) that contributes directly to the primary discharge. Then work up from the final device, entering each device that limits flow or contributes to the discharge. The process is then repeated for any secondary and/or discarded discharge.

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[16] This procedure uses the standard hydraulic equations given previously, with consideration of the minimum tailwater created when a device is lower than the next device downstream. However, it does not consider more complex interactions that may occur between devices, except to limit the flow to the lesser of the two. Like all complex calculations, it is important to verify these results by independent means to ensure they are sufficiently accurate for your purposes.

Pond Routing Procedures

HydroCAD currently provides two basic procedures for pond routing:

- Storage-Indication method
- Simultaneous pond routing

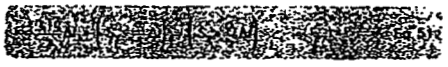
Storage-Indication Method

Storage-indication method is based on the conservation of mass, as expressed in the following relationship. (See Hydrologic Analysis and Design p.545.)

I=Inflow rate
O=Outflow rate
Δt=Time increment (dt)
ΔS=Change in storage

Using subscripts 1 and 2 to denote values at the beginning and end of the time interval Δt, yields the following expression:

Rearranging the equation with unknown terms on the left and known terms on the right yields:



The right hand portion of this equation is known as the storage-indication value, which can be evaluated at any stage (elevation) using the stage-storage and stage-discharge relationships previously determined.

Performing the Storage-Indication Routing

The following procedure is used to perform the actual hydrograph routing:

1) The pond's stage-discharge relationship is calculated based on the specified outlet devices.

2) The stage-storage relationship is determined from the specified stage-area or stage-storage data.

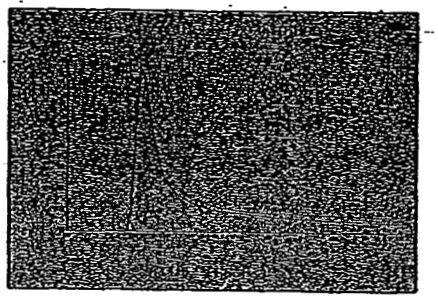
3) The stage-discharge and stage-storage curves are used to create the storage-indication curve.

outflow, and volume in the pond.

5) The current storage-indication value and the storage-indication curve are used to determine the new elevation.

6) Using the new elevation, the stage-storage and stage-discharge curves are consulted to determine the new storage and discharge.

7) This process is repeated for all points in the inflow hydrograph, producing a complete outflow hydrograph as shown below.[17]



Special Considerations

When using the storage-indication method, keep in mind that a zero velocity is assumed in the pond. This is an accurate assumption for most ponds where the storage volume is large in comparison to the inflow. However, if the velocity approaching the outlet device(s) is significant, this method may underestimate the discharge and overestimate the peak elevation and storage of the pond.

[17] If the pond has multiple outlets, the routing is performed based on the total discharge, and is then split according to the characteristics of the individual outlets.

Additional Routing Features

In addition to the basic routing procedure described above, HydroCAD provides the following special routing capabilities.

1) The inflow hydrograph is automatically adjusted for any base flow (or inflow loss) by adding (or subtracting) the specified value from each point on the hydrograph. If "automatic base flow" is selected, the base flow is set to the pond's discharge at the specified starting elevation. This places the pond in an equilibrium condition (stable water surface elevation) when routing begins.

2) If a starting elevation is specified, routing begins with the water at this level. If this is above the lowest outlet device, the pond begins discharging immediately, possibly before any inflow has occurred. If the starting elevation is below the lowest device, no outflow occurs until this level is attained. (The outflow volume will also be reduced by the amount of storage below this level.)

3) Routing is normally performed using the time interval (dt) of the inflow hydrograph, although a finer interval may be specified for each pond to provide improved tracking. The normal dt is *divided* by the specified finer routing value. Finer routing (usually 2) can also be used to eliminate any oscillations in the pond's outflow, which will usually be indicated by a specific warning message.

4) If the peak elevation exceeds the specified flood elevation, a warning message is issued and routing will *continue*. The setting of the flood elevation has *no effect* on the routing itself.

Simultaneous vs. Sequential Routing

Previous versions of HydroCAD provided only sequential routing techniques, in which each node is routed in its entirety before the next node is evaluated. The storage-indication method is one of the most common sequential routing methods. This technique requires a static rating curve, that is, the stage-discharge relationship must be known before routing begins, and cannot change until the routing is complete. This prevents any node from responding to downstream conditions (such as varying tailwater) and enforces a sequential evaluation of the watershed.

To respond to downstream variations it is necessary to use a simultaneous pond routing technique, in which all nodes are routed essentially at the same time. To produce this effect, all nodes are routed one time increment at a time, allowing them to respond to changes elsewhere in the drainage system. (For details see Tailwater Capabilities on page 89.)

While simultaneous routing tends to provide greater capabilities, it is inherently more complex and requires more time to perform. It may also require that upstream nodes be recalculated, if they are sensitive to tailwater that has changed as a result of downstream modifications.

Since HydroCAD now provides a choice of sequential and simultaneous routing techniques, you can select the best approach for each project. In general, the storage-indication method can continue to be used for projects that operate with free discharge or fixed tailwater conditions. The SI method has the advantages of being fast, widely used, and compatible with TR-20 pond routing. On the other hand, systems that are influenced by variable tailwater conditions may be better handled by simultaneous routing.

Simultaneous Pond Routing

The Sim-Route pond routing procedure allows each pond to respond to dynamic changes in the watershed, such as a variable tailwater created by a downstream node. This procedure re-evaluates the pond's discharge capability at each time increment during the routing, rather than using the static stage-discharge relationship employed by the storage-indication method.

Simultaneous pond routing is based on a direct application of the basic equation for conservation of mass. (See Hydrologic Analysis and Design p.545.)

I=Inflow rate
O=Outflow rate
Δt=Time increment (dt)
ΔS=Change in storage
S_1=Storage at start of time interval
S_2=Storage at end of time interval

The following procedure is used to perform the actual hydrograph routing:

1) Routing is performed using the specified time span and time increment. The initial storage is assumed to be zero, unless an initial elevation is specified.

2) The new pond storage (S_2) is calculated using the above equation with the *previous* rates of inflow and outflow. (Using the *previous* value allows non-sequential flows, for which the current inflow is unknown.)

3) Using the new storage, a new elevation is determined directly from the stage-storage relationship.

4) New outflow(s) are calculated using the new pond elevation (the headwater) and the previous elevation of each downstream node (the tailwater.) Each outlet structure is directly evaluated under these conditions, without use of an intermediate stage-discharge table.

5) Steps 2 through 4 are repeated at each time interval until the entire hydrograph has been developed.

Special Considerations

When performing a simultaneous routing, each outflow is calculated based on the inflow, outflow, and elevations that existed at the *previous* time step. This eliminates the need to calculate the nodes in a fixed flow order, making it possible to model systems where the nodes may not have a fixed linear sequence. However, it also introduces an inherent time delay, which can be minimized by using the smallest feasible time increment.

Since this technique directly evaluates all outlet devices at each time increment, it eliminates the approximations inherent in a pre-calculated stage-discharge curve, as used by the storage-indication method. The drawback is slower calculation time, particularly with small time increments.

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dt. An inadequate dt will cause the outflow to oscillate, which will usually generate a warning message. Very small reaches or ponds (such as catch basins) may require so small a time increment as to make simultaneous routing impractical. (See page 106 for further information on when to use the Sim-Route procedure.)

Tailwater Capabilities

When using any sequential routing method, nodes can respond to tailwater influences only when the tailwater is set by hand. This occurs because the downstream node (which creates the tailwater) cannot be calculated until after the upper node has been routed.

In contrast, a simultaneous routing method updates all interdependent nodes at each time step, allowing the possibility for each node to respond to the current condition of its neighbors, including any tailwater they may produce. In order for tailwater effects to be automatically accommodated, two conditions must exist:

1) The upper node must use a routing procedure that is "tailwater-aware." That is, it must take the downstream condition (tailwater) into account when performing the routing calculation.

2) The lower node must use a routing procedure that defines a water surface elevation, which is seen as the tailwater for inflowing nodes.

The following table summarizes these characteristics for each type of node when using the Sim-Route procedure.

	Tailwater Aware	Defines Elevation
Subcat.	no	no
Reach	no	yes
Pond	yes	yes
Link	no	no

Applying the previous rules to all node combinations indicates that automatic tailwater calculations occur for the following combinations:

- A pond flowing into another pond
- A pond flowing into a reach

HydroCAD is designed to model flows that occur in the same direction as the outflow arrows on the routing diagram. If the potential exists for flow in the reverse direction, an appropriate warning message is issued. Since HydroCAD does not automatically model reverse flows, the user must take appropriate action to address the situation. This may include the following options:

1) Systems with tailwater or reverse flow effects should generally be modeled using a simultaneous routing technique. This allows each pond to respond to dynamic tailwater conditions.

2) To model a reverse flow from one pond to another, create an appropriate outlet going in the reverse direction, that is, routed from the "lower" pond to the "upper" pond. (This will appear on the diagram as a double-ended arrow.) This outlet will mirror the normal down flow from the upper pond, but is described from the standpoint of water flowing in the opposite direction.[18]

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[18] A reverse outlet is permitted only for a simultaneous routing, which doesn't require a linear flow sequence. Sequential routing methods cannot accommodate such a "flow loop" and will report an error condition.

Section 22 - Link Calculations

Basic Applications

A link is a multipurpose mechanism that can be used to:

- Manually enter a hydrograph
- Import a hydrograph from an ASCII file
- Import a hydrograph from another project
- Apply a flow threshold or flow limit
- Change the duration of a hydrograph
- Rescale a hydrograph to a different peak
- Sum hydrographs without performing any routing

These capabilities are provided by the following basic types of links:

- An Internal link is used to process only the inflows that are connected on the routing diagram.
- A manual link is used to manually enter an arbitrary hydrograph.
- A file link is used to read a hydrograph from an external data file. This capability can be used to import a hydrograph from another program, or to link several projects as described below.

Note that any type of link may have inflows on the routing diagram. For a manual link or file link, the imported hydrograph is added to any inflows shown on the diagram.

Advanced Settings

A link also provides several settings that can be used to perform special hydrograph operations:

Flow Threshold If a threshold is specified, only the portion of the inflow that exceeds this value is retained. The default threshold of zero causes all flow to be passed.

Flow Limit If a limit is specified, only the portion of the inflow below this limit is retained.

Discharge Multiplier After applying any flow threshold and/or limit, each flow is multiplied by this value. The default value of one produces no net change to the hydrograph.

Time Multiplier Scales any external inflow to a different duration. The default value of one produces no net change to the hydrograph. Internal (onscreen) inflows are *not* affected by this setting.

(The Time Multiplier allows the use of dimensionless hydrographs, as used for runoff studies in Ohio. A link file containing the Ohio rural hydrograph is included in the Ohio rural hydrograph.hce file supplied with HydroCAD.)

Link Routing Procedure

The basic link routing procedure is as follows:

1) If a Time Multiplier is specified, it is applied to any external inflow by multiplying each time ordinate by this value. The time multiplier has no effect on any internal (onscreen) inflows.

2) The adjusted external inflow is converted to the current time span and dt, and is added to any internal (onscreen) inflows. The result is considered to be the total inflow for the link.

3) If a Flow Threshold is specified, only the portion of the inflow hydrograph above the threshold is retained.

4) If a Flow Limit is specified, only the remainder of the inflow that falls below the threshold is retained

5) If a Discharge Multiplier is specified, each hydrograph ordinate (flow) is multiplied by the specified value.

6) If the Flow Limit, Threshold, or Discharge Multiplier has caused a reduction of the inflow hydrograph, a secondary outflow will be generated containing the remainder of the inflow hydrograph. In some cases this may then be routed separately, providing a basic flow-diversion mechanism.

The results of these operations are readily apparent upon viewing the link's hydrograph, which shows the inflow and outflow curves as described above.

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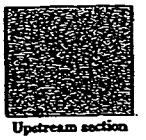
If you exceed the node capacity of your program, you can break a project into two (or more) sections and then connect them using an automatic link. (This technique does not apply to the HydroCAD Sampler, which does not have the file export capability.)

1) First break the project into two or more sections. You can do this by dragging nodes from one project to another, or by cut-and-paste. One project will typically contain the upstream portion of the watershed, and will end with an unrouted outflow, as show at right.


Upstream section

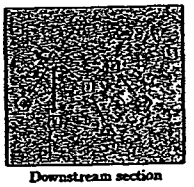
2) Verify the calculation settings for the upstream portion of the project. These must be set independently for each section of the project. On the Advanced tab of the calculation settings, set the Export Mode to "Unrouted Outflows" and click OK.

3) Close and save the upstream project. As the project is closed, the unrouted nodes are automatically updated and exported.

4) Open the downstream portion of the split project and create a link. Edit the link and select File. Link. Select the File tab and press Browse to see a list of available export files. Select the desired file from the upstream portion of the project.

5) If the file contains multiple outflows, use the "File Hydrograph" box to select the desired hydrograph. Click OK to save the link's description.

6) You can now route the link's outflow on the diagram as shown at the right. The link will automatically import the hydrograph as calculations are performed.


Downstream section

Important: If you change the upstream project while the downstream portion is open, the downstream project will retain the earlier (outdated) inflow. To update the downstream project you must either (1) close and reopen the downstream project, or (2) Select Settings:Calculation and press OK. In either case, you must close the upstream project in order for the exported flow(s) to become available.

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External data files are commonly used to connect separate projects with a file link, as described above. HydroCAD automatically creates and deletes these files as required, based on the Export Mode. External data files may also be created manually or generated by other software. These are ASCII text files with an .hce extension, and must follow the format described in the sample file LinkTest.hce

To edit an external file by hand, click on the file and select "Notepad" when asked what program you want to use to open it. Windows will remember this selection the next time you attempt to open an external data file.

External files created by HydroCAD use the same file name as their project, with a tilde and the node number added to the end. If you create your own external files, you may use any name that does not match this format. Any files that match this specification will be overwritten each time the project is opened by HydroCAD!

To import an external data file into HydroCAD, create a file link on the diagram and use it to import the file.

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Export Mode

The Export Mode indicates which node outflows (if any) will be exported from the current project:

- None: No nodes are exported. (default)
- Unrouted Outflows: Only unrouted outflows are exported.
- All Outflows: All node outflows are exported.

The export mode is set under Settings:Calculation:Advanced. When the project is saved and closed, the specified outflows are exported. The exported data is *not* available while the project is open.

The export mode allows HydroCAD to automatically export calculation results to a file for use with an automatic link or with other software. In order to conserve disk space, the Export Mode should normally be set to "None."

If you plan to route the current project into another project using a link, use the "Unrouted Outflows" setting. This optimizes disk space by exporting only the outflows that are not being routed on the diagram. This will include all outflows that are likely to be imported with a link.

The "All Outflows" setting should be used only when absolutely necessary, since it can consume large amounts of disk space. (The exact amount depends primarily on the number of points in each hydrograph. A 1000-point hydrograph requires about 15K of storage per outflow, or 150K for a 10-node project.)

Section 23 - Additional Calculations

This section explains the procedures used to calculate certain values appearing in HydroCAD reports, and to perform certain hydrograph operations.

Hydrograph Parameters

The peak flow for each hydrograph is calculated using the three highest points on the hydrograph.[19] A parabola is fitted to these points and the apex of the parabola specifies the true peak. This eliminates variations in the peak that would occur if only a single point were considered. This improvement in accuracy is most pronounced with a narrow peak, where the two closest points fall on either side of the peak and may be several percent below the actual peak.

The peak attenuation indicates the percentage reduction in peak inflow caused by a routing operation. This is determined by comparing the peak of the inflow and outflow hydrographs as calculated above.

The time of peak is determined by the same parabolic fit to the three highest points. The apex of the parabola establishes a time of peak with far greater resolution than the time between points. Like the peak flow, this value is not affected by the placement of the points on the "true" curve.

The time lag caused by a reach or pond is the difference between the time of peak obtained from the inflow and outflow hydrographs. (This is distinct from the *travel time*, described below.)

The hydrograph volume is determined by integrating the flow over the time span of the hydrograph. Since the volume can include flow only within the given time span, any flow before or after is excluded. Also note that the lag introduced by a pond or reach can cause a discrepancy between the calculated inflow and outflow volume. If necessary, this can be remedied by increasing the calculation time span to include the entire duration of the inflow and outflow hydrographs.

The peak elevation, peak depth, and peak storage are determined by interpolation, in the same manner as peak flow. (This is a change from HydroCAD-5, which reported the highest discrete value as the peak.)

The maximum velocity is the largest value obtained by dividing each discrete flow rate by the corresponding cross-sectional area. This result may be somewhat different than dividing the peak flow by the corresponding area.

The average velocity is determined by averaging the flow rate divided by the corresponding area at each time interval during the routing calculation.

The travel time is calculated by dividing the length of the reach, channel, or pipe by the velocity. For a reach routing, the average and minimum travel time are calculated using the average and maximum velocity, respectively. For some reach routing procedures, the travel time is used to further translate (delay) the outflow.

[19] HydroCAD also checks for flat-topped hydrographs, where curve fitting and extrapolation are not appropriate.

Adding Hydrographs

When adding hydrographs with the same starting time (To) and time interval (dT), the ordinates at matching times are added directly. If the hydrographs differ as to To or dT, such direct addition is not possible. (This can occur when using a link to introduce an external hydrograph.) In this case, HydroCAD will interpolate from the external hydrograph in order to obtain values at the same time steps as the current project. The resulting hydrograph will always have the same time span and dt as the current project.

Detention Time

When addressing water *quality*, one of the more useful and objective measures is the *average detention time*. This is a measure of how long water is detained in a pond or other impoundment, and can be used to determine the time available for removal of sediments or the neutralization of runoff contaminants. (For further details see Applied Hydrology and Sedimentology for Disturbed Areas p.257.)

The *center of mass* method is one of the most basic methods of calculating detention time. It evaluates the difference in time between the center-of-mass of the inflow and outflow hydrographs. One of the chief advantages of this technique is that it is easily calculated, and can even be estimated graphically. However, the technique does not consider the actual movement of water through the pond, and can fail to give a good measure of detention time in many situations.

The *plug flow method* provides a more physically meaningful measure of the average detention time. This technique divides the inflow hydrograph into a number of "plugs" of equal volume, and then calculates the time between each plug entering and leaving the pond. The average time for all plugs is then calculated and used as an overall measure of detention time.

HydroCAD employs the plug flow method to determine the average detention time for each pond.[20] The *theoretical* detention time is calculated by assuming that water initially in the pond is allowed to discharge *before* the first plug from the inflow is allowed to discharge. This "first-in first-out" assumption will yield a maximum detention time, and means that the amount of water initially in the pond *will* affect the calculated result. (Since all water in the pond is displaced before any of the inflow starts to discharge, the detention time is increased by the time required to flush the initial volume.)

Any water retained in the pond, or discharging after the specified time span, is excluded from the calculation. To obtain an accurate measure of detention time, it is therefore important to use a time span that allows the pond to discharge fully. This can be determined by comparing the *volume* of inflow and outflow. These should be roughly the same (unless the pond was surcharged or water was retained). Also compare the volume of flow included in the plug flow calculation (this is shown to the right of the detention time). For accurate (maximum) results, this should be close to the volume of the outflow hydrograph.

When evaluating detention time regulations, care must be taken to understand the exact standard that must be met. Wording such as "detain the ten-year storm for 24 hours" is common, but is sometimes incomplete or ambiguous. The plug flow method provides a more specific standard that can be used to address water quality issues related to detention time.

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[20] Note that the plug flow method is not a routing method. It is used *after* the hydrograph routing has been performed.

This appendix lists samples of the various messages that may occur during runoff and routing calculations. In actual use, the text of each message will vary to reflect the exact situation, however the message number (shown in brackets) will remain the same.

When running HydroCAD, you can click on any item in the message window for complete information. This will display the entire text shown here, as well as links to related topics, calculations and definitions.

[1] Note: {node} Duplicate node number skipped

A node was encountered with a number that was already in use. The node is skipped, and the program continues to process any additional nodes.

This message usually occurs while adding a project that contains nodes that don't have unique numbers. Before adding a project, you should generally renumber any nodes with conflicting numbers. To add any nodes that were skipped, renumber the applicable nodes and add the project again.

The message can also occur when pasting nodes from the clipboard, or opening a project that contains duplicate node numbers. Tip: To make a clone of an existing node use Ctrl-drag (rather than cut and paste.)

[02] Note: Exceeded node capacity

The current project has exceeded the nominal node capacity of your program.

You can continue to work with the project, but you will not be able to save the project or produce multi-page reports unless you reduce the number of nodes.

Warning: If you're using the HydroCAD Sampler, your changes will be lost when the Sampler's time limit expires. To save your project you must reduce the number of nodes before the time limit expires.

[10] Note: Updating to {node} as needed

Routing calculations are being performed up to a specific node. To save time, downstream nodes are not being calculated, unless a simultaneous routing is being performed. Any other nodes will be automatically updated when required.

[13] Note: Time span = 5-20 hrs, dt= .05 hrs, 301 Points

This message indicates the time span and time increment (dt) being used to generate and route hydrographs. The message also indicates the number of points in the resulting hydrographs.

This message indicates the method being used to produce runoff hydrographs. When using the SCS method, the message also indicates the Unit Hydrograph (UH) being employed.

When using the Rational method, the message indicates the hydrograph rise/fall rates. These parameters may be changed with Settings:Calculation.

[18] Note: Rainfall Duration=20 min, Intens=4.30 in/hr

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This message indicates the rainfall duration and intensity being used with the Rational method. These parameters may be changed with Settings:Calculation.

[19] Note: Type II 24-hr Rainfall= 4.30" x 2 (AMC=2)

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This message indicates the rainfall distribution and depth being used to generate runoff hydrographs.

An "x" at the end indicates the number of back-to-back storms to generate. In the case of back-to-back storms, note that the specified rainfall depth occurs in each of the storms.

Finally, the Antecedent Moisture Condition (AMC) is shown. These parameters may be changed with Settings:Calculation.

[22] Note: Reach routing by Stor-Ind+Trans method

This message indicates the method being used to perform hydrograph routing through each reach. The routing method may be changed using Settings:Calculation.

[25] Note: Pond routing by Stor-Ind method

This message indicates the method being used to perform hydrograph routing through each pond. The routing method may be changed using Settings:Calculation.

[28] Note: Updating {node}

This message indicates that runoff or routing calculations are being updated for a given node.

Routing calculations are automatically updated as required to view or print reports. HydroCAD employs a "minimal recalculation" feature, so that only the required nodes are updated at any given time.

When updating a node, all upstream nodes are automatically updated when required. Downstream nodes may also be updated during a simultaneous routing.

Additional information is available on the calculation process employed for each subcatchment, reach, pond, and link.

[30] Note: Calculations complete

This message indicates that all the calculations required at this time have been completed. Some nodes may not have been updated, if their results were not immediately required.

[40] Hint: {node} Not described

No description has been entered for the node, or the data is incomplete. For a subcatchment, no runoff is produced. For a reach, pond, or link, any inflow is passed through unchanged.

To describe the node, select Node:Edit.

An undescribed node can be useful during initial design work, since it allows a node to be placed on the diagram but not described until later.

[43] Hint: {node} Has no inflow (Outflow=Zero)

This node has no inflow on the routing diagram, so it will produce no outflow unless it has a base flow and/or initial water surface elevation.

[45] Hint: Subcat Runoff=Zero

The subcatchment has produced no runoff. This can occur in any of the following situations:

1) The entire runoff may be occurring before or after the specified time span. To change the time span use Settings:Calculation.

2) For the SCS or SBUH methods, the rainfall depth may be insufficient to generate any runoff as determined by the SCS runoff equation. This is normal when low rainfall depths are used in combination with low curve numbers.

[46] Hint: Subcat Tc=0 (Instant runoff peak depends on dt)

When the time-of-concentration is zero, the precipitation excess appears immediately as runoff. Since the calculated peak flow is based on the average over each time interval (dt), using a longer dt (in relation to the peak duration) will yield a lower "peak" flow.

If the instantaneous peak is required, reduce the dt. The dt may be changed using Settings:Calculation: Time Span.

Note: The calculated runoff volume is not effected by the dt setting.

[49] Hint: Subcat Tc<2dt may require smaller dt

When the time-of-concentration is less than twice the time increment (dt), the instantaneous peak may exceed the (average) hydrograph peak for a brief time (less than dt).

If the instantaneous peak is required, reduce the dt. A dt of one-half the smallest Tc will prevent this message from occurring. The dt may be changed using Settings:Calculation: Time Span.

Note: The runoff *volume* is not affected by the dt setting.

[52] Hint: Reach Inlet conditions not evaluated

Reach routing calculations assume normal-flow conditions in the channel or pipe. The software does not evaluate inlet conditions for the reach, although these may often be a controlling factor.

If you wish to consider entrance losses, pressure flow, or other conditions for a pipe, it should be modeled as a pond with a culvert outlet.

[55] Hint: Reach Peak inflow is 105% of Manning's capacity

The reach is operating above its Manning's normal-flow capacity, but has not overtopped. This may be acceptable depending on the design criteria.

[58] Hint: {node} Peaked x.x' above defined flood level

The peak depth in a reach or pond has exceeded the defined flood elevation. Routing continues as usual.

The significance of this message depends on the flood level that has been specified for this node. The message does not indicate that the calculations themselves have been compromised.

A separate warning message is produced whenever a reach or pond exceeds the highest defined stage.

[61] Hint: {node} Submerged 45% of Reach 4 bottom

The node's peak elevation has partially submerged the bottom of an inflowing reach.

This message occurs when the peak elevation (tailwater) is greater then the outlet invert but less than the inlet invert. The percentage indicates the fraction of the reach length that is submerged. If the tailwater had risen above the inlet invert a separate warning message would have been issued.

Important: The reach routing calculations are not altered by this situation. The routing continues to be performed as if the reach were operating under normal Manning's flow with no tailwater influence. The user is responsible for adjusting the model in any way that is deemed necessary to accommodate this situation. In some situations an alternate routing method or modeling technique may be required.

Reminder: In most situations, a pipe reach is best modeled as a pond with a culvert outlet.

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The node's pond size has partially submerged the inlet of an inflowing reach.

This message occurs when the peak elevation (tailwater) rises above the inlet invert but remains below the calculated inlet depth at all times. The percentage indicates the fraction of the defined reach depth that is submerged at the inlet.

Important: The reach routing calculations are not altered by this situation, even though it may reduce the reach discharge or even cause a reverse flow. The routing continues to be performed as if the reach were operating under normal Manning's flow with no tailwater influence. Since these basic routing assumptions are no longer valid, an alternate routing method or modeling technique may be required. The user is responsible for adjusting the model in any way that is deemed necessary to accommodate this situation.

Reminder: In most situations, a pipe reach is best modeled as a pond with a culvert outlet, which can accommodate a wider range of tailwater conditions.

[63] Warning: {node} Exceeded Reach 4 inflow depth by 0.0' @ 0.0 hrs

At some point during the routing, the node's elevation has exceeded the depth of flow at the reach inlet, creating a potential for reverse flow. The message shows the maximum amount of reverse head and the time at which it occurred

Important: The reach routing calculations are not altered by this situation, even though the higher tailwater may in reality cause a reverse flow. The routing continues to be performed as if a one-way valve were preventing the backflow. The user is responsible for adjusting the model in any way that is deemed necessary to accommodate this situation.

[65] Warning: Reach Inlet elevation not specified

The reach inlet elevation has not been specified. This information is required in order to detect potential tailwater effects.

Note: An undefined invert elevation commonly occurs with projects that were imported from HydroCAD 5 or earlier. These projects considered only the reach depth, and had no knowledge of the reach elevation in relation to other nodes.

Use Node|Edit: Profile to specify the inlet elevation for each reach.

[67] Warning: {node} Inflow not allowed - Ignored

This node cannot accept an inflow hydrograph. The inflow is ignored.

Separate procedures are available if you need to route a hydrograph through a subcatchment.

The rising limb of a Rational Method hydrograph contains fewer than eight ordinates. A smaller dt is recommended in order to accurately represent the hydrograph. (A dt of .01 hours is generally appropriate for most Rational method calculations.) Inspection of the hydrograph is also advised. The dt may be changed using Settings|Calculation: Time Span.

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[73] Warning: Subcat Peak may fall outside time span

The calculated runoff peak isn't within the middle 90% of the specified time span. Under these conditions, the reported "peak" is the highest flow within the time span, and may not be the true peak.

Inspect the hydrograph and change the time span to include the peak. The time span may be changed using Settings|Calculation: Time Span.

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[76] Warning: Reach Detained 1.23 AF (Pond w/culvert advised)

A pipe reach has filled with water, causing the flow to be limited and the excess volume to be detained without head.

IMPORTANT: Pipe reach calculations assume normal-flow conditions in the pipe. If you wish to consider entrance losses, pressure flow, or other conditions, the pipe should be modeled as a pond with a culvert outlet.

[79] Warning: {node} Submerged Pond 5 device # by 0.0'

The node's peak elevation has submerged the specified pond outlet device. This message occurs when the peak elevation (tailwater) rises above the invert of one of the pond's final outlet device(s).

Important: The pond routing calculations are not altered by this situation, even though the tailwater may reduce the pond's discharge or even cause a reverse flow. The routing continues to be performed based on the existing stage-discharge relationship, as if the tailwater did not exist.

Since a static stage-discharge curve cannot accommodate a variable tailwater, the tailwater must be specified manually using Node|Edit: Tailwater. If one of these tailwater options isn't sufficient, an alternate routing method may be required, such as a simultaneous routing. The user is responsible for adjusting the model in any way that is deemed necessary to accommodate this situation.

[80] Warning: {node} Exceeded Pond 5 by 0.0' @ 0.0 hrs (0.0 cfs)

At some point during the routing, the node's elevation has exceeded the elevation of an inflowing pond, creating a potential for reverse flow. The message shows the maximum amount of reverse head, the time at which it occurred, and an estimate of the potential reverse flow.

Important: The pond routing calculations are not altered by this situation, even though the higher tailwater may in reality cause a reverse flow. The routing continues to be performed as if a one-way valve were preventing the backflow. The user is responsible for adjusting the model in any way that is deemed necessary to accommodate this situation. For further details read about modeling reverse flows.

[82] Warning: Early inflow requires earlier time span

Some inflow may be occurring before the beginning of the specified time span, and is therefore not included in the routing. An earlier time span is required in order to include the early part of the inflow hydrograph.

The time span may be changed using Settings|Calculation: Time Span.

[85] Warning: {node} Oscillations may require Finer Routing>1

The outflow of a pond or reach contains a greater number of peaks than the inflow, suggesting that oscillations may have been induced by the routing.

If a visual inspection reveals oscillations, they can usually be eliminated by setting the finer routing value to 2 for that particular node. If this fails to correct the problem, the available storage may be too small to permit an accurate routing for this node.

Note: Reducing the overall time increment (dt) may also resolve the problem, but this will unnecessarily increase the calculation time for other nodes.

[86] Warning: {node} Oscillations may require smaller dt

The outflow of a pond or reach contains a greater number of peaks than the inflow. This suggests that oscillations were induced by the routing and that the routing results may not be valid!

If a visual inspection reveals oscillations, reduce the time increment (dt) until the situation is corrected. This may require a reduction to the minimum dt of 0.01 hours.

If the problem persists, the available storage may be too small to permit an accurate routing with the simultaneous routing method. This method is intended for "coupled ponds" of reasonable size. In general, it is not intended for reaches or ponds with very small amounts of storage, such as catch basins or manholes.

[88] Warning: {node} Qout>Qin may require Finer Routing>1 or smaller dt

The peak outflow of a pond or reach was greater than the peak inflow. This can occur if the storage is very small in relation to the inflow volume, or if there are abrupt changes in the stage-discharge curve or inflow hydrograph.

This can usually be corrected by setting the finer routing value to 2 for that particular node, or using a smaller time increment for the entire project. (The choice is determined by the current routing method and will be reflected in the actual warning message that is issued.)

[91] Warning: {node} Storage range exceeded by xx'

The depth in a reach or pond has exceeded the highest defined stage. Routing continues using a linear extrapolation of the storage and discharge curves.

Important: For accuracy, you must extend the storage and discharge curves to prevent extrapolation.

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Why can't I route an upstream node through a subcatchment?

A subcatchment contains only the information needed to perform a runoff calculation. Use a reach if you want to route another hydrograph through this land area. For shallow overland flow, use a wide channel with a suitable Manning's number.

Why isn't the entire outflow of my pond being routed?

Make sure there isn't an un-routed primary or secondary discharge, which will appear as an outflow node on the node. If so, you must route the outflow to another node or reconfigure the outlet ices to eliminate the outflow.

What is the best way to model a pipe?

A pipe can be modeled in three ways. 1) If the pipe always operates under open channel flow, you can model it as a separate pipe reach. 2) Some open-channel pipes are most easily modeled as a flow segment within a subcatchment. 3) The most complete solution is to model the pipe as a culvert outlet on a pond, even if the "pond" is simply a roadway impoundment, approach channel, or drop inlet.

How do I model a catch basin?

A catch-basin is best modeled as a pond with a culvert outlet. The "pond" should include not only the below-ground volume of the catch-basin, but also any above-ground storage that is used when the basin overflows. (Always enter enough stage-storage data to prevent a "data exceeded" warning.) This will allow a more accurate culvert analysis to be performed on the pipe, including the effects of headwater and inlet losses. In some cases the simultaneous routing procedure can also be used to handle varying tailwater conditions, although it may be unable to track the rapid changes in water level that can occur in such small "ponds."

What about a closed storm sewer?

A storm sewer can sometimes be modeled as a series of ponds with culvert outlets as described above, subject to the same tailwater considerations. Due to the computational problems of routing hydrographs through a closed storm sewer, these systems may have to be modeled with two separate tools, first performing a steady-state analysis of the closed drainage system, followed by a hydrograph routing to consider detention effects.

Can HydroCAD calculate the Hydraulic Grade Line (HGL)?

Determining the HGL requires that the entire drainage system be at equilibrium. Since hydrograph routing models are handling a time-varying flow, there is no single HGL for the system. The closest approximation would be to determine the HGL at the peak flow, but even this is flawed, since the peak flows occur at different times throughout the drainage system.

First create and save the model for the existing conditions. Then use Project|SaveAs to save a copy of the project under a new name for modeling the proposed conditions.

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How do I compare different rainfall events?

Due to the large volume of information associated with any given rainfall, HydroCAD retains only one set of results at a time. The easiest way to compare multiple events is to print a report for each one. Automatic calculations make this very easy. Using a separate "project" for each rainfall is not recommended, since each project will have to be manually updated whenever changes are required.

When should I use the new "simultaneous" routing procedures?

The new Sim-Route procedure is intended specifically to model "coupled ponds." This includes many situations where the upper pond's outlet(s) are influenced by a varying tailwater created by the lower pond. A common example is a culverted road crossing with ponding occurring on both sides of the road.

If there is no tailwater effect, or the tailwater is constant, the traditional storage-indication method is still recommended. The Sim-Route procedure may also be precluded for very small ponds (such as catch basins) that will not "track" properly, even with the smallest dt. Although the Sim-Route procedure may work with some catch basins, it is intended for larger ponds that have a significant storage volume in relation to the inflow hydrograph.

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Section 26 - References

The following references contain additional information on the hydrology and hydraulics utilized by HydroCAD. These publications are referred to by number throughout this manual and are listed in approximate order of usage.

[1] McCuen, Richard H. A Guide to Hydrologic Analysis Using SCS Methods, Prentice Hall, 1982. (Out of print. Also see [13], Chapter 8.)

[2] Soil Conservation Service Technical Release Number 20 (TR-20), National Technical Information Service, 1982.

[3] Smith, P.D. Basic Hydraulics, Butterworth Scientific, 1982.

[4] Sharp, J.J. & Sawden, P. Basic Hydrology, Butterworth Scientific, 1984.

[5] King, H.W. & Brater, E.F. Handbook of Hydraulics, McGraw Hill, 1963.

[6] Simon, Andrew Practical Hydraulics, John Wiley & Sons, 1981.

[7] Chow, Ven Te Open Channel Hydraulics, McGraw Hill, 1959.

[8] Merrit, Frederick Standard Handbook for Civil Engineers

[9] Jerome M. Norman et al Culverts - Hydrology & Hydraulics, Lehigh University, 1980.

[10] Soil Conservation Service National Engineering Handbook, Section 4 - Hydrology (NEH-4), National Technical Information Service, 1985.

[11] Soil Conservation Service Technical Release Number 55 (TR-55), 1986.

[12] American Concrete Pipe Association Concrete Pipe Handbook, 1981.

[13] McCuen, Richard H. Hydrologic Analysis and Design, Prentice Hall, 1989.

[14] Barfield and Warner Applied Hydrology and Sedimentology for Disturbed Areas, Oklahoma Technical Press, 1983.

[15] NRCS (Formerly SCS) Agricultural Handbook Number 590, Ponds - Planning, Design, Construction.

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ATTACHMENT A-4

CulvertMaster® THEORY SECTION

Chapter 5

CulvertMaster Theory

Analysis of Culvert Systems

When engineers analyze culvert systems, they are usually trying to make one or more of the following basic determinations:

- Determine the size, shape, and number of new or additional culverts required to pass a design discharge.
- Predict the hydraulic capacity of an existing culvert system under some allowable headwater elevation.
- Predict the upstream flood level at an existing culvert system resulting from some check discharge or other discharge magnitude of special interest.
- Develop hydraulic performance curves for a culvert system for assessing hydraulic risk at a crossing or as input to another hydraulic or hydrologic model.

CulvertMaster models complete culvert systems. A roadway cross-drainage culvert system is typically designed to safely carry flood flows from one side of the road to the other. The culvert system consists of the following hydraulic components:

- **Hydrology** – An upstream watershed drainage area discharging design and check storm flows to the culvert system. The magnitude of these discharges is computed using an accepted hydrological method such as Rational, SCS Peak, application of a state Regression Equation, or some other suitable methodology.
- **Culvert Hydraulics** – One or more culvert barrels along with associated headwalls, wingwalls, and other types of end treatments, which convey flow through a roadway embankment. The performance of these culverts is described using culvert hydraulics.
- **Roadway Overtopping** – A roadway embankment may be subject to overtopping flows if the total capacity of the culvert(s) is exceeded. Such overtopping flows are analyzed using weir hydraulics.
- **Tailwater** – A natural stream, improved channel, or other waterway at the discharge or tailwater side of the roadway embankment. The hydraulic response of the downstream discharge areas affects the capacity of the total culvert system. Tailwater is analyzed using uniform flow assumptions or separate floodplain analyses.

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5.2 Hydrology

CulvertMaster offers the Rational Method, SCS peak discharge method, and user-defined peak discharge for determination of the design and check storm flows.

5.2.1 Rational Method

The Rational Method solves for peak discharge based on watershed area, rational coefficient, and rainfall intensity for the watershed.

The Rational Method is based on the simple rational equation:

$$Q = CiA \quad \text{or} \quad Q = AiR \tag{5.1}$$

Where
- Q = Design flow rate (ft^3/s, m^3/s)
- C = Rational coefficient for drainage area
- R = Rational coefficient for drainage area
- i = Rainfall intensity (in/hr, mm/hr)
- A = Drainage area (acres, hectares)

Because of the units that are used in the above equation, CulvertMaster uses a factor to convert the units of intensity and drainage area to units of flow. In English units, this conversion factor is 1.008 ac-in/hr per ft^3/s, and in SI units it is 0.001778 hectare-mm/hr per m^3/s. C, the rational coefficient, is the parameter that is most open to engineering judgment. Engineering references contain tables that will help you estimate C. The following table shows rational coefficients for common land uses. In many cases, an area weighted average of C coefficients is used for the entire drainage area. CulvertMaster will automatically calculate the weighted C for drainage areas.

Table 5-1

Table of Rational Coefficients

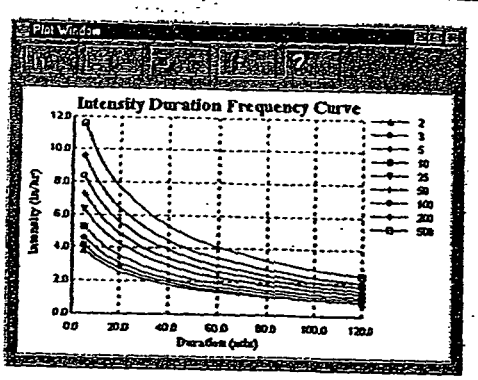
AREA	C Values
Business	
Downtown	0.70-0.95
Neighborhood	0.50-0.70
Residential	
Single Family	0.30-0.50
Multiunit detached	0.40-0.60
Multiunit attached	0.60-0.75
Suburban resident	0.25-0.40
Apartment	0.50-0.70
Residential (1.2 acre lots or more)	0.30-0.45
Industrial	
Light	0.50-0.80
Heavy	0.60-0.90
Parks and Cemeteries	0.10-0.25
Playgrounds	0.20-0.40
Unimproved	0.10-0.30
Pavement	
Asphalt/Concrete	0.70-0.95
Brick	0.70-0.85
Drives and Walks	0.75-0.85
Lawns, Sandy soils	
Flat, 2%	0.05-0.10
Average, 2-7%	0.10-0.15
Steep, 7%	0.15-0.20
Lawns, Heavy Soils	
Flat, 2%	0.13-0.17
Average, 2-7%	0.18-0.22
Steep, 7%	0.25-0.35
Railroad Yard	0.20-0.40
Roofs	0.70-0.95

ensity-Duration-Frequency (IDF) Curves

ainfall intensities for which you will be designing your culverts are determined by regulatory , which typically analyze historical rainfall information and compile it into IDF Curves based on ncy of the storm events. These curves provide a quick reference for determining the intensity of will occur at given return periods.

Figure 5.1

Intensity Duration Frequency Curve



IDF curves can be extremely useful when performing hand calculations using the Rational Method. They are less useful when used for computer programs or spreadsheet calculations because you have to look up values and enter them each time you need intensity data. For this reason, it is often easier to use rainfall tables or rainfall equations to calculate IDF curves.

Rainfall Tables

CulvertMaster lets you enter data in a rainfall table and saves the data so you may use it again for other projects. Entering the design intensities for your culvert analysis is simply a matter of looking up data from a graph and entering it into the Rainfall Table. Once the rainfall intensities are gathered, it is helpful if you make a table to enter the data.

Table 5-2

Table of Rainfall Intensities (in/hr)

Duration	Return Periods					
	2-year	5-year	10-year	25-year	50-year	100-year
5 min	7.20	7.86	8.42	9.33	10.01	10.80
10 min	6.02	6.67	7.20	8.04	8.71	9.38
15 min	5.20	5.84	6.35	7.14	7.77	8.40
30 min	3.88	4.42	4.84	5.48	5.98	6.49
60 min	2.50	2.94	3.26	3.74	4.12	4.50

CulvertMaster has provided a tabular format for entering rainfall volumes obtained from the National Weather Services' Hydro-35 technical report. Hydro-35 provides a methodology for estimating rainfall volumes for durations of 5 minutes to 60 minutes for the eastern United States.

Rainfall Equations

Equations can generally be fit to IDF curves with high accuracy. The most common form of these equations is:

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$$i = \frac{a}{(b+D)^n} \quad (5.2)$$

Where
- i = Intensity of rainfall
- D = Duration of rainfall
- a, b = Equation coefficients
- n = Exponent

ber equations supported in CulvertMaster are:

$$i = \frac{a(RP)^m}{(b+D)^n} \quad (5.3)$$

$$i = a + b(\ln D) + c(\ln D)^2 + d(\ln D)^3 \quad (5.4)$$

Where
- i = Intensity of rainfall
- D = Duration of rainfall
- RP = Return period
- a, b, c, d = Equation coefficients
- m, n = Equation exponents

2.3 SCS Peak Discharge Method

The SCS Peak Discharge method solves for peak discharge based on watershed area, site specific hydrologic conditions expressed through the curve number (CN), rainfall distribution type, and rainfall depth.

SCS Peak Discharge method is based on the following equations:

$$Q_p = q_u A Q F_p \quad (5.5)$$

Where
- Q_p = Peak discharge (ft^3/s)
- q_u = Unit peak discharge (cfs/ mi^2/in)
- A = Drainage area (mi^2)
- Q = Runoff (in)
- F_p = Pond and swamp adjustment factor

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \quad (5.6)$$

Where
- Q = Runoff (in)
- P = Rainfall (in)
- S = Potential maximum retention after runoff begins (in)
- I_a = Initial abstraction (in)

$$I_a = 0.2S \quad (5.7)$$

Where $S = \frac{1000}{CN} - 10$

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The CulvertMaster implementation of the SCS-graphical peak discharge follows the procedures and methodology set forth in Chapter 4 and Appendix F of the SCS-TR-55 (1986) manual.

Table 5-3

Runoff Curve Numbers for Urban Areas[1]

[illegible]					
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.):					
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)					
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)		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)					
1/4 acre	65	77	85	90	92
1/3 acre	38	61	75	83	87
1/2 acre	30	57	72	81	86
1 acre	25	54	70	80	85
2 acres	20	51	68	79	84
	12	46	65	77	82
[illegible]					

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

Other runoff curve number tables can be found in Chapter 2 of the SCS-TR-55 (1986) manual.

3 Culvert Hydraulics

Obtaining an accurate solution of culvert hydraulics represents a formidable computational task. Culverts often act as a significant constriction to flow and are subject to a range of flow types including both rapidly varied and gradually varied flow.

It is this mix of flow conditions and the highly transitional nature of culvert hydraulics that make the culvert hydraulic solution difficult. For this reason, the accepted approach is to simplify the hydraulics problem and solve the culvert using two different assumptions of flow control:

- **Inlet control assumption** – Computes the upstream energy grade or headwater depth resulting from the constriction effect at the culvert entrance while neglecting the culvert barrel friction and other minor losses.
- **Outlet control assumption** – Computes the upstream headwater depth using conventional hydraulic methodologies that consider the predominant losses due to the culvert barrel friction as well as the minor entrance and exit losses.

CulvertMaster uses the methodologies set forth in *Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts* (1985) as prepared for the U.S. Federal Highway Administration, and included as Chapter 6 in this manual, to perform these hydraulic calculations automatically under each control assumption. The controlling headwater depth is then the greater of the inlet control headwater or the outlet control headwater.

3.1 Inlet Control Hydraulics

When a culvert is operating under inlet control, the hydraulic control section is the culvert entrance itself. The losses due to barrel friction and other minor losses are not as significant as the losses caused by the entrance constriction. This entrance capacity is determined primarily by available opening area, the shape of the opening, and the inlet configuration of the entrance.

Generally, since the control section of a culvert operating under inlet control is at the upstream end of the culvert, barrel flows are in the supercritical flow regime and outlet velocities are determined using frontwater gradually varied flow profiles.

Three types of inlet control hydraulics are in effect over a range of culvert discharges:

- **Unsubmerged** – Occurs in low discharge conditions, and the culvert entrance is performing mainly as a weir. The hydraulics of weir flow are governed by empirical working equations developed as a result of model tests.
- **Submerged** – Occurs in higher discharge ranges when the culvert entrance is fully submerged and the culvert is assumed to be operating as an orifice.
- **Transition** – Occurs in the poorly defined region just above the unsubmerged zone below the culvert entrance crown and the fully submerged zone above the culvert entrance crown.

vertMaster computes the inlet control headwater depth using a set of inlet control working equations h are implemented by the design nomographs published in HDS-5 and many other hydraulics manuals handbooks.

Inlet Control Working Equations

The equations for unsubmerged (weir) and submerged (orifice) flow conditions are presented below. The transition zone is taken by linear interpolation in the region described by Notes 1 and 3. The constant coefficients for use in the working equations, as well as the use of Form (1) and Form (2) unsubmerged equations, vary according to section shape and material.

Inlet Control Design Equations

Unsubmerged[1]:

Form (1) 2:

$$\frac{HW_i}{D} = \frac{H_c}{D} + K\left[\frac{Q}{AD^{0.5}}\right]^M - 0.5S \quad (5.8a)$$

Form (2):

$$\frac{HW_i}{D} = K\left[\frac{Q}{AD^{0.5}}\right]^M \quad (5.8b)$$

Submerged[3]:

$$\frac{HW_i}{D} = c\left[\frac{Q}{AD^{0.5}}\right]^2 + Y - 0.5S \quad (5.9)$$

Where
- HW_i = Headwater depth above inlet control section invert (ft, m)
- D = Interior height of culvert barrel (ft, m)
- H_c = Specific head at critical depth ($d_c + V_c^2/2g$) (ft, m)
- Q = Discharge (ft^3/s, m^3/s)
- A = Full cross-sectional area of culvert barrel (ft^2, m^2)
- S = Culvert barrel slope (ft/ft, m/m)
- K, M, c, Y = Constants from the following table

Notes:

[1] Unsubmerged equations apply up to $Q/AD^{0.5} = 3.5$
[2] For mitered inlets, use +0.7S instead of –0.5S as the slope correction factor
[3] The submerged equation applies above $Q/AD^{0.5} = 4.0$.

Table 5-4

Constants for Inlet Control Design Equations

Ch No	Shape and Material	Nomograph Scale	Inlet Edge Description	Unsubmerged Form	Unsubmerged K	Unsubmerged M	Submerged C	Submerged Y
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	Circular CMP	1	Headwall	1	.0078	2.0	.0379	.69
		2	Mitered to slope		.0210	1.33	.0463	.75
		3	Projecting		.0340	1.50	.0553	.54
[illegible]	Circular CMP	4	Beveled edge, 45° bevels	[illegible]	.0018	2.50	[illegible]	[illegible]
		5	Beveled edge, 33.7° bevels	[illegible]	.0018	2.50	[illegible]	[illegible]
6	Rectangular Box	1	30° to 75° wingwall flares	1	0.26	1.0	.0347	.86
		2	90° to 15° wingwall flares		.061	.75	.0400	.80
		3	0° wingwall flares		.061	.75	.0423	.82
9	Rectangular Box	1	45° wingwall flare d = 0.043D	[illegible]	.510	.667	[illegible]	[illegible]
		2	18°–33.7° wingwall flare d = 0.043D	[illegible]	.486	.667	[illegible]	[illegible]

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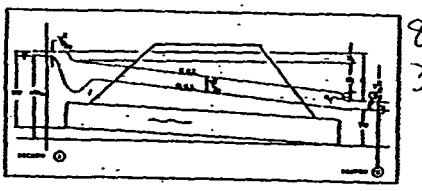
Table 5-4
Continued

Ch. No	Shape and Material	Nomograph Scale	Inlet Edge Description	Form	Unsubmerged K	Unsubmerged M	Submerged c	Submerged Y
15	Rectangular Box	1 2 3	90°headwall w/6" chamfers 90°headwall w/45° bevels 90°headwall w/33.7° bevels	2	.515 .435 .436	.667 .667 .667	.0575 .0534 .0252	.79 .82 .865
[illegible]								
17	Rectangular Box	1 2 3	45°non-offset wingwall flares 18.4°non-offset wingwall flares 18.4°non-offset wingwall flares 30°skewed barrel	2	.497 .493 .495	.667 .667 .667	.0339 .0361 .0326	.803 .806 .71
[illegible]								
16-19	C M Bents	1 2 3	90°headwall Thick wall projecting Thin wall projecting	1	.0083 .0145 .0340	2.0 1.75 1.5	.0379 .0419 .0496	.69 .64 .57
[illegible]								
30	Vertical Ellipse Concrete	1 2 3	Square edge headwall Groove end headwall Groove end projecting	1	0.0100 .0018 .0095	2.0 2.5 2.0	0.0398 .0292 .0317	0.67 .74 .69
34	Pipe Arch 18" Corner Radius CM	1 2 3	90° headwall Mitered to slope Projecting	1	.0083 .0300 .0340	2.0 1.0 1.5	.0379 .0463 .0496	.69 .75 .57
[illegible]								
36	Pipe Arch 18" Corner Radius CM	1 2 3	Projecting No bevels 33.7° bevels	1	.03 .0088 .0030	1.5 2.0 2.0	.0496 .0368 .0269	.57 .68 .77
[illegible]								
55	Circular	1 2	Smooth tapered inlet throat Rough tapered inlet throat	2	.534 .519	.555 .64	.0196 .021	.90 .90
[illegible]								
57	Rectangular	1	Tapered inlet throat	2	.675	.667	.0179	.97
58	Rectangular Concrete	1 2	Side tapered-less favorable edges side tapered-more favorable edges	2	.56 .56	.667 .667	.0446 .0378	.85 .87
59	Rectangular Concrete	1 2	Slope tapered-less favorable edges Slope tapered-more favorable edges	2	.50 .50	.667 .667	.0446 .0378	.65 .71

5.3.2 Outlet Control Hydraulics

Outlet control headwater depths are computed by summing entrance, exit, friction, and other losses along the culvert barrel. The energy basis for solving the outlet control headwater, *HW*, for a culvert is presented graphically in Figure 5.2 and the basic energy equation, Equation 5.10.

Figure 5.2
Full flow energy and hydraulic grade lines



$$HW_o + \frac{V_o^2}{2g} = TW + \frac{V_d^2}{2g} + H_t \qquad (5.10)$$

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Where
- HW_o = Headwater depth above the outlet invert (ft, m)
- V_o = Approach velocity (ft/s, m/s)
- TW = Tailwater depth above the outlet invert (ft,m)
- V_d = Exit velocity (ft/s, m/s)
- H_t = Sum of all losses including entrance (H_e), friction loss (H_f), exit loss (H_x), and other losses
- g = Gravitational acceleration constant (ft/s², m/s²)

HDS-5 presents some simplified procedures and nomographs that can be used to compute outlet control losses, H_t. However, such simplified approaches will result in degenerative solutions in low flow or part-full barrels. With the need for performance curves, which quantify culvert response and upstream and downstream impacts over a full range of flow magnitudes, it is necessary to take a more rigorous energy approach to computing outlet control hydraulics.

Since culverts are frequently hydraulically short, uniform flow depths are not always achieved. CulvertMaster incorporates a powerful set of gradually varied flow algorithms, which can correctly analyze the following conditions:

- **Partial flow** – Water surface profiles are computed so the actual flow depths at the entrance and exit of the culvert during part-full conditions are accurately calculated.
- **Pressure flow** – Backwater is computed during full barrel submergence.
- **Composite pressure and free surface flows** – Both scaling and unscaling conditions are used for computations.
- **Composite flow regime profiles** - Mixed supercritical and subcritical flow profiles can be analyzed.
- **Adverse and horizontal culverts** – Backwater profiles can be performed for culverts for which uniform flows are undefined.

Entrance Minor Loss

The entrance loss H_e is a function of the barrel velocity head just inside the entrance, and is expressed by the equation:

$$H_e = k_e\left(\frac{V^2}{2g}\right) \qquad (5.11)$$

Where
- H_e = Entrance loss (ft, m)
- V = Velocity head inside of barrel entrance (ft/s, m/s)
- k_e = Entrance loss coefficient (unitless)
- g = Gravitational acceleration constant (ft/s², m/s²)

The entrance loss coefficient, k_e, is a function of inlet configuration. Values for the coefficients are presented in table 5-5 below.

Table 5-5
Entrance Loss Coefficients: Outlet Control, Full or Partly Full Entrance Head Loss

Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/20)	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded 3 edges to radius to 1/12 barrel dimension, or beveled edges 3 sides	0.2

Table 5-5
Continued

Box, Reinforced Concrete (continued)	
Wingwalls at 30° to 75° barrel	
Square-edged at crown	0.5
Crown edge rounded to radius of 1/12 barrel dimension, or bevelled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

* "End Section conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance.

Exit Minor Loss

The exit loss is actually an expansion loss, which is a function of the change in velocity head occurring at the discharge location. In culvert hydraulics, the sudden expansion loss is expressed as:

$$H_x = 1.0\left[\frac{V^2}{2g} - \frac{V_d^2}{2g}\right] \qquad (5.12)$$

Where
- H_x = Exit minor loss (ft, m)
- V = Velocity just inside the barrel exit (ft/s, m/s)
- V_d = Outfall channel velocity (ft/s, m/s)
- g = Gravitational acceleration constant (ft/s², m/s²)

The discharge velocity can be neglected, in which case CulvertMaster assumes the exit loss is equal to the barrel velocity head.

Friction Loss

CulvertMaster calculates friction losses using gradually varied flow profiles.

Gradually Varied Flow

Gradually varied flow occurs for free surface flow conditions. Starting from a given boundary control depth, usually the tailwater elevation, the depth will change gradually until (if the barrel or conduit is sufficiently long) normal depth is achieved. If the water surface moves above or below the crown of the conduit in scaling or unscaling flow conditions, the program will automatically transition into and out of a pressure analysis mode. Friction losses for the submerged part of the barrel or conduit will be based on full flow friction slope.

CulvertMaster computes both frontwater and backwater profiles. The program automatically determines whether a structure is operating under upstream or downstream [illegible] the correct gradually varied flow analysis.

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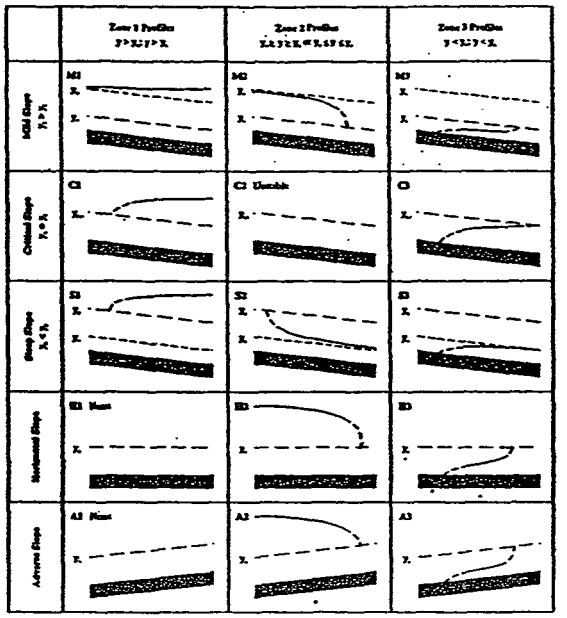
Gradually varied flow profiles express the water surface depth curve along the length of the barrel and are developed in an upstream or downstream direction depending on the hydraulic slope of the conduit and the controlling water surface elevations. For structures on a mild slope, which is when the constructed slope is less than critical slope, the depth of flow will increase gradually if the downstream starting elevation is less than normal depth (M2 drawdown curve, Figure 5.3). The depth of flow will decrease gradually if the starting water surface elevation is greater than normal depth (M1 backwater curve, Figure 5.3). In these types of water surface profiles, the flow is operating under subcritical flow conditions.

or a structure operating at a hydraulically steep slope (i.e. constructed slope is greater than critical slope), adually varied flow profiles will be developed in an upstream direction whenever the controlling water elevation lies well above critical depth and subcritical flow exists at the pipe exit. Unless the pipe ry short, steep pipes that have tailwater depths above critical depth will experience a hydraulic jump where along their length.

Figure 5.3

Gradually Varied Flow Classifications

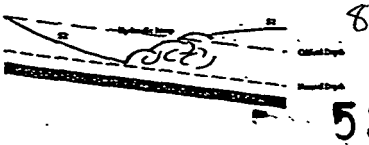


Usually, culverts on a steep slope are either entrance controlled or inlet controlled, and operate under supercritical flow. The gradually varied flow algorithm sets the upstream hydraulic grade equal to the critical depth elevation at the entrance and develops a frontwater curve by computing depth variation in a downstream direction. In this type of frontwater analysis, the depth decreases from critical depth and approaches normal depth at the culvert exit.

CulvertMaster uses two different algorithms for computing the gradually varied flow profile through the culvert barrel depending on the hydraulic context of the pipe component as defined by the constructed slope and the governing tailwater elevations. The two methods are direct step and standard step. Both are computationally equivalent, and the choice of which method to use is based on performance considerations.

Figure 5.4

Plot of Hydraulic Jump



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Backwater Analysis

A backwater analysis for outlet control computations starts at the downstream outfall under free discharge, submerged, or tailwater control, and proceeds in an upstream direction. CulvertMaster will perform backwater analysis in both free surface flow conditions and pressure flow computations under full flow conditions.

Frontwater Analysis

CulvertMaster will perform a frontwater analysis in a steep culvert operating under supercritical flow. The hydraulic control will be at the upstream end of a hydraulically steep culvert, and the gradually varied flow analysis will proceed in a downstream direction until normal depth is achieved, a hydraulic jump occurs, or the end of the culvert is reached. Even though outlet control rarely occurs in supercritical flow situations, the frontwater analysis is still performed for purposes of determining exit velocity.

Direct Method

This is a method for solving gradually varied flow profiles in which a series of explicit solutions for flow length are made that will result in a specified depth of flow. In the direct step method, the program iterates over a range of depth changes resulting from a backwater or drawdown curve, and computes the interval distance that results in the correct amount of headloss to produce the energy balance. This interval distance is then summed with all previous intervals to compute the total distance over which the flow profile has been computed, and the next interval computation is performed.

The program uses a trial and error procedure to solve for a depth that will yield a final interval, which, when summed with the previous profile distance, will equal the total length of the conduit.

The basic equation for energy balance is:

$$H_1 = H_2 + h_f + h_e \tag{5.13}$$

Where H_1 = Total head at section 1
H_2 = Total head at section 2
h_f = Friction loss
h_e = Eddy loss

For prismatic channels, the eddy loss, h_e is practically zero and is assumed as zero by the program.

The total head at both ends of the section is defined as:

$$H = Z + \frac{V^2}{2g} \tag{5.14}$$

Where H = Total head (ft, m)
Z = Water surface elevation (ft, m)
V = Velocity at the end of the section (ft/s, m/s)
g = Gravitational acceleration constant (ft/s², m/s²)

The friction loss, h_f, is the product of step length and uniform flow friction slope, or:

$$S_f \Delta x = \frac{1}{2}(S_1 + S_2)\Delta x \tag{5.15}$$

Where S_f = Friction slope (ft/ft, m/m)
Δx = Change in horizontal distance in the section (ft, m)
S_1, S_2 = Friction slopes at the end of the section (ft/ft, m/m)

In the direct step solution, the only unknown given two depths at each end of a sub-reach is the parameter Δx. This is solved for each trial depth.

Standard Step Method

The standard step method is the most popular method of determining the profiles of gradually varied flow. In standard step analysis, the reach is divided into a number of sub-reaches. Computations are performed in steps from one section to the next, where the depth is either incremented or decremented to yield a correct energy balance in the basic equation.

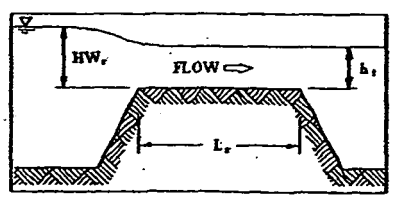
Unlike the direct step method, the standard step method varies the depth at the next section until the friction slope relationship, shown above, yields an average friction slope, S_f, which balances energy between each end of the sub-reach.

5.4 Roadway Overtopping

Whenever the culvert headwater begins to rise above the minimum elevation of the roadway, overtopping will occur. Overtopping flow is modeled as a special type of weir flow expressed by the general broad-crested weir equation. Overtopping flow is one component of the total culvert system.

Figure 5.5

Roadway overtopping



$$Q_r = C_d \times L \times HW_r^{1.5} \tag{5.16}$$

Where Q_r = Overtopping flow rate (ft³/s, m³/s)
C_d = Overtopping discharge coefficient
L = Length of the roadway crest (ft, m)
HW_r = Overtopping depth (ft, m)

The overtopping discharge coefficient is a function of submergence using the equation:

$$C_d = k_s C_r \tag{5.17}$$

along with the figures below. The first two figures are used to derive the base weir coefficient resulting from deep and shallow overtopping, respectively. The submergence correction is determined implicitly using the final figure and applied against the base coefficient.

Figure 5.6

Discharge coefficient for $HW/L_r > 0.15$

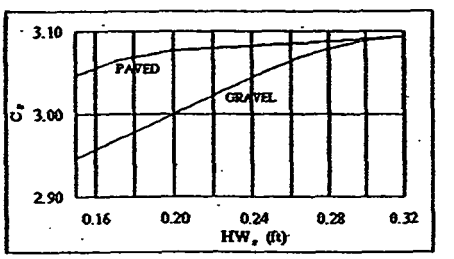


Figure 5.7

Discharge coefficient for $HW/L_r \leq 0.15$

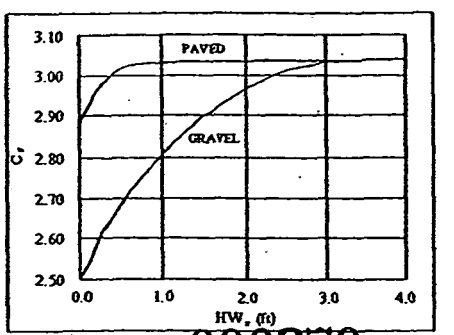


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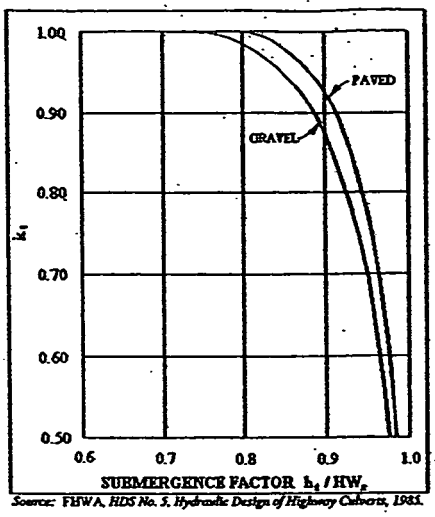
Figure 5.8

Submergence Factor h/HW,



Source: FHWA, *HDS No. 5, Hydraulic Design of Highway Culverts*, 1985.

5.5 Tailwater

The tailwater depth at the culvert discharge channel is an important parameter for computing the response of the culvert. For backwater analyses, the tailwater elevation may be the starting gradually varied flow boundary. CulvertMaster will automatically compute discharge variable tailwater depths using its uniform flow calculation capability.

5.5.1 Uniform Flow

In uniform flow, the discharge, depth, and velocity are constant with distance along the pipe or ditch section. The physical slope of the flow element, friction slope or energy slope, and the water surface slope are all parallel. This means that the hydraulic grade line of flow is parallel to the channel slope and that the depth will be the same at all points along its length. This depth of uniform flow is called the *normal depth*. Uniform flow can occur as free surface flow in a prismatic conduit flowing partially full. A prismatic channel or conduit has a non-varying cross-section and a constant bottom slope.

Uniform flow can be described by the generalized friction equation:

$$V = CR^x S^y \tag{5.18}$$

Where
- V = Mean velocity (ft/s, m/s)
- R = Hydraulic radius (ft, m)
- S = Energy slope (ft/ft, m/m)
- C = Flow resistance factor (units vary by method)
- x = Exponent
- y = Exponent.

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The roughness, or flow resistance, factor, C, is usually determined by the material lining the flow channel. However, the ultimate value of the C component may be a function of the channel shape, depth, and velocity of flow. The hydraulic radius, R, is a strict function of the channel shape. For every geometric shape, R can be readily calculated once a depth is known or assumed. The energy slope, S, is constant under the uniform flow assumption.

Since velocity is constant under uniform flow conditions, combining the general uniform flow equation with the continuity equation

$$Q = VA \tag{5.19}$$

results in the equation:

$$Q = ACR^x S^y \tag{5.20}$$

Where
- Q = Discharge (ft^3/s, m^3/s)
- A = Cross-sectional flow area (ft^2, m^2)
- C = Flow resistance factor (units vary by method)
- R = Hydraulic radius (ft, m)
- S = Energy slope (ft/ft, m/m)
- x = Exponent
- y = Exponent

Manning's Formula

CulvertMaster implements the Manning's formula for computing uniform flows in tailwater channels, and for computing friction slopes in its gradually varied flow computations in culvert barrels.

The use of Manning's formula is applicable to uniform flow provided the slope of the energy grade line is used and is applied when the flow range is rough. Culvert flow tends to be turbulent when the flow range is rough and during peak flows. The turbulent regime is comprised of three ranges of flow: smooth, transition, and rough. When the flow is rough, Manning's formula is most often used.

Manning's formula is derived from the Chezy Formula, which computes velocity based on a C coefficient, hydraulic radius, and friction slope. Manning's formula relates this C coefficient to a roughness coefficient and hydraulic radius. The original format incorporates the roughness coefficient:

$$V = CR^{1/2} S^{1/2} \tag{5.21}$$

Where
- C = Factor of flow resistance
- R = Hydraulic radius (ft, m)
- S = Energy slope (ft/ft, m/m)

This equation was further modified by others to become the well-known Manning's formula:

U.S. Units:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \tag{5.22a}$$

Where
- V = Section velocity (ft/s)
- R = Hydraulic radius (ft)
- S = Energy slope
- n = Manning's roughness coefficient

Metric:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \tag{5.22b}$$

Where
- V = Section velocity (m/s)
- R = Hydraulic radius (m)
- S = Energy slope
- n = Manning's roughness coefficient

.6 Comparing Results with HY-8

CulvertMaster results will generally be similar to HY-8 results. However, in some complex hydraulic cases, HY-8 uses a simplified solution technique that may produce differences. The following is a list of cases where calculation methodology between CulvertMaster and HY-8 differ:

1. CulvertMaster computes inlet control headwater strictly by the inlet control equations presented in HDS-5. HY-8 uses polynomial curve fits for inlet control headwater computation.
2. HY-8 simplifies the computation of the M2 backwater profile for the case where a culvert has unsubmerged tailwater and has discharge in excess of full flow capacity. In this case, HY-8 will assume pressure flow for the full length of the culvert. CulvertMaster will compute the M2 profile backwater curve, and will transition to pressure flow where the profile runs into the top of the pipe.

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ATTACHMENT A-5

USDA-SCS SOIL SURVEY MAP

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USDA-SCS SOIL SURVEY MAP
BULTER AND HAMILTON COUNTIES , OHIO

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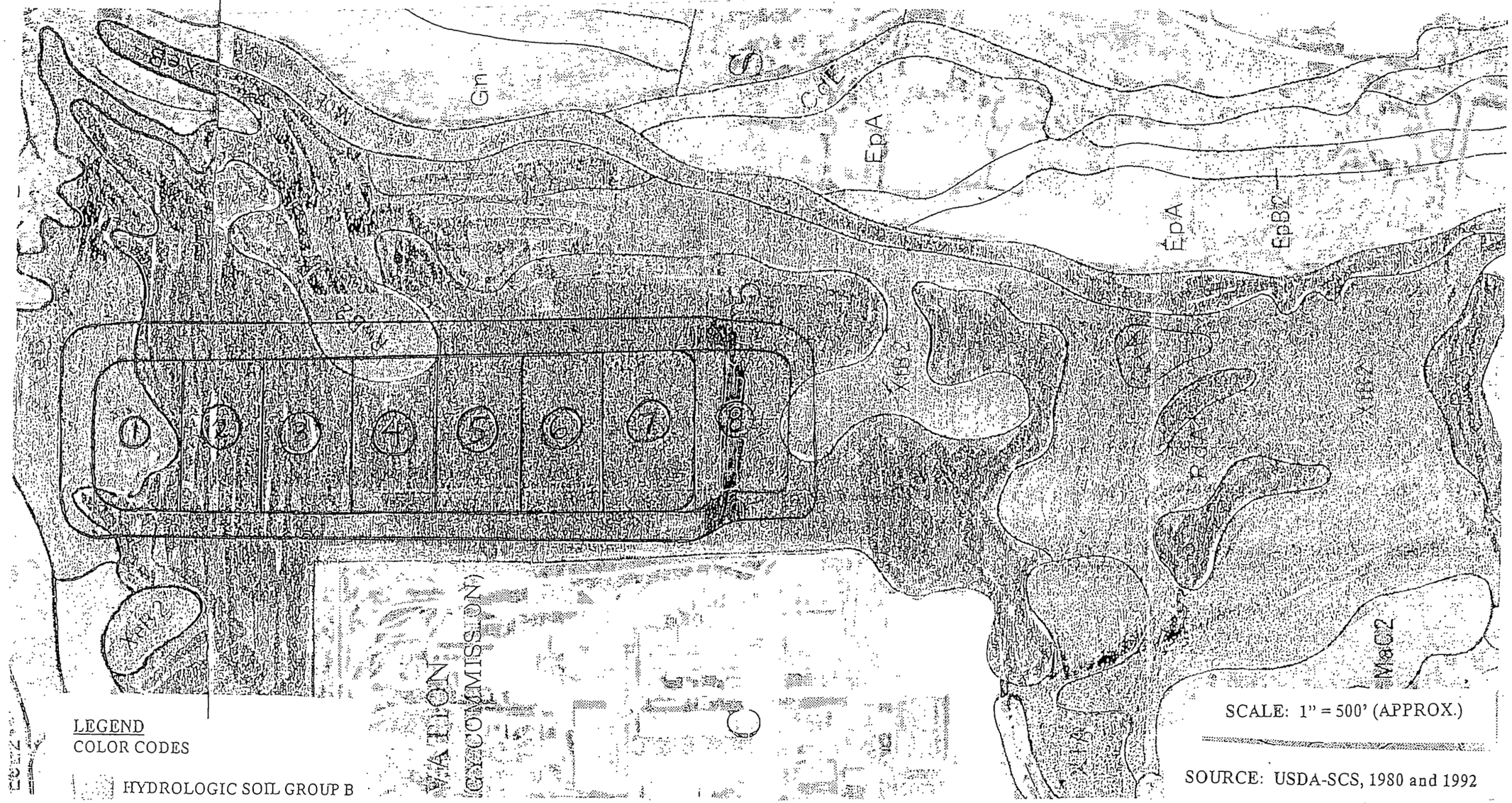

LEGEND
COLOR CODES

HYDROLOGIC SOIL GROUP B

HYDROLOGIC SOIL GROUP C

OSDF – PHASE V
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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ATTACHMENT A-6

HYDROLOGIC SOIL DATA

TABLE 18.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
ArA, ArB2, ArC2---- Ava	C	None---------	---	---	2.0-4.0	Perched	Mar-Jun	>60	---	High------	Moderate	High.
AsB*, AsC*:												
Ava----------	C	None---------	---	---	2.0-4.0	Perched	Mar-Jun	>60	---	High------	Moderate	High.
Urban land.												
AvA---------- Avonburg	D	None---------	---	---	1.0-3.0	Perched	Jan-Apr	>60	---	High------	High------	High.
AwA*:												
Avonburg----------	D	None---------	---	---	1.0-3.0	Perched	Jan-Apr	>60	---	High------	High------	High.
Urban land.												
BoD, BoE, BoF----- Bonnell	C	None---------	---	---	>6.0	---	---	>60	---	Moderate	High------	Moderate.
CcC2, CdD, CdE, CdF---------- Casco	B	None---------	---	---	>6.0	---	---	>60	---	Low-------	Low-------	Low.
CnB2, CnC2-------- Cincinnati	C	None---------	---	---	>4.0	Perched	Jan-Apr	>60	---	High------	Moderate	High.
DaB---------- Dana	B	None---------	---	---	3.0-6.0	Perched	Mar-Apr	>60	---	High------	Moderate	Moderate.
EcB2, EcC2, EcD, EcE, EdF--------- Eden	C	None---------	---	---	>6.0	---	---	20-40	Soft	High------	Moderate	Low.
EeB*, EeC*, EeD*:												
Eden----------	C	None---------	---	---	>6.0	---	---	20-40	Soft	High------	Moderate	Low.
Urban land.												
EpA, EpB2, EpC2--- Eldean	B	None---------	---	---	>6.0	---	---	>60	---	Moderate	High------	Moderate.
ErA*, ErB*:												
Eldean----------	B	None---------	---	---	>6.0	---	---	>60	---	Moderate	High------	Moderate.
Urban land.												
FdA---------- Fincastle	C	None---------	---	---	1.0-3.0	Apparent	Jan-Apr	>60	---	High------	High------	Moderate.

See footnotes at end of table.

Source: USDA-SCS, 1992.

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name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	Depth (Ft)	Water table: Kind	Water table: Months	Bedrock: Depth (In)	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
FeA*:												
Fincastle	C	None	---	---	1.0-3.0	Apparent	Jan-Apr	>60	---	High	High	Moderate.
Urban land.												
FoA, FoB2 Fox	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Moderate.
FpA*:												
Fox	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Moderate.
Urban land.												
Gn Genesee	B	Occasional	Brief	Oct-Jun	>6.0	---	---	>60	---	Moderate	Low	Low.
Go*:												
Genesee	B	Occasional	Brief	Oct-Jun	>6.0	---	---	>60	---	Moderate	Low	Low.
Urban land.												
HeF Hennepin	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Low.
HoA Henshaw	C	None	---	---	1.0-2.0	Apparent	Nov-Mar	>60	---	High	High	Moderate.
Hu Huntington	B	Occasional	Brief	Dec-May	4.0-6.0	Apparent	Dec-Apr	>60	---	High	Low	Moderate.
Ju Jules	B	Occasional	Brief	Mar-Jun	>6.0	---	---	>60	---	High	Low	Low.
Lg Lanier	A	Occasional	Brief	Nov-Jun	>6.0	---	---	>60	---	Low	Low	Low.
MaB, MaC2, MaD2, MaE2 Markland	C	None	---	---	3.0-6.0	Perched	Mar-Apr	>60	---	Moderate	High	Moderate.
McA, McB Martinsville	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
MnC2 Miamian	C	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
MoD2*, MoE2*:												
Miamian	C	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
Hennepin	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Low.
MuC*:												
Miamian	C	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.

See footnotes at end of table.

Source: USDA-SCS-1982.

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TABLE 18.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
MuC*:												
Urban land.												
PbB2, PbC2, PbD, PbE: Parke	B	None	---	---	>6.0	---	---	>60	---	High	Moderate	High.
PcB*, PcC*:												
Parke	B	None	---	---	>6.0	---	---	>60	---	High	Moderate	High.
Urban land.												
PfC, PfD, PfE: Pate	C	None	---	---	>6.0	---	---	>50	Soft	Moderate	High	Moderate.
PhD*:												
Pate	C	None	---	---	>6.0	---	---	>50	Soft	Moderate	High	Moderate.
Urban land.												
Pn**: Patton	B/D	None	---	---	+.5-2.0	Apparent	Mar-Jun	>60	---	High	High	Low.
Po*.												
Pits												
PrA, PrB, PrC2: Princeton	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
RdA: Raub	C	None	---	---	1.0-3.0	Apparent	Jan-Apr	>60	---	High	High	Moderate.
Rn: Ross	B	Rare	---	---	4.0-6.0	Apparent	Feb-Apr	>60	---	Moderate	Low	Low.
RpA, RpB2, RpC2: Rossmoyne	C	None	---	---	1.5-3.0	Perched	Jan-Apr	>60	---	High	High	High.
RtA*, RtB*, RtC*:												
Rossmoyne	C	None	---	---	1.5-3.0	Perched	Jan-Apr	>60	---	High	High	High.
Urban land.												
RwB2: Russell	B	None	---	---	>6.0	---	---	>60	---	High	Moderate	Moderate.
RxB*:												
Russell	B	None	---	---	>6.0	---	---	>60	---	High	Moderate	Moderate.
Urban land.												
St: Stonelick	B	Frequent	Very brief	Nov-Jun	>6.0	---	---	>60	---	Moderate	Low	Low.

See footnotes at end of table.

Source: USDA-SCS, 1992.

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Soil survey

TABLE 18.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
XfA, XfB2--------- Xenia	B	None--------	---	---	2.0-6.0	Apparent	Mar-Apr	>60	---	High-----	High-----	Moderate.

* See description of the map unit for composition and behavior characteristics of the map unit.
** The plus sign preceding the range in depth to the water table means that the range in this soil is from .5 foot above the surface to 2.0 feet below.

Source: USDA-SCS, 1992

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TABLE 16.— WATER FEATURES

[The definitions of "flooding" and "water table" in the text explain terms such as "rare," "brief," "apparent," and "perch". The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
AvA: Avonburg	D	None	---	---	1.0-3.0	Perched	Jan-Apr	>60	---	High	High	High.
Bt: Brenton	B	None	---	---	1.0-3.0	Apparent	Mar-Jun	>60	---	High	High	Moderate.
CdD2*, CdE*:												
Casco	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Low.
Rodman	A	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
CeB: Celina	C	None	---	---	1.5-3.0	Perched	Jan-Apr	>60	---	High	High	Moderate.
CnC2: Cincinnati	C	None	---	---	>6.0	---	---	>60	---	High	Moderate	High.
CrA: Crosby	C	None	---	---	1.0-3.0	Apparent	Jan-Apr	>60	---	High	High	Moderate.
DaA, DaB: Dana	B	None	---	---	3.0-6.0	Perched	Mar-Apr	>60	---	High	Moderate	Moderate.
DbB: Dana	B	None	---	---	3.5-6.0	Perched	Mar-Apr	40-60	Rippable	High	Moderate	Moderate.
EcE2, EcF2: Eden	C	None	---	---	>6.0	---	---	20-40	Rippable	---	Moderate	Low.
Ee: Eel	C	Occasional	Brief	Oct-Jun	3.0-6.0	Apparent	Jan-Apr	>60	---	High	Moderate	Low.
ElA, ElB2, ElC2, EnA, EnB2: Eldean	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Moderate.
EuA*, EuB*:												
Eldean	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Moderate.
Urban land.												
FcA, FcB: Fincastle	C	None	---	---	1.0-3.0	Apparent	Jan-Apr	>60	---	High	High	Moderate
FdA, FdB: Fincastle	C	None	---	---	1.0-3.0	Perched	Jan-Apr	48-72	Rippable	High	High	Moderate
Gn: Genesee	B	Common	Brief	Oct-Jun	>6.0	---	---	>60	---	Moderate	Low	Low.

See footnote at end of table.

Source: USDA-SCS, 1980.

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TABLE 16.--SOIL [illegible]R FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
UnA, UnB---------- Uniontown	B	None--------	---	---	2.5-6.0	Apparent	Nov-May	>60	---	High------	Low-------	Moderate.
UpA*: Urban land.												
Eldean----------	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	High------	Moderate.
UsA*: Urban land.												
Patton----------	B/D	None--------	---	---	0-2.0	Apparent	Mar-Jun	>60	---	High------	High------	Low.
WbA---------- Warsaw	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Low-------	Moderate.
WeA, WeB---------- Wea	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
WyB, WyB2, WyC2, WzC3---------- Wynn	B	None--------	---	---	>6.0	---	---	20-40	Rippable	Moderate	High------	Low.
WuB*, WuC*: Wynn----------	B	None--------	---	---	>6.0	---	---	20-40	Rippable	Moderate	High------	Low.
Urban land.												
XeA, XeB, XeB2---- Xenia	B	None--------	---	---	2.0-6.0	Apparent	Mar-Apr	>60	---	High------	High------	Moderate.
XfA, XfB, XfB2---- Xenia	B	None--------	---	---	2.0-4.0	Perched	Mar-Apr	48-72	Rippable	High------	High------	Moderate.

* See map unit description for the composition and behavior of the map unit.

Source: USDA-SCS, 1980.

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SOIL SURVEY

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ATTACHMENT A-7

TR-55 LAND USE CATEGORIES AND RUNOFF CURVE NUMBERS

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BORROW AREA SOILS B/C

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)		VEGETATED FINAL COVER SYSTEM CONSTRUCTION PHASE			
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:			83		
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:	VEGETATED FINAL COVER SYSTEM POST DEVELOPMENT				AREAS ADJACENT TO OSDF, POST DEVELOPME
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:	PAVEMENT				
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:					SUBGRADE
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]	NON VEGETATED FINAL COVER SYSTEM; LINER RUNOFF	77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).			89		

[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.

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Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

RUNON AREAS EAST OF OSDF, NORTH OF BORROW AREA

BORROW AREA RUNOFF, RUNON TO BORROW AREA, VEGETATED BORROW AREA

AREAS ADJACENT TO OSDF. CONSTRUCTION PHASE

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

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

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ATTACHMENT A-8

NODAL NETWORK DIAGRAMS

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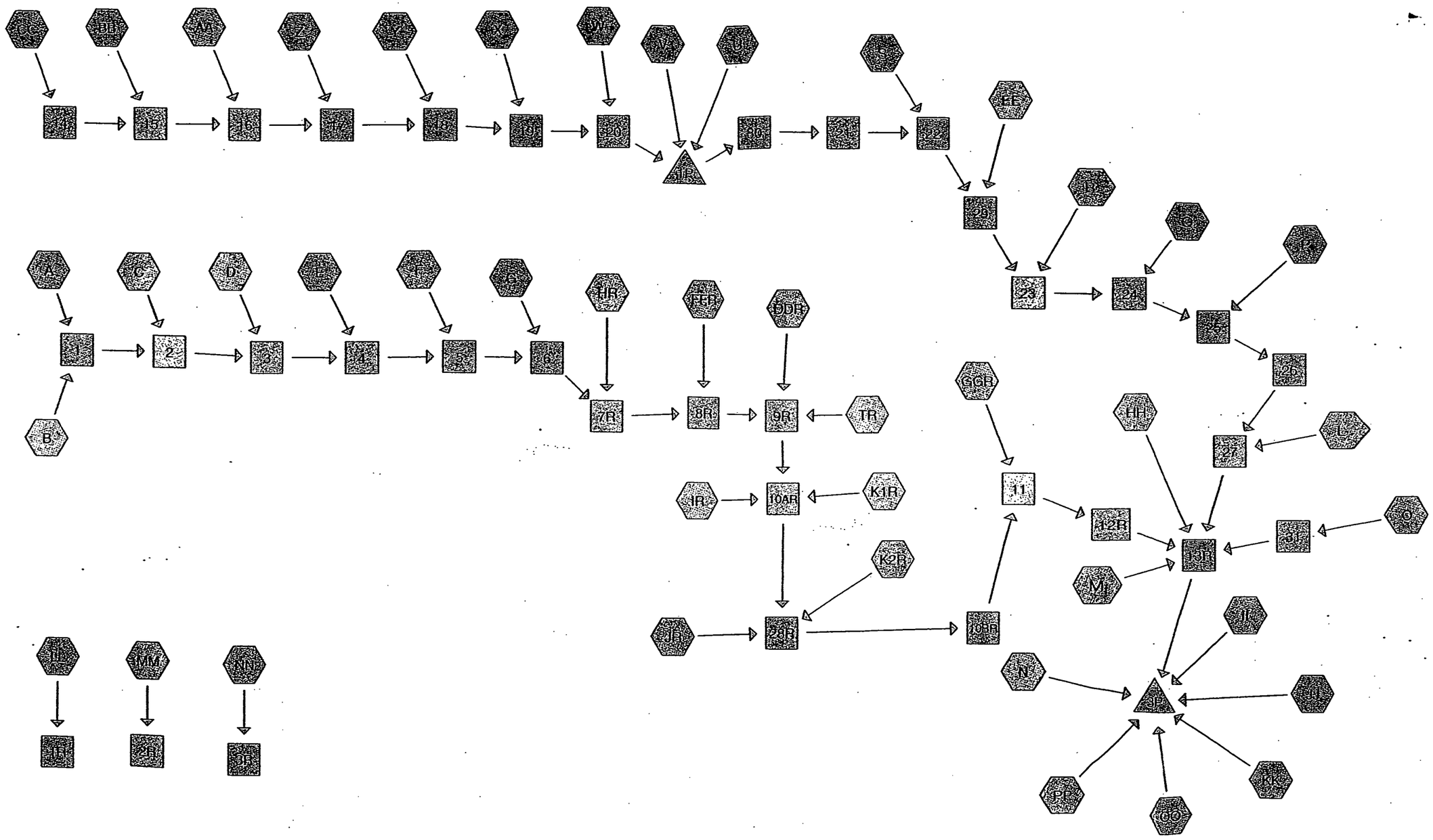
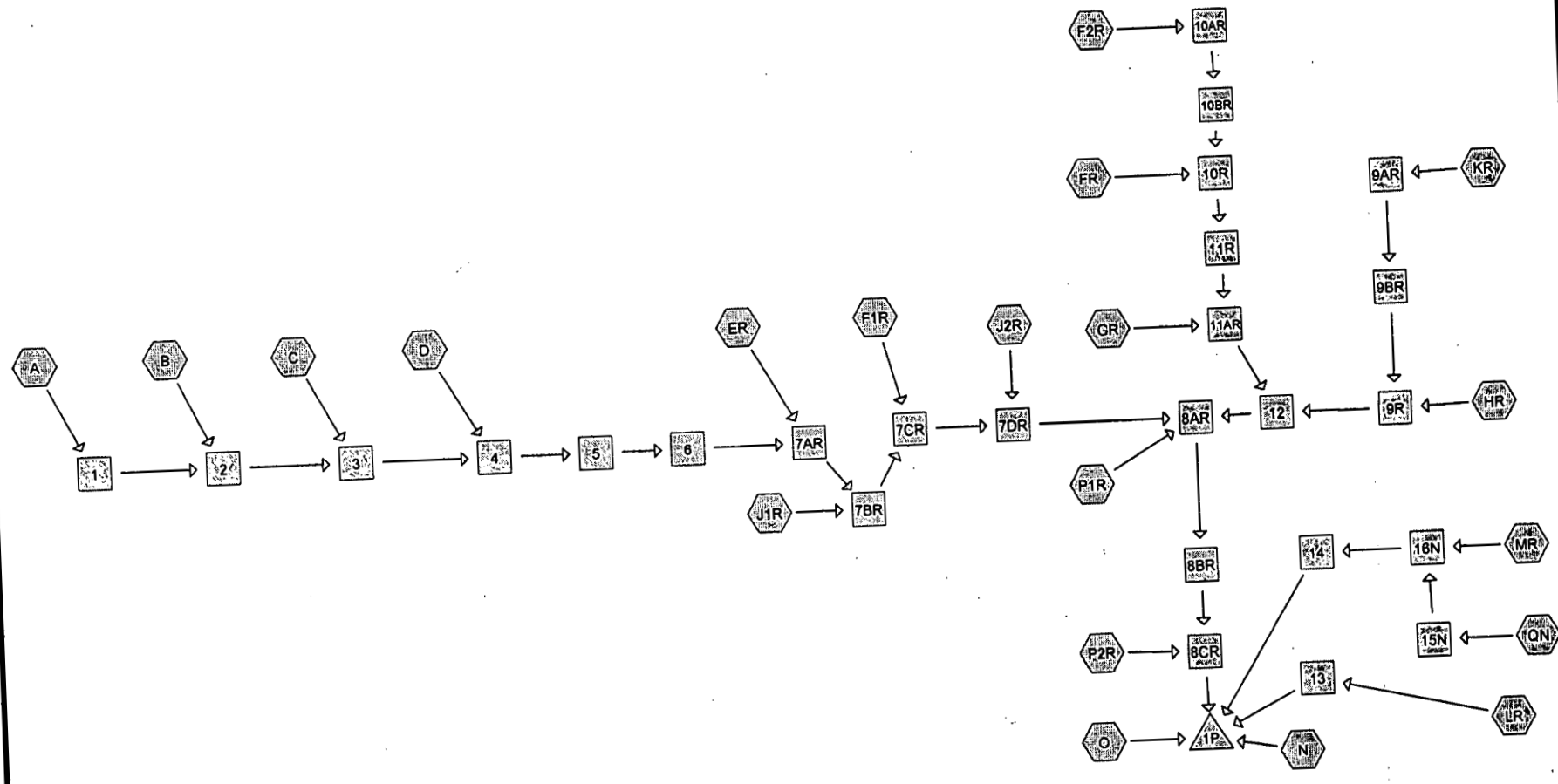


Drainage Diagram for East OSDF

Prepared by GeoSyntec Consultants 10/17/2003

HydroCAD® 6.00 s/n 000929 © 1986-2001 Applied Microcomputer Systems



Subcat Reach Pond Link

Drainage Diagram for West OSDF
Prepared by GeoSyntec Consultants 1/16/2004
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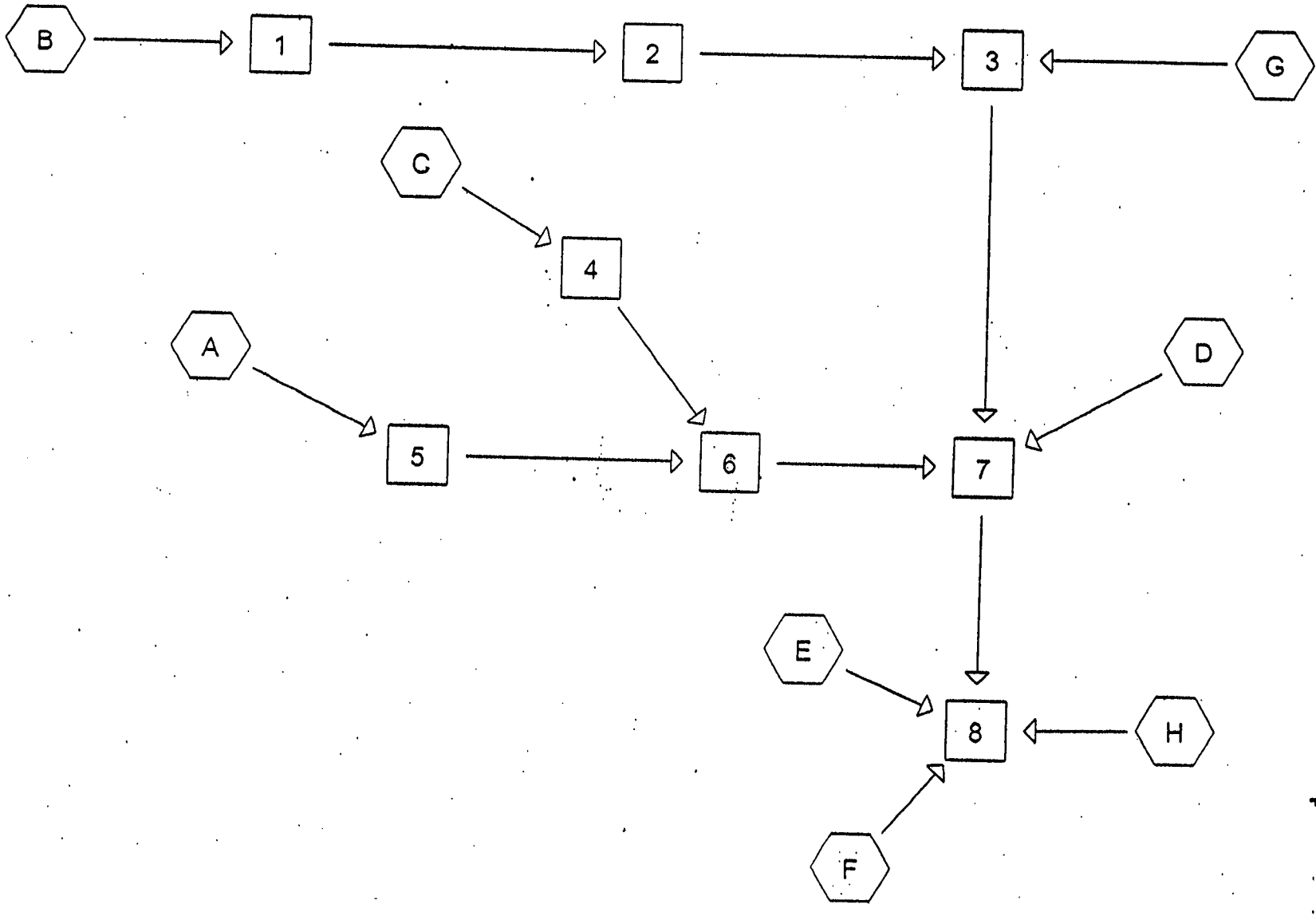

Subcat Reach Pond Link

Nodal Network for Design Case "A"
Prepared by GeoSyntec Consultants 1/29/2002
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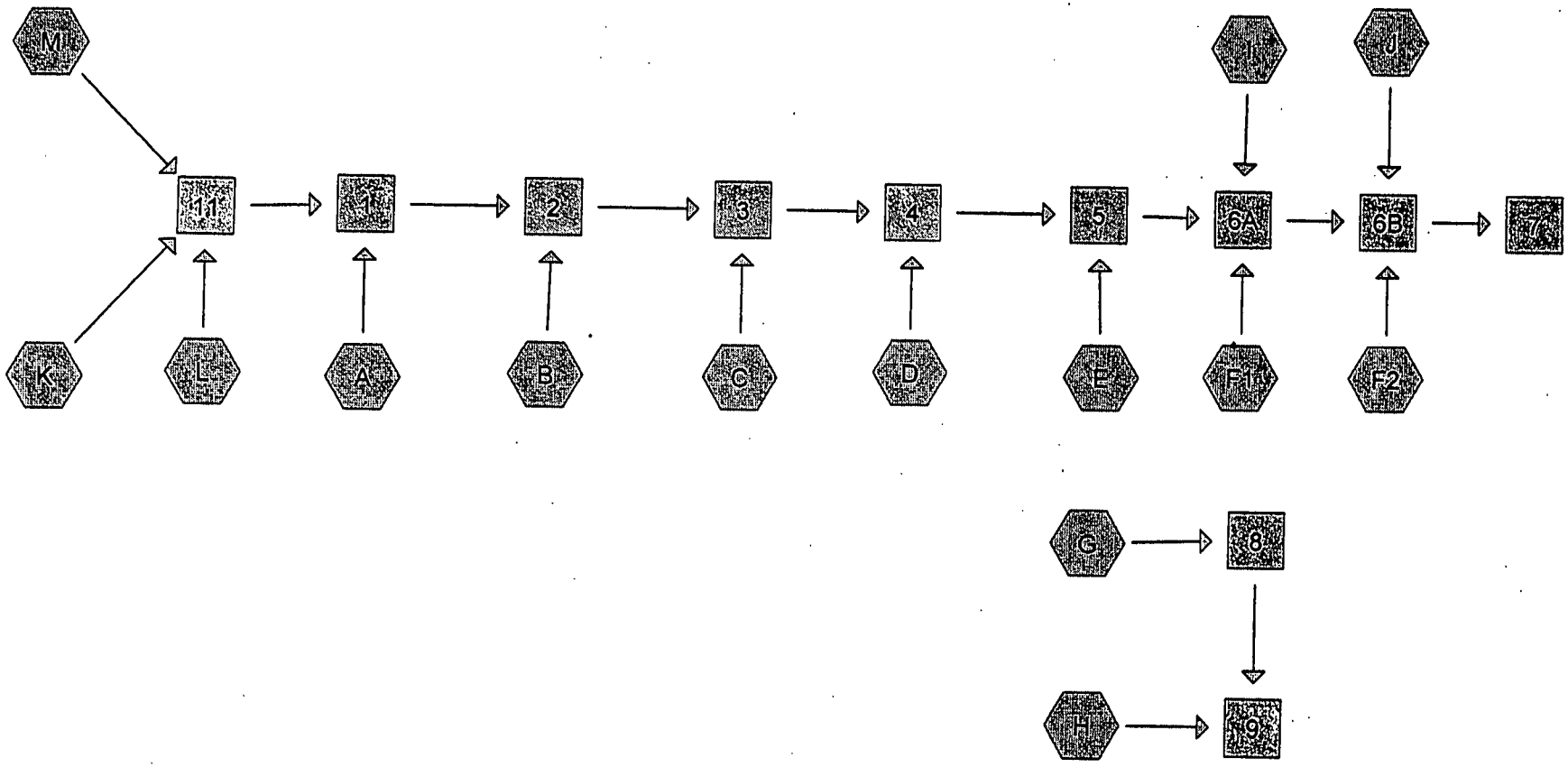

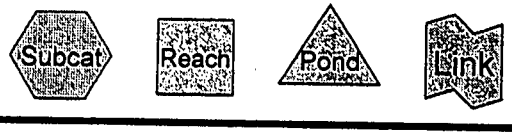

Drainage Diagram for DesignCaseB
Prepared by GeoSyntec Consultants 12/4/2003
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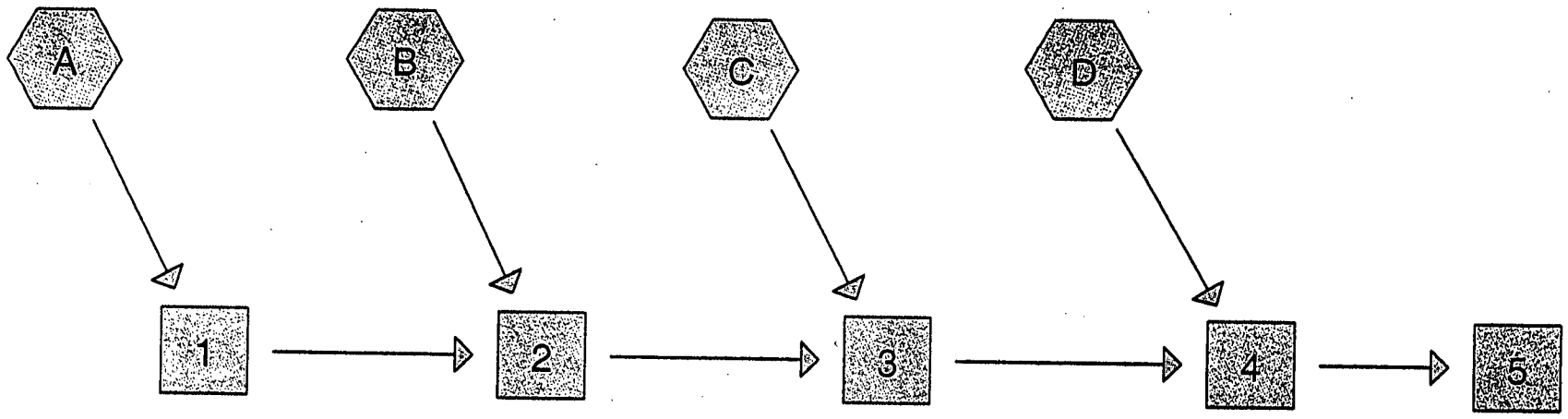

Drainage Diagram for DesignCaseC
Prepared by GeoSyntec Consultants 12/5/2003
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ATTACHMENT A-9

CMP COVER REQUIREMENTS

CMP COVER REQUIREMENTS

General Guidelines for Minimum Cover Required for Heavy Off-Road Construction Equipment				
Pipe Span, Inches	Minimum Cover (feet) for Indicated Axle Loads (kips)			
	18-50	50-75	75-110	110-150
12-42	2.0	2.5	3.0	3.0
48-72	3.0	3.0	3.5	4.0
78-120	3.0	3.5	4.0	4.0
126-144	3.5	4.0	4.5	4.5

Information reproduced from: [Contech, 1999]

PHASE V SURFACE-WATER MANAGEMENT SYSTEM DESIGN

DATA VERIFICATION

INTRODUCTION

As described in the Procedures Section, the purpose of this calculation package is to design the OSDF surface-water management (SWM) structures to be constructed as part of the Phase V development of the OSDF. In addition, the adequacy of existing SWM structures to convey the 25-year, 24-hour storm event is assessed. Required modifications or additions to existing structures are incorporated into the Construction Drawings. This section presents the selection of parameters used to perform analyses in the Calculation Section of this calculation package.

HYDROLOGIC AND BASIN ROUTING ANALYSES [HydroCad™, 2001]

Subcatchment Runoff

For both design scenarios and both design cases, the relationships of subcatchments, reaches, and basins are shown in the nodal network diagrams presented in Attachment A-8.

Rainfall Distribution

A SCS Type II Rainfall Distribution is selected for the Fernald site location. Attachment B-1 shows the location of the OSDF on a rainfall distribution map of the United States [SCS, 1986].

Rainfall Depth

Attachment B-2 [Parsons, 1995] provides rainfall depths for design storms of 24-hour duration for the Fernald site. The rainfall depths for use in these analyses are listed below.

Return Period (years)	Rainfall Depth (inches)
2	2.6
10	4.1
25	4.7
100	5.6

Runoff curve numbers

Subcatchment characteristics including total area and data for calculation of weighted CN are tabulated for each design scenario and design case in Attachment B-3. Data includes the percentage of subcatchment area for combinations of HSG, CN, and land use for each subcatchment.

Subcatchment Time of Concentration

Subcatchment characteristics for calculation of time of concentration are tabulated in Attachment B-4. Parameters include those for sheet, shallow concentrated, pipe, and channel flow.

Reaches

Channels

For the purpose of hydrologic modeling, the Manning's roughness coefficient for all channels, both grass and riprap (permanent channels along OSDF perimeter) lined, is selected as 0.030. Similarly, representative average geometric characteristics (i.e., sideslopes, width, longitudinal slope) were selected. Data for additional channel parameters are tabulated in Attachment B-5.

Culverts

The Manning's roughness coefficients for annular CMP, RCP, PVC, CMPA and HDPE culverts are selected as 0.024, 0.013, 0.010, 0.018, and 0.010 respectively. For new culverts, which will be helically corrugated CMP, a Manning's roughness coefficient of 0.017, 0.018,

0.019, and 0.020 for equivalent diameters of 30, 36, 42, and 48 inches, respectively are selected [American Iron and Steel Institute, 1994].

Sedimentation Basins

Planimetered areas within contour elevation lines (for calculation of the stage-storage relationship) are presented in Attachment B-7. Coefficients for principal and emergency spillways are selected as follows and input into the HydroCAD™ models.

Principal Spillway Riser Pipes

- Discharge coefficient for orifice flow, C = 0.60

Principal Spillway Outlet Pipes

- Manning's roughness coefficient, n = 0.024 (for CMP)
- Entrance energy loss coefficient, Ke = 0.7
- Contraction coefficient, Cc = 0.9

OSDF Basin 2 Emergency Spillway

- Type, shape = broad crested weir, rectangular (approximation)
- Weir coefficient (English units), C = 3.0 [Stahre and Urbonas, 1990]

Borrow Area Sedimentation Basin Emergency Spillway

- Type, shape = broad crested weir, rectangular (approximation)
- Weir coefficient (English units), C = 3.0 [Stahre and Urbonas, 1990]

Additional data concerning the size, shapes, and elevations of the principal and emergency spillways are tabulated in Attachment B-8.

HYDRAULIC ANALYSES

Channels

Data for channel segments are obtained from the Construction Drawings and are presented in Attachment B-5. The Manning's roughness coefficient for all channels (grass-lined) is selected as 0.030 [Chow, 1959].

Culverts

Input data for culverts includes: (i) physical characteristics; (ii) CulvertMaster® modeling characteristics; and (iii) profile. Physical characteristics and profile data were obtained from the following sources: (i) as-built drawings; (ii) inspection by GeoSyntec or Fluor Fernald personnel; (iii) existing maps showing topography and features; (iv) optical survey; and (v) site utility plans. Available thickness of cover for each culvert is obtained from the Construction Drawings and presented along with input data for hydraulic analyses in Attachment B-6.

REFERENCES

American Iron and Steel Institute. *Handbook of Steel Drainage & Highway Construction Products*, American Iron and Steel Institute, Washington, D.C., 1994.

Chow, V.T. *Open Channel Hydraulics*, McGraw-Hill, Inc., New York, 1959, 680 p.

HydroCAD. *HydroCAD™: Stormwater Modeling System, Version 6.0.* Applied Microcomputer Systems, Chocorua, New Hampshire, 2001.

Parsons. *2000-Year Peak Water and Probable Maximum Peak Water, Site-Wide Peak Water Plain Determination*, Parsons Engineering, Revision A, Aug 1995.

Stahre, P. and Urbonas, B. *Stormwater Detention*, Prentice Hall, Englewood Cliffs, New Jersey, 1990, 338 p.

U.S. Department of Agriculture (USDA-SCS). *Urban Hydrology for Small Watersheds, Technical Release 55.* 2nd ed., Soil Conservation Service Washington, D.C., 1986.

ATTACHMENT B-1

SCS RAINFALL DISTRIBUTION TYPE

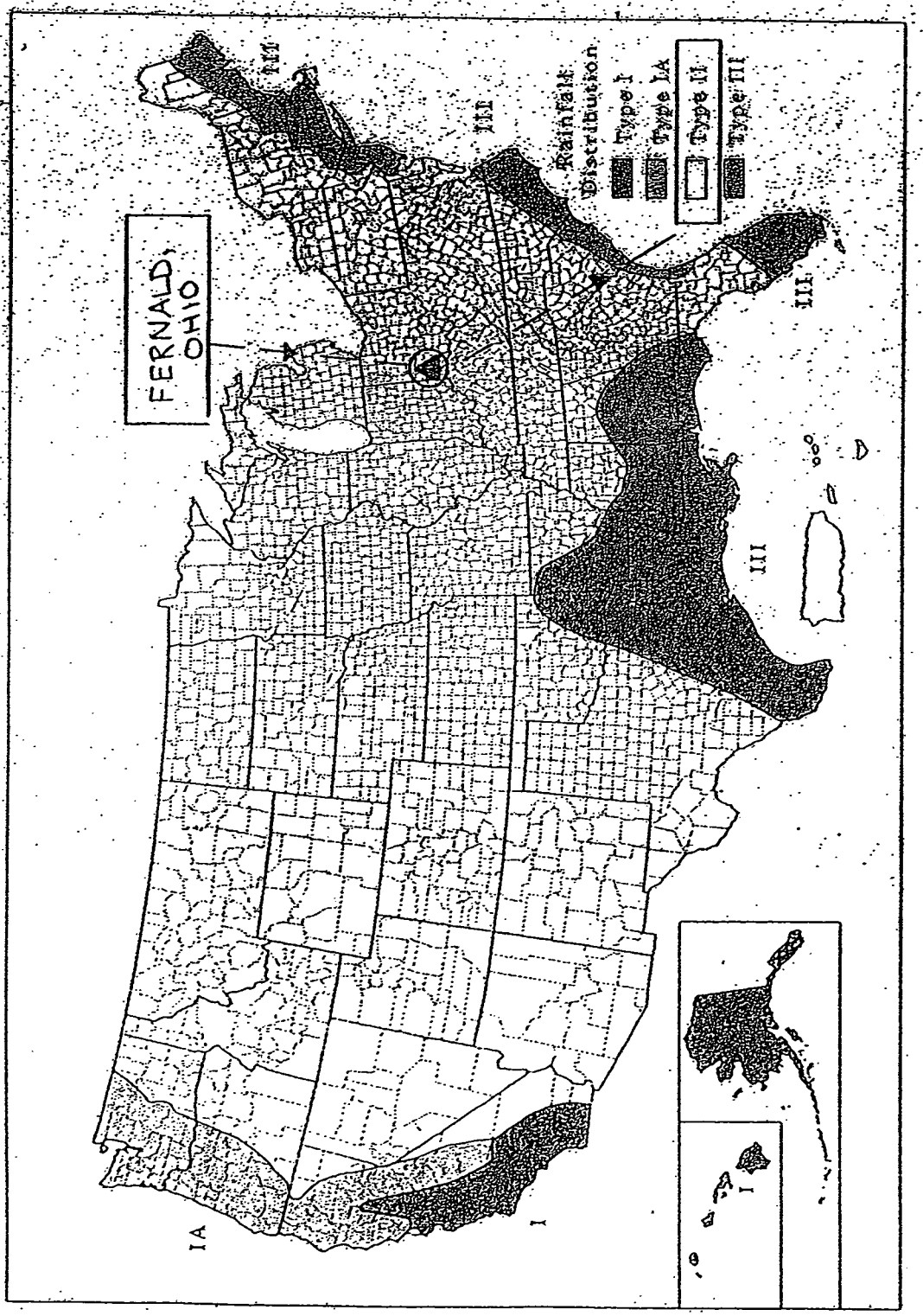

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions

ATTACHMENT B-2

RAINFALL DEPTHS

TABLE 1 - RAINFALL DEPTH FOR A GIVEN DURATION
(INCHES)

DURATION (YEARS)	TIME							
	HYDRO-35			TP-40				
	5 MIN	15 MIN	60 MIN	2 HOURS	3 HOURS	6 HOURS	12 HOURS	24 HOURS
2	0.387	0.739	1.223	1.408	1.54	1.848	2.2	2.552
5	0.49	0.979	1.69	2.016	2.112	2.496	2.88	3.072
10	0.564	1.139	1.99	2.277	2.475	3.069	3.465	4.059
25	0.65	1.34	2.38	2.6	3.0	3.4	4.0	4.7
50	0.72	1.49	2.67	3.0	3.25	3.9	4.2	5.2
• 100	0.78	1.64	2.95	3.3	3.6	4.1	5.0	5.6
• 500	0.93	2.1	4.3	5.2	5.9	7.3	8.5	9.4
2000	1.2	2.6	5.8	7.2	8.2	10.2	12.0	13.0
10,000	1.4	3.4	8.2	10.5	12.0	15.5	18.0	19.2
100,000	1.9	5.0	13.3	17.7	20.8	27.4	31.8	33.4
	DESIGN OF SMALL DAMS					HMR-51		

NOTE: Rainfall Points for 2, 5, and 10 year rainfall events were adjusted per TP-40. Values for the 500, 2000, and 10,000 Year Events were interpolated from Figure 3 (Appendix E)

• These Values are used on PH records for HEC-1.

Reference: Parsons, "2,000-Year Flood and Probable Maximum Flood, Sitewide Flood Plan Determination", August 1995.

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

ATTACHMENT B-3

SUBCATCHMENT AREA AND WEIGHTED CURVE NUMBER DATA

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

East OSDF Construction Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.96	100%	B/C	vegetated final cover	83	
B	1.18	100%	B/C	vegetated final cover	83	
C	5.21	100%	B/C	vegetated final cover	83	
D	5.13	100%	B/C	vegetated final cover	83	
E	5.09	100%	B/C	vegetated final cover	83	
F	5.05	100%	B/C	vegetated final cover	83	
G	5.31	100%	B/C	vegetated final cover	83	
HR	4.59	100%	B/C	unvegetated final cover	89	
IR	0.60	100%	B/C	unvegetated final cover	89	
JR	2.52	100%	B/C	unvegetated final cover	89	
K1R	0.38	100%	C	construction laydown	82	
K2R	0.53	65% 35%	B C	construction laydown construction laydown	74 82	
L	1.68	30% 70%	B C	runon north of borrow area runon north of borrow area	69 79	
M	1.00	100%	C	runon north of borrow area	79	
N	7.82	100%	N/A	direct runos to pond	98	
O	1.32	100%	C	runon north of borrow area	79	
P	5.24	45% 55%	B C	runon north of borrow area runon north of borrow area	69 79	
Q	7.70	70% 30%	B C	runon north of borrow area runon north of borrow area	69 79	
R	2.61	55% 45%	B C	runon north of borrow area runon north of borrow area	69 79	
S	0.40	10% 90%	B C	runon north of borrow area runon north of borrow area	69 79	
TR	0.04	100%	C	construction laydown	82	
U	4.15	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
V	0.27	100%	N/A	direct runon to pond	98	
W	10.59	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
X	11.85	80% 20%	B C	runon east of OSDF runon east of OSDF	69 79	
Y	6.52	60% 40%	B C	runon east of OSDF runon east of OSDF	69 79	
Z	1.61	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
AA	2.71	55% 45%	B C	runon east of OSDF runon east of OSDF	69 79	
BB	0.76	100%	C	runon east of OSDF	79	
CC	0.12	100%	C	runon east of OSDF	79	
DDR	0.86	100%	B/C	unvegetated final cover	89	
EE	0.93	20% 80%	B C	runon north of borrow area runon north of borrow area	69 79	
FFR	2.41	100%	B/C	unvegetated final cover	89	
GGR	2.35	55% 45%	B C	construction laydown construction laydown	74 82	
HH	0.55	100%	C	runon north of borrow area	79	
II	1.67	50% 50%	B C	runon area to borrow area runon area to borrow area	61 74	
JJ	0.91	93% 7%	B C	runon area to borrow area runon area to borrow area	61 74	
KK	5.89	80% 20%	B C	runon area to borrow area runon area to borrow area	61 74	
LL	7.05	100%	B	runoff	61	
MM	1.94	100%	B	runoff	61	
NN	1.27	60% 40%	B C	runoff runoff	61 74	
OO	0.40	65% 35%	B C	runon area to borrow area runon area to borrow area	61 74	
PP	40.96	80% 20%	B C	vegetated borrow area vegetated borrow area	61 74	

Is intentionally left blank. Is addressed in the calculation section.

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

East OSDF Post Development Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.96	100%	B/C	vegetated final cover	74	Intentionally left blank. is addressed in the calculation section.
B	1.18	100%	B/C	vegetated final cover	74	
C	5.21	100%	B/C	vegetated final cover	74	
D	5.13	100%	B/C	vegetated final cover	74	
E	5.09	100%	B/C	vegetated final cover	74	
F	5.05	100%	B/C	vegetated final cover	74	
G	5.31	100%	B/C	vegetated final cover	74	
HR	4.59	100%	B/C	vegetated final cover	74	
IR	0.60	100%	B/C	vegetated final cover	74	
JR	2.52	100%	B/C	vegetated final cover	74	
K1R	0.38	100%	C	grass area	74	
K2R	0.53	65% 35%	B C	grass area grass area	61 74	
L	1.68	30% 70%	B C	runon north of borrow area runon north of borrow area	69 79	
M	1.00	100%	C	runon north of borrow area	79	
N	7.82	100%	N/A	direct runon to pond	98	
O	1.37	100%	C	runon north of borrow area	79	
P	5.24	45% 55%	B C	runon north of borrow area runon north of borrow area	69 79	
Q	7.70	70% 30%	B C	runon north of borrow area runon north of borrow area	69 79	
R	2.61	55% 45%	B C	runon north of borrow area runon north of borrow area	69 79	
S	0.40	10% 90%	B C	runon north of borrow area runon north of borrow area	69 79	
TR	0.04	100%	C	grass area	74	
U	4.15	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
V	0.27	100%	N/A	direct runon to pond	98	
W	10.59	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
X	11.85	80% 20%	B C	runon east of OSDF runon east of OSDF	69 79	
Y	6.52	60% 40%	B C	runon east of OSDF runon east of OSDF	69 79	
Z	1.61	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	
AA	2.71	55% 45%	B C	runon east of OSDF runon east of OSDF	69 79	
BB	0.26	100%	C	runon east of OSDF	79	
CC	0.12	100%	C	runon east of OSDF	79	
DDR	0.86	100%	B/C	vegetated final cover	74	
EE	0.93	20% 80%	B C	runon north of borrow area runon north of borrow area	69 79	
FFR	2.41	100%	B/C	vegetated final cover	74	
GGR	2.35	55% 45%	B C	grass area grass area	61 74	
HH	0.55	100%	C	runon north of borrow area	79	
II	1.67	50% 50%	B C	runon area to borrow area runon area to borrow area	61 74	
JJ	0.91	93% 7%	B C	runon area to borrow area runon area to borrow area	61 74	
KK	5.89	80% 20%	B C	runon area to borrow area runon area to borrow area	61 74	
LL	7.05	100%	B	borrow area runoff	61	
MM	1.94	100%	B	borrow area runoff	61	
NN	1.37	60% 40%	B C	borrow area runoff borrow area runoff	61 74	
OO	0.40	65% 35%	B C	runon area to borrow area runon area to borrow area	61 74	
PP	40.96	80% 20%	B C	vegetated borrow area vegetated borrow area	61 74	

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

West OSDF Construction Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	83	Intentionally left blank. Is addressed in the calculation section.
B	5.34	100%	B/C	vegetated final cover	83	
C	5.40	100%	B/C	vegetated final cover	83	
D	5.53	100%	B/C	vegetated final cover	83	
ER	5.32	100%	B/C	unvegetated final cover	89	
F1R	0.92	100%	B/C	unvegetated final cover	89	
F2R	1.55	100%	B/C	unvegetated final cover	89	
FR	1.85	100%	B/C	unvegetated final cover	89	
GR	0.37	72% 28%	B/C C	unvegetated final cover runon north of borrow area	89 79	
HR	0.09	100%	B/C	runon north of borrow area	79	
J1R	0.31	100%	C	construction laydown	82	
J2R	0.85	100%	C	construction laydown	82	
KR	2.37	38% 62%	C B/C	runon north of borrow area unvegetated final cover	79 89	
LR	2.29	100%	C	construction laydown	82	
MR	0.68	100%	C	runon north of borrow area	79	
N	1.04	100%	C	construction laydown	82	
O	2.25	100%	N/A	direct runon to pond	98	
P1R	0.67	100%	C	construction laydown	82	
P2R	0.21	100%	C	construction laydown	82	
QN	0.13	100%	C	runon north of borrow area	79	

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

West OSDF Post Development Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	74	Intentionally left blank. Is addressed in the calculation section.
B	5.34	100%	B/C	vegetated final cover	74	
C	5.40	100%	B/C	vegetated final cover	74	
D	5.53	100%	B/C	vegetated final cover	74	
ER	5.32	100%	B/C	vegetated final cover	74	
F1R	0.92	100%	B/C	vegetated final cover	74	
F2R	1.55	100%	B/C	vegetated final cover	74	
FR	1.85	100%	B/C	vegetated final cover	74	
GR	0.37	72% 28%	B/C C	vegetated final cover runon north of borrow area	74 79	
HR	0.09	100%	B/C	runon north of borrow area	79	
J1R	0.31	100%	C	grass area	74	
J2R	0.85	100%	C	grass area	74	
KR	2.37	38% 62%	C B/C	runon north of borrow area vegetated final cover	79 74	
LR	2.29	100%	C	grass area	74	
MR	0.68	100%	C	runon north of borrow area	79	
N	1.04	100%	C	grass area	74	
O	2.25	100%	N/A	direct runon to pond	98	
P1R	0.67	100%	C	grass area	74	
P2R	0.21	100%	C	grass area	74	
QN	0.13	100%	C	runon north of borrow area	79	

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

Design Case "A"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.93	100%	B/C	liner runout	89	Intentionally left blank. Is addressed in the calculation section.
B	0.88	100%	C	construction laydown	82	
C	0.71	100%	C	construction laydown	82	
D	0.65	100%	C	construction laydown	82	
E	1.29	100%	C	construction laydown	82	
F	0.34	100%	C	construction laydown	82	
G	1.86	100%	C	construction laydown	82	
H	0.65	60% 40%	C C	pavement construction laydown	98 82	

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

Design Case "B"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	5.13	100%	B/C	non vegetated final cover	89	Is intentionally left blank. Is addressed in the calculation section.
B	5.09	100%	B/C	non vegetated final cover	89	
C	1.19	100%	B/C	subgrade	87	
D	1.19	100%	B/C	subgrade	87	
E	1.76	100%	B/C	subgrade	87	
F1	0.24	100%	C	construction support	82	
F2	0.51	100%	C	construction support	82	
G	2.19	100%	B/C	subgrade	87	
H	0.50	50% 50%	C B/C	construction support subgrade	82 87	
I	1.45	100%	C	construction support	82	
J	0.74	100%	C	construction support	82	
K	1.96	100%	B/C	vegetated final cover	83	
L	1.68	100%	B/C	vegetated final cover	83	
M	1.18	100%	B/C	vegetated final cover	83	

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

Design Case "C"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	83	Intentionally left blank. Is addressed in the calculation section.
B	5.34	100%	B/C	vegetated final cover	83	
C	5.40	100%	B/C	vegetated final cover	83	
D	5.53	100%	B/C	non vegetated final cover	89	

N/A - Not Applicable

ATTACHMENT B-4

DATA FOR CALCULATION OF TIME OF CONCENTRATION

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
EAST OSDF POST DEVELOPMENT DESIGN SCENARIO

2-year, 24-hr Design Rainfall Depth, $P_{5,24}$ = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW 1			SHALLOW CONCENTRATED FLOW 2			SHALLOW CONCENTRATED FLOW 3			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	80	UNPAVED	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	VEGETATED FINAL COVER	50	GRASS: SHORT	0.150	0.1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450	0	1.02	6.0, 3.0	0.030	0.0045	-	-	-	-	-	-
C	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	400	0	1.02	6.0, 4.0	0.030	0.0045	-	-	-	-	-	-
D	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	250	0	1.29	5.0, 3.0	0.030	0.0045	150	0	1.59	4.0, 3.0	0.030	0.0050
E	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	380	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
F	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	390	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
G	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	410	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
HR	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	50	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	160	UNPAVED	0.1700	-	-	-	-	-	-	400	0	5.70	6.0, 3.0	0.030	0.0100	-	-	-	-	-	-
IR	VEGETATED FINAL COVER	150	GRASS: SHORT	0.150	0.1500	-	-	-	-	-	-	-	-	220	UNPAVED	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JR	VEGETATED FINAL COVER	80	GRASS: SHORT	0.150	0.0176	60	GRASS: SHORT	0.150	0.0830	150	GRASS: SHORT	0.150	0.1700	190	UNPAVED	0.1700	-	-	-	-	-	-	80	10.12	3.85	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
K1R	OPEN SPACE WITH GOOD GRASS COVER	33	GRASS: SHORT	0.150	0.0160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2R	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0110	-	-	-	-	-	-	-	-	13	UNPAVED	0.0110	-	-	-	-	-	-	200	10	2.00	3.0, 3.0	0.030	0.0045	-	-	-	-	-	-
L	OPEN SPACE WITH GOOD GRASS COVER	140	GRASS: SHORT	0.150	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	290	0	2.00	3.0, 3.0	0.030	0.0075	-	-	-	-	-	-
M	OPEN SPACE WITH GOOD GRASS COVER	170	GRASS: SHORT	0.150	0.0500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	20	2.50	3.0, 3.0	0.030	0.0045	-	-	-	-	-	-
N	DIRECT RUNON TO POND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O	OPEN SPACE WITH GOOD GRASS COVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	230	0	1.00	5.0, 5.0	0.030	0.0086	-	-	-	-	-	-
P	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0150	-	-	-	-	-	-	-	-	350	UNPAVED	0.0070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Q	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0260	-	-	-	-	-	-	-	-	1280	UNPAVED	0.0260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0400	-	-	-	-	-	-	-	-	350	UNPAVED	0.0400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	OPEN SPACE WITH GOOD GRASS COVER	280	GRASS: SHORT	0.150	0.0150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	0	3.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
TR	OPEN SPACE WITH GOOD GRASS COVER	40	GRASS: SHORT	0.150	0.0460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0140	-	-	-	-	-	-	-	-	240	UNPAVED	0.0140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	DIRECT RUNON TO POND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.1780	-	-	-	-	-	-	-	-	400	UNPAVED	0.1780	-	-	-	-	-	-	270	0	3.00	3.0, 30.0	0.030	0.0144	-	-	-	-	-	-
X	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0190	-	-	-	-	-	-	-	-	730	UNPAVED	0.0190	-	-	-	-	-	-	330	0	2.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
Y	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0130	-	-	-	-	-	-	-	-	510	UNPAVED	0.0130	-	-	-	-	-	-	340	0	2.00	5.0, 4.0	0.030	0.0110	-	-	-	-	-	-
Z	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0310	-	-	-	-	-	-	-	-	250	UNPAVED	0.0310	-	-	-	-	-	-	50	0	2.00	5.0, 4.0	0.030	0.0070	-	-	-	-	-	-
AA	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	170	UNPAVED	0.0800	-	-	-	-	-	-	300	0	2.00	3.0, 3.0	0.030	0.0070	-	-	-	-	-	-
BB	OPEN SPACE WITH GOOD GRASS COVER	110	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	360	0	1.50	3.0, 5.0	0.030	0.0040	-	-	-	-	-	-
CC	OPEN SPACE WITH GOOD GRASS COVER	110	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDR	VEGETATED FINAL COVER	150	GRASS: SHORT	0.150	0.1500	-	-	-	-	-	-	-	-	330	UNPAVED	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EE	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0230	-	-	-	-	-	-	-	-	80	UNPAVED	0.0230	-	-	-	-	-	-	40	0	4.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
FFR	VEGETATED FINAL COVER	85	GRASS: SHORT	0.150	0.0500	50	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	160	UNPAVED	0.1700	-	-	-	-	-	-	365	0	5.49	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
GGR	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0200	-	-	-	-	-	-	-	-	290	UNPAVED	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HH	OPEN SPACE WITH GOOD GRASS COVER	90	GRASS: SHORT	0.150	0.0100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	230	20	2.50	3.0, 3.0	0.030	0.0045	-	-	-	-	-	-
II	OPEN SPACE WITH GOOD GRASS COVER	210	GRASS: SHORT	0.150	0.0400	-	-	-	-	-	-	-	-	70	UNPAVED	0.1660	380	UNPAVED	0.0025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JJ	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0250	-	-	-	-	-	-	-	-	40	UNPAVED	0.0250	110	UNPAVED	0.1660	840	UNPAVED	0.0025	-	-	-	-	-	-	-	-	-	-	-	-
KK	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0280	-	-	-	-	-	-	-	-	150	UNPAVED	0.0140	110	UNPAVED	0.1660	630	UNPAVED	0.0030	-	-	-	-	-	-	-	-	-	-	-	-
LL	OPEN SPACE WITH GOOD GRASS COVER	300	GRASS: SHORT	0.150	0.0240	-	-	-	-	-	-	-	-	200	UNPAVED	0.0240	-	-		-	-	-	900	0	3.00	3.0, 3.0	0.030	0.0090	-	-	-	-	-	-
MM	OPEN SPACE WITH GOOD GRASS COVER	100	GRASS: SHORT	0.150	0.0700	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	980	0	3.00	5.0, 4.0	0.030	0.0060	-	-	-	-	-	-
NN	OPEN SPACE WITH GOOD GRASS COVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	600	0	3.00	3.0, 3.0	0.030	0.0130	-	-	-	-	-	-
OO	OPEN SPACE WITH GOOD GRASS COVER	120	GRASS: SHORT	0.150	0.1660	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PP	OPEN SPACE WITH GOOD GRASS COVER	150	GRASS: SHORT	0.150	0.1660	150	GRASS: SHORT	0.150	0.0025	-	-	-	-	1190	UNPAVED	0.0025	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
EAST OSDF CONSTRUCTION DESIGN SCENARIO

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	80	UNPAVED	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	VEGETATED FINAL COVER	50	GRASS: SHORT	0.150	0.1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450	0	1.02	6.0, 3.0	0.030	0.0045	-	-	-	-	-	-
C	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	400	0	1.02	6.0, 4.0	0.030	0.0045	-	-	-	-	-	-
D	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	250	0	1.29	5.0, 3.0	0.030	0.0045	150	0	1.59	4.0, 3.0	0.030	0.0050
E	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	380	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
F	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	390	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
G	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	410	0	1.60	4.0, 3.0	0.030	0.0050	-	-	-	-	-	-
HR	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	50	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	160	UNPAVED	0.1700	-	-	-	-	-	-	400	0	5.70	6.0, 3.0	0.030	0.0100	-	-	-	-	-	-
IR	NON VEGETATED FINAL COVER	150	SMOOTH	0.011	0.1500	-	-	-	-	-	-	-	-	220	UNPAVED	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JR	NON VEGETATED FINAL COVER	80	SMOOTH	0.011	0.0176	60	SMOOTH	0.011	0.0830	150	SMOOTH	0.011	0.1700	190	UNPAVED	0.1700	-	-	-	-	-	-	80	10.12	3.85	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
K1R	CONSTRUCTION LAYDOWN	33	GRASS: SHORT	0.150	0.0160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2R	CONSTRUCTION LAYDOWN	300	GRASS: SHORT	0.150	0.0110	-	-	-	-	-	-	-	-	23	UNPAVED	0.0110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	RUNON NORTH OF BORROW AREA	140	GRASS: SHORT	0.150	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	290	0	2.00	3.0, 3.0	0.030	0.0075	-	-	-	-	-	-
M	RUNON NORTH OF BORROW AREA	170	GRASS: SHORT	0.150	0.0500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	20	2.50	3.0, 3.0	0.030	0.0045	-	-	-	-	-	-
N	DIRECT RUNON TO POND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O	RUNON NORTH OF BORROW AREA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	230	0	1.00	5.0, 5.0	0.030	0.0086	-	-	-	-	-	-
P	RUNON NORTH OF BORROW AREA	300	GRASS: SHORT	0.150	0.0150	-	-	-	-	-	-	-	-	350	UNPAVED	0.0070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Q	RUNON NORTH OF BORROW AREA	300	GRASS: SHORT	0.150	0.0260	-	-	-	-	-	-	-	-	1280	UNPAVED	0.0260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R	RUNON NORTH OF BORROW AREA	300	GRASS: SHORT	0.150	0.0400	-	-	-	-	-	-	-	-	350	UNPAVED	0.0400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	RUNON NORTH OF BORROW AREA	280	GRASS: SHORT	0.150	0.0150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	0	3.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
TR	CONSTRUCTION LAYDOWN	40	GRASS: SHORT	0.150	0.0460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U	RUNON EAST OF OSDF	300	GRASS: SHORT	0.150	0.0140	-	-	-	-	-	-	-	-	240	UNPAVED	0.0140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	DIRECT RUNON TO POND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W	RUNON EAST OF OSDF	300	GRASS: SHORT	0.150	0.1780	-	-	-	-	-	-	-	-	400	UNPAVED	0.1780	-	-	-	-	-	-	270	0	3.00	3.0, 30.0	0.030	0.0144	-	-	-	-	-	-
X	RUNON EAST OF OSDF	300	GRASS: SHORT	0.150	0.0190	-	-	-	-	-	-	-	-	730	UNPAVED	0.0190	-	-	-	-	-	-	330	0	2.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
Y	RUNON EAST OF OSDF	300	GRASS: SHORT	0.150	0.0130	-	-	-	-	-	-	-	-	510	UNPAVED	0.0130	-	-	-	-	-	-	340	0	2.00	5.0, 4.0	0.030	0.0110	-	-	-	-	-	-
Z	RUNON EAST OF OSDF	300	GRASS: SHORT	0.150	0.0310	-	-	-	-	-	-	-	-	250	UNPAVED	0.0310	-	-	-	-	-	-	50	0	2.00	5.0, 4.0	0.030	0.0070	-	-	-	-	-	-
AA	RUNON AREA EAST OF OSDF	300	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	170	UNPAVED	0.0800	-	-	-	-	-	-	300	0	2.00	3.0, 3.0	0.030	0.0070	-	-	-	-	-	-
BB	RUNON AREA EAST OF OSDF	110	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	360	0	1.50	3.0, 5.0	0.030	0.0040	-	-	-	-	-	-
CC	RUNON AREA EAST OF OSDF	110	GRASS: SHORT	0.150	0.0800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDR	NON VEGETATED FINAL COVER	150	SMOOTH	0.011	0.1500	-	-	-	-	-	-	-	-	330	UNPAVED	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EE	RUNON NORTH OF BORROW AREA	300	GRASS: SHORT	0.150	0.0230	-	-	-	-	-	-	-	-	80	UNPAVED	0.0230	-	-	-	-	-	-	40	0	4.00	3.0, 3.0	0.030	0.0100	-	-	-	-	-	-
FFR	NON VEGETATED FINAL COVER	85	SMOOTH	0.011	0.0500	50	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	160	UNPAVED	0.1700	-	-	-	-	-	-	365	0	5.49	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
GGR	CONSTRUCTION LAYDOWN	300	GRASS: SHORT	0.150	0.0200	-	-	-	-	-	-	-	-	290	UNPAVED	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HH	RUNON NORTH OF BORROW AREA	90	GRASS: SHORT	0.150	0.0100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	230	20	2.50	3.0, 3.0	0.030	0.0045	-	-	-	-	-	-
II	RUNON AREA TO BORROW AREA	210	GRASS: SHORT	0.150	0.0400	-	-	-	-	-	-	-	-	70	UNPAVED	0.1660	380	UNPAVED	0.0025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JJ	RUNON AREA TO BORROW AREA	300	GRASS: SHORT	0.150	0.0250	-	-	-	-	-	-	-	-	40	UNPAVED	0.0250	110	UNPAVED	0.1660	840	UNPAVED	0.0025	-	-	-	-	-	-	-	-	-	-	-	-
KK	RUNON AREA TO BORROW AREA	300	GRASS: SHORT	0.150	0.0280	-	-	-	-	-	-	-	-	150	UNPAVED	0.0140	110	UNPAVED	0.1660	630	UNPAVED	0.0030	-	-	-	-	-	-	-	-	-	-	-	-
LL	RUNOFF	300	GRASS: SHORT	0.150	0.0240	-	-	-	-	-	-	-	-	200	UNPAVED	0.0240	-	-	-	-	-	-	900	0	3.00	3.0, 3.0	0.030	0.0090	-	-	-	-	-	-
MM	RUNOFF	100	GRASS: SHORT	0.150	0.0700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	980	0	3.00	5.0, 4.0	0.030	0.0060	-	-	-	-	-	-
NN	RUNOFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	0	3.00	3.0, 3.0	0.030	0.0130	-	-	-	-	-	-
OO	RUNON AREA TO BORROW AREA	120	GRASS: SHORT	0.150	0.1660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PP	VEGETATED BORROW AREA	150	GRASS: SHORT	0.150	0.1660	150	GRASS: SHORT	0.150	0.0025	-	-	-	-	1190	UNPAVED	0.0025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
WEST OSDF CONSTRUCTION DESIGN SCENARIO

2-year, 24-hr Design Rainfall Depth, $P_{2,24}$ = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW 1			SHALLOW CONCENTRATED FLOW 2			CHANNEL FLOW 1						PIPE FLOW				CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Diameter (inch)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	190	UNPAVED	0.1700	-	-	-	180	0	2.00	3.0, 6.0	0.030	0.0075	-	-	-	-	-	-	-	-	-	-
B	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	200	0	4.00	6.0, 2.0	0.030	0.0075
C	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075
D	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	205	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075
ER	NON VEGETATED FINAL COVER	110	SMOOTH	0.011	0.0625	45	SMOOTH	0.011	0.1110	150	SMOOTH	0.011	0.1700	200	UNPAVED	0.1700	-	-	-	510	0	3.50	3.0, 6.0	0.030	0.0075	85	72	0.013	0.0029	-	-	-	-	-	-
F1R	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0530	50	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1670	200	UNPAVED	0.1670	-	-	-	160	0	3.50	3.0, 6.0	0.030	0.0075	53	72	0.013	0.0580	-	-	-	-	-	-
F2R	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	55	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1667	200	UNPAVED	0.1670																			
FR	NON VEGETATED FINAL COVER	30	SMOOTH	0.011	0.0500	55	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1670	180	UNPAVED	0.1700	30	UNPAVED	0.3300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GR	NON VEGETATED FINAL COVER/ RUNON NORTH OF BORROW AREA	150	SMOOTH	0.011	0.1670	-	-	-	-	-	-	-	-	270	UNPAVED	0.1670	60	UNPAVED	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HR	RUNON NORTH OF BORROW AREA	80	GRASS: SHORT	0.150	0.0180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J1R	CONSTRUCTION LAYDOWN	54	GRASS: SHORT	0.150	0.1670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J2R	CONSTRUCTION LAYDOWN	72	GRASS: SHORT	0.150	0.0427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KR	NON VEGETATED FINAL COVER/ RUNON NORTH OF BORROW AREA	70	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	-	-	-	-	155	UNPAVED	0.1700	95	UNPAVED	0.0180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR	CONSTRUCTION LAYDOWN	300	GRASS: SHORT	0.150	0.0167	-	-	-	-	-	-	-	-	65	UNPAVED	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MR	RUNON NORTH OF BORROW AREA	40	GRASS: SHORT	0.150	0.0985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	CONSTRUCTION LAYDOWN	170	GRASS: SHORT	0.150	0.0250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O	DIRECT RUNON TO POND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P1R	CONSTRUCTION LAYDOWN	80	GRASS: SHORT	0.150	0.0385	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P2R	CONSTRUCTION LAYDOWN	110	GRASS: SHORT	0.150	0.0473	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QN	RUNON NORTH OF BORROW AREA	100	GRASS: SHORT	0.150	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
WEST OSDF POST DEVELOPMENT DESIGN SCENARIO

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW 1			SHALLOW CONCENTRATED FLOW 2			CHANNEL FLOW 1						PIPE FLOW				CHANNEL FLOW 2					
		Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Diameter (inch)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
No.	Description																																		
A	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	190	UNPAVED	0.1700	-	-	-	180	0	2.00	3.0, 6.0	0.030	0.0075	-	-	-	-	-	-	-	-	-	-
B	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	200	0	4.00	6.0, 2.0	0.030	0.0075
C	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075
D	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	205	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075
ER	VEGETATED FINAL COVER	110	GRASS: SHORT	0.150	0.0625	45	GRASS: SHORT	0.150	0.1110	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	510	0	3.50	3.0, 6.0	0.030	0.0075	85	72	0.013	0.0029	-	-	-	-	-	-
F1R	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0530	50	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1670	200	UNPAVED	0.1670	-	-	-	160	0	3.50	3.0, 6.0	0.030	0.0075	53	72	0.013	0.0580	-	-	-	-	-	-
F2R	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	55	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1667	200	UNPAVED	0.1670																			
FR	VEGETATED FINAL COVER	30	GRASS: SHORT	0.150	0.0500	55	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1670	180	UNPAVED	0.1700	30	UNPAVED	0.3300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GR	VEGETATED FINAL COVER/ RUNON NORTH OF BORROW AREA	150	GRASS: SHORT	0.150	0.1670	-	-	-	-	-	-	-	-	270	UNPAVED	0.1670	60	UNPAVED	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HR	RUNON NORTH OF BORROW AREA	80	GRASS: SHORT	0.150	0.0180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J1R	GRASS AREA	54	GRASS: SHORT	0.150	0.1670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J2R	GRASS AREA	72	GRASS: SHORT	0.150	0.0427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KR	VEGETATED FINAL COVER/ RUNON NORTH OF BORROW AREA	70	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	-	-	-	-	155	UNPAVED	0.1700	95	UNPAVED	0.0180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR	GRASS AREA	300	GRASS: SHORT	0.150	0.0167	-	-	-	-	-	-	-	-	65	UNPAVED	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MR	RUNON NORTH OF BORROW AREA	40	GRASS: SHORT	0.150	0.0985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	GRASS AREA	170	GRASS: SHORT	0.150	0.0250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O	GRASS AREA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P1R	GRASS AREA	80	GRASS: SHORT	0.150	0.0385	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P2R	GRASS AREA	110	GRASS: SHORT	0.150	0.0473	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QN	RUNON NORTH OF BORROW AREA	100	GRASS: SHORT	0.150	0.0167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
DESIGN CASE "A"

2-year, 24-hr Design Rainfall Depth, $P_{2,24}$ = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHEET FLOW 4				SHALLOW CONCENTRATED FLOW			CHANNEL FLOW					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	LINER RUNOUT	8	SMOOTH	0.011	0.6660	18	SMOOTH	0.011	0.0215	31	SMOOTH	0.011	0.2500	90	SMOOTH	0.011	0.0222	-	-	-	590	0	2.50	3.0, 50.0	0.030	0.0100
B	CONSTRUCTION LAYDOWN	300	GRASS: SHORT	0.150	0.0125	-	-	-	-	-	-	-	-	-	-	-	-	145	UNPAVED	0.0125	-	-	-	-	-	-
C	CONSTRUCTION LAYDOWN	260	GRASS: SHORT	0.150	0.0154	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	CONSTRUCTION LAYDOWN	85	GRASS: SHORT	0.150	0.0500	215	GRASS: SHORT	0.150	0.0136	-	-	-	-	-	-	-	-	30	UNPAVED	0.0136	60	0	1.50	3.0, 3.0	0.030	0.0050
E	CONSTRUCTION LAYDOWN	300	GRASS: SHORT	0.150	0.0133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	CONSTRUCTION LAYDOWN	20	SMOOTH	0.011	0.3750	60	GRASS: SHORT	0.150	0.0500	55	GRASS: SHORT	0.150	0.0600	165	GRASS: SHORT	0.015	0.0161	150	UNPAVED	0.0161	-	-	-	-	-	-
G	CONSTRUCTION LAYDOWN	85	GRASS: SHORT	0.150	0.0235	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	330	0	2.00	4.0, 6.0	0.030	0.0150
H	CONSTRUCTION LAYDOWN/PAVEMENT	165	SMOOTH	0.011	0.0182	115	GRASS: SHORT	0.150	0.0087	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
DESIGN CASE "B"

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	60	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	60	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	170	UNPAVED	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	SUBGRADE	55	SMOOTH	0.011	0.2000	50	SMOOTH	0.011	0.0602	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	SUBGRADE	55	SMOOTH	0.011	0.2000	50	SMOOTH	0.011	0.0602	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	SUBGRADE	55	SMOOTH	0.011	0.2000	50	SMOOTH	0.011	0.0602	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F1	CONSTRUCTION SUPPORT	12	GRASS: SHORT	0.150	0.0100	8	GRASS: SHORT	0.150	0.3300	15	GRASS: SHORT	0.150	0.0180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F2	CONSTRUCTION SUPPORT	12	GRASS: SHORT	0.150	0.0100	14	GRASS: SHORT	0.150	0.3300	21	GRASS: SHORT	0.150	0.0540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G	SUBGRADE	24	SMOOTH	0.011	0.2500	48	SMOOTH	0.011	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	SUBGRADE/CONSTRUCTION SUPPORT	93	GRASS: SHORT	0.150	0.0127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I	CONSTRUCTION SUPPORT	150	GRASS: SHORT	0.150	0.0040	-	-	-	-	-	-	-	-	116	UNPAVED	0.0040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J	CONSTRUCTION SUPPORT	166	GRASS: SHORT	0.150	0.0160	-	-	-	-	-	-	-	-	169	UNPAVED	0.0120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	60	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	80	UNPAVED	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	VEGETATED FINAL COVER	140	GRASS: SHORT	0.150	0.0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	VEGETATED FINAL COVER	50	SMOOTH	0.011	0.1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450	0	1.02	3.0, 6.0	0.030	0.0045	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
DESIGN CASE "C"

2-year, 24-hr Design Rainfall Depth, $P_{2,24}$ = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW 1			SHALLOW CONCENTRATED FLOW 2			CHANNEL FLOW 1						PIPE FLOW				CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Diameter (inch)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	190	UNPAVED	0.1700	-	-	-	180	0	2.00	3.0, 6.0	0.030	0.0075	-	-	-	-	-	-	-	-	-	-
B	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	200	0	4.00	6.0, 2.0	0.030	0.0075
C	VEGETATED FINAL COVER	90	GRASS: SHORT	0.150	0.0500	60	GRASS: SHORT	0.150	0.1000	150	GRASS: SHORT	0.150	0.1700	200	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075
D	NON VEGETATED FINAL COVER	90	SMOOTH	0.011	0.0500	60	SMOOTH	0.011	0.1000	150	SMOOTH	0.011	0.1700	205	UNPAVED	0.1700	-	-	-	190	0	2.00	3.0, 6.0	0.030	0.0075	60	72	0.013	0.0100	195	0	4.00	6.0, 2.0	0.030	0.0075

ATTACHMENT B-5

CHANNEL INPUT DATA

OSDF CONSTRUCTION/FILLING PERIOD CONDITIONS
SUMMARY OF CHANNEL INPUT DATA

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node[3]	HydroCAD Q (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth Y (ft)	Estimated Q (cfs)	Channel Freeboard (ft)	Peak Flow Velocity (fps)	Lining Type
7R	new	E OSDF	vee	6.0	1.00%	0.030	0	6	3	8R	Intentionally left blank. Is addressed in the calculation section.								
8R	new	E OSDF	vee	5.5	0.50%	0.030	0	6	2	9R									
9R	new	E OSDF	trapezoidal	3.8	0.50%	0.030	4.35	6	3	10AR									
10AR	new	E OSDF	trapezoidal	3.9	0.50%	0.030	10.12	6	3	28R									
10BR	new/existing	E OSDF	trapezoidal	2.6	0.29%	0.030	10.21	3	4.6	11									
12R	existing	E OSDF	trapezoidal	2.5	0.63%	0.030	14	3	4.3	12R + HH									
13R	existing	E OSDF	trapezoidal	2.1	0.67%	0.030	23.11	2.3	4	13R									
18	new	E OSDF	vee	3.0	1.00%	0.030	0	3	3	19									
19	new	E OSDF	vee	3.0	0.90%	0.030	0	3	3	20									
20	new	E OSDF	vee	3.0	0.83%	0.030	0	3	3	1P - U - V									
30	new	E OSDF	vee	2.5	1.00%	0.030	0	3	3	30									
21	new	E OSDF	vee	3.0	1.00%	0.030	0	3	3	22									
22	new	E OSDF	vee	4.0	1.00%	0.030	0	3	3	29									
29	new	E OSDF	vee	3.5	1.00%	0.030	0	3	3	23									
24	new	E OSDF	trapezoidal	2.0	0.75%	0.030	8.5	3	3	24									
26	new	E OSDF	vee	2.5	0.75%	0.030	0	3	3	27									
7BR	new	W OSDF	vee	3.77	0.23%	0.030	0	6	2	7BR	Intentionally left blank. Is addressed in the calculation section.								
7DR	existing	W OSDF	trapezoidal	4.7	0.42%	0.030	2.56	4.3	3.9	7DR									
8AR	existing	W OSDF	trapezoidal	3.0	0.48%	0.030	13.28	4.2	2.6	8AR									
8CR	existing	W OSDF	trapezoidal	5.0	1.59%	0.030	1.17	2.4	2.3	8CR									
9AR	new	W OSDF	vee	3.0	2.50%	0.030	0	3	3	9AR									
9R	new	W OSDF	vee	6.0	2.49%	0.030	0	3	3	9R									
10AR	new	W OSDF	trapezoidal	1.8	6.50%	0.030	5	3	3	10AR									
10R	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	3	3	10R									
11AR	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	2.8	3	11AR									
16N	existing	W OSDF	vee	2.9	0.69%	0.030	0	2.2	1.4	16N									
2	existing	DC A	vee	3.0	1.50%	0.030	0	4	6	1 + G	Intentionally left blank. Is addressed in the calculation section.								
5	new	DC A	vee	2.5	0.34%	0.030	0	3	3	5									
6	new	DC A	vee	2.5	0.23%	0.030	0	3	3	6 + D									
7	existing	DC A	vee	2.0	2.00%	0.030	0	4	6	7 + E									
1	existing	DC B	vee	6.5	0.45%	0.030	0	5	3	1	Intentionally left blank. Is addressed in the calculation section.								
2	new	DC B	vee	7.4	0.50%	0.030	0	3	4	2									
3	new	DC B	vee	6.5	0.50%	0.030	0	3	4	3									
4	new	DC B	vee	3	0.50%	0.030	0	3	6	4									
5	new	DC B	vee	3	0.50%	0.030	0	3	6	5									
6A	new	DC B	trapezoidal	2.75	0.50%	0.030	5.73	3.2	6	6A									
6B	new	DC B	trapezoidal	2	0.50%	0.030	7.1	3.2	3.5	6B									
8	new	DC B	trapezoidal	1.28	1.00%	0.030	2	3	5	8									
9	new	DC B	vee	2.5	1.50%	0.030	0	3	3	9									
11	existing	DC B	vee	5	0.45%	0.030	0	6	4	11									
1	new	DC C	vee	4	0.75%	0.030	0	2	6	2	Intentionally left blank. Is addressed in the calculation section.								
2	new	DC C	vee	4	0.75%	0.030	0	2	6	3									
3	new	DC C	vee	4	0.75%	0.030	0	2	6	4									
4	new	DC C	vee	4	0.76%	0.030	0	2	6	5									

E OSDF = East OSDF Construction-Phase Design Scenario
W OSDF = West OSDF Construction-Phase Design Scenario
DC A = Design Case "A"
DC B = Design Case "B"
DC C = Design Case "C"

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from the Drawings.
3. N/A indicates that there is not specific HydroCAD node associated with the particular channel.

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East & West Section B Attachments/rev B5 CF

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OSDF POST DEVELOPMENT PERIOD CONDITIONS
SUMMARY OF CHANNEL INPUT DATA

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations								
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node	HydroCAD Q (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth Y (ft)	Estimated Q (cfs)	Channel Freeboard (ft)	Peak Flow Velocity (fps)	Sufficient to Minimize Sedimentation?	Lining Type
1	existing	E OSDF PD	vee	5	0.45%	0.030	0	6	4	2										
2	existing	E OSDF PD	vee	6.5	0.45%	0.030	0	3	5	3										
3	new	E OSDF PD	vee	7.4	0.50%	0.030	0	3	4	4										
4	new	E OSDF PD	vee	6.5	0.50%	0.030	0	3	4	5										
5	new	E OSDF PD	vee	3	0.50%	0.030	0	3	6	6										
6	new	E OSDF PD	vee	3	1.00%	0.030	0	3	6	7R										
7R	new	E OSDF PD	vee	6.0	1.00%	0.030	0	6	3	8R										
8R	new	E OSDF PD	vee	5.5	0.50%	0.030	0	6	2	9R										
9R	new	E OSDF PD	trapezoidal	3.8	0.50%	0.030	4.35	6	3	10AR										
10AR	new	E OSDF PD	trapezoidal	3.9	0.50%	0.030	10.12	6	3	28R										
10BR	new/existing	E OSDF PD	trapezoidal	2.6	0.29%	0.030	10.21	3	4.6	11										
12R	existing	E OSDF PD	trapezoidal	2.5	0.63%	0.030	14	3	4.3	12R + HH										
13R	existing	E OSDF PD	trapezoidal	2.1	0.67%	0.030	23.11	2.3	4	13R										
14	existing	E OSDF PD	vee	1.5	0.40%	0.030	0	3	5	15										
15	existing	E OSDF PD	vee	2.0	0.63%	0.030	0	3	5	16										
16	existing	E OSDF PD	vee	3.4	0.74%	0.030	0	2.5	5	17										
17	existing	E OSDF PD	vee	3.5	1.25%	0.030	0	4	5	18										
18	new	E OSDF PD	vee	3.0	1.00%	0.030	0	3	3	19										
19	new	E OSDF PD	vee	3.0	0.90%	0.030	0	3	3	20										
20	new	E OSDF PD	vee	3.0	0.83%	0.030	0	3	3	1P - U - V										
30	new	E OSDF PD	vee	2.5	1.00%	0.030	0	3	3	30										
21	new	E OSDF PD	vee	3.0	1.00%	0.030	0	3	3	22										
22	new	E OSDF PD	vee	4.0	1.00%	0.030	0	3	3	29										
29	new	E OSDF PD	vee	3.5	1.00%	0.030	0	3	3	23										
24	new	E OSDF PD	trapezoidal	2.0	0.75%	0.030	8.5	3	3	24										
26	new	E OSDF PD	vee	2.5	0.75%	0.030	0	3	3	27										
1	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	2										
2	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	3										
3	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	4										
4	new	W OSDF PD	vee	4	0.76%	0.030	0	2	6	5										
6	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	7AR										
7BR	new	W OSDF	vee	3.77	0.23%	0.030	0	6	2	7BR										
7DR	existing	W OSDF	trapezoidal	4.7	0.42%	0.030	2.56	4.3	3.9	7DR										
8AR	existing	W OSDF	trapezoidal	3.0	0.48%	0.030	13.28	4.2	2.6	8AR										
8CR	existing	W OSDF	trapezoidal	5.0	1.59%	0.030	1.17	2.4	2.3	8CR										
9AR	new	W OSDF	vee	3.0	2.50%	0.030	0	3	3	9AR										
9R	new	W OSDF	vee	6.0	2.49%	0.030	0	3	3	9R										
10AR	new	W OSDF	trapezoidal	1.8	6.50%	0.030	5	3	3	10AR										
10R	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	3	3	10R										
11AR	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	2.8	3	11AR										
16N	existing	W OSDF	vee	2.9	0.69%	0.030	0	2.2	1.4	16N										

Intentionally left blank. Is addressed in the calculation section.

Intentionally left blank. Is addressed in the calculation section.

E OSDF PD= East OSDF Post Development Design Scenario
W OSDF PD= West OSDF Post Development Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from the Drawings.

000319

132/344
5316

ATTACHMENT B-6

CULVERT INPUT DATA

OSDF CONSTRUCTION/FILLING PERIOD CONDITION

SUMMARY OF CULVERT DESIGN PARAMETERS

CULVERT IDENTIFICATION			PHYSICAL CHARACTERISTICS OF CULVERT						CULVERT PROFILE				CULVERTMASTER® MODELING CHARACTERISTICS			HYDRAULIC CAPACITY					STRUCTURAL CAPACITY				OUTLET PROTECTION				
Culvert Name	Status (1)	Design Scenario	Material - Type	Entrance Loss Coefficient (Ke)	Manning's n	Entrance Configuration	Number of Culverts - Diameter	Approximate Length (ft)	Inlet Invert Elevation (ft MSL)	Outlet Invert Elevation (ft MSL)	Slope ft/ft	Overtopping Elevation (ft MSL)	Entrance Configuration (2)	Entrance Loss Coefficient (Ke)	Number of Culverts - Diameter (3)	HydroCad Node for Peak Flow Rate (cfs)	Tailwater Elevation (ft MSL)	Depth of Flow Downstream - HydroCad Results (ft)	Calculated Headwater Depth Outlet Control (ft MSL)	Calculated Freeboard (ft)	Available Cover (ft)	Design Traffic Type	Minimum Required Cover (ft)	Structurally Stable	Outlet Velocity (ft/s)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	d_{50} (in)	Thickness (in)
11a	existing	E OSDF	HDPE	0.2	0.010	Projecting	2 - 27 inch	40	583.67	583.58	0.0023	587.20	Groove - Projecting	0.2	3 - 27 inch	11R / 79.26	Intentionally left blank. Is addressed in the calculation section.												
11b	existing	E OSDF	RCP	0.2	0.013	Projecting	1 - 30 inch	40																					
23	new	E OSDF	Helical CMP	0.9	0.018	Projecting	2 - 36 inch	92	586.32	585.78	0.0059	590.00	Projecting	0.9	2 - 36 inch	23 / 48.76													
25	new	E OSDF	Helical CMP - Arch	0.9	0.018	Projecting	2 - 42 x 29 inch	53	584.85	584.53	0.0060	588.50	Thin Wall Projecting	0.9	2 - 42 x 29 inch	25 / 64.24													
27	new	E OSDF	Helical CMP - Arch	0.9	0.018	Projecting	2 - 42 x 29 inch	106	582.80	582.36	0.0042	587.00	Thin Wall Projecting	0.9	2 - 42 x 29 inch	27 / 65.00													
28R	new - temporary	E OSDF	Helical CMP - Arch	0.9	0.019	Projecting	2 - 49 x 33 inch	140	585.75	585.00	0.0054	592.39	Thin Wall Projecting	0.9	2 - 49 x 33 inch	28R / 77.19													
31	existing	E OSDF	HDPE	0.9	0.012	Projecting	1 - 27 inch	80	584.00	583.00	0.0125	588.50	Groove - Projecting	0.9	1 - 27 inch	31 / 6.54													
5	new - temporary	W OSDF	Helical CMP	0.9	0.024	Projecting	1 - 42 inch	95	560.68	579.98	0.0737	585.34	Projecting	0.9	1 - 42 inch	5 / 55.45	Intentionally left blank. Is addressed in the calculation section.												
7AR	new	W OSDF	CMP	0.9	0.024	Projecting	1 - 42 inch	82	577.67	577.23	0.0053	582.57	Projecting	0.9	1 - 42 inch	7AR / 57.96													
7CR	existing	W OSDF	RCP - Horizontal Ellipse	0.2	0.013	Concrete Headwall	1 - 34 x 53 inch	296	574.96	573.50	0.00493	580.00	Groove - Headwall	0.2	1 - 34 x 53 inch	7CR / 58.08													
8BR	existing	W OSDF	RCP	0.2	0.013	Concrete Headwall	2 - 36 inch	30	572.12	572.00	0.00400	577.00	Groove - Headwall	0.2	2 - 36 inch	8BR / 81.21													
9BR	new	W OSDF	Helical CMP	0.9	0.018	Projecting	1 - 18 inch	88	578.08	576.00	0.02361	585.00	Projecting	0.9	1 - 18 inch	9BR / 13.09													
10BR	new	W OSDF	RCP	0.2	0.013	Projecting	2 - 15 inch	44	579.67	579.52	0.00341	581.92	Groove - Projecting	0.2	2 - 15 inch	10BR / 9.65													
11R	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 24 inch	49	578.01	577.81	0.00412	583.66	Groove -Projecting	0.2	1 - 24 inch	11R / 19.28													
12	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 30 inch	105	576.00	575.75	0.0024	582.40	Groove -Projecting	0.2	1 - 30 inch	12 / 32.49													
13	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 18 inch	120	579.00	578.00	0.0083	582.33	Groove - Projecting	0.2	1 - 18 inch	13 / 5.73													
14	existing	W OSDF	CMP	0.9	0.024	Projecting	1 - 50 x 31 inch	112	578.60	575.00	0.0321	581.90	Projecting	0.9	1 - 50 x 31 inch	14 / 3.20													
15N	existing	W OSDF	HDPE	0.2	0.010	Projecting	1 - 18 inch	55	583.90	583.60	0.0055	585.05	Groove - Projecting	0.2	1 - 18 inch	15N / 0.46													
1	existing - temporary	DC A	CMPA - Arch	0.5	0.018	Flared End Section	1 - 13 x 17 inch	80	587.35	586.37	0.0123	590.00	Headwall	0.5	1 - 11 x 18 inch	1 / 2.02	Intentionally left blank. Is addressed in the calculation section.												
3	existing - temporary	DC A	PVC	0.2	0.010	Concrete Headwall	2 - 18 inch	55	581.60	581.30	0.0055	585.50	Groove Headwall	0.2	2 - 18 inch	3 / 8.41													
4	existing - temporary	DC A	PVC	0.2	0.010	Concrete Headwall	2 - 18 inch	60	582.70	581.50	0.0200	587.00	Groove Headwall	0.2	2 - 18 inch	4 / 1.90													
8	new - temporary	DC A	Helical CMP	0.9	0.017	Projecting	2 - 30 inch	49	579.33	578.84	0.0100	582.50	Projecting	0.9	2 - 30 inch	8 / 24.73													
7	new - temporary	DC B	Helical CMP - Arch	0.9	0.019	Projecting	2 - 49 x 33 inch	65	586.95	586.53	0.0046	593.5	Thin Wall Projecting	0.9	2 - 49 x 33 inch	7 / 64.43	Intentionally left blank. Is addressed in the calculation section.												
5	new - temporary	DC C	Helical CMP	0.9	0.018	Projecting	1 - 42 inch	95	580.68	579.98	0.0074	592	Projecting	0.9	1 - 42 inch	5 / 45.14	Intentionally left blank. Is addressed in the calculation section.												

- E OSDF = East OSDF Construction-PhaseDesign Scenario
- W OSDF = West OSDF Construction-Phase Design Scenario
- DC A = Design Case "A"
- DC B = Design Case "B"
- N/A = Not Applicable
- d_{50} = Average particle diameter

Notes
(1) New indicates a new culvert to be installed.
(2) Entrance configuration assumed.
(3) Dimensions and entrance configurations used in the Culvertmaster software package were selected to match existing culvert characteristics as closely as possible.

OSDF CONSTRUCTION/FILLING PERIOD CONDITIONS
SUMMARY OF CULVERT RIP RAP ANALYSES RESULTS

CULVERT IDENTIFICATION			PHYSICAL CHARACTERISTICS OF CULVERT				OUTLET PROTECTION									
									Temporary Protection		Permanent Protection		DCP Minimum Apron Length			
Culvert Name	Status [1]	Design Scenario	Material - Type	Manning's n	Number of Culverts - Diameter	Approximate Length (ft)	HydroCad Node / Peak Flow Rate (cfs)	Outlet Velocity (ft/s)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	d_{50} (in)	Thickness (in)
11a	existing	E OSDF	HDPE	0.010	2 - 27 inch	40	11R / 79.26	Intentionally left blank. Is adressed in the calculation section.								
11b	existing	E OSDF	RCP	0.013	1 - 30 inch	40										
23	new	E OSDF	Helical CMP	0.018	2 - 36 inch	92	23 / 48.76									
25	new	E OSDF	Helical CMP - Arch	0.018	2 - 42 x 29 inch	53	25 / 64.24									
27	new	E OSDF	Helical CMP - Arch	0.018	2 - 42 x 29 inch	106	27 / 65.00									
28R	new - temporary	E OSDF	Helical CMP - Arch	0.019	2 - 49 x 33 inch	140	28R / 77.19									
31	existing	E OSDF	HDPE	0.012	1 - 27 inch	80	31 / 6.54									
5	new - temporary	W OSDF	Helical CMP	0.024	1 - 42 inch	95	5 / 55.45	Intentionally left blank. Is adressed in the calculation section.								
7AR	new	W OSDF	CMP	0.024	1 - 42 inch	82	7AR / 57.96									
7CR	existing	W OSDF	RCP - Horizontal Ellipse	0.013	1 - 34 x 53 inch	296	7CR / 58.08									
8BR	existing	W OSDF	RCP	0.013	2 - 36 inch	30	8BR / 81.21									
9BR	new	W OSDF	Helical CMP	0.018	1 - 18 inch	88	9BR / 13.09									
10BR	new	W OSDF	RCP	0.013	2 - 15 inch	44	10BR / 9.65									
11R	new	W OSDF	RCP	0.013	1 - 24 inch	49	11R / 19.28									
12	new	W OSDF	RCP	0.013	1 - 30 inch	105	12 / 32.49									
13	new	W OSDF	RCP	0.013	1 - 18 inch	120	13 / 5.73									
14	existing	W OSDF	CMP	0.024	1 - 50 x 31 inch	112	14 / 3.20									
15N	existing	W OSDF	HDPE	0.010	1 - 18 inch	55	15N / 0.46									
1	existing - temporary	DC A	CMPA - Arch	0.018	1 - 13 x 17 inch	80	1 / 2.02	Intentionally left blank. Is adressed in the calculation section.								
3	existing - temporary	DC A	PVC	0.010	2 - 18 inch	55	3 / 8.41									
4	existing - temporary	DC A	PVC	0.010	2 - 18 inch	60	4 / 1.90									
8	new - temporary	DC A	Helical CMP	0.017	2 - 30 inch	49	8 / 24.73									
7	new - temporary	DC B	Helical CMP - Arch	0.019	2 - 49 x 33 inch	65	7 / 64.43	Intentionally left blank. Is adressed in the calculation section.								
5	new - temporary	DC C	Helical CMP	0.9	1 - 42 inch	95	5 / 45.14	Intentionally left blank. Is addressed in the calculation section.								

- E OSDF = East OSDF Construction-Phase Design Scenario
- W OSDF = West OSDF Construction-Phase Design Scenario
- DC A = Design Case "A"
- DC B = Design Case "B"
- N/A = Not Applicable
- d_{50} = Average particle diameter

ATTACHMENT B-7

BASIN ELEVATION CONTOURS DATA

STAGE-STORAGE INPUT DATA FOR SEDIMENTATION BASIN

BORROW AREA BASIN	
Elevation (ft MSL)	Planimetered Area (acres)
570.0	6.391
571.0	6.687
572.0	7.017
573.0	7.290
574.0	7.613
575.0	7.921
-	-
-	-

STAGE-STORAGE INPUT DATA FOR SEDIMENTATION BASIN

OSDF SEDIMENTATION BASIN 2	
Elevation (ft MSL)	Planimetered Area (acres)
570.5	1.460
571.0	1.512
572.0	1.614
573.0	1.713
574.0	1.819
575.0	1.917
576.0	2.026
577.0	2.162

ATTACHMENT B-8

BASIN OUTLET STRUCTURE DATA

BORROW AREA BASIN ROUTING INPUT DATA

ITEM		BORROW AREA BASIN		
		DESCRIPTION	PARAMETER VALUE IN UNITS SHOWN	
PRINCIPAL SPILLWAY	Riser Pipe	Existing Twin 48" CMP	ELEVATION (ft MSL)	575.3
	Outlet Pipe	Existing Twin 48" CMP		569.8
EMERGENCY SPILLWAY		20' long rectangular		578.0
EMBANKMENT		Cut to existing ground surface		579.0
AVAILABLE STORAGE VOLUME (TO RISER INLET)		To primary spillway riser pipe inlet	VOLUME (acre-ft)	35.8
SUBCATCHMENT		Total Upstream Drainage area	AREA (acres)	174.86

OSDF SEDIMENTATION BASIN 2 ROUTING INPUT DATA

ITEM		OSDF SEDIMENTATION BASIN 2		
		DESCRIPTION	PARAMETER VALUE IN UNITS SHOWN	
PRINCIPAL SPILLWAY	Riser Pipe	48"	ELEVATION (ft MSL)	575.5
	Outlet Pipe	New 36" CMP pipe/72" x 44" CMP pipe arch bulkhead eccentric reducer coupled to existing 72" x 44" CMP pipe arch		570.8
EMERGENCY SPILLWAY		20' long rectangular		576.0
EMBANKMENT		Cut to existing ground surface		577.0
AVAILABLE STORAGE VOLUME (TO RISER INLET)		To primary spillway riser pipe inlet	VOLUME (acre-ft)	8.6
SUBCATCHMENT		Total Upstream Drainage area	AREA (acres)	39.09

PHASE V SURFACE-WATER MANAGEMENT SYSTEM DESIGN

CALCULATIONS

INTRODUCTION

As described in the Procedures Section, the purpose of this calculation package is to design the OSDF surface-water management (SWM) structures to be constructed as part of the revised Phase V development of the OSDF. In addition, the adequacy of existing SWM structures is assessed. Required modifications or additions to existing structures are incorporated into the Construction Drawings and this calculation package. This section presents calculations based on procedures and data presented in the Procedures and Data Verification Sections of this calculation package.

HYDROLOGIC AND BASIN ROUTING ANALYSES

Hydrologic analyses are completed for the construction and the post-development phases of both the East OSDF and the West OSDF design scenarios and for the construction phase of Design Cases "A", "B", and "C". For each design scenario (i.e., West OSDF and East OSDF Design Scenarios) and design case (i.e., Design Cases "A", "B", and "C"), a nodal network is prepared, for a total of five nodal networks. For the East OSDF Construction Phase Design Scenario, a HydroCAD™ run is performed for the 25-year, 24-hour storm event. For the West OSDF Construction Phase Design Scenario, HydroCAD™ runs are performed for the 10-year, 25-year, and 100-year, 24-hour storm events. For both the East and West OSDF Post-Development Design Scenario, HydroCAD™ runs are performed for the 2-year 24-hour and the 25-year 24-hour storm events. For each Design Case, "A", "B", and "C", a HydroCAD™ run is performed for the 25-year, 24-hour storm event. In total, 11 runs are performed. HydroCAD™ output reports for these runs are presented in Attachments C-1A, C-1B, C-1C, C-1D, C1-E, C1-F and C-1G for the East OSDF Construction Phase, West OSDF Construction Phase, East OSDF

Post-Development, West OSDF Post-Development Design Scenarios, Design Case "A", Design Case "B", and Design Case "C", respectively.

Subcatchment Runoff

Runoff curve numbers

Weighted runoff curve numbers are calculated using a spreadsheet. Results are presented in Attachment C-2. An example calculation is provided in the same attachment. The calculated weighted runoff curve numbers are input directly to HydroCAD™.

HYDRAULIC ANALYSES

Calculation parameters obtained from HydroCAD™ for use in design include the following.

- For channels: 25-year, 24-hour peak flow rates (cfs).
- For evaluating sedimentation potential in permanent channels: 2-year, 24-hour velocities (fps).
- For culverts: 25-year, 24-hour peak flow rates (cfs).
- For the OSDF Basin 2: 25-year and 100-year, 24-hour peak water elevations (ft MSL), and 10-year, 24-hour runoff volumes (acre-ft).
- For the Borrow Area Basin: 25-year, 24-hour peak water elevations (ft MSL).

Channels

Hydraulic Capacity

For each new and existing channel, peak flow depths are calculated using a computer spreadsheet. The peak flow depth is subtracted from the minimum available depth (from Construction Drawings) to obtain the minimum available freeboard. A computer spreadsheet is presented in Attachment C-3 that includes minimum available freeboard and example calculations for the computations performed in the spreadsheets. For both new and existing channels, the minimum available freeboard is equal or greater than 0.5 ft with only one exception. For the exception, the channel has 0.3 ft of freeboard. However, if this channel were to overflow, the water would be contained and routed back into the channel by the existing ground topography.

Lining

For each channel, peak flow velocity is calculated using a computer spreadsheet. Peak flow velocities and channel linings are presented for each channel in Attachment C-3. All grass-lined channels maintain flow velocities less than 5 fps. Two channels convey flow at velocities greater than 5 fps. These two channels are: (i) the channel just upstream of the OSDF Basin 2, labeled as "8CR" in the HydroCAD™ model and West OSDF Design Scenario, which has a maximum flow velocity of 6.45 fps; and (ii) the runoff channel located on the northern end of the west side of Cell 8, labeled as "10AR" in the HydroCAD™ model and West OSDF Design Scenario, which has a maximum flow velocity of 5.21 fps. Both of these channels require and are designed with riprap lining.

Sedimentation

For each permanent channel, hydrology results for post-closure conditions and the 25-year 24-hour storm event are calculated for use in the Phase V calculation "Sedimentation Evaluation of Permanent Drainage Channels for High Frequency Design Storms". These results are provided as part of HydroCAD™ output reports presented in Attachments C-1C and C-1D.

Culverts

Hydraulic Capacity

For each culvert, peak flow rates are obtained from HydroCAD™ output. Based on peak flow rates and culvert input data, CulvertMaster® is used to calculate headwater elevations for inlet and outlet control conditions. CulvertMaster® output summary sheets are presented in Attachment C-4A. Calculated headwater elevations and overtopping elevations are tabulated and presented in Attachment C-4B. For all new and existing culverts, the overtopping elevation exceeds the maximum calculated headwater elevation by at least 0.5 feet.

Outlet Protection

For each new culvert, recommendations for outlet protection, based on guidelines described in the Procedure Section of this calculation package, are presented in Attachment C-4B. Downstream riprap length for the outlet of new culverts 23, 25, 27, and 28 from the East OSDF Design Scenario are 12 ft, 0 ft, 14 ft, and 16 ft respectively. Upstream riprap length for the inlet

of new culverts 23, 25, 27, and 28 from the East OSDF Design Scenario are 6 ft, 0 ft, 7 ft, and 8 ft respectively. Downstream riprap length for the outlet of new culverts 5, 7AR, 9BR, 10BR, 11R, 12, and 13 from the West OSDF Design Scenario are 14 ft, 12 ft, 6 ft, 5 ft, 8 ft, 10 ft, and 6 ft respectively. Upstream riprap length for the inlet of new culverts 5, 7AR, 9BR, 10BR, 11R, 12, and 13 from the West OSDF Design Scenario are 7 ft, , 6 ft, 3 ft, 2.5 ft, 4 ft, 5 ft, and 3 ft respectively. Riprap lengths for new temporary culvert 8 from Design Case "A" are 10 ft downstream and 5 ft upstream. Riprap lengths for new temporary culvert 7 from Design Case "B" are 16 ft downstream and 8 ft upstream. Riprap lengths for new temporary culvert 5 from Design Case "C" correspond to those of culvert 5 in the West OSDF Design Scenario, i.e. 14 ft upstream and 7 ft downstream.

Structural Stability

For each new CMP culvert, minimum required and available cover are tabulated and presented in Attachment C-4B. For each new culvert, the available cover exceeds the minimum required cover. Calculations are provided in Attachment C-4B.

Sedimentation Basins

OSDF Basin 2

The required storage volume based on the 10-year, 24-hour storm event is obtained from HydroCAD™ output. In addition, the required storage based on total upstream drainage area is calculated (an example calculation is provided in Attachment C-5). The available storage volume exceeds both of the required storage volumes. Analysis results are tabulated and presented in Attachment C-5.

The peak water elevations for the 25-year and 100-year storm events are obtained from HydroCAD™ output. The peak water elevation for the 25-year storm event is below the elevation of the emergency spillway, and the peak water elevation for the 100-year storm allows for more than 1 ft of freeboard to the minimum embankment crest elevation. Analysis results are tabulated and presented in Attachment C-5.

Borrow Area Sedimentation Basin

The minimum required storage volume based on the total upstream drainage area is calculated (an example calculation is provided in Attachment C-5). The available storage volume exceeds the minimum required storage volume. Analysis results are tabulated and presented in Attachment C-5.

The peak water elevation in the emergency spillway for the 25-year, 24-hour storm event allows in excess of 1 ft of freeboard from the minimum embankment crest elevation.

Post-Development Sedimentation Basin Discharges

The post-development outflow from the 25-year, 24-hour storm event for the OSDF Sedimentation Basin 2 is 0 cfs. In addition, the post-development outflow from the 25-year, 24-hour storm event for the Borrow Area Sedimentation Basin is 0 cfs. HydroCAD™ output reports for these runs are presented in Attachments C-1C and C-1D for the East OSDF Post-Development (for the Borrow Area Sedimentation Basin) and West OSDF Post-Development (for the OSDF Sedimentation Basin 2) Design Scenarios, respectively.

ATTACHMENT C

HydroCAD™ OUTPUT REPORTS

ATTACHMENT C-1A

HydroCAD™ OUTPUT REPORTS

EAST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GQ3211 Task No.: 6/4 5316

EAST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO
25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover system
Tc=17.3 min CN=83 Area=1.964 ac Runoff= 6.81 cfs 0.473 af

Subcatchment AA: runon area east of OSDF
Tc=16.8 min CN=74 Area=2.708 ac Runoff= 6.97 cfs 0.478 af

Subcatchment B: vegetated final cover system
Tc=6.2 min CN=83 Area=1.179 ac Runoff= 5.75 cfs 0.285 af

Subcatchment BB: runon east of OSDF
Tc=9.1 min CN=79 Area=0.761 ac Runoff= 3.03 cfs 0.161 af

Subcatchment C: vegetated final cover
Tc=20.7 min CN=83 Area=5.209 ac Runoff= 16.37 cfs 1.255 af

Subcatchment CC: runon east of OSDF
Tc=6.7 min CN=79 Area=0.121 ac Runoff= 0.52 cfs 0.026 af

Subcatchment D: vegetated final cover
Tc=20.1 min CN=83 Area=5.131 ac Runoff= 16.39 cfs 1.236 af

Subcatchment DDR: unvegetated final cover system
Tc=1.7 min CN=89 Area=0.860 ac Runoff= 5.43 cfs 0.250 af

Subcatchment E: vegetated final cover
Tc=19.7 min CN=83 Area=5.092 ac Runoff= 16.48 cfs 1.227 af

Subcatchment EE: runon north of borrow area
Tc=25.4 min CN=77 Area=0.925 ac Runoff= 2.10 cfs 0.182 af

Subcatchment F: vegetated final cover
Tc=19.7 min CN=83 Area=5.053 ac Runoff= 16.35 cfs 1.217 af

Subcatchment FFR: unvegetated final cover system
Tc=3.3 min CN=89 Area=2.410 ac Runoff= 15.10 cfs 0.700 af

Subcatchment G: vegetated final cover
Tc=19.8 min CN=83 Area=5.309 ac Runoff= 17.13 cfs 1.279 af

Subcatchment GGR: construction laydown area
Tc=28.3 min CN=78 Area=2.350 ac Runoff= 5.17 cfs 0.478 af

Subcatchment HH: runon north of borrow area
Tc=13.9 min CN=79 Area=0.548 ac Runoff= 1.86 cfs 0.116 af

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Subcatchment HR: un-vegetated final cover
Tc=3.2 min CN=89 Area=4.590 ac Runoff= 28.80 cfs 1.333 af

Subcatchment II: runon area to borrow area
Tc=23.0 min CN=68 Area=1.669 ac Runoff= 2.73 cfs 0.230 af

Subcatchment IR: un vegetated final cover
Tc=1.4 min CN=89 Area=0.600 ac Runoff= 3.85 cfs 0.174 af

Subcatchment JJ: runon area to borrow area
Tc=41.9 min CN=62 Area=0.914 ac Runoff= 0.69 cfs 0.094 af

Subcatchment JR: un-vegetated final cover
Tc=3.2 min CN=89 Area=2.520 ac Runoff= 15.81 cfs 0.732 af

Subcatchment K1R: construction support
Tc=4.9 min CN=82 Area=0.382 ac Runoff= 1.91 cfs 0.089 af

Subcatchment K2R: construction support
Tc=33.4 min CN=77 Area=0.530 ac Runoff= 1.01 cfs 0.104 af

Subcatchment KK: runon area to borrow area
Tc=36.4 min CN=64 Area=5.893 ac Runoff= 5.63 cfs 0.674 af

Subcatchment L: runon north of borrow area
Tc=15.4 min CN=76 Area=1.683 ac Runoff= 4.88 cfs 0.320 af

Subcatchment LL: runoff area
Tc=28.1 min CN=61 Area=7.049 ac Runoff= 6.61 cfs 0.693 af

Subcatchment M: runon north of borrow area
Tc=12.1 min CN=79 Area=1.000 ac Runoff= 3.60 cfs 0.212 af

Subcatchment MM: runoff area
Tc=9.9 min CN=61 Area=1.943 ac Runoff= 3.30 cfs 0.192 af

Subcatchment N: direct runon to pond
Tc=1.0 min CN=98 Area=7.818 ac Runoff= 57.89 cfs 2.908 af

Subcatchment NN: runoff area
Tc=1.4 min CN=66 Area=1.274 ac Runoff= 3.78 cfs 0.162 af

Subcatchment O: runon north of borrow area
Tc=1.3 min CN=79 Area=1.317 ac Runoff= 6.54 cfs 0.279 af

Subcatchment OO: runon area to borrow area
Tc=5.4 min CN=66 Area=0.399 ac Runoff= 1.06 cfs 0.051 af

Subcatchment P: runon north of borrow area
Tc=33.7 min CN=75 Area=5.238 ac Runoff= 9.16 cfs 0.955 af

Subcatchment PP: vegetated borrow area
Tc=65.5 min CN=64 Area=40.964 ac Runoff= 25.40 cfs 4.631 af

Subcatchment Q: runon north of borrow area
Tc=31.8 min CN=72 Area=7.700 ac Runoff= 12.29 cfs 1.252 af

Subcatchment R: runon north of borrow area
Tc=21.6 min CN=74 Area=2.612 ac Runoff= 5.83 cfs 0.460 af

Subcatchment S: runon north of borrow area
Tc=27.9 min CN=78 Area=0.402 ac Runoff= 0.89 cfs 0.082 af

Subcatchment TR: construction support
Tc=3.7 min CN=82 Area=0.040 ac Runoff= 0.21 cfs 0.009 af

Subcatchment U: runon east of OSDF
Tc=32.3 min CN=72 Area=4.149 ac Runoff= 6.57 cfs 0.674 af

Subcatchment V: direct runon to pond
Tc=1.0 min CN=98 Area=0.274 ac Runoff= 2.03 cfs 0.102 af

Subcatchment W: runon east of OSDF
Tc=12.6 min CN=72 Area=10.593 ac Runoff= 28.88 cfs 1.733 af

Subcatchment X: runon east of OSDF
Tc=33.4 min CN=71 Area=11.853 ac Runoff= 17.50 cfs 1.851 af

Subcatchment Y: runon area east of OSDF
Tc=36.8 min CN=73 Area=6.522 ac Runoff= 9.84 cfs 1.101 af

Subcatchment Z: runon area east of OSDF
Tc=23.7 min CN=72 Area=1.606 ac Runoff= 3.11 cfs 0.262 af

Reach 1: east drainage channel Inflow= 10.81 cfs 0.758 af
Length= 420.0' Max Vel= 2.1 fps Capacity= 754.76 cfs Outflow= 10.06 cfs 0.756 af

Reach 1R: (new node) Inflow= 6.61 cfs 0.693 af
Length= 100.0' Max Vel= 5.4 fps Capacity= 1,101.12 cfs Outflow= 6.59 cfs 0.693 af

Reach 2: east drainage channel Inflow= 26.37 cfs 2.010 af
Length= 420.0' Max Vel= 2.7 fps Capacity= 1,205.98 cfs Outflow= 25.59 cfs 2.005 af

Reach 2R: (new node) Inflow= 3.30 cfs 0.192 af
Length= 100.0' Max Vel= 4.3 fps Capacity= 1,101.12 cfs Outflow= 3.25 cfs 0.192 af

Reach 3: east drainage channel Inflow= 40.77 cfs 3.241 af
Length= 420.0' Max Vel= 3.3 fps Capacity= 1,563.67 cfs Outflow= 39.76 cfs 3.234 af

Reach 3R: (new node) Inflow= 3.78 cfs 0.162 af
Length= 100.0' Max Vel= 4.5 fps Capacity= 1,101.12 cfs Outflow= 3.72 cfs 0.162 af

Reach 4: east drainage channel Inflow= 53.10 cfs 4.461 af
Length= 420.0' Max Vel= 3.5 fps Capacity= 1,106.53 cfs Outflow= 52.07 cfs 4.451 af

Reach 5: east drainage channel Inflow= 63.69 cfs 5.669 af
Length= 440.0' Max Vel= 3.5 fps Capacity= 182.58 cfs Outflow= 62.69 cfs 5.656 af

Reach 6: east drainage channel Inflow= 73.28 cfs 6.935 af
Length= 480.0' Max Vel= 4.6 fps Capacity= 258.21 cfs Outflow= 72.46 cfs 6.923 af

Reach 7R: runoff diversion channel Inflow= 75.24 cfs 8.256 af
Length= 400.0' Max Vel= 4.7 fps Capacity= 1,632.24 cfs Outflow= 74.54 cfs 8.244 af

Reach 8R: runoff diversion channel Inflow= 75.90 cfs 8.944 af
Length= 220.0' Max Vel= 3.1 fps Capacity= 1,597.49 cfs Outflow= 75.29 cfs 8.934 af

Reach 9R: runoff diversion channel Inflow= 75.75 cfs 9.193 af
Length= 120.0' Max Vel= 3.6 fps Capacity= 462.89 cfs Outflow= 75.46 cfs 9.188 af

Reach 10AR: (new node) Inflow= 75.94 cfs 9.452 af
Length= 365.0' Max Vel= 3.4 fps Capacity= 646.10 cfs Outflow= 75.21 cfs 9.432 af

Reach 10BR: runoff diversion channel Inflow= 76.97 cfs 10.263 af
Length= 179.0' Max Vel= 2.9 fps Capacity= 202.01 cfs Outflow= 76.47 cfs 10.251 af

Reach 11: new CMP arch Inflow= 79.26 cfs 10.729 af
Length= 40.0' Max Vel= 6.7 fps Capacity= 522.31 cfs Outflow= 79.21 cfs 10.728 af

Reach 12R: runoff diversion channel Inflow= 79.21 cfs 10.728 af
Length= 240.0' Max Vel= 3.7 fps Capacity= 317.79 cfs Outflow= 78.70 cfs 10.713 af

Reach 13R: runoff diversion channel Inflow= 144.60 cfs 20.681 af
Length= 450.0' Max Vel= 4.3 fps Capacity= 346.63 cfs Outflow= 143.76 cfs 20.630 af

Reach 14: east runon channel Inflow= 0.52 cfs 0.026 af
Length= 420.0' Max Vel= 0.9 fps Capacity= 22.78 cfs Outflow= 0.38 cfs 0.025 af

Reach 15: east runon channel Inflow= 3.20 cfs 0.186 af
Length= 420.0' Max Vel= 1.8 fps Capacity= 61.82 cfs Outflow= 2.82 cfs 0.186 af

Reach 16: east runon channel Inflow= 9.76 cfs 0.664 af
Length= 420.0' Max Vel= 2.6 fps Capacity= 256.58 cfs Outflow= 9.33 cfs 0.661 af

Reach 17: east runon channel Inflow= 12.43 cfs 0.923 af
Length= 420.0' Max Vel= 3.2 fps Capacity= 436.18 cfs Outflow= 12.07 cfs 0.921 af

Reach 18: east runon channel Inflow= 21.43 cfs 2.022 af
Length= 440.0' Max Vel= 3.7 fps Capacity= 169.20 cfs Outflow= 20.99 cfs 2.017 af

Reach 19: east runon channel Inflow= 38.43 cfs 3.868 af
Length= 470.0' Max Vel= 2.8 fps Capacity= 911.12 cfs Outflow= 37.75 cfs 3.855 af

Reach 20: east runon channel Inflow= 43.35 cfs 5.587 af
Length= 75.0' Max Vel= 4.2 fps Capacity= 153.84 cfs Outflow= 43.26 cfs 5.586 af

Reach 21: east runon channel Inflow= 45.89 cfs 6.151 af
Length= 65.0' Max Vel= 4.5 fps Capacity= 169.20 cfs Outflow= 45.84 cfs 6.149 af

Reach 22: east runon channel Inflow= 46.33 cfs 6.231 af
Length= 190.0' Max Vel= 4.5 fps Capacity= 364.40 cfs Outflow= 46.18 cfs 6.226 af

Reach 23: new CMP culverts Inflow= 48.76 cfs 6.862 af
Length= 92.0' Max Vel= 5.4 fps Capacity= 468.67 cfs Outflow= 48.70 cfs 6.859 af

Reach 24: runon channel Inflow= 57.15 cfs 8.111 af
Length= 160.0' Max Vel= 4.0 fps Capacity= 153.54 cfs Outflow= 56.99 cfs 8.104 af

Reach 25: new CMP arch Inflow= 64.24 cfs 9.059 af
Length= 53.0' Max Vel= 5.9 fps Capacity= 475.34 cfs Outflow= 64.21 cfs 9.057 af

Reach 26: runon channel Inflow= 64.21 cfs 9.057 af
Length= 300.0' Max Vel= 4.4 fps Capacity= 90.11 cfs Outflow= 64.05 cfs 9.045 af

Reach 27: new CMP arch Inflow= 65.00 cfs 9.365 af
Length= 106.0' Max Vel= 5.2 fps Capacity= 398.58 cfs Outflow= 64.88 cfs 9.361 af

Reach 28R: new CMP culverts Inflow= 77.19 cfs 10.267 af
Length= 140.0' Max Vel= 5.7 fps Capacity= 427.00 cfs Outflow= 76.97 cfs 10.263 af

Reach 29: east runon channel Inflow= 47.10 cfs 6.408 af
Length= 230.0' Max Vel= 4.6 fps Capacity= 255.23 cfs Outflow= 46.91 cfs 6.402 af

Reach 30: east runon channel Inflow= 45.98 cfs 6.152 af
Length= 30.0' Max Vel= 4.5 fps Capacity= 104.05 cfs Outflow= 45.89 cfs 6.151 af

Reach 31: culvert Inflow= 6.54 cfs 0.279 af
Length= 80.0' Max Vel= 5.1 fps Capacity= 1,025.91 cfs Outflow= 6.34 cfs 0.279 af

Pond 1P: (new node) Peak Storage= 1.584 af Inflow= 49.32 cfs 6.362 af
Primary= 45.98 cfs 6.152 af Outflow= 45.98 cfs 6.152 af

Pond 3P: Borrow Area Basin Peak Storage= 29.204 af Inflow= 175.81 cfs 29.218 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

Runoff Area = 171.154 ac Volume = 30.721 af Average Depth = 2.15"

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Subcatchment A: vegetated final cover system

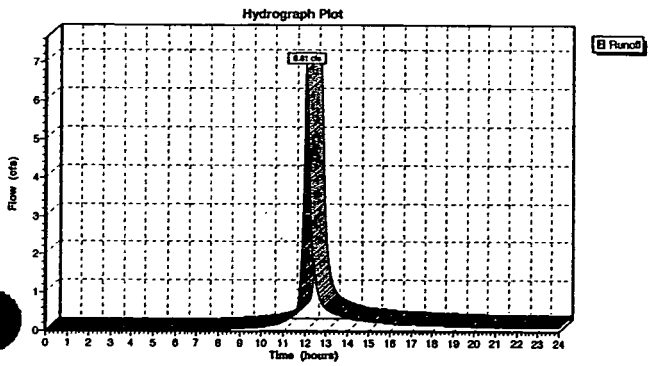
Runoff = 6.81 cfs @ 12.10 hrs, Volume= 0.473 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.964	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	80	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
17.3	380	Total			

Subcatchment A: vegetated final cover system



Subcatchment AA: runon area east of OSDF

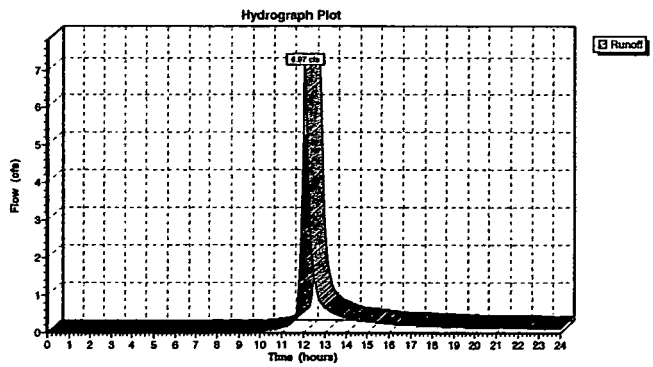
Runoff = 6.97 cfs @ 12.10 hrs, Volume= 0.478 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.708	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0	300	0.0800	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.6	170	0.0800	4.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.2	300	0.0070	4.0	48.01	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
16.8	770	Total			

Subcatchment AA: runon area east of OSDF



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Subcatchment B: vegetated final cover system

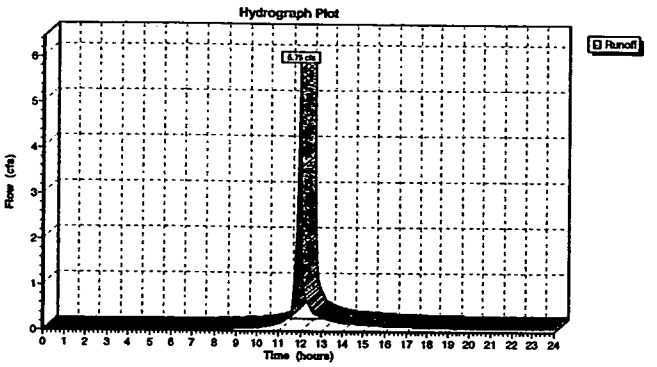
Runoff = 5.75 cfs @ 11.97 hrs, Volume= 0.285 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.179	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	50	0.1800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.6	450	0.0045	2.1	9.75	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.02' Z= 6.0 & 3.0 '/' n= 0.030
6.2	500	Total			

Subcatchment B: vegetated final cover system



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Subcatchment BB: runon east of OSDF

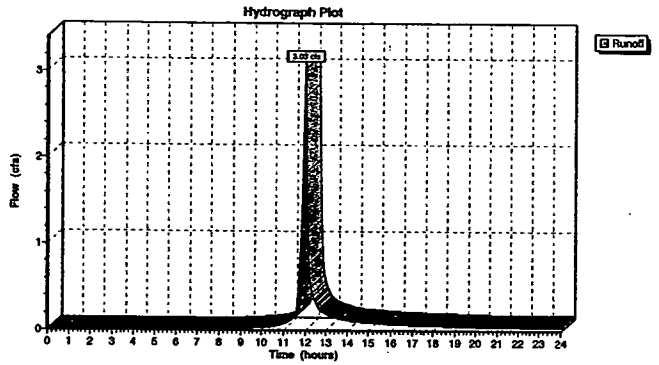
Runoff = 3.03 cfs @ 12.01 hrs, Volume= 0.161 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.761	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	110	0.0800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.4	360	0.0040	2.5	22.78	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.50' Z= 3.0 & 5.0 '/' n= 0.030
9.1	470	Total			

Subcatchment BB: runon east of OSDF



Subcatchment C: vegetated final cover

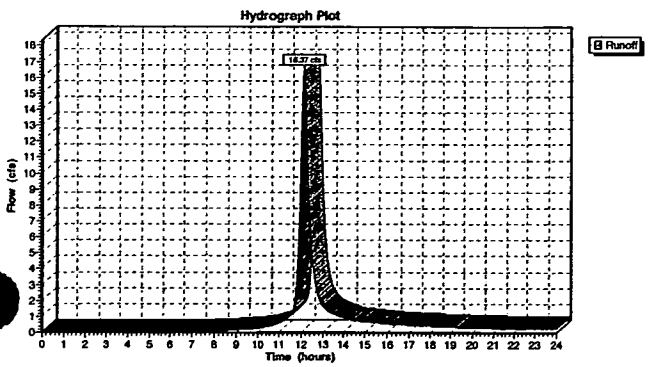
Runoff = 16.37 cfs @ 12.13 hrs, Volume= 1.255 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.209	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
3.2	400	0.0045	2.1	10.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.02' Z= 6.0 & 4.0 '/' n= 0.030
20.7	870	Total			

Subcatchment C: vegetated final cover



Subcatchment CC: runon east of OSDF

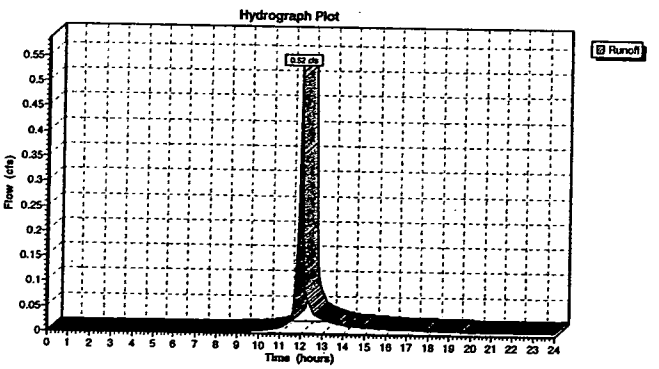
Runoff = 0.52 cfs @ 11.98 hrs, Volume= 0.026 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.121	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	110	0.0800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment CC: runon east of OSDF



Subcatchment D: vegetated final cover

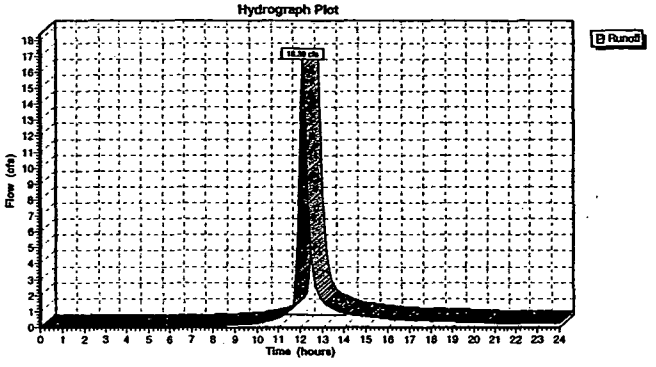
Runoff = 16.39 cfs @ 12.13 hrs, Volume= 1.236 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.131	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.7	250	0.0045	2.4	16.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.29' Z= 5.0 & 3.0 '/' n= 0.030
0.9	150	0.0050	2.9	25.90	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.59' Z= 4.0 & 3.0 '/' n= 0.030
20.1	870	Total			

Subcatchment D: vegetated final cover



Subcatchment DDR: unvegetated final cover system

[49] Hint: Tc<2dt may require smaller dt

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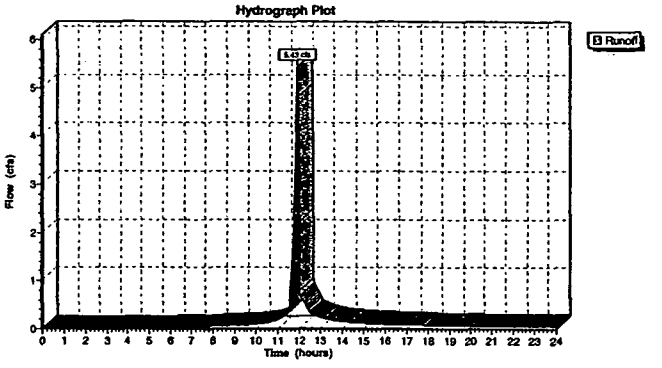
Runoff = 5.43 cfs @ 11.91 hrs, Volume= 0.250 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.860	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	150	0.1500	3.0		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.7	480	Total			

Subcatchment DDR: unvegetated final cover system



Subcatchment E: vegetated final cover

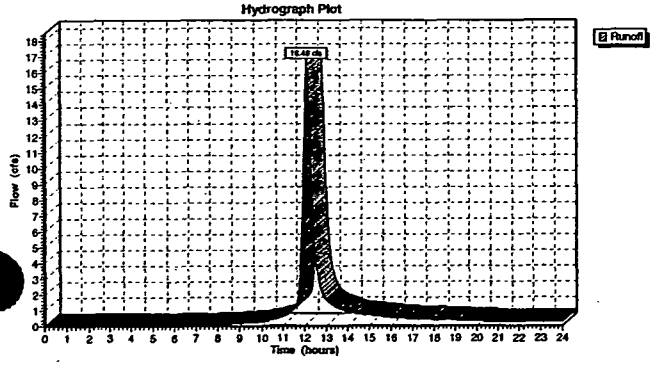
Runoff = 16.48 cfs @ 12.12 hrs, Volume= 1.227 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.092	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	380	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	850	Total			

Subcatchment E: vegetated final cover



Subcatchment EE: runon north of borrow area

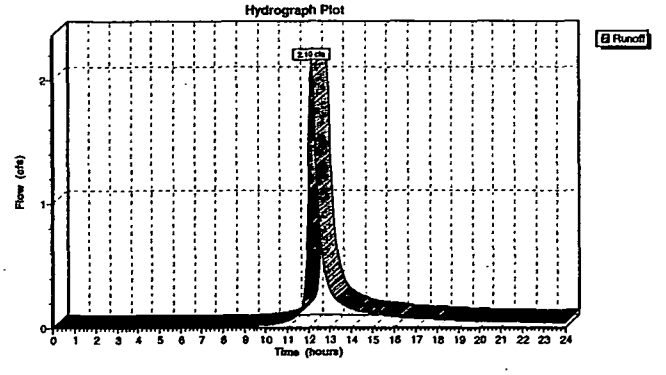
Runoff = 2.10 cfs @ 12.19 hrs, Volume= 0.182 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.925	77	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.8	300	0.0230	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	80	0.0230	2.4		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	40	0.0100	7.6	364.40	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 3.0 '/' n= 0.030
25.4	420	Total			

Subcatchment EE: runon north of borrow area



Subcatchment F: vegetated final cover

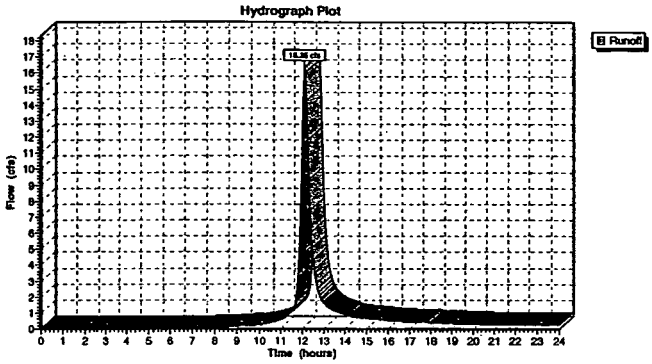
Runoff = 16.35 cfs @ 12.12 hrs, Volume= 1.217 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.053	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	390	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	860	Total			

Subcatchment F: vegetated final cover



Subcatchment FFR: unvegetated final cover system

[49] Hint: Tc<2dt may require smaller dt

Runoff = 15.10 cfs @ 11.94 hrs, Volume= 0.700 af

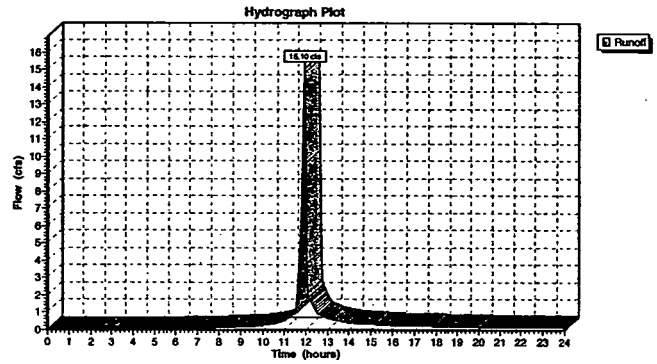
5316

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.410	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	85	0.0500	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.4	50	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1700	3.2		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	365	0.0050	6.7	914.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.030
3.3	810	Total			

Subcatchment FFR: unvegetated final cover system



Subcatchment G: vegetated final cover

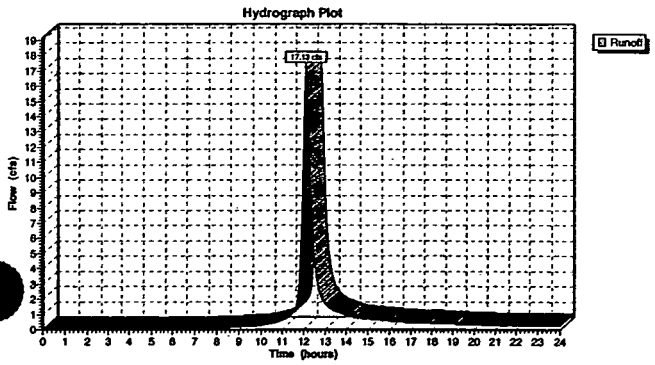
Runoff = 17.13 cfs @ 12.12 hrs, Volume= 1.279 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.309	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	410	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.8	880	Total			

Subcatchment G: vegetated final cover



Subcatchment GGR: construction laydown area

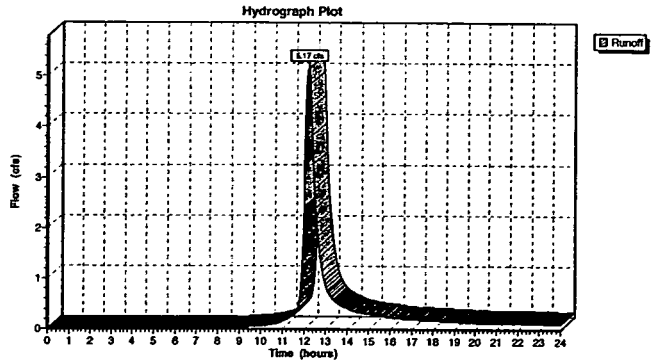
Runoff = 5.17 cfs @ 12.23 hrs, Volume= 0.478 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.350	78	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.2	300	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.3	590	Total			

Subcatchment GGR: construction laydown area



Subcatchment HH: runon north of borrow area

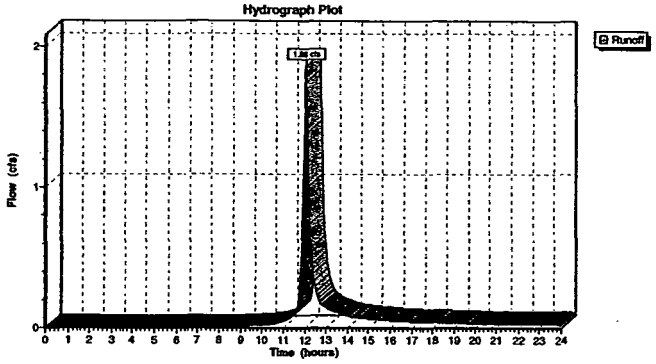
Runoff = 1.86 cfs @ 12.06 hrs, Volume= 0.116 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.548	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	90	0.0100	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.7	230	0.0045	5.1	352.87	**Trap/Vee/Rect Channel Flow,** Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
13.9	320	Total			

Subcatchment HH: runon north of borrow area



Subcatchment HR: un-vegetated final cover

5316

[49] Hint: Tc<2dt may require smaller dt

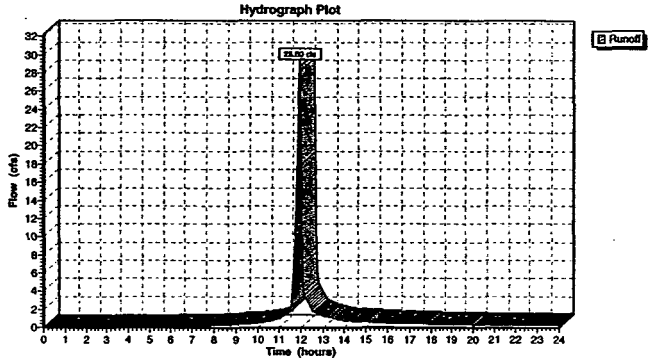
Runoff = 28.80 cfs @ 11.93 hrs, Volume= 1.333 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
4.590	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.8		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.4	50	0.1000	2.1		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1700	3.2		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.4	160	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.7	400	0.0100	9.8	1,429.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=5.70' Z= 6.0 & 3.0 '/' n= 0.030
3.2	850	Total			

Subcatchment HR: un-vegetated final cover



Subcatchment II: runon area to borrow area

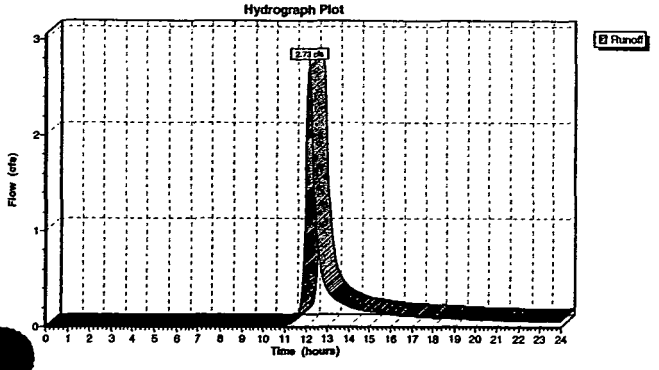
Runoff = 2.73 cfs @ 12.17 hrs, Volume= 0.230 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.669	68	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.9	210	0.0400	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	70	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
7.9	380	0.0025	0.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
23.0	660	Total			

Subcatchment II: runon area to borrow area



Subcatchment IR: un vegetated final cover

[49] Hint: Tc<2dt may require smaller dt

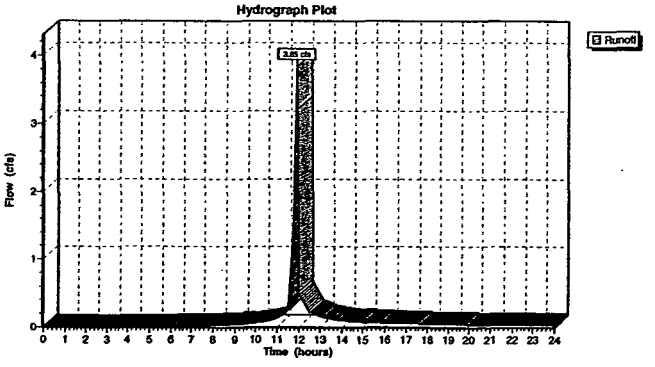
Runoff = 3.85 cfs @ 11.90 hrs, Volume= 0.174 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.600	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	150	0.1500	3.0		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.6	220	0.1500	6.2		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.4	370	Total			

Subcatchment IR: un vegetated final cover



Subcatchment JJ: runon area to borrow area

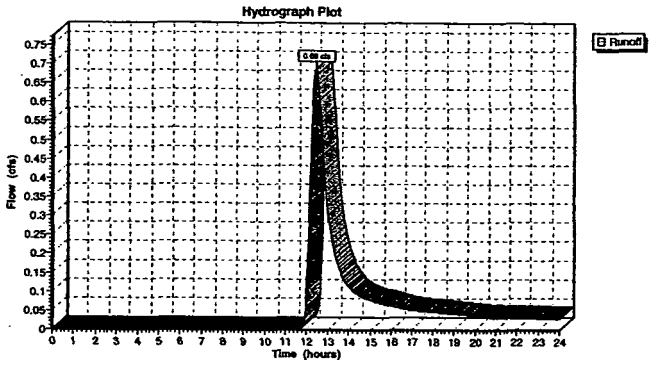
Runoff = 0.69 cfs @ 12.44 hrs, Volume= 0.094 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.914	62	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.9	300	0.0250	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.3	40	0.0250	2.5		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
17.4	840	0.0025	0.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
41.9	1,290	Total			

Subcatchment JJ: runon area to borrow area



Subcatchment JR: un-vegetated final cover

5316

[49] Hint: Tc<2dt may require smaller dt

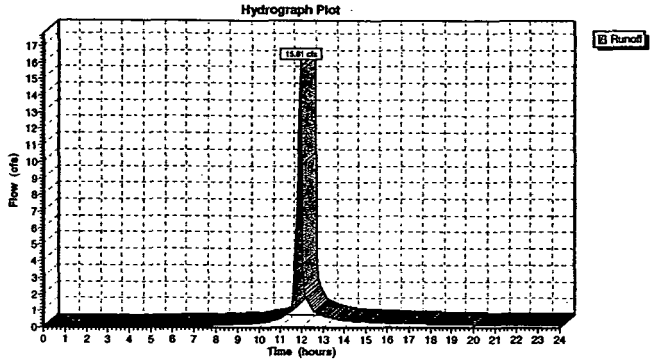
Runoff = 15.81 cfs @ 11.93 hrs, Volume= 0.732 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.520	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.2	80	0.0176	1.1		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.5	60	0.0830	2.0		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1700	3.2		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.60"
0.5	190	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.2	80	0.0050	6.1	646.98	**Trap/Vee/Rect Channel Flow,** Bot.W=10.12' D=3.85' Z= 6.0 & 3.0 '/' n= 0.030
3.2	560	Total			

Subcatchment JR: un-vegetated final cover



Subcatchment K1R: construction support

[49] Hint: Tc<2dt may require smaller dt

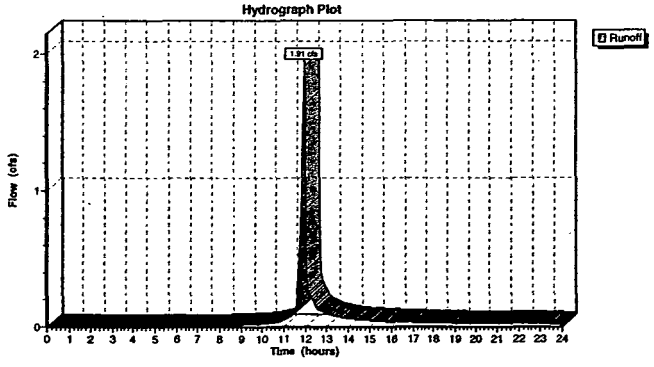
Runoff = 1.91 cfs @ 11.95 hrs, Volume= 0.089 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.382	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	33	0.0160	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment K1R: construction support



Subcatchment K2R: construction support

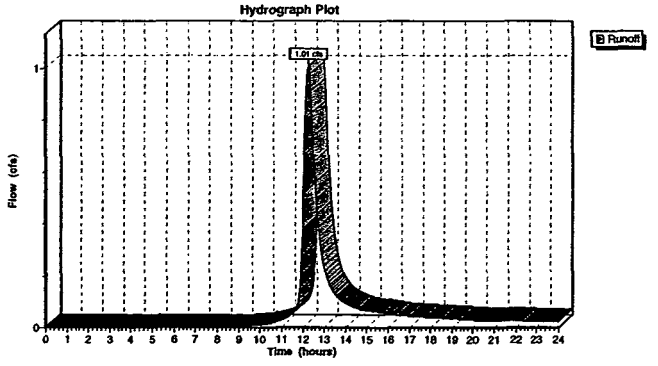
Runoff = 1.01 cfs @ 12.29 hrs, Volume= 0.104 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.530	77	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.2	300	0.0110	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	23	0.0110	1.7		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
33.4	323	Total			

Subcatchment K2R: construction support



Subcatchment KK: runon area to borrow area

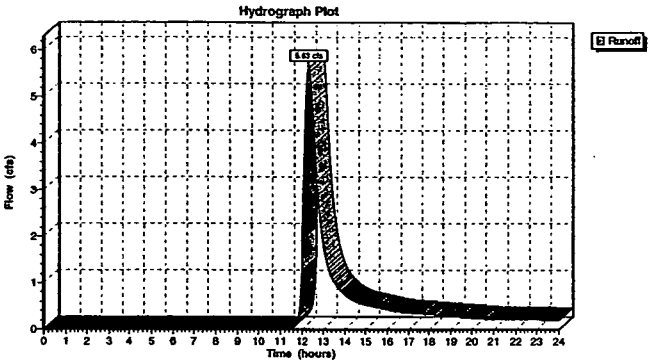
Runoff = 5.63 cfs @ 12.36 hrs, Volume= 0.674 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.893	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	300	0.0280	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.3	150	0.0140	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
11.9	630	0.0030	0.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
36.4	1,190	Total			

Subcatchment KK: runon area to borrow area



5316

Subcatchment L: runon north of borrow area

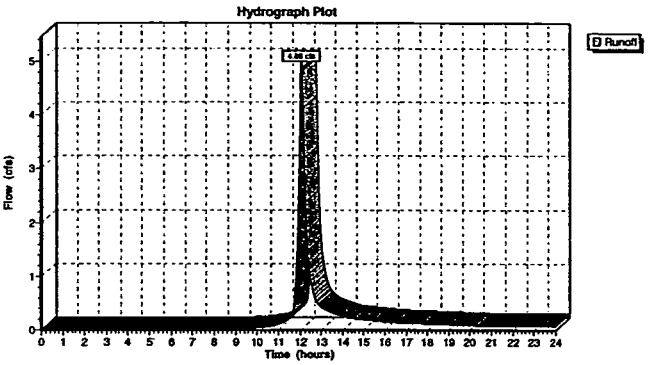
Runoff = 4.88 cfs @ 12.08 hrs, Volume= 0.320 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.683	76	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2	140	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.2	290	0.0075	4.1	49.70	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
15.4	430	Total			

Subcatchment L: runon north of borrow area



Subcatchment LL: runoff area

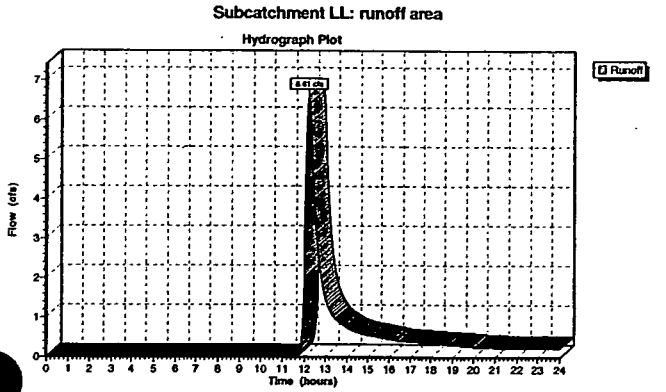
Runoff = 6.61 cfs @ 12.25 hrs, Volume= 0.693 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.049	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.3	300	0.0240	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.3	200	0.0240	2.5		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.5	900	0.0090	5.9	160.52	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
28.1	1,400	Total			

Subcatchment LL: runoff area



Subcatchment M: runon north of borrow area

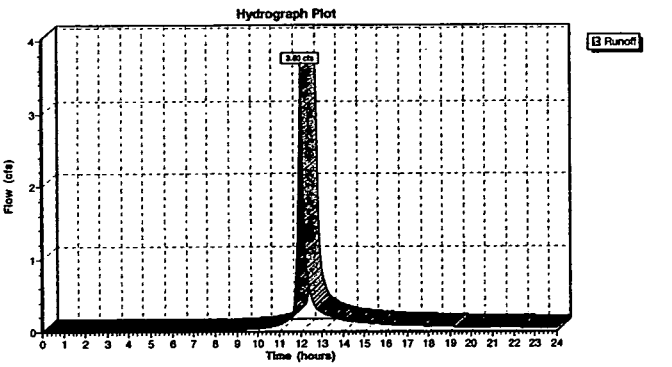
Runoff = 3.60 cfs @ 12.04 hrs, Volume= 0.212 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.000	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5	170	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.6	200	0.0045	5.1	352.87	Trap/Vee/Rect Channel Flow, Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
12.1	370	Total			

Subcatchment M: runon north of borrow area



Subcatchment MM: runoff area

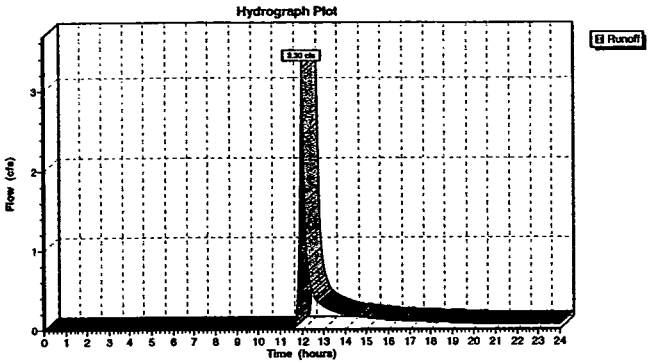
Runoff = 3.30 cfs @ 12.03 hrs, Volume= 0.192 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.943	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	100	0.0700	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.3	980	0.0060	4.9	200.34	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 5.0 & 4.0 '/' n= 0.030
9.9	1,080	Total			

Subcatchment MM: runoff area



Subcatchment N: direct runon to pond

5316

[49] Hint: Tc<2dt may require smaller dt

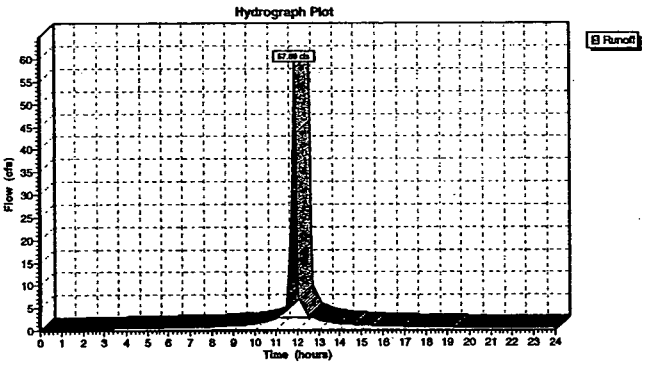
Runoff = 57.89 cfs @ 11.90 hrs, Volume= 2.908 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.818	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					**Direct Entry,**

Subcatchment N: direct runon to pond



Subcatchment NN: runoff area

[49] Hint: Tc<2dt may require smaller dt

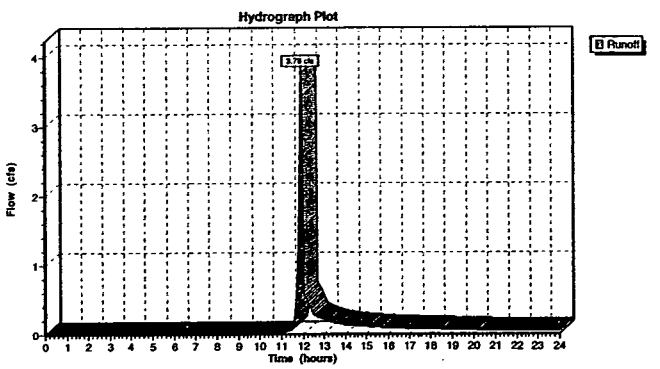
Runoff = 3.78 cfs @ 11.92 hrs, Volume= 0.162 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.274	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	600	0.0130	7.1	192.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030

Subcatchment NN: runoff area



Subcatchment O: runon north of borrow area

[49] Hint: Tc<2dt may require smaller dt

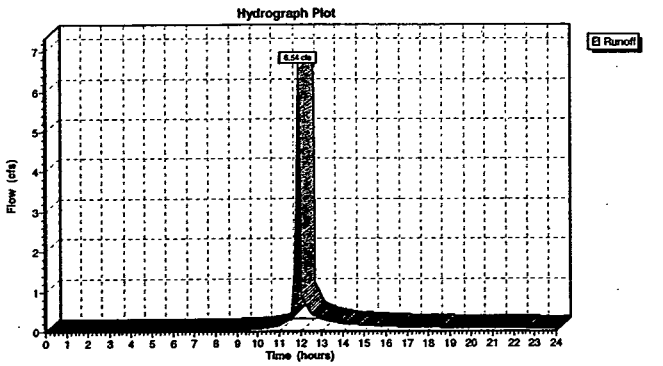
Runoff = 6.54 cfs @ 11.91 hrs, Volume= 0.279 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.317	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	230	0.0086	2.9	14.28	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 5.0 '/' n= 0.030

Subcatchment O: runon north of borrow area



Subcatchment OO: runon area to borrow area

[49] Hint: Tc<2dt may require smaller dt

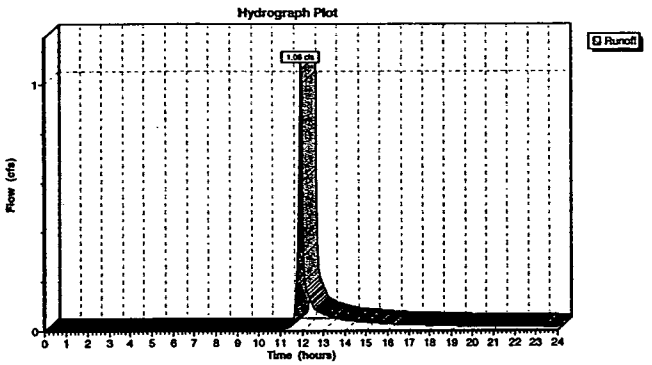
Runoff = 1.06 cfs @ 11.97 hrs, Volume= 0.051 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.399	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	120	0.1660	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment OO: runon area to borrow area



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Subcatchment P: runon north of borrow area

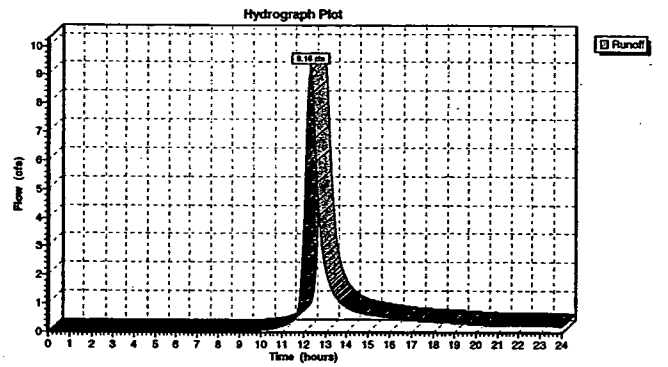
Runoff = 9.16 cfs @ 12.30 hrs, Volume= 0.955 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.238	75	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.4	300	0.0150	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.3	350	0.0070	1.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
33.7	650	Total			

Subcatchment P: runon north of borrow area



Subcatchment PP: vegetated borrow area

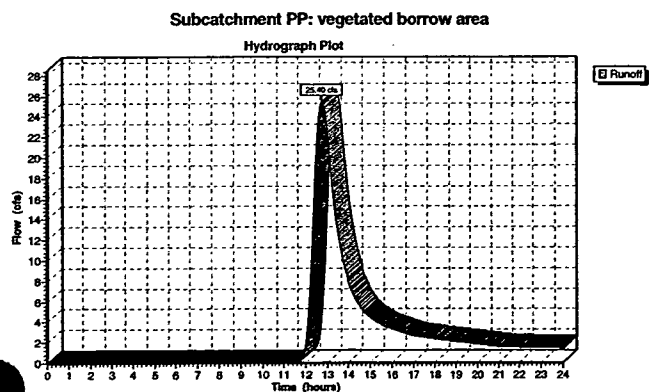
Runoff = 25.40 cfs @ 12.75 hrs, Volume= 4.631 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
40.964	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	150	0.1660	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
34.5	150	0.0025	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
24.6	1,190	0.0025	0.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
65.5	1,490	Total			

Subcatchment PP: vegetated borrow area



Subcatchment Q: runon north of borrow area

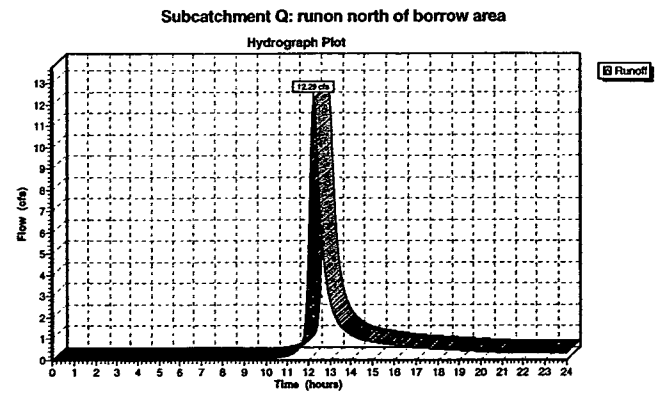
Runoff = 12.29 cfs @ 12.28 hrs, Volume= 1.252 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.700	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.6	300	0.0260	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
8.2	1,280	0.0260	2.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
31.8	1,580	Total			

Subcatchment Q: runon north of borrow area



Subcatchment R: runon north of borrow area

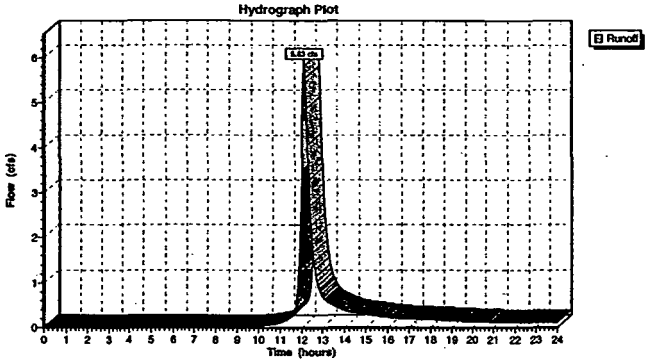
Runoff = 5.83 cfs @ 12.15 hrs, Volume= 0.460 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.612	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.8	300	0.0400	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.8	350	0.0400	3.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
21.6	650	Total			

Subcatchment R: runon north of borrow area



Subcatchment S: runon north of borrow area

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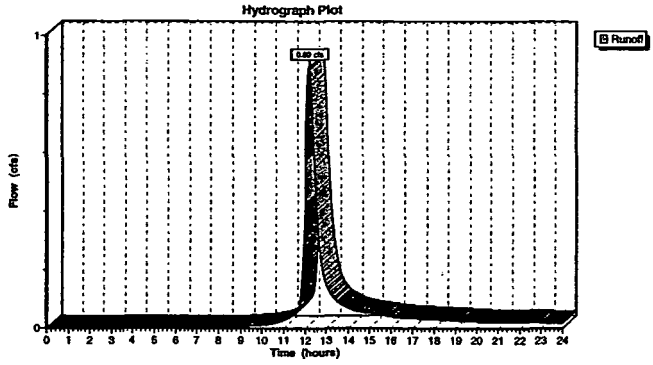
Runoff = 0.89 cfs @ 12.22 hrs, Volume= 0.082 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.402	78	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.8	280	0.0150	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.1	30	0.0100	6.3	169.20	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
27.9	310	Total			

Subcatchment S: runon north of borrow area



Subcatchment TR: construction support

[49] Hint: Tc<2dt may require smaller dt

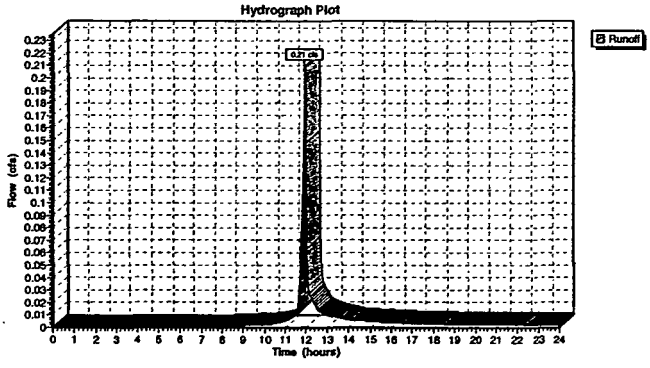
Runoff = 0.21 cfs @ 11.94 hrs, Volume= 0.009 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.040	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	40	0.0460	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment TR: construction support



Subcatchment U: runon east of OSDF

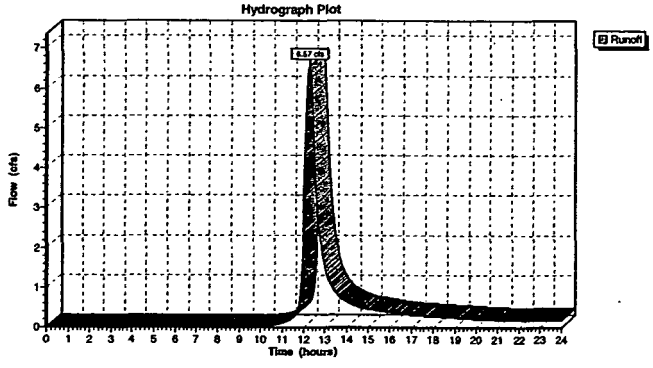
Runoff = 6.57 cfs @ 12.28 hrs, Volume= 0.674 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
4.149	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.2	300	0.0140	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	240	0.0140	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
32.3	540	Total			

Subcatchment U: runon east of OSDF



Subcatchment V: direct runon to pond

[49] Hint: Tc<2dt may require smaller dt

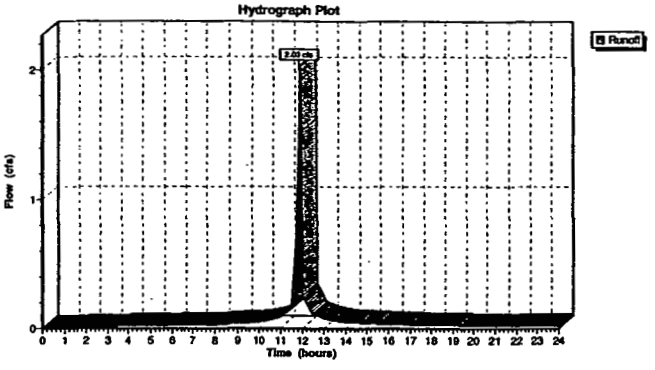
Runoff = 2.03 cfs @ 11.90 hrs, Volume= 0.102 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.274	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment V: direct runon to pond



Subcatchment W: runon east of OSDF

5316

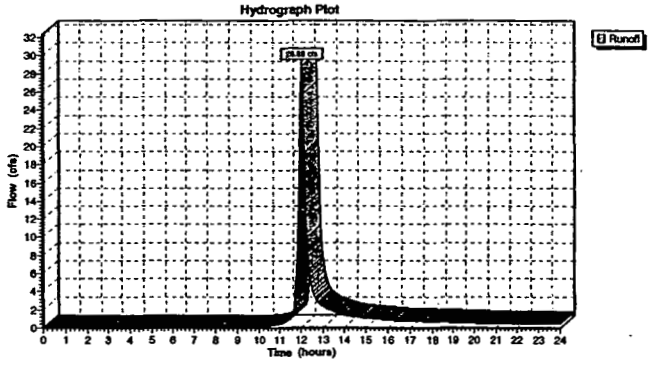
Runoff = 28.88 cfs @ 12.05 hrs, Volume= 1.733 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
10.593	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	300	0.1780	0.5		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.0	400	0.1780	6.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	270	0.0114	6.9	1,025.43	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 & 30.0 '/' n= 0.030
12.6	970	Total			

Subcatchment W: runon east of OSDF



Subcatchment X: runon east of OSDF

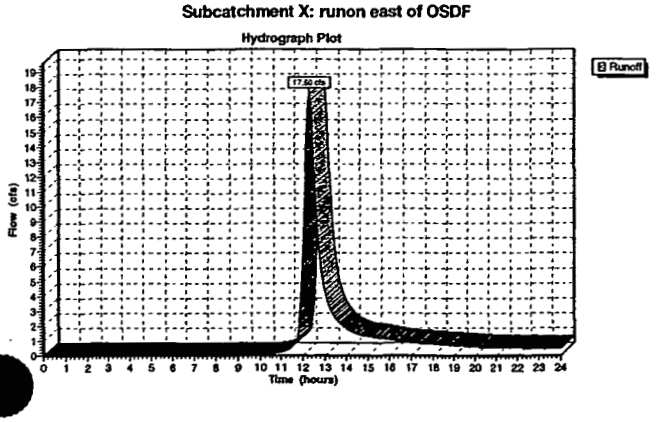
Runoff = 17.50 cfs @ 12.30 hrs, Volume= 1.851 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
11.853	71	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7	300	0.0190	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
5.5	730	0.0190	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	330	0.0100	4.8	57.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
33.4	1,360	Total			

Subcatchment X: runon east of OSDF



Subcatchment Y: runon area east of OSDF

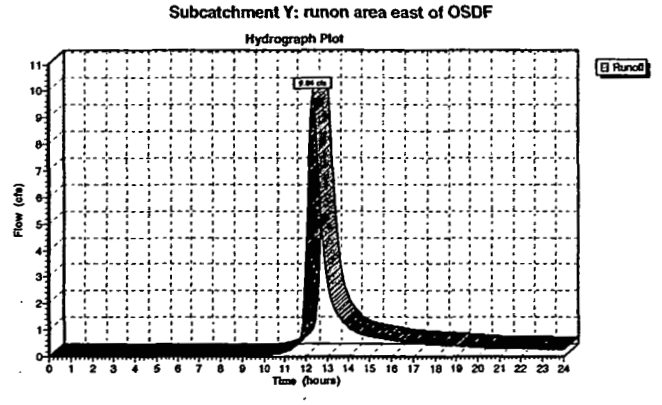
Runoff = 9.84 cfs @ 12.34 hrs, Volume= 1.101 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
6.522	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.1	300	0.0130	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.6	510	0.0130	1.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.1	340	0.0110	5.1	92.00	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
36.8	1,150	Total			

Subcatchment Y: runon area east of OSDF



Subcatchment Z: runon area east of OSDF

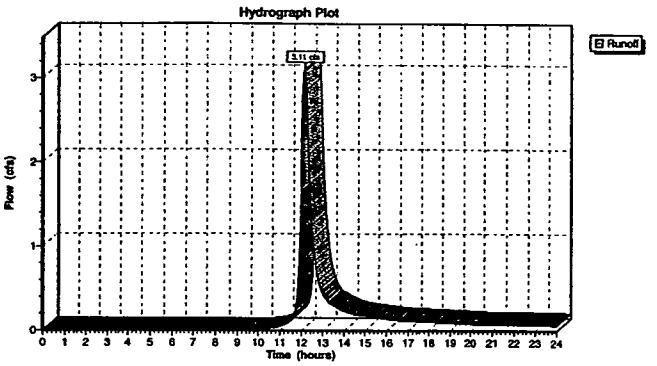
Runoff = 3.11 cfs @ 12.18 hrs, Volume= 0.262 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.606	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.0	300	0.0310	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.5	250	0.0310	2.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	50	0.0070	4.1	73.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
23.7	600	Total			

Subcatchment Z: runon area east of OSDF



5316

Reach 1: east drainage channel

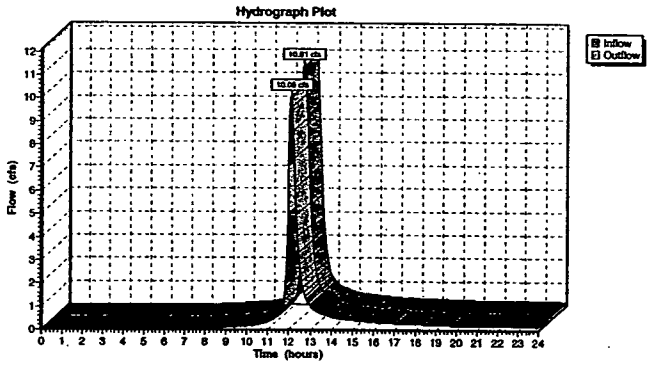
[65] Warning: Inlet elevation not specified

Inflow = 10.81 cfs @ 12.01 hrs, Volume= 0.758 af
Outflow = 10.06 cfs @ 12.11 hrs, Volume= 0.756 af, Atten= 7%, Lag= 6.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 8.5 min

Peak Depth= 0.99'
Capacity at bank full= 754.76 cfs
0.00' x 5.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: east drainage channel



Reach 1R: (new node)

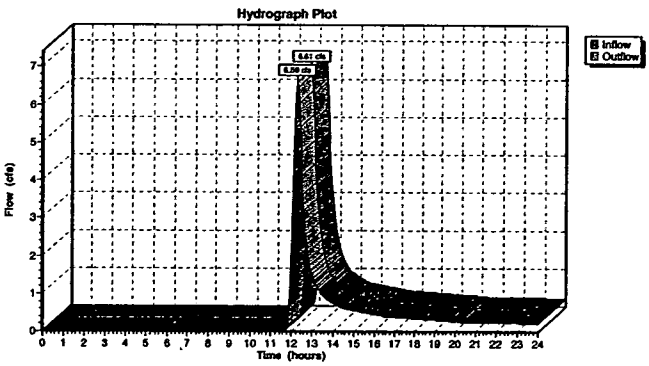
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 6.61 cfs @ 12.25 hrs, Volume= 0.693 af
Outflow = 6.59 cfs @ 12.26 hrs, Volume= 0.693 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.33'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Ptpe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 1R: (new node)



Reach 2: east drainage channel

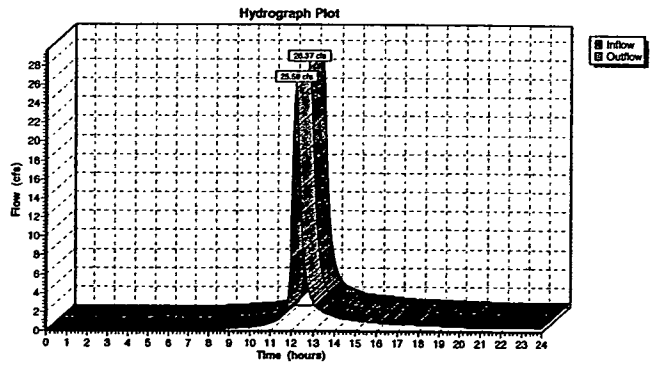
[65] Warning: Inlet elevation not specified

Inflow = 26.37 cfs @ 12.12 hrs, Volume= 2.010 af
Outflow = 25.59 cfs @ 12.20 hrs, Volume= 2.005 af, Atten= 3%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 2.6 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.3 min

Peak Depth= 1.54'
Capacity at bank full= 1,205.98 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 2: east drainage channel



Reach 2R: (new node)

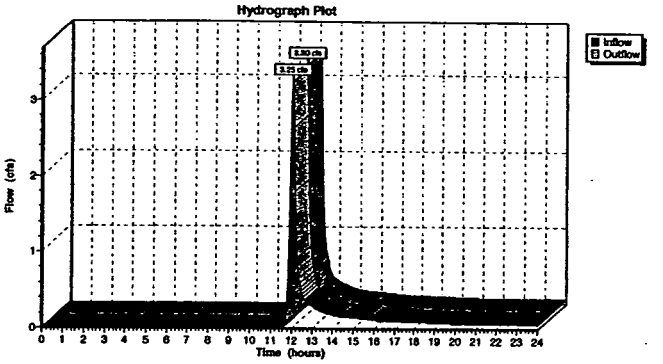
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 3.30 cfs @ 12.03 hrs, Volume= 0.192 af
Outflow = 3.25 cfs @ 12.04 hrs, Volume= 0.192 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 0.9 min

Peak Depth= 0.24'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 2R: (new node)



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Reach 3: east drainage channel

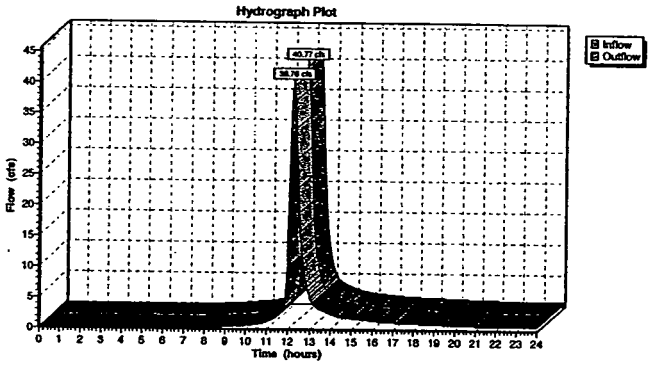
[65] Warning: Inlet elevation not specified

Inflow = 40.77 cfs @ 12.17 hrs, Volume= 3.241 af
Outflow = 39.76 cfs @ 12.24 hrs, Volume= 3.234 af, Atten= 2%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.3 min

Peak Depth= 1.87'
Capacity at bank full= 1,563.67 cfs
0.00' x 7.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 3: east drainage channel



Reach 3R: (new node)

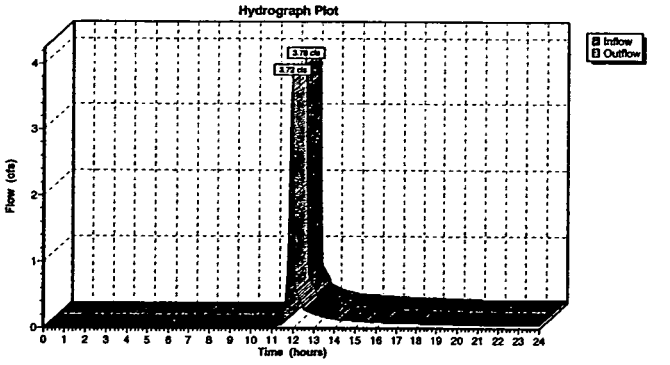
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 3.78 cfs @ 11.92 hrs, Volume= 0.162 af
Outflow = 3.72 cfs @ 11.93 hrs, Volume= 0.162 af, Atten= 2%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.9 min

Peak Depth= 0.25'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 3R: (new node)



Reach 4: east drainage channel

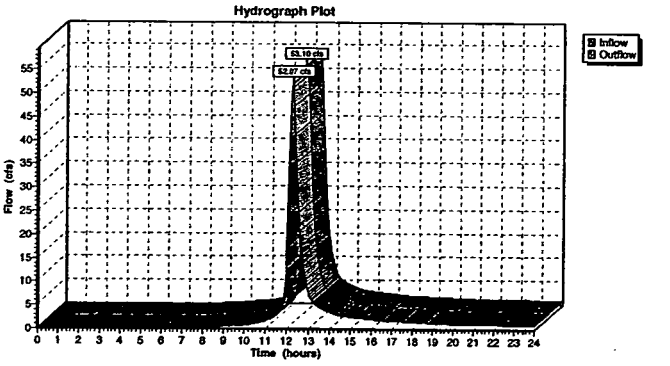
[65] Warning: Inlet elevation not specified

Inflow = 53.10 cfs @ 12.21 hrs, Volume= 4.461 af
Outflow = 52.07 cfs @ 12.27 hrs, Volume= 4.451 af, Atten= 2%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 4.9 min

Peak Depth= 2.07'
Capacity at bank full= 1,106.53 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 4: east drainage channel



Reach 5: east drainage channel

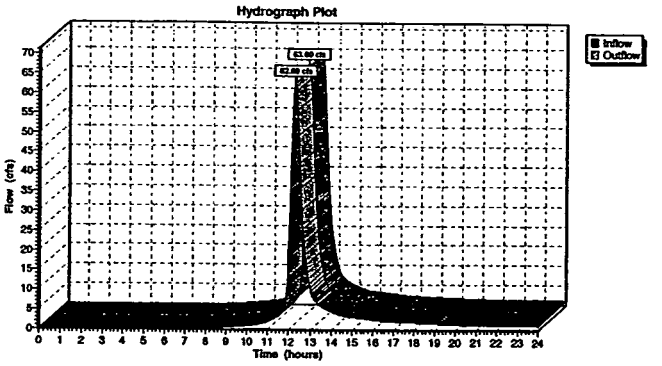
[65] Warning: Inlet elevation not specified

Inflow = 63.69 cfs @ 12.24 hrs, Volume= 5.669 af
Outflow = 62.69 cfs @ 12.30 hrs, Volume= 5.656 af, Atten= 2%, Lag= 3.8 min

[illegible]ting by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
[illegible]. Velocity= 3.5 fps, Min. Travel Time= 2.1 min
[illegible]. Velocity = 1.4 fps, Avg. Travel Time= 5.1 min

Peak Depth= 2.01'
Capacity at bank full= 182.58 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 5: east drainage channel



5316

Reach 6: east drainage channel

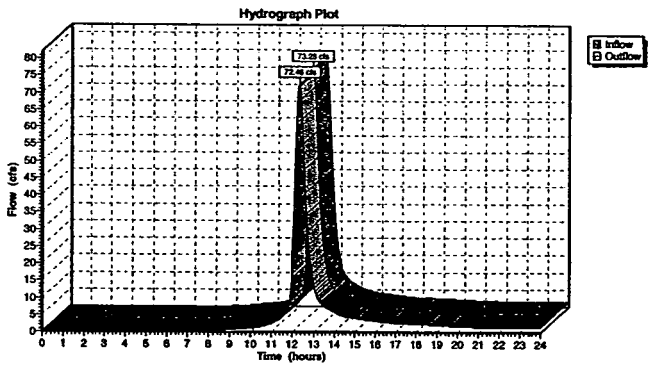
[65] Warning: Inlet elevation not specified

Inflow = 73.28 cfs @ 12.27 hrs, Volume= 6.935 af
Outflow = 72.46 cfs @ 12.32 hrs, Volume= 6.923 af, Atten= 1%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 1.7 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 4.1 min

Peak Depth= 1.87'
Capacity at bank full= 258.21 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 480.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 6: east drainage channel



Reach 7R: runoff diversion channel

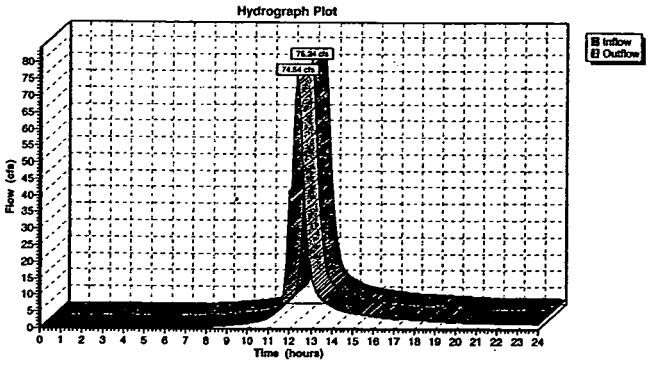
[65] Warning: Inlet elevation not specified

Inflow = 75.24 cfs @ 12.32 hrs, Volume= 8.256 af
Outflow = 74.54 cfs @ 12.36 hrs, Volume= 8.244 af, Atten= 1%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 3.5 min

Peak Depth= 1.89'
Capacity at bank full= 1,632.24 cfs
0.00' x 5.99' deep channel, n= 0.030 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 7R: runoff diversion channel



Reach 8R: runoff diversion channel

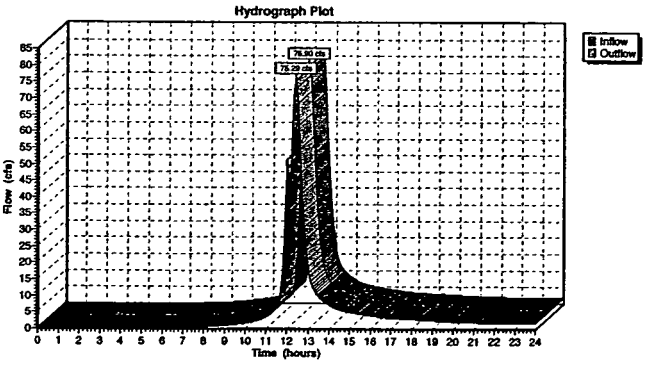
[65] Warning: Inlet elevation not specified

Inflow = 75.90 cfs @ 12.36 hrs, Volume= 8.944 af
Outflow = 75.29 cfs @ 12.40 hrs, Volume= 8.934 af, Atten= 1%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.1 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 2.8 min

Peak Depth= 1.74'
Capacity at bank full= 1,597.49 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
0.00' x 5.47' deep channel, n= 0.030 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: runoff diversion channel



Reach 9R: runoff diversion channel

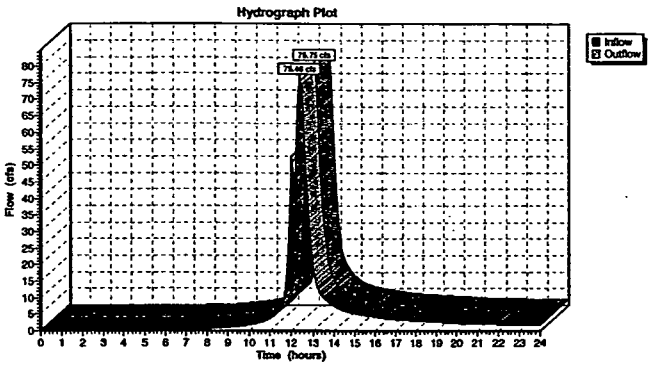
[65] Warning: Inlet elevation not specified

Inflow = 75.75 cfs @ 12.40 hrs, Volume= 9.193 af
Outflow = 75.46 cfs @ 12.41 hrs, Volume= 9.188 af, Atten= 0%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.6 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.4 min

Peak Depth= 1.74'
Capacity at bank full= 462.89 cfs
4.35' x 3.80' deep channel, n= 0.030 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: runoff diversion channel



165/344

Reach 10AR: (new node)

5316

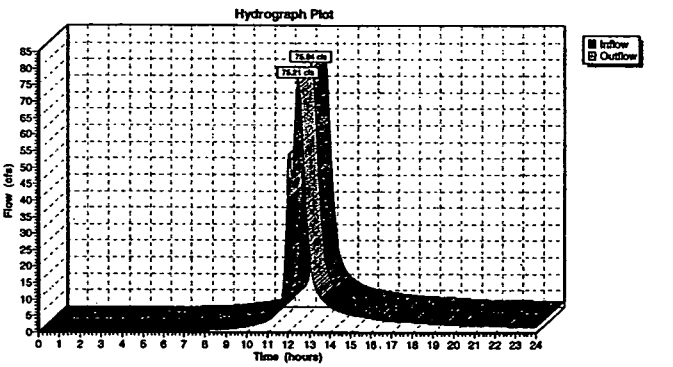
[65] Warning: Inlet elevation not specified

Inflow = 75.94 cfs @ 12.41 hrs, Volume= 9.452 af
Outflow = 75.21 cfs @ 12.46 hrs, Volume= 9.432 af, Atten= 1%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.1 min

Peak Depth= 1.36'
Capacity at bank full= 646.10 cfs
10.12' x 3.85' deep channel, n= 0.030 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 10AR: (new node)



Reach 10BR: runoff diversion channel

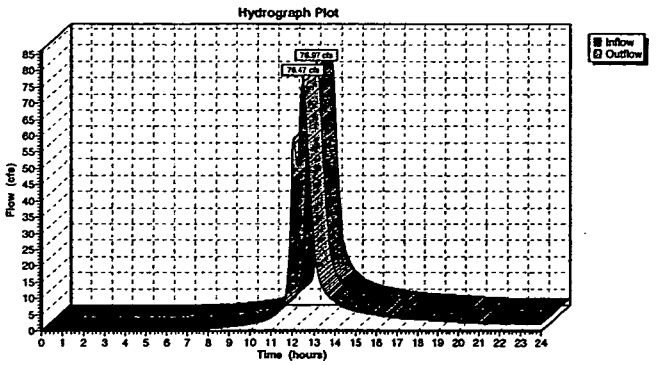
[65] Warning: Inlet elevation not specified

Inflow = 76.97 cfs @ 12.47 hrs, Volume= 10.263 af
Outflow = 76.47 cfs @ 12.50 hrs, Volume= 10.251 af, Atten= 1%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 2.9 min

Peak Depth= 1.61'
Capacity at bank full= 202.01 cfs
10.21' x 2.62' deep channel, n= 0.030 Length= 179.0' Slope= 0.0029 '/'
Side Slope Z-value= 3.0 4.6 '/'

Reach 10BR: runoff diversion channel



Reach 11: new CMP arch

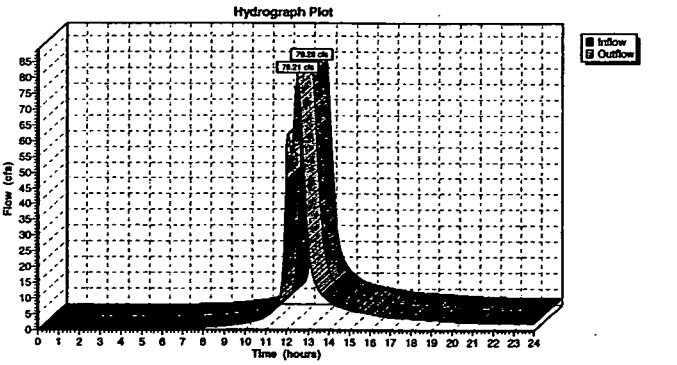
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 79.26 cfs @ 12.50 hrs, Volume= 10.729 af
Outflow = 79.21 cfs @ 12.50 hrs, Volume= 10.728 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.7 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.58'
Capacity at bank full= 522.31 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 40.0' Slope= 0.0022 '/'

Reach 11: new CMP arch



Reach 12R: runoff diversion channel

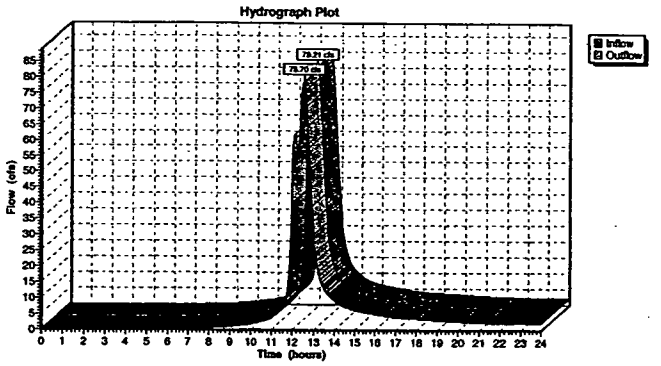
[65] Warning: Inlet elevation not specified

Inflow = 79.21 cfs @ 12.50 hrs, Volume= 10.728 af
Outflow = 78.70 cfs @ 12.53 hrs, Volume= 10.713 af, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 3.3 min

Peak Depth= 1.16'
Capacity at bank full= 317.79 cfs
14.00' x 2.45' deep channel, n= 0.030 Length= 240.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 4.3 '/'

Reach 12R: runoff diversion channel



Reach 13R: runoff diversion channel

5316

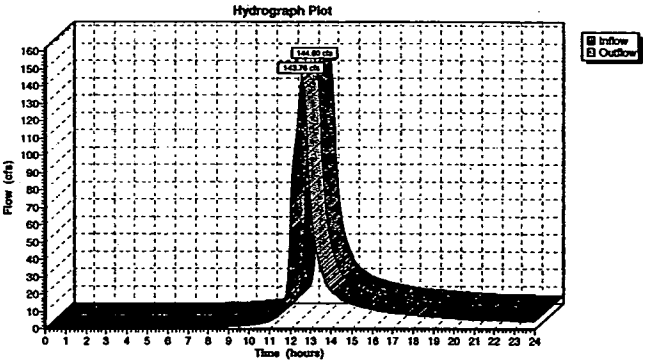
[65] Warning: Inlet elevation not specified

Inflow = 144.60 cfs @ 12.52 hrs, Volume= 20.681 af
Outflow = 143.76 cfs @ 12.57 hrs, Volume= 20.630 af, Atten= 1%, Lag= 3.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 6.0 min

Peak Depth= 1.25'
Capacity at bank full= 346.63 cfs
23.11' x 2.06' deep channel, n= 0.030 Length= 450.0' Slope= 0.0067 '/'
Side Slope Z-value= 2.3 4.0 '/'

Reach 13R: runoff diversion channel



Reach 14: east runon channel

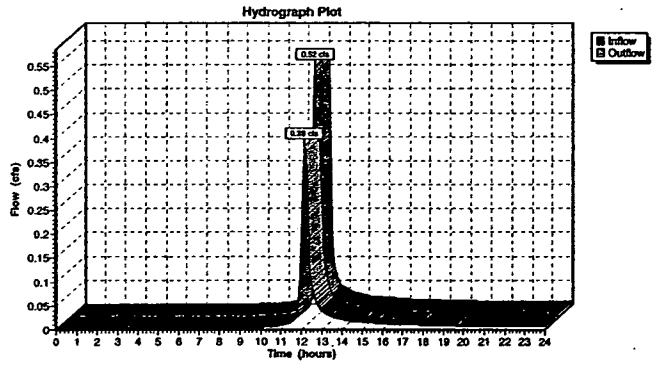
[65] Warning: Inlet elevation not specified

Inflow = 0.52 cfs @ 11.98 hrs, Volume= 0.026 af
Outflow = 0.38 cfs @ 12.17 hrs, Volume= 0.025 af, Atten= 27%, Lag= 11.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.9 fps, Min. Travel Time= 7.6 min
Avg. Velocity = 0.4 fps, Avg. Travel Time= 19.1 min

Peak Depth= 0.33'
Capacity at bank full= 22.78 cfs
0.00' x 1.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0040 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 14: east runon channel



Reach 15: east runon channel

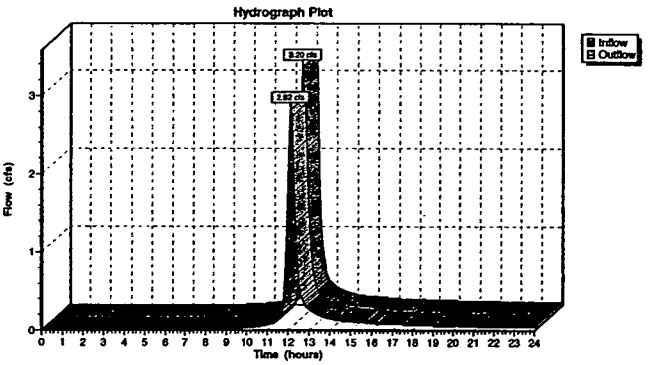
[65] Warning: Inlet elevation not specified

Inflow = 3.20 cfs @ 12.01 hrs, Volume= 0.186 af
Outflow = 2.82 cfs @ 12.12 hrs, Volume= 0.186 af, Atten= 12%, Lag= 6.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.8 fps, Min. Travel Time= 3.9 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 9.9 min

Peak Depth= 0.64'
Capacity at bank full= 61.62 cfs
0.00' x 2.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 15: east runon channel



Reach 16: east runon channel

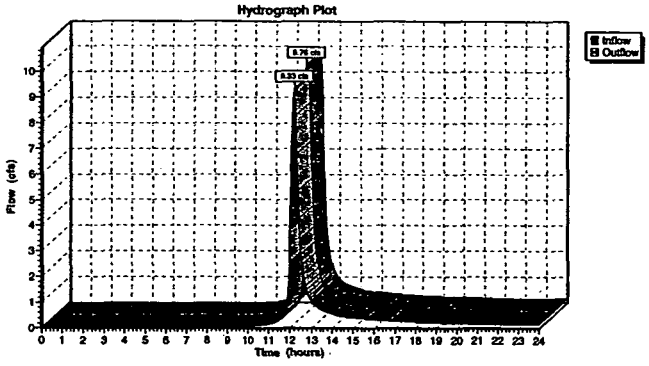
[65] Warning: Inlet elevation not specified

Inflow = 9.76 cfs @ 12.10 hrs, Volume= 0.664 af
Outflow = 9.33 cfs @ 12.19 hrs, Volume= 0.661 af, Atten= 4%, Lag= 4.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.7 min

Peak Depth= 0.98'
Capacity at bank full= 256.58 cfs
0.00' x 3.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0074 '/'
Side Slope Z-value= 2.5 5.0 '/'

Reach 16: east runon channel



5316

Reach 17: east runon channel

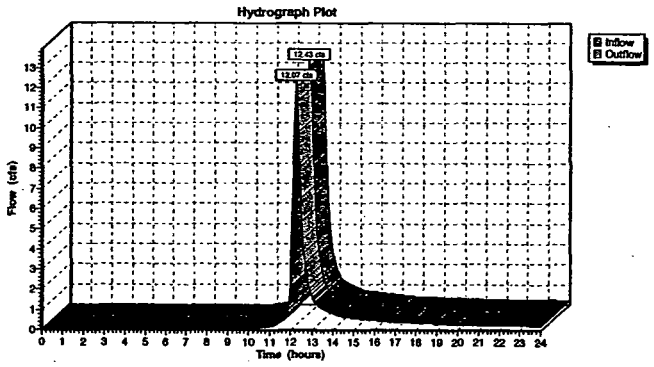
[65] Warning: Inlet elevation not specified

Inflow = 12.43 cfs @ 12.18 hrs, Volume= 0.923 af
Outflow = 12.07 cfs @ 12.25 hrs, Volume= 0.921 af, Atten= 3%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.3 min

Peak Depth= 0.92'
Capacity at bank full= 436.18 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 5.0 '/'

Reach 17: east runon channel



Reach 18: east runon channel

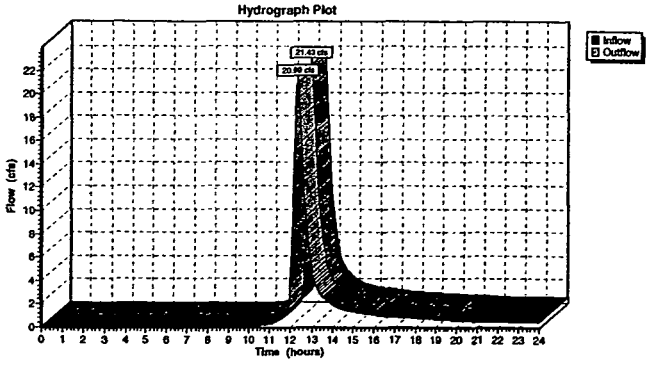
[65] Warning: Inlet elevation not specified

Inflow = 21.43 cfs @ 12.27 hrs, Volume= 2.022 af
Outflow = 20.99 cfs @ 12.33 hrs, Volume= 2.017 af, Atten= 2%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 4.5 min

Peak Depth= 1.38'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 18: east runon channel



Reach 19: east runon channel

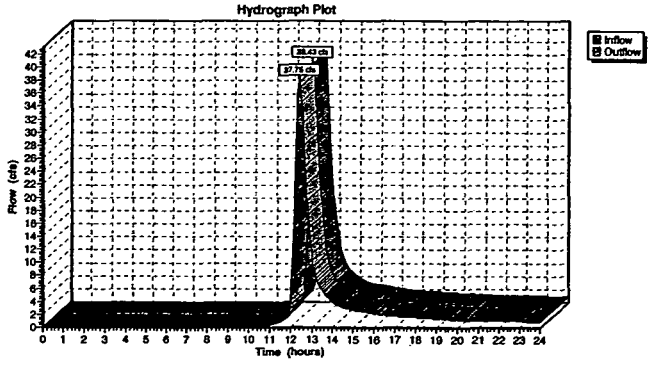
[65] Warning: Inlet elevation not specified

Inflow = 38.43 cfs @ 12.32 hrs, Volume= 3.868 af
Outflow = 37.75 cfs @ 12.41 hrs, Volume= 3.855 af, Atten= 2%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 6.4 min

Peak Depth= 0.91'
Capacity at bank full= 911.12 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 470.0' Slope= 0.0090 '/'
Side Slope Z-value= 3.0 30.0 '/'

Reach 19: east runon channel



Reach 20: east runon channel

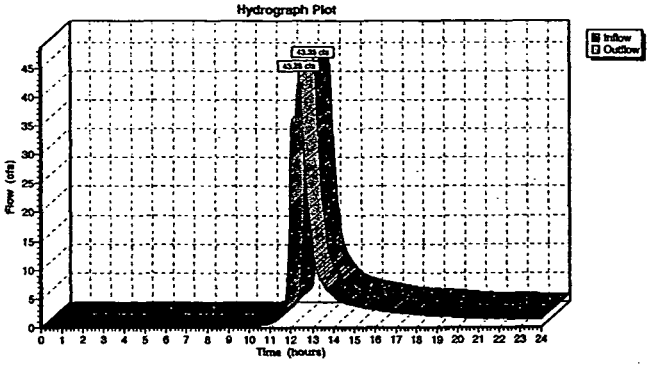
[65] Warning: Inlet elevation not specified

Inflow = 43.35 cfs @ 12.39 hrs, Volume= 5.587 af
Outflow = 43.26 cfs @ 12.40 hrs, Volume= 5.586 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 0.6 min

Peak Depth= 1.87'
Capacity at bank full= 153.84 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 75.0' Slope= 0.0083 '/'
Side Slope Z-value= 3.0 '/'

Reach 20: east runon channel



5316

Reach 21: east runon channel

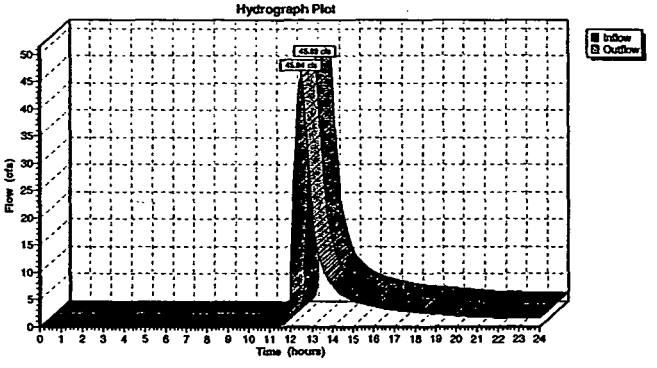
[65] Warning: Inlet elevation not specified

Inflow = 45.89 cfs @ 12.48 hrs, Volume= 6.151 af
Outflow = 45.84 cfs @ 12.49 hrs, Volume= 6.149 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.7 min

Peak Depth= 1.84'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 65.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 21: east runon channel



Reach 22: east runon channel

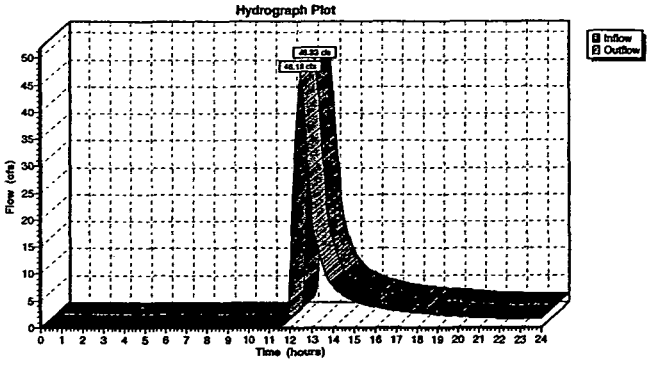
[65] Warning: Inlet elevation not specified

Inflow = 46.33 cfs @ 12.49 hrs, Volume= 6.231 af
Outflow = 46.18 cfs @ 12.51 hrs, Volume= 6.226 af, Atten= 0%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 2.0 min

Peak Depth= 1.85'
Capacity at bank full= 364.40 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 190.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 22: east runon channel



Reach 23: new CMP culverts

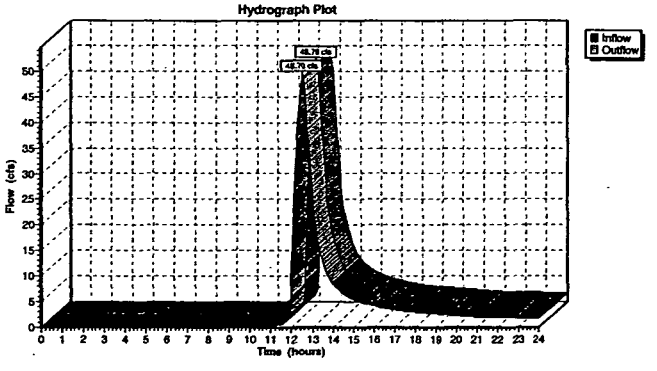
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 48.76 cfs @ 12.51 hrs, Volume= 6.862 af
Outflow = 48.70 cfs @ 12.52 hrs, Volume= 6.859 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.8 min

Peak Depth= 1.31'
Capacity at bank full= 468.67 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 92.0' Slope= 0.0059 '/'

Reach 23: new CMP culverts



Reach 24: runon channel

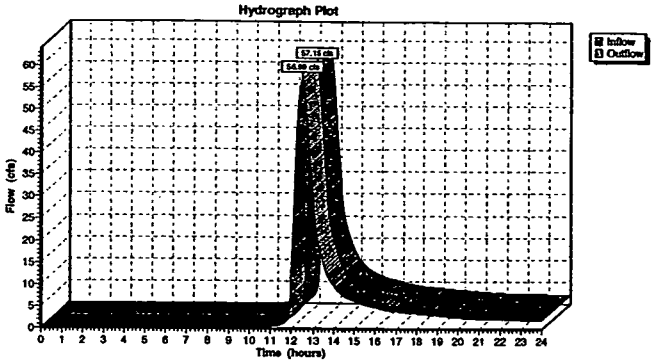
[65] Warning: Inlet elevation not specified

Inflow = 57.15 cfs @ 12.47 hrs, Volume= 8.111 af
Outflow = 56.99 cfs @ 12.49 hrs, Volume= 8.104 af, Atten= 0%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 2
Max. Velocity= 4.0 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 2.3 min

Peak Depth= 1.19'
Capacity at bank full= 153.54 cfs
8.50' x 2.00' deep channel, n= 0.030 Length= 160.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 24: runon channel



Reach 25: new CMP arch

5316

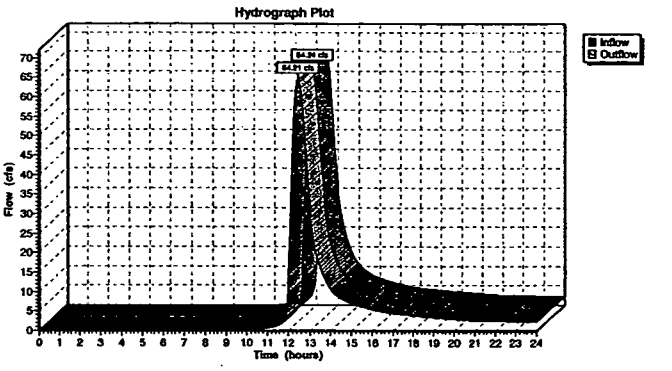
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 64.24 cfs @ 12.45 hrs, Volume= 9.059 af
Outflow = 64.21 cfs @ 12.46 hrs, Volume= 9.057 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.9 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 0.4 min

Peak Depth= 1.49'
Capacity at bank full= 475.34 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 53.0' Slope= 0.0060 '/'

Reach 25: new CMP arch



Reach 26: runon channel

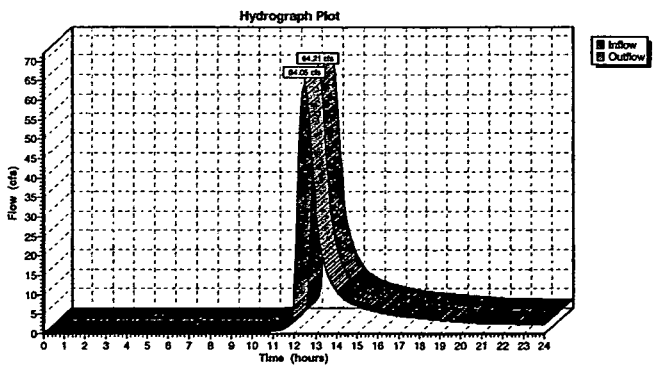
[65] Warning: Inlet elevation not specified

Inflow = 64.21 cfs @ 12.46 hrs, Volume= 9.057 af
Outflow = 64.05 cfs @ 12.49 hrs, Volume= 9.045 af, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.4 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 3.2 min

Peak Depth= 2.20'
Capacity at bank full= 90.11 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 300.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 26: runon channel



Reach 27: new CMP arch

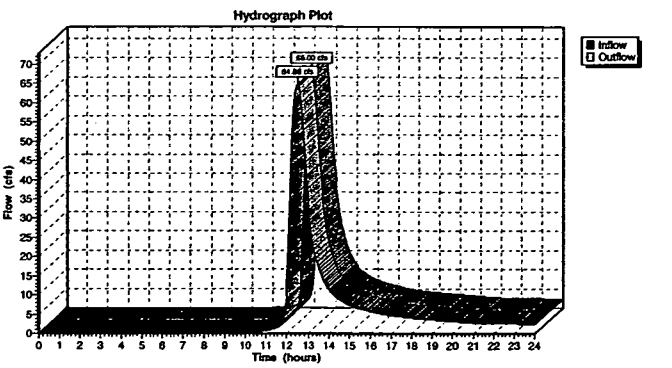
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 65.00 cfs @ 12.48 hrs, Volume= 9.365 af
Outflow = 64.88 cfs @ 12.49 hrs, Volume= 9.361 af, Atten= 0%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 2
Max. Velocity= 5.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.64'
Capacity at bank full= 398.58 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 106.0' Slope= 0.0042 '/'

Reach 27: new CMP arch



Reach 28R: new CMP culverts

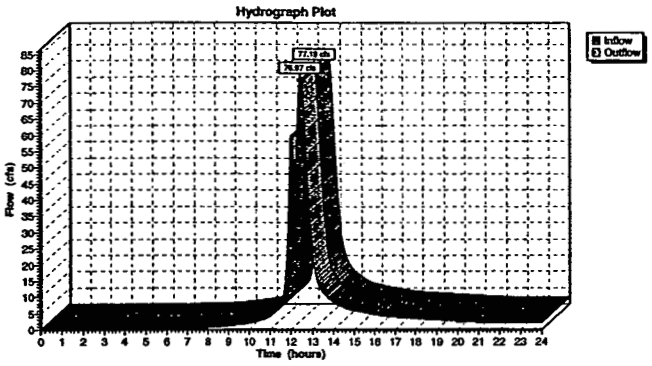
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 77.19 cfs @ 12.46 hrs, Volume= 10.267 af
Outflow = 76.97 cfs @ 12.47 hrs, Volume= 10.263 af, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.7 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 1.1 min

Peak Depth= 1.73'
Capacity at bank full= 427.00 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.019 Length= 140.0' Slope= 0.0054 '/'

Reach 28R: new CMP culverts



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Reach 29: east runon channel

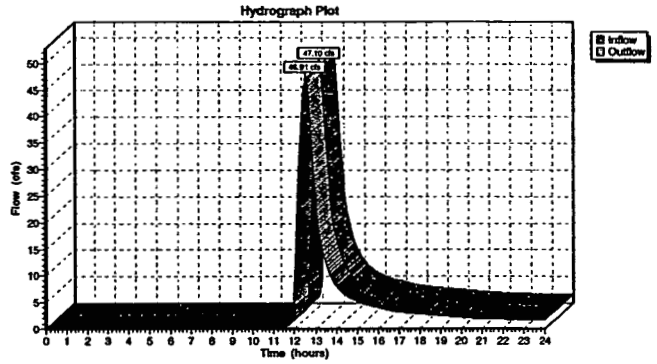
[65] Warning: Inlet elevation not specified

Inflow = 47.10 cfs @ 12.50 hrs, Volume= 6.408 af
Outflow = 46.91 cfs @ 12.53 hrs, Volume= 6.402 af, Atten= 0%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 2.4 min

Peak Depth= 1.86'
Capacity at bank full= 255.23 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 230.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 29: east runon channel



Reach 30: east runon channel

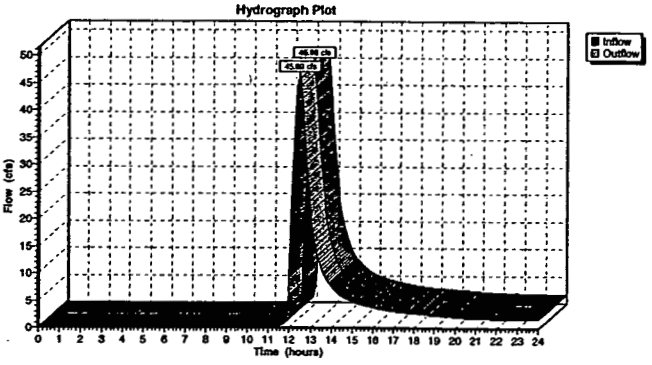
[65] Warning: Inlet elevation not specified

Inflow = 45.98 cfs @ 12.48 hrs, Volume= 6.152 af
Outflow = 45.89 cfs @ 12.48 hrs, Volume= 6.151 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 2
Max. Velocity= 4.5 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.84'
Capacity at bank full= 104.05 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 30.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 30: east runon channel



Reach 31: culvert

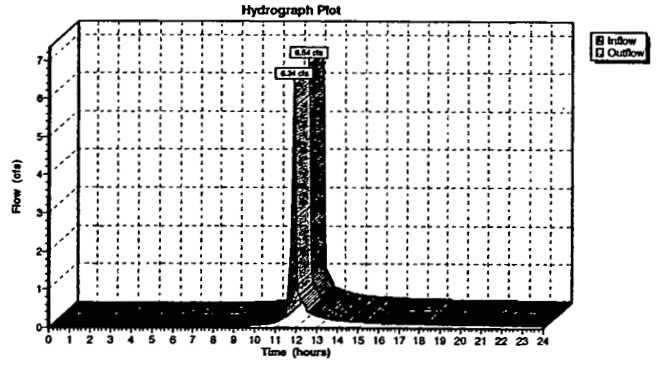
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 6.54 cfs @ 11.91 hrs, Volume= 0.279 af
Outflow = 6.34 cfs @ 11.91 hrs, Volume= 0.279 af, Atten= 3%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.1 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.34'
Capacity at bank full= 1,025.91 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.012 Length= 80.0' Slope= 0.0125 '/'

Reach 31: culvert



Pond 1P: (new node)

Inflow	=	49.32 cfs @	12.39 hrs,	Volume=	6.362 af
Outflow	=	45.98 cfs @	12.48 hrs,	Volume=	6.152 af, Atten= 7%, Lag= 5.4 min
Primary	=	45.98 cfs @	12.48 hrs,	Volume=	6.152 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

ting Elev= 592.00' Storage= 0.691 af
k Elev= 593.91' Storage= 1.584 af (0.893 af above starting storage)
Plug-Flow detention time= 102.4 min calculated for 5.461 af (86% of inflow)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
589.30	0.186	0.000	0.000	0.186
590.00	0.210	0.139	0.139	0.211
591.00	0.278	0.243	0.382	0.279
592.00	0.342	0.309	0.691	0.344
593.00	0.463	0.401	1.092	0.465
594.00	0.624	0.542	1.634	0.627

Primary OutFlow (Free Discharge)
└─1=Special (user-defined)

#	Routing	Invert	Outlet Devices
1	Primary	592.00'	**Special (user-defined)** Head (feet) 0.00 0.01 0.18 0.51 1.01 1.34 1.67 2.00 Disch. (cfs) 0.00 0.00 0.08 1.33 8.21 17.57 31.73 51.47

Pond 1P: (new node)

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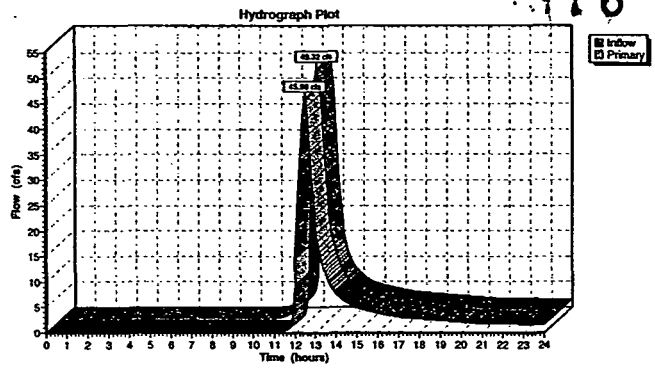
Hydrograph Plot



Pond 3P: Borrow Area Basin

Inflow	=	175.81 cfs @	12.58 hrs,	Volume=	29.218 af
Outflow	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af, Atten= 100%, Lag= 0.0 min
Primary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 574.16' Storage= 29.204 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

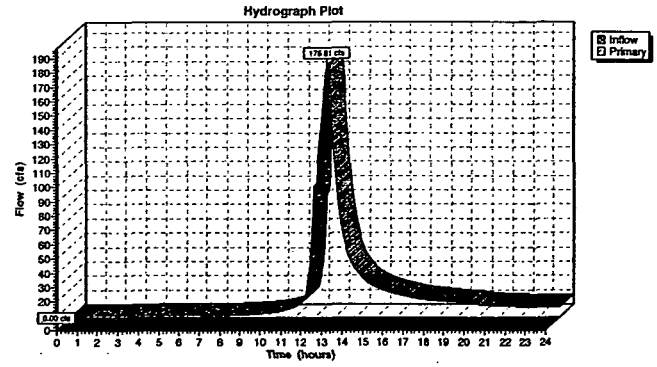
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.00	6.391	0.000	0.000	6.391
571.00	6.687	6.538	6.538	6.690
572.00	7.017	6.851	13.390	7.023
573.00	7.290	7.153	20.543	7.300
574.00	7.613	7.451	27.994	7.626
575.00	7.921	7.766	35.760	7.938

Primary OutFlow (Free Discharge)
├─2=Culvert
│ └─1=Orifice/Grate
└─3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.30'	**48.0" Horiz. Orifice/Grate X 2.00** Limited to weir flow C= 0.600
2	Primary	569.80'	**48.0" x 200.0' long Culvert X 2.00** Ke= 0.700 Outlet Invert= 569.00' S= 0.0040 '/' n= 0.024 Cc= 0.900
3	Primary	578.00'	**20.0' long Broad-Crested Rectangular Weir** Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00 Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 3P: Borrow Area Basin

Hydrograph Plot



ATTACHMENT C-1B

HydroCAD™ OUTPUT REPORTS

WEST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO

WEST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO
10-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.10"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Pond 1P: Sedimentation Basin 2

Peak Storage= 8.507 af Inflow= 77.03 cfs 8.511 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

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Pond 1P: Sedimentation Basin 2

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Inflow	=	77.03 cfs @	12.05 hrs, Volume=	8.511 af	
Outflow	=	0.00 cfs @	0.00 hrs, Volume=	0.000 af,	Atten= 100%, Lag= 0.0 min
Primary	=	0.00 cfs @	0.00 hrs, Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

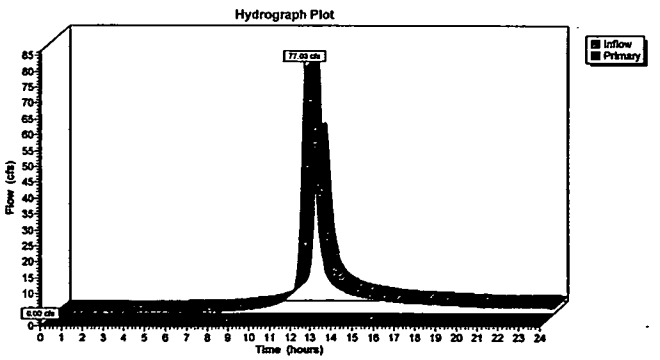
Peak Elev= 575.46' Storage= 8.507 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.50	1.460	0.000	0.000	1.460
571.00	1.512	0.743	0.743	1.513
572.00	1.614	1.563	2.306	1.617
573.00	1.713	1.663	3.969	1.719
574.00	1.819	1.766	5.735	1.827
575.00	1.917	1.868	7.602	1.928
576.00	2.026	1.971	9.574	2.039
577.00	2.162	2.094	11.667	2.177

Primary OutFlow (Free Discharge)
- 2=Culvert
  - 1=Orifice/Grate
- 3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.50'	48.0" Hortz. Orifice/Grate Limited to weir flow C= 0.600
2	Primary	570.78'	36.0" x 680.0' long Culvert Ke= 0.700 Outlet Invert= 563.30' S= 0.0110 '/' n= 0.024 Cc= 0.900
3	Primary	576.00'	20.0' long Broad-Crested Rectangular Weir Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00 Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 1P: Sedimentation Basin 2



WEST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO
25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=18.3 min CN=83 Area=2.730 ac Runoff= 9.20 cfs 0.658 af

Subcatchment B: vegetated final cover
Tc=19.0 min CN=83 Area=5.342 ac Runoff= 17.63 cfs 1.287 af

Subcatchment C: vegetated final cover
Tc=19.0 min CN=83 Area=5.399 ac Runoff= 17.82 cfs 1.301 af

Subcatchment D: vegetated final cover
Tc=19.0 min CN=83 Area=5.530 ac Runoff= 18.25 cfs 1.332 af

Subcatchment ER: non-vegetated final cover
Tc=4.2 min CN=89 Area=5.320 ac Runoff= 32.56 cfs 1.544 af

Subcatchment F1R: non-vegetated final cover
Tc=2.9 min CN=89 Area=0.918 ac Runoff= 5.78 cfs 0.267 af

Subcatchment F2R: (new node)
Tc=2.6 min CN=89 Area=1.550 ac Runoff= 9.78 cfs 0.450 af

Subcatchment FR: non-vegetated final cover/construction laydown
Tc=2.2 min CN=89 Area=1.853 ac Runoff= 11.47 cfs 0.538 af

Subcatchment GR: (new node)
Tc=2.0 min CN=86 Area=0.366 ac Runoff= 2.13 cfs 0.097 af

Subcatchment HR: non-vegetated final cover area
Tc=9.5 min CN=79 Area=0.092 ac Runoff= 0.36 cfs 0.019 af

Subcatchment J1R: construction laydown area
Tc=2.8 min CN=82 Area=0.312 ac Runoff= 1.66 cfs 0.073 af

Subcatchment J2R: construction laydown area
Tc=6.2 min CN=82 Area=0.854 ac Runoff= 4.05 cfs 0.200 af

Subcatchment KR: runon north of borrow area
Tc=2.4 min CN=85 Area=2.370 ac Runoff= 13.68 cfs 0.611 af

Subcatchment LR: construction laydown area
Tc=28.6 min CN=82 Area=2.287 ac Runoff= 5.73 cfs 0.532 af

Subcatchment MR: runon north of borrow area
Tc=2.8 min CN=79 Area=0.675 ac Runoff= 3.30 cfs 0.143 af

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Subcatchment N: construction laydown area
Tc=15.2 min CN=82 Area=1.043 ac Runoff= 3.73 cfs 0.244 af

Subcatchment O: pond
Tc=1.0 min CN=98 Area=2.252 ac Runoff= 16.67 cfs 0.838 af

Subcatchment P1R: construction laydown area
Tc=7.0 min CN=82 Area=0.666 ac Runoff= 3.12 cfs 0.156 af

Subcatchment P2R: construction laydown area
Tc=8.3 min CN=82 Area=0.214 ac Runoff= 0.96 cfs 0.050 af

Subcatchment QN: runon north of borrow area
Tc=11.8 min CN=79 Area=0.127 ac Runoff= 0.46 cfs 0.027 af

Reach 1: west channel
Inflow= 9.20 cfs 0.658 af
Length= 400.0' Max Vel= 2.5 fps Capacity= 424.60 cfs Outflow= 8.87 cfs 0.656 af

Reach 2: west channel
Inflow= 25.75 cfs 1.943 af
Length= 400.0' Max Vel= 3.3 fps Capacity= 424.60 cfs Outflow= 25.10 cfs 1.939 af

Reach 3: west channel
Inflow= 41.23 cfs 3.240 af
Length= 400.0' Max Vel= 3.7 fps Capacity= 424.60 cfs Outflow= 40.35 cfs 3.234 af

Reach 4: west channel
Inflow= 55.70 cfs 4.566 af
Length= 90.0' Max Vel= 4.0 fps Capacity= 426.17 cfs Outflow= 55.45 cfs 4.565 af

Reach 5: culvert
Inflow= 55.45 cfs 4.565 af
Length= 95.0' Max Vel= 4.9 fps Capacity= 396.64 cfs Outflow= 55.23 cfs 4.563 af

Reach 6: west channel
Inflow= 55.23 cfs 4.563 af
Length= 380.0' Max Vel= 4.0 fps Capacity= 424.60 cfs Outflow= 54.31 cfs 4.555 af

Reach 7AR: Haul Road Culvert 1
Inflow= 57.96 cfs 6.100 af
Length= 81.5' Max Vel= 5.4 fps Capacity= 166.63 cfs Outflow= 57.80 cfs 6.098 af

Reach 7BR: Channel between GIS 14 & 15
Inflow= 57.88 cfs 6.171 af
Length= 100.0' Max Vel= 2.6 fps Capacity= 200.78 cfs Outflow= 57.49 cfs 6.167 af

Reach 7CR: Rimia Parking Lot Culvert
Inflow= 58.08 cfs 6.434 af
Length= 296.0' Max Vel= 8.1 fps Capacity= 296.41 cfs Outflow= 57.75 cfs 6.430 af

Reach 7DR: Runoff Drainage Channel south of Rimia
Inflow= 58.26 cfs 6.629 af
Length= 237.0' Max Vel= 3.2 fps Capacity= 599.79 cfs Outflow= 57.56 cfs 6.621 af

Reach 8AR: west channel
Inflow= 83.95 cfs 8.487 af
Length= 220.0' Max Vel= 3.5 fps Capacity= 389.11 cfs Outflow= 81.21 cfs 8.475 af

Reach 8BR: Culvert at Sed Basin 2 entrance
Inflow= 81.21 cfs 8.475 af
Length= 30.0' Max Vel= 6.8 fps Capacity= 535.70 cfs Outflow= 81.08 cfs 8.475 af

Reach 8CR: Channel into Sed Basin 2
Inflow= 81.93 cfs 8.525 af
Length= 62.7' Max Vel= 6.5 fps Capacity= 728.12 cfs Outflow= 81.64 cfs 8.523 af

Reach 9AR: Extended Drainge Channel South of Cell 8
Inflow= 13.68 cfs 0.611 af
Length= 197.0' Max Vel= 4.7 fps Capacity= 267.67 cfs Outflow= 13.09 cfs 0.610 af

Reach 9BR: (new node)
Inflow= 13.09 cfs 0.610 af
Length= 88.0' Max Vel= 5.9 fps Capacity= 353.53 cfs Outflow= 12.87 cfs 0.610 af

Reach 9R: Channel U/S of 30" Culvert
Inflow= 13.16 cfs 0.629 af
Length= 27.3' Max Vel= 4.7 fps Capacity= 1,695.60 cfs Outflow= 13.07 cfs 0.629 af

Reach 10AR: (new node)
Inflow= 9.78 cfs 0.450 af
Length= 71.4' Max Vel= 5.2 fps Capacity= 243.75 cfs Outflow= 9.65 cfs 0.450 af

Reach 10BR: (new node)
Inflow= 9.65 cfs 0.450 af
Length= 38.0' Max Vel= 5.3 fps Capacity= 343.51 cfs Outflow= 9.58 cfs 0.450 af

Reach 10R: access road diversion channel
Inflow= 21.20 cfs 0.988 af
Length= 320.0' Max Vel= 2.6 fps Capacity= 172.90 cfs Outflow= 19.28 cfs 0.985 af

Reach 11AR: (new node)
Inflow= 20.52 cfs 1.082 af
Length= 60.0' Max Vel= 2.6 fps Capacity= 170.32 cfs Outflow= 20.24 cfs 1.081 af

Reach 11R: culvert
Inflow= 19.28 cfs 0.985 af
Length= 48.6' Max Vel= 5.4 fps Capacity= 264.80 cfs Outflow= 19.17 cfs 0.985 af

Reach 12: Culvert from F Street Drainage Channel
Inflow= 32.49 cfs 1.711 af
Length= 104.8' Max Vel= 4.3 fps Capacity= 413.70 cfs Outflow= 32.07 cfs 1.710 af

Reach 13: (new node)
Inflow= 5.73 cfs 0.532 af
Length= 120.0' Max Vel= 4.9 fps Capacity= 388.61 cfs Outflow= 5.71 cfs 0.532 af

Reach 14: Culvert from North Entrance Road channel
Inflow= 3.20 cfs 0.169 af
Length= 112.0' Max Vel= 3.5 fps Capacity= 822.56 cfs Outflow= 3.11 cfs 0.169 af

Reach 15N: Culvert adjacent to North Entrance Road
Inflow= 0.46 cfs 0.027 af
Length= 55.0' Max Vel= 2.4 fps Capacity= 406.62 cfs Outflow= 0.46 cfs 0.027 af

Reach 16N: Channel east of North Entrance Road
Inflow= 3.56 cfs 0.170 af
Length= 382.0' Max Vel= 2.2 fps Capacity= 71.46 cfs Outflow= 3.20 cfs 0.169 af

Pond 1P: Sedimentation Basin 2
Peak Storage= 8.922 af Inflow= 94.01 cfs 10.306 af
Primary= 2.91 cfs 1.453 af Outflow= 2.91 cfs 1.453 af

Runoff Area = 39.900 ac Volume = 10.367 af Average Depth = 3.12"

Subcatchment A: vegetated final cover

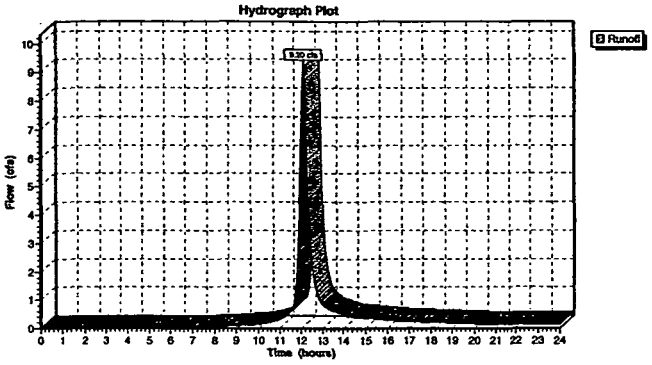
Runoff = 9.20 cfs @ 12.11 hrs, Volume= 0.658 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.730	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	180	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
18.3	670	Total			

Subcatchment A: vegetated final cover



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Subcatchment B: vegetated final cover

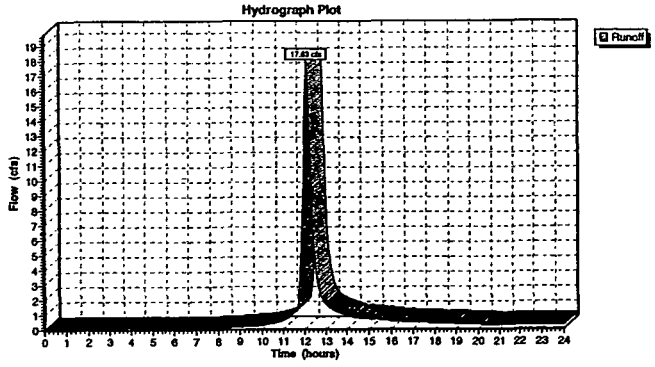
Runoff = 17.63 cfs @ 12.11 hrs, Volume= 1.287 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.342	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	200	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

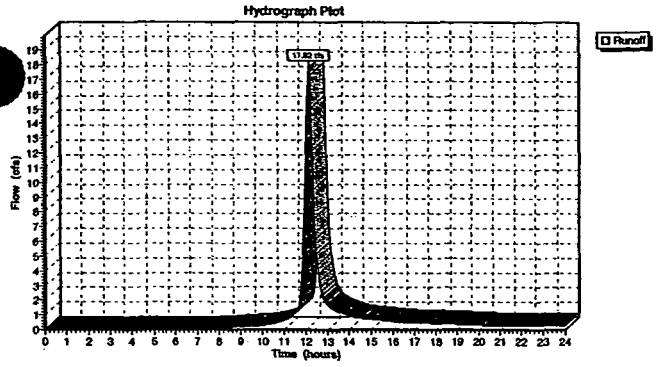
Runoff = 17.82 cfs @ 12.11 hrs, Volume= 1.301 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.399	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	945	Total			

Subcatchment C: vegetated final cover



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Subcatchment D: vegetated final cover

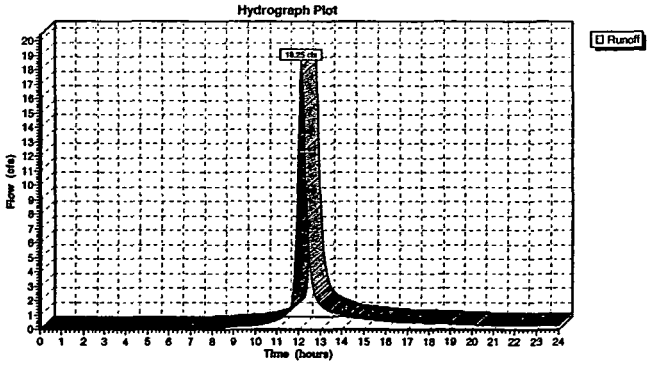
Runoff = 18.25 cfs @ 12.11 hrs, Volume= 1.332 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.530	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	205	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment D: vegetated final cover



Subcatchment ER: non-vegetated final cover

[49] Hint: Tc<2dt may require smaller dt

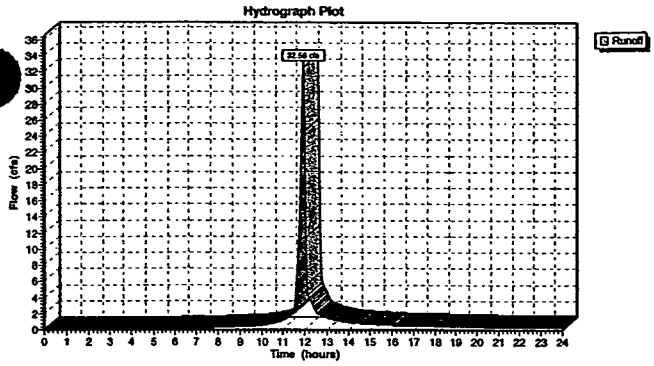
Runoff = 32.56 cfs @ 11.94 hrs, Volume= 1.544 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.320	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	110	0.0625	2.0		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.4	45	0.1110	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1700	3.2		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.4	510	0.0075	6.1	337.31	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.50' Z= 3.0 & 6.0 '/' n= 0.030
0.2	85	0.0029	8.1	228.07	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
4.2	1,100	Total			

Subcatchment ER: non-vegetated final cover



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Subcatchment F1R: non-vegetated final cover

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[49] Hint: Tc<2dt may require smaller dt

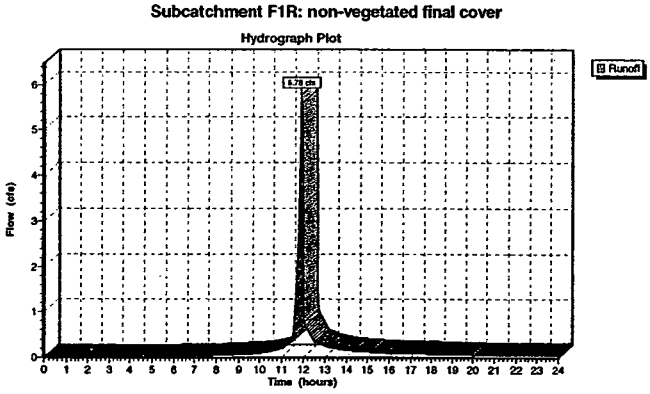
Runoff = 5.78 cfs @ 11.93 hrs, Volume= 0.267 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.918	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	90	0.0530	1.8		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.4	50	0.1000	2.0		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1670	3.1		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.5	200	0.1670	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.4	160	0.0075	6.1	337.31	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.50' Z= 6.0 & 3.0 '/' n= 0.030
0.0	53	0.0580	36.1	1,019.94	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
2.9	703	Total			

Subcatchment F1R: non-vegetated final cover



Subcatchment F2R: (new node)

[49] Hint: Tc<2dt may require smaller dt

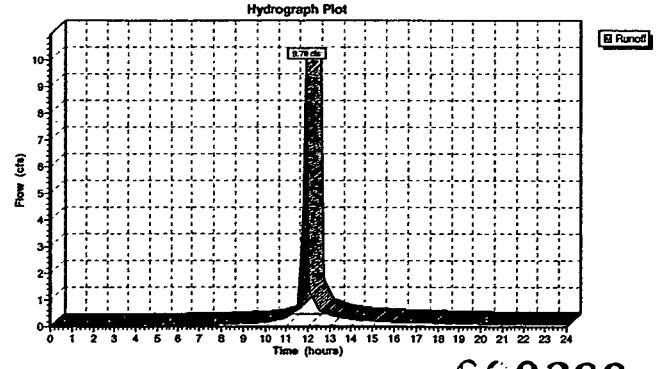
Runoff = 9.78 cfs @ 11.93 hrs, Volume= 0.450 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.550	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.7		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.4	55	0.1000	2.1		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1667	3.1		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.55"
0.5	200	0.1667	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
2.6	495	Total			

Subcatchment F2R: (new node)



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Subcatchment FR: non-vegetated final cover/construction laydown

[49] Hint: Tc<2dt may require smaller dt

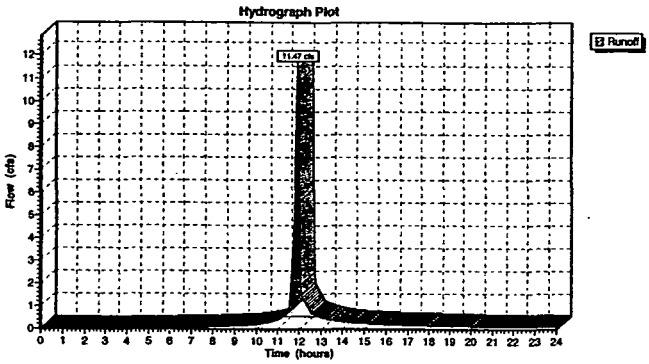
Runoff = 11.47 cfs @ 11.92 hrs, Volume= 0.538 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.853	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	30	0.0500	1.4		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.4	55	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1670	3.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	30	0.3300	9.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	445	Total			

Subcatchment FR: non-vegetated final cover/construction laydown



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Subcatchment GR: (new node)

[49] Hint: Tc<2dt may require smaller dt

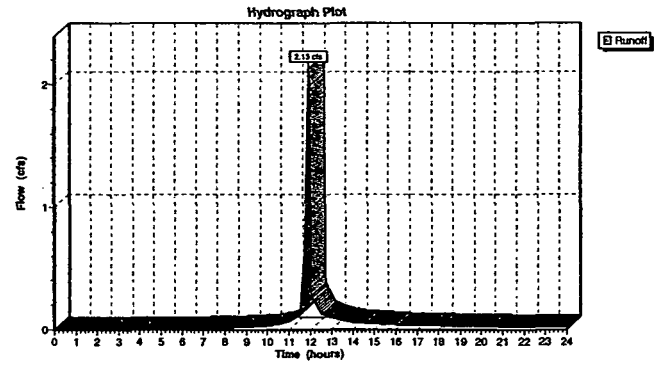
Runoff = 2.13 cfs @ 11.92 hrs, Volume= 0.097 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.262	89	
0.035	79	
0.069	79	
0.366	86	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	150	0.1670	3.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.7	270	0.1670	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.5	60	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.0	480	Total			

Subcatchment GR: (new node)



Subcatchment HR: non-vegetated final cover area

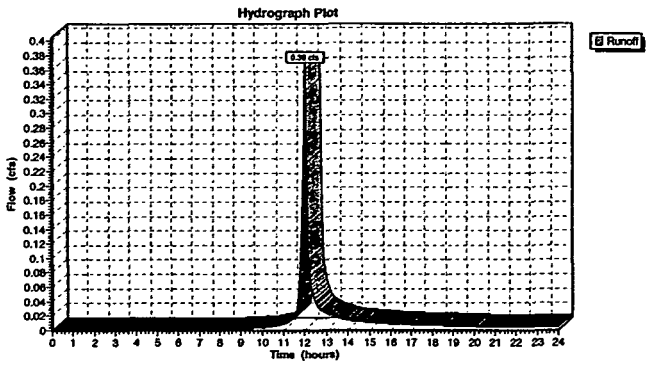
Runoff = 0.36 cfs @ 12.01 hrs, Volume= 0.019 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.092	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	80	0.0180	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment HR: non-vegetated final cover area



Subcatchment J1R: construction laydown area

[49] Hint: Tc<2dt may require smaller dt

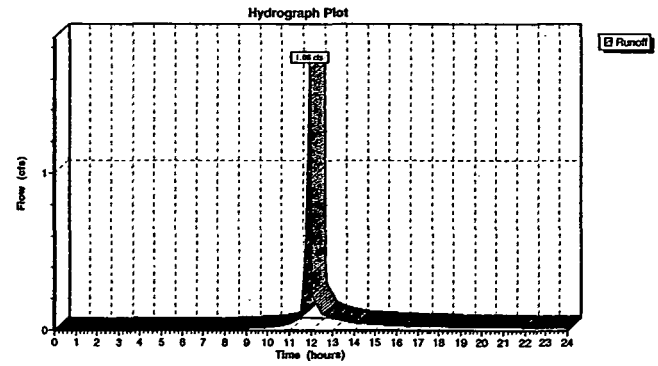
Runoff = 1.66 cfs @ 11.93 hrs, Volume= 0.073 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.312	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	54	0.1670	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J1R: construction laydown area



Subcatchment J2R: construction laydown area

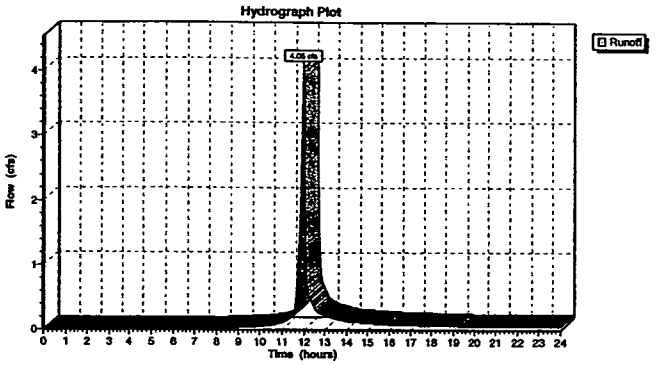
Runoff = 4.05 cfs @ 11.97 hrs, Volume= 0.200 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.854	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	72	0.0427	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J2R: construction laydown area



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Subcatchment KR: runon north of borrow area

[49] Hint: Tc<2dt may require smaller dt

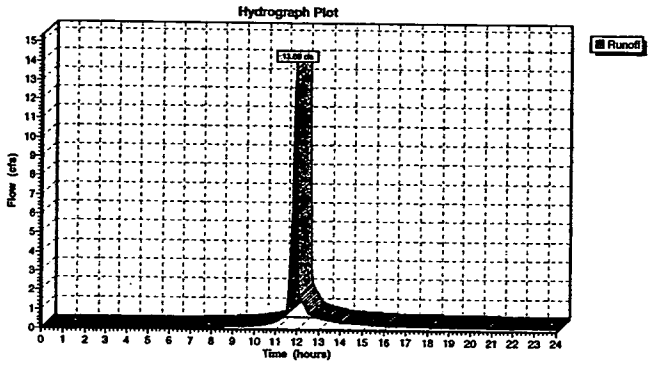
Runoff = 13.68 cfs @ 11.93 hrs, Volume= 0.611 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.469	89	
0.792	79	
0.109	79	
2.370	85	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	70	0.1000	2.2		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1700	3.2		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.4	155	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	95	0.0180	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.4	470	Total			

Subcatchment KR: runon north of borrow area



Subcatchment LR: construction laydown area

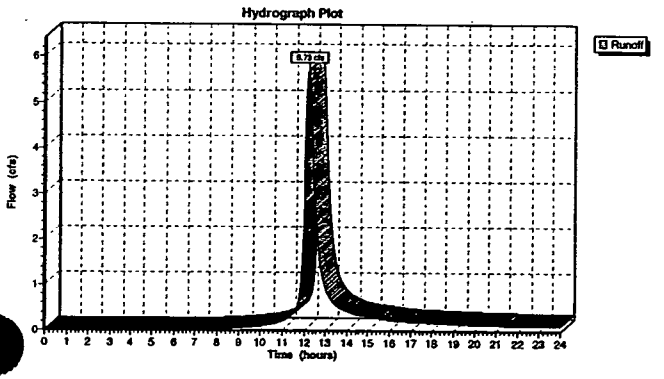
Runoff = 5.73 cfs @ 12.23 hrs, Volume= 0.532 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.287	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0167	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	65	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.6	365	Total			

Subcatchment LR: construction laydown area



Subcatchment MR: runon north of borrow area

[49] Hint: Tc<2dt may require smaller dt

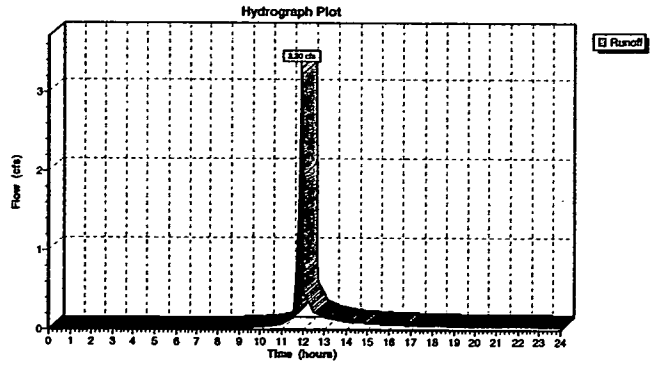
Runoff = 3.30 cfs @ 11.93 hrs, Volume= 0.143 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.675	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	40	0.0985	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment MR: runon north of borrow area



Subcatchment N: construction laydown area

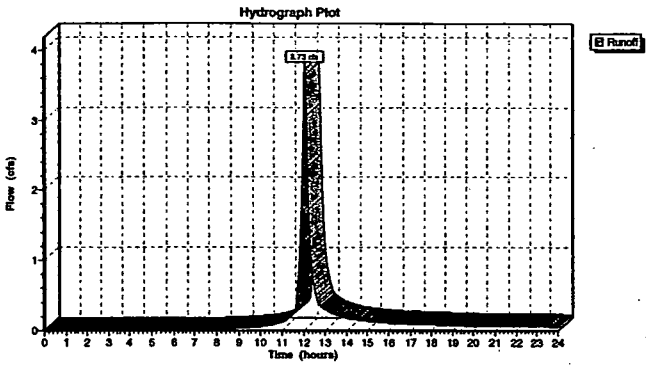
Runoff = 3.73 cfs @ 12.07 hrs, Volume= 0.244 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.043	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2	170	0.0250	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment N: construction laydown area



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Subcatchment O: pond

[49] Hint: Tc<2dt may require smaller dt

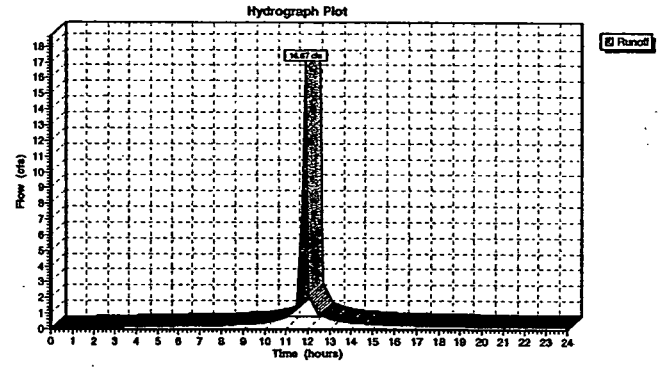
Runoff = 18.67 cfs @ 11.90 hrs, Volume= 0.838 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.252	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment O: pond



Subcatchment P1R: construction laydown area

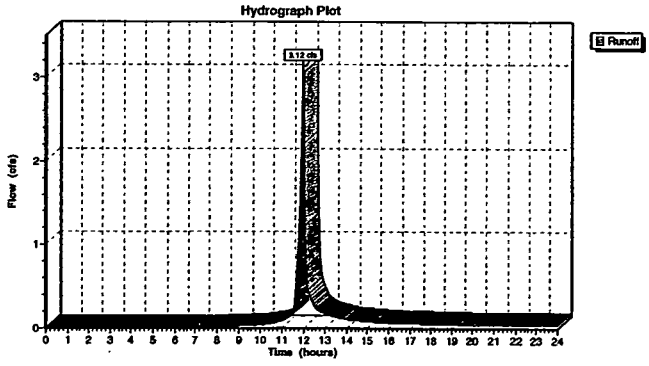
Runoff = 3.12 cfs @ 11.98 hrs, Volume= 0.156 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.666	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	80	0.0385	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P1R: construction laydown area



Subcatchment P2R: construction laydown area

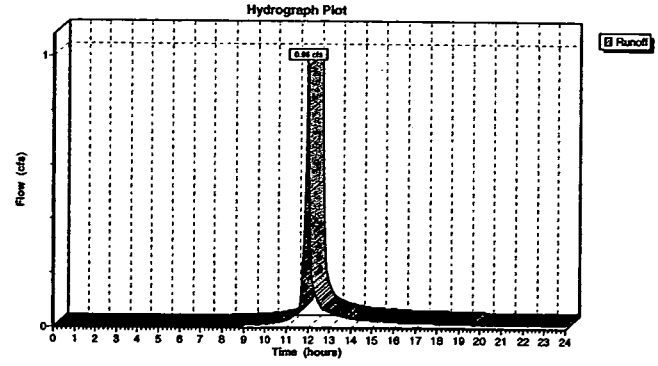
Runoff = 0.96 cfs @ 12.00 hrs, Volume= 0.050 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.214	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	110	0.0473	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P2R: construction laydown area



Subcatchment QN: runon north of borrow area

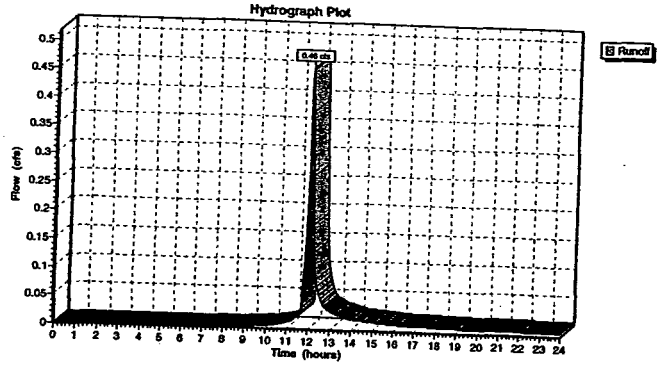
Runoff = 0.46 cfs @ 12.04 hrs, Volume= 0.027 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
e II 24-hr Rainfall=4.70"

rea (ac)	CN	Description
0.127	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	100	0.0167	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"

Subcatchment QN: runon north of borrow area



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Reach 1: west channel

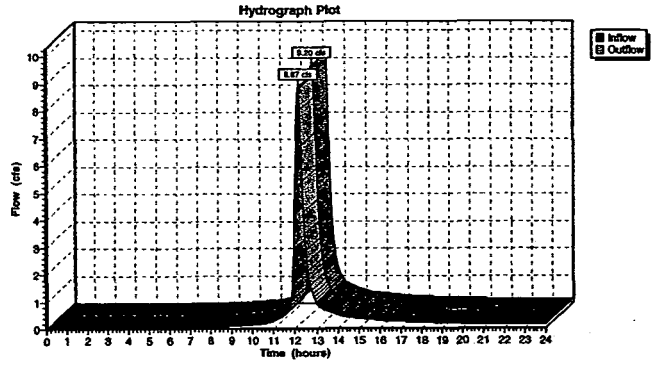
[65] Warning: Inlet elevation not specified

Inflow = 9.20 cfs @ 12.11 hrs, Volume= 0.658 af
Outflow = 8.87 cfs @ 12.19 hrs, Volume= 0.656 af, Atten= 4%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 2.6 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.6 min

Peak Depth= 0.94'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 1: west channel



Reach 2: west channel

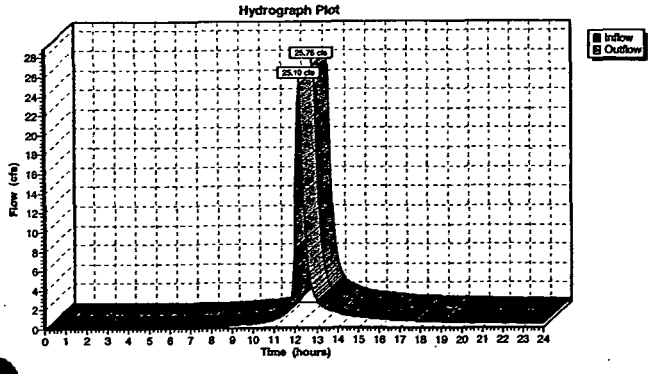
[65] Warning: Inlet elevation not specified

Inflow = 25.75 cfs @ 12.14 hrs, Volume= 1.943 af
Outflow = 25.10 cfs @ 12.20 hrs, Volume= 1.939 af, Atten= 3%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.1 min

Peak Depth= 1.39'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 2: west channel



Reach 3: west channel

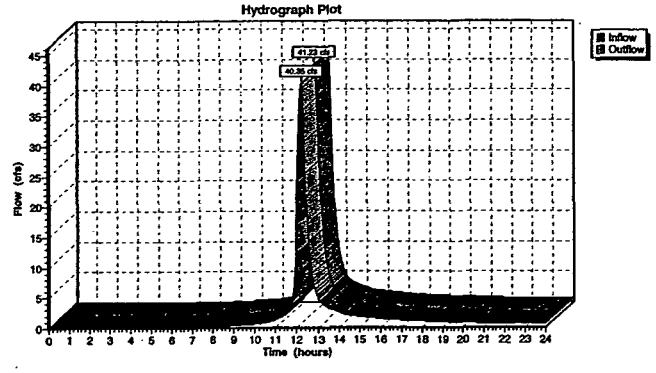
[65] Warning: Inlet elevation not specified

Inflow = 41.23 cfs @ 12.16 hrs, Volume= 3.240 af
Outflow = 40.35 cfs @ 12.22 hrs, Volume= 3.234 af, Atten= 2%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 4.5 min

Peak Depth= 1.66'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 3: west channel



Reach 4: west channel

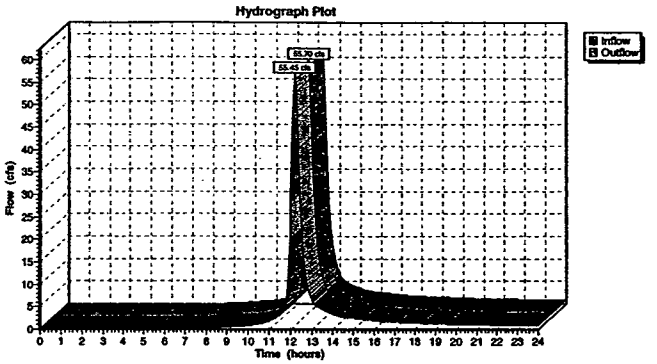
[65] Warning: Inlet elevation not specified

Inflow = 55.70 cfs @ 12.19 hrs, Volume= 4.566 af
Outflow = 55.45 cfs @ 12.20 hrs, Volume= 4.565 af, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.0 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.9 min

Peak Depth= 1.86'
Capacity at bank full= 426.17 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 90.0' Slope= 0.0076 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 4: west channel



Reach 5: culvert

5316

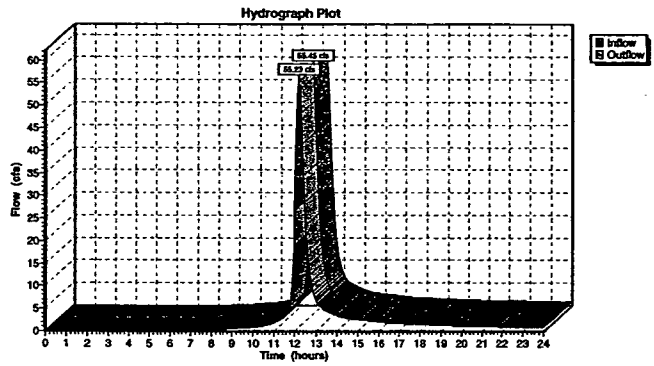
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 55.45 cfs @ 12.20 hrs, Volume= 4.565 af
Outflow = 55.23 cfs @ 12.21 hrs, Volume= 4.563 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 0.9 min

Peak Depth= 1.52'
Capacity at bank full= 396.64 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 95.0' Slope= 0.0075 '/'

Reach 5: culvert



Reach 6: west channel

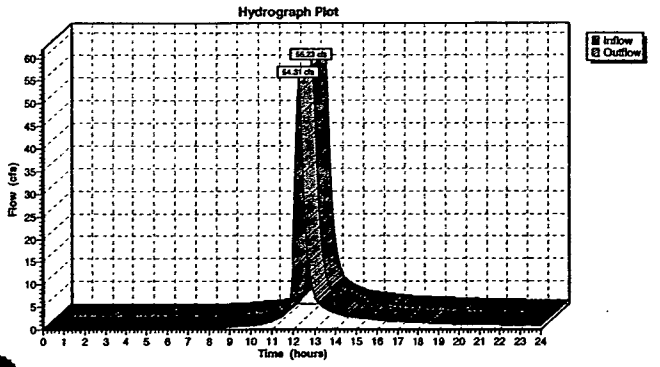
[65] Warning: Inlet elevation not specified

Inflow = 55.23 cfs @ 12.21 hrs, Volume= 4.563 af
Outflow = 54.31 cfs @ 12.25 hrs, Volume= 4.555 af, Atten= 2%, Lag= 2.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.0 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 3.9 min

Peak Depth= 1.86'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 380.0' Slope= 0.0075 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 6: west channel



Reach 7AR: Haul Road Culvert 1

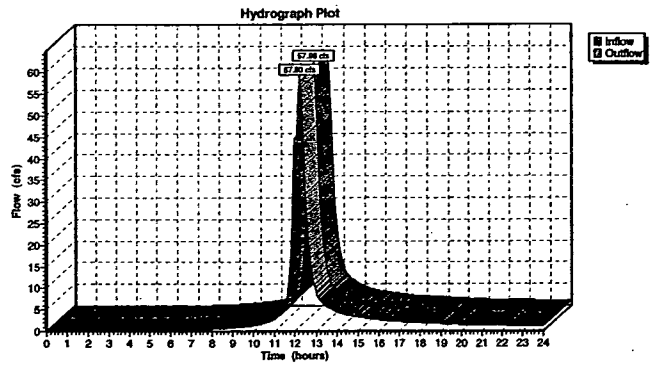
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 57.96 cfs @ 12.25 hrs, Volume= 6.100 af
Outflow = 57.80 cfs @ 12.26 hrs, Volume= 6.098 af, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 0.7 min

Peak Depth= 2.44'
Capacity at bank full= 166.63 cfs
72.0" Diameter Pipe n= 0.024 Length= 81.5' Slope= 0.0053 '/'

Reach 7AR: Haul Road Culvert 1



Reach 7BR: Channel between GIS 14 & 15

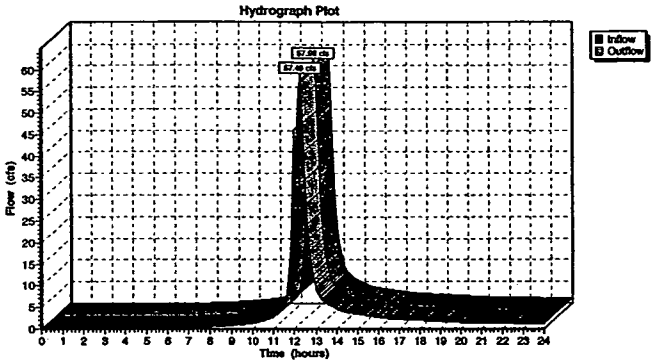
[65] Warning: Inlet elevation not specified

Inflow = 57.98 cfs @ 12.26 hrs, Volume= 6.171 af
Outflow = 57.49 cfs @ 12.28 hrs, Volume= 6.167 af, Atten= 1%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 1.6 min

Peak Depth= 2.37'
Capacity at bank full= 200.78 cfs
0.00' x 3.77' deep channel, n= 0.030 Length= 100.0' Slope= 0.0023 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 7BR: Channel between GIS 14 & 15



Reach 7CR: Rimia Parking Lot Culvert

5316

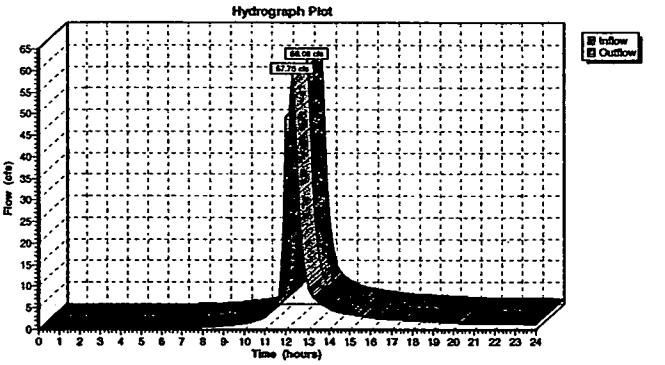
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 58.08 cfs @ 12.28 hrs, Volume= 6.434 af
Outflow = 57.75 cfs @ 12.30 hrs, Volume= 6.430 af, Atten= 1%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.1 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 1.7 min

Peak Depth= 1.80'
Capacity at bank full= 296.41 cfs
72.0" Diameter Pipe n= 0.013 Length= 296.0' Slope= 0.0049 '/'

Reach 7CR: Rimia Parking Lot Culvert



Reach 7DR: Runoff Drainage Channel south of Rimia

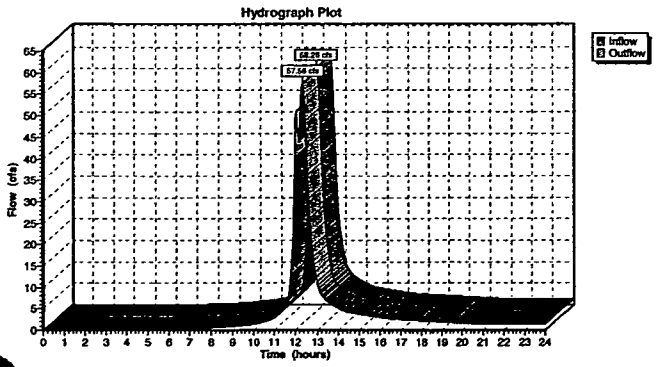
[65] Warning: Inlet elevation not specified

Inflow = 58.26 cfs @ 12.29 hrs, Volume= 6.629 af
Outflow = 57.56 cfs @ 12.33 hrs, Volume= 6.621 af, Atten= 1%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 3.1 min

Peak Depth= 1.80'
Capacity at bank full= 599.79 cfs
2.56' x 4.71' deep channel, n= 0.030 Length= 237.0' Slope= 0.0042 '/'
Side Slope Z-value= 4.3 3.9 '/'

Reach 7DR: Runoff Drainage Channel south of Rimia



Reach 8AR: west channel

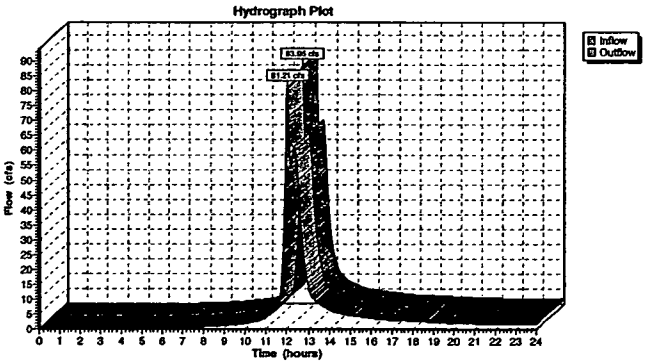
[65] Warning: Inlet elevation not specified

Inflow = 83.95 cfs @ 12.01 hrs, Volume= 8.487 af
Outflow = 81.21 cfs @ 12.04 hrs, Volume= 8.475 af, Atten= 3%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 3.4 min

Peak Depth= 1.33'
Capacity at bank full= 389.11 cfs
13.28' x 3.00' deep channel, n= 0.030 Length= 220.0' Slope= 0.0048 '/'
Side Slope Z-value= 4.2 2.6 '/'

Reach 8AR: west channel



Reach 8BR: Culvert at Sed Basin 2 entrance

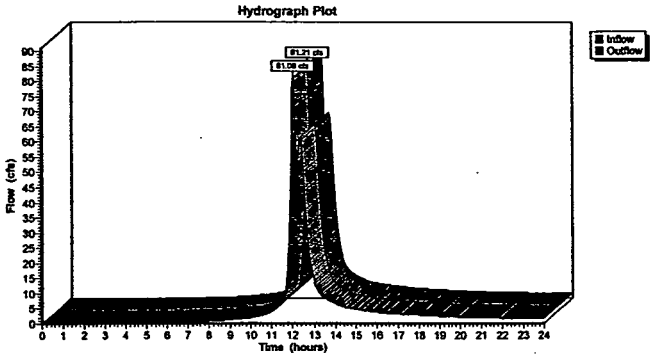
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	81.21 cfs @	12.04 hrs,	Volume=	8.475 af
[illegible]w	=	81.08 cfs @	12.04 hrs,	Volume=	8.475 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.8 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.58'
Capacity at bank full= 535.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 30.0' Slope= 0.0040 '/'

Reach 8BR: Culvert at Sed Basin 2 entrance



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Reach 8CR: Channel into Sed Basin 2

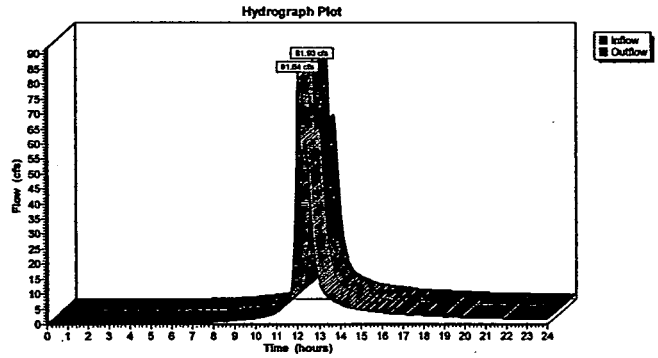
[65] Warning: Inlet elevation not specified

Inflow	=	81.93 cfs @	12.04 hrs,	Volume=	8.525 af
Outflow	=	81.64 cfs @	12.04 hrs,	Volume=	8.523 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.5 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 0.4 min

Peak Depth= 2.08'
Capacity at bank full= 728.12 cfs
1.17' x 5.00' deep channel, n= 0.030 Length= 62.7' Slope= 0.0159 '/'
Side Slope Z-value= 2.4 2.3 '/'

Reach 8CR: Channel into Sed Basin 2



Reach 9AR: Extended Drainge Channel South of Cell 8

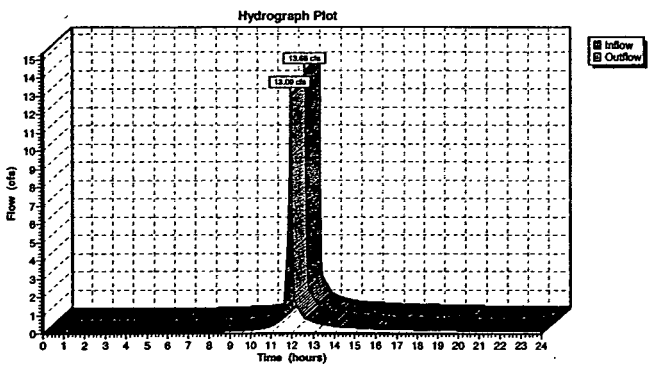
[65] Warning: Inlet elevation not specified

Inflow	=	13.68 cfs @	11.93 hrs,	Volume=	0.611 af
Outflow	=	13.09 cfs @	11.94 hrs,	Volume=	0.610 af, Atten= 4%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 2.0 min

Peak Depth= 0.98'
Capacity at bank full= 267.67 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 197.0' Slope= 0.0250 '/'
Side Slope Z-value= 3.0 '/'

Reach 9AR: Extended Drainge Channel South of Cell 8



Reach 9BR: (new node)

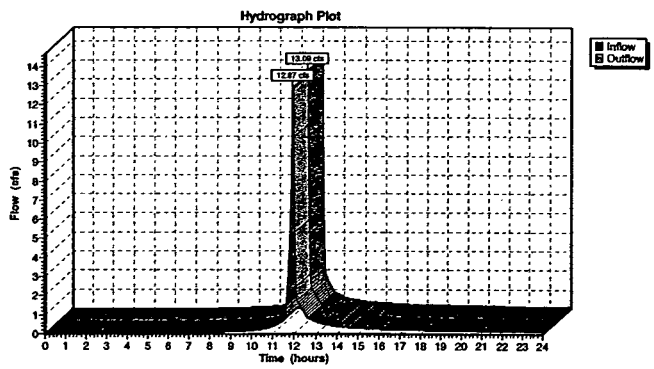
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	13.09 cfs @	11.94 hrs,	Volume=	0.610 af
Outflow	=	12.87 cfs @	11.95 hrs,	Volume=	0.610 af, Atten= 2%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.9 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.79'
Capacity at bank full= 353.53 cfs
72.0" Diameter Pipe n= 0.024 Length= 88.0' Slope= 0.0237 '/'

Reach 9BR: (new node)



Reach 9R: Channel U/S of 30" Culvert

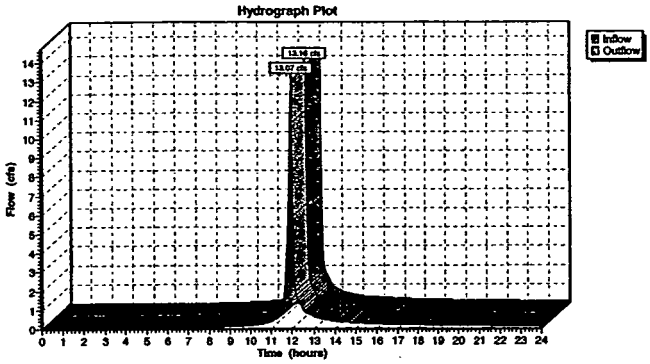
[65] Warning: Inlet elevation not specified

= 13.16 cfs @ 11.95 hrs, Volume= 0.629 af
= 13.07 cfs @ 11.95 hrs, Volume= 0.629 af, Atten= 1%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 0.3 min

Peak Depth= 0.97'
Capacity at bank full= 1,695.60 cfs
0.00' x 6.00' deep channel, n= 0.030 Length= 27.3' Slope= 0.0249 '/'
Side Slope Z-value= 3.0 '/'

Reach 9R: Channel U/S of 30" Culvert



5316

Reach 10AR: (new node)

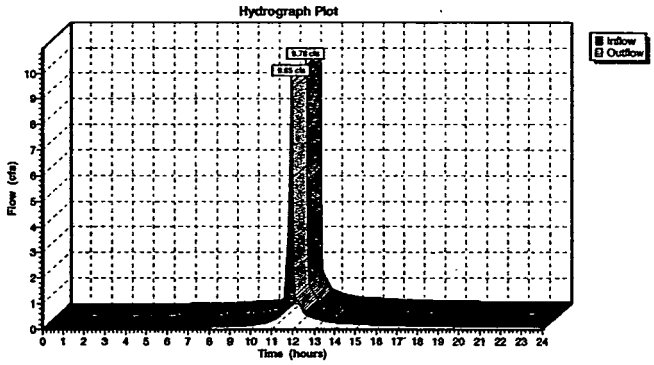
[65] Warning: Inlet elevation not specified

Inflow = 9.78 cfs @ 11.93 hrs, Volume= 0.450 af
Outflow = 9.65 cfs @ 11.93 hrs, Volume= 0.450 af, Atten= 1%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.2 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.0 min

Peak Depth= 0.31'
Capacity at bank full= 243.75 cfs
5.00' x 1.75' deep channel, n= 0.030 Length= 71.4' Slope= 0.0650 '/'
Side Slope Z-value= 3.0 '/'

Reach 10AR: (new node)



Reach 10BR: (new node)

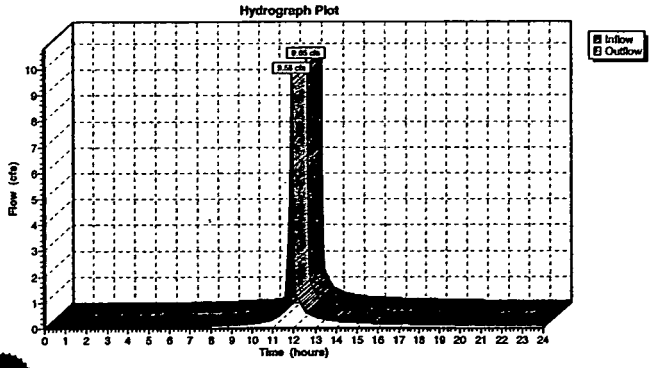
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 9.65 cfs @ 11.93 hrs, Volume= 0.450 af
Outflow = 9.58 cfs @ 11.93 hrs, Volume= 0.450 af, Atten= 1%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.69'
Capacity at bank full= 343.51 cfs
72.0" Diameter Pipe n= 0.013 Length= 38.0' Slope= 0.0066 '/'

Reach 10BR: (new node)



Reach 10R: access road diversion channel

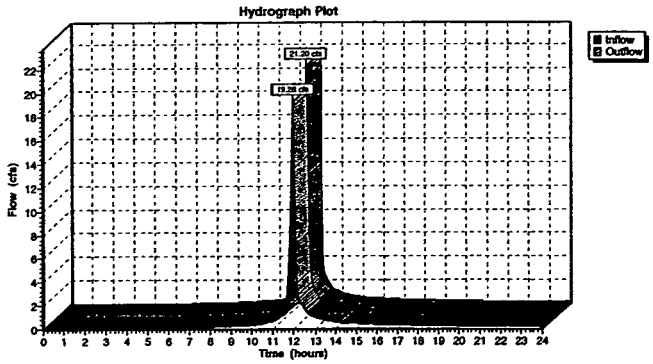
[65] Warning: Inlet elevation not specified

Inflow = 21.20 cfs @ 11.93 hrs, Volume= 0.988 af
Outflow = 19.28 cfs @ 11.98 hrs, Volume= 0.985 af, Atten= 9%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 8.7 min

Peak Depth= 0.82'
Capacity at bank full= 172.90 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 320.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 '/'

Reach 10R: access road diversion channel



Reach 11AR: (new node)

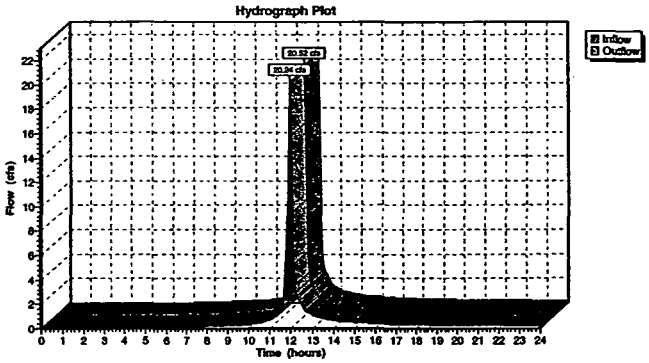
[65] Warning: Inlet elevation not specified

Inflow = 20.52 cfs @ 11.98 hrs, Volume= 1.082 af
Outflow = 20.24 cfs @ 11.99 hrs, Volume= 1.081 af, Atten= 1%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 1.6 min

Peak Depth= 0.83'
Capacity at bank full= 170.32 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 60.0' Slope= 0.0050 '/'
Side Slope Z-value= 2.8 3.0 '/'

Reach 11AR: (new node)



Reach 11R: culvert

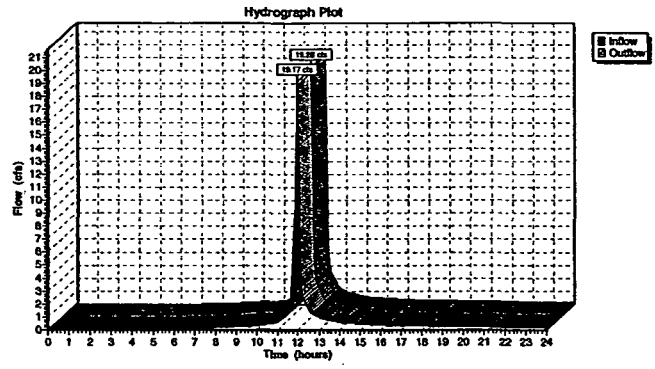
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 19.28 cfs @ 11.98 hrs, Volume= 0.985 af
Outflow = 19.17 cfs @ 11.98 hrs, Volume= 0.985 af, Atten= 1%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.5 min

Peak Depth= 1.10'
Capacity at bank full= 264.80 cfs
72.0" Diameter Pipe n= 0.013 Length= 48.6' Slope= 0.0039 '/'

Reach 11R: culvert



Reach 12: Culvert from F Street Drainage Channel

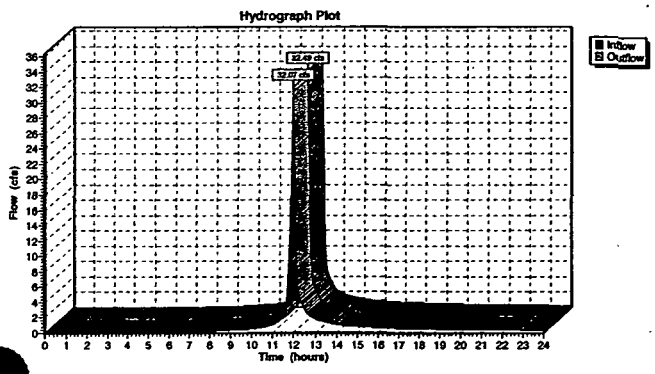
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 32.49 cfs @ 11.97 hrs, Volume= 1.711 af
Outflow = 32.07 cfs @ 11.98 hrs, Volume= 1.710 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 1.4 min

Peak Depth= 1.14'
Capacity at bank full= 413.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 104.8' Slope= 0.0024 '/'

Reach 12: Culvert from F Street Drainage Channel



Reach 13: (new node)

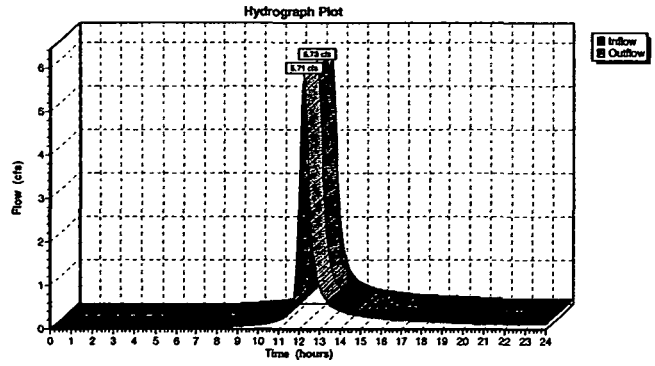
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 5.73 cfs @ 12.23 hrs, Volume= 0.532 af
Outflow = 5.71 cfs @ 12.24 hrs, Volume= 0.532 af, Atten= 0%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.51'
Capacity at bank full= 386.61 cfs
72.0" Diameter Pipe n= 0.013 Length= 120.0' Slope= 0.0083 '/'

Reach 13: (new node)



Reach 14: Culvert from North Entrance Road channel

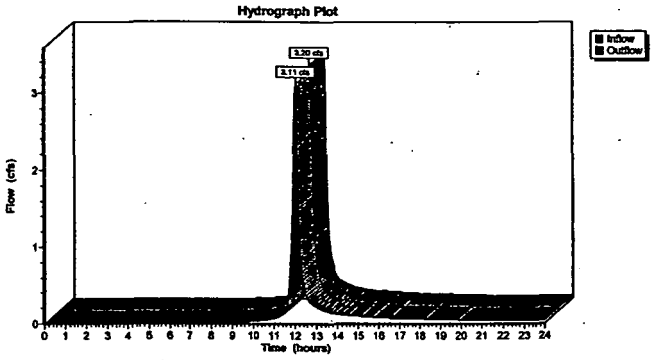
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	3.20 cfs @ 12.01 hrs, Volume=	0.169 af	
[illegible]	=	3.11 cfs @ 12.03 hrs, Volume=	0.169 af, Atten= 3%, Lag= 1.0 min	

[illegible]ing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.3 min

Peak Depth= 0.27'
Capacity at bank full= 822.56 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 112.0' Slope= 0.0321 '/'

Reach 14: Culvert from North Entrance Road channel



Reach 15N: Culvert adjacent to North Entrance Road

5316

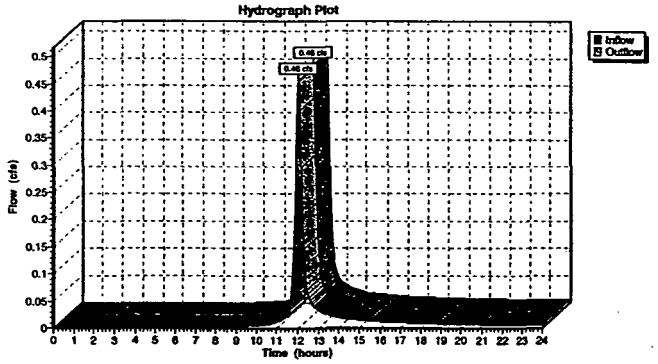
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	0.46 cfs @ 12.04 hrs, Volume=	0.027 af	
Outflow	=	0.46 cfs @ 12.05 hrs, Volume=	0.027 af, Atten= 1%, Lag= 0.6 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.15'
Capacity at bank full= 406.62 cfs
72.0" Diameter Pipe n= 0.010 Length= 55.0' Slope= 0.0055 '/'

Reach 15N: Culvert adjacent to North Entrance Road



Reach 16N: Channel east of North Entrance Road

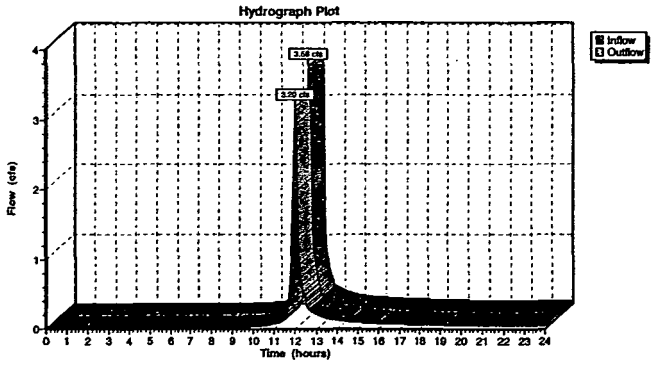
[65] Warning: Inlet elevation not specified

Inflow	=	3.58 cfs @ 11.94 hrs, Volume=	0.170 af	
Outflow	=	3.20 cfs @ 12.01 hrs, Volume=	0.169 af, Atten= 11%, Lag= 4.6 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 7.7 min

Peak Depth= 0.90'
Capacity at bank full= 71.46 cfs
0.00' x 2.88' deep channel, n= 0.030 Length= 382.0' Slope= 0.0069 '/'
Side Slope Z-value= 2.2 1.4 '/'

Reach 16N: Channel east of North Entrance Road



Pond 1P: Sedimentation Basin 2

Inflow	=	94.01 cfs @ 12.04 hrs, Volume=	10.306 af	
Outflow	=	2.91 cfs @ 18.86 hrs, Volume=	1.453 af, Atten= 97%, Lag= 409.0 min	
Primary	=	2.91 cfs @ 18.86 hrs, Volume=	1.453 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 575.67' Storage= 8.922 af
Plug-Flow detention time= 583.8 min calculated for 1.453 af (14% of inflow)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.50	1.460	0.000	0.000	1.460
571.00	1.512	0.743	0.743	1.513
572.00	1.614	1.563	2.306	1.617
573.00	1.713	1.663	3.969	1.719
574.00	1.819	1.766	5.735	1.827
575.00	1.917	1.868	7.602	1.928
576.00	2.026	1.971	9.574	2.039
577.00	2.162	2.094	11.667	2.177

Primary OutFlow (Free Discharge)
- 2=Culvert
  - 1=Orifice/Grate
- 3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.50'	**48.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600
2	Primary	570.78'	**36.0" x 680.0' long Culvert** Ke= 0.700
			Outlet Invert= 563.30' S= 0.0110 '/' n= 0.024 Cc= 0.900
3	Primary	576.00'	**20.0' long Broad-Crested Rectangular Weir**
			Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00
			Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

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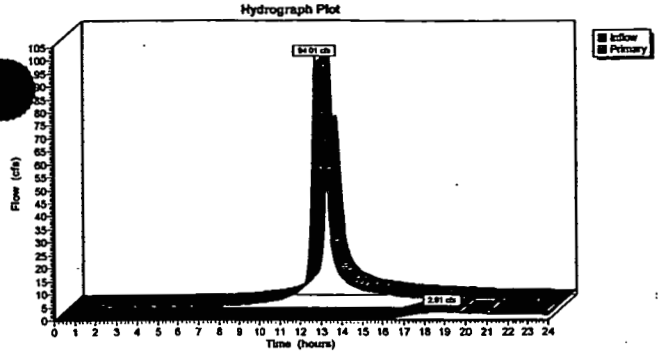
Pond 1P: Sedimentation Basin 2

Hydrograph Plot



WEST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO
100-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=5.60"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Pond 1P: Sedimentation Basin 2

Peak Storage= 9.279 af Inflow= 119.96 cfs 13.059 af
Primary= 8.55 cfs 4.171 af Outflow= 8.55 cfs 4.171 af

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Pond 1P: Sedimentation Basin 2

Inflow	=	119.96 cfs @	12.03 hrs,	Volume=	13.059 af
Outflow	=	8.55 cfs @	14.20 hrs,	Volume=	4.171 af, Atten= 93%, Lag= 129.8 min
Primary	=	8.55 cfs @	14.20 hrs,	Volume=	4.171 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

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Peak Elev= 575.85' Storage= 9.279 af
Plug-Flow detention time= 370.3 min calculated for 4.171 af (32% of inflow)
Storage and wetted areas determined by Conic sections

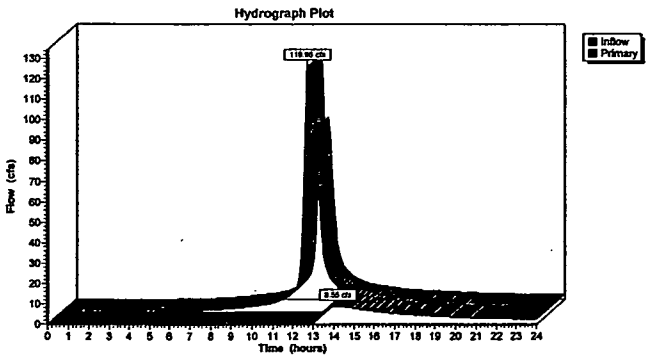
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.50	1.460	0.000	0.000	1.460
571.00	1.512	0.743	0.743	1.513
572.00	1.614	1.563	2.306	1.617
573.00	1.713	1.663	3.969	1.719
574.00	1.819	1.766	5.735	1.827
575.00	1.917	1.868	7.602	1.928
576.00	2.026	1.971	9.574	2.039
577.00	2.162	2.094	11.667	2.177

Primary OutFlow (Free Discharge)
- 2=Culvert
  - 1=Orifice/Grate
- 3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.50'	48.0" Hortz. Orifice/Grate Limited to weir flow C= 0.600
2	Primary	570.78'	36.0" x 680.0' long Culvert Ke= 0.700
			Outlet Invert= 563.30' S= 0.0110 '/' n= 0.024 Cc= 0.900
3	Primary	576.00'	20.0' long Broad-Crested Rectangular Weir
			Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00
			Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 1P: Sedimentation Basin 2

Hydrograph Plot



ATTACHMENT C-1C

HydroCAD™ OUTPUT REPORTS

EAST OSDF POST-DEVELOPMENT DESIGN SCENARIO

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4 5316

EAST OSDF POST-DEVELOPMENT DESIGN SCENARIO
2-YEAR, 24-HOUR STORM EVENT

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=2.55"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover system
Tc=17.3 min CN=74 Area=1.964 ac Runoff= 1.34 cfs 0.104 af

[illegible]hment AA: open space with good grass cover
Tc=16.8 min CN=74 Area=2.708 ac Runoff= 1.89 cfs 0.144 af

Subcatchment B: vegetated final cover system
Tc=6.2 min CN=74 Area=1.179 ac Runoff= 1.25 cfs 0.063 af

Subcatchment BB: open space with good grass cover
Tc=9.1 min CN=79 Area=0.761 ac Runoff= 1.02 cfs 0.055 af

Subcatchment C: vegetated final cover system
Tc=20.7 min CN=74 Area=5.209 ac Runoff= 3.18 cfs 0.276 af

Subcatchment CC: open space with good grass cover
Tc=6.7 min CN=79 Area=0.121 ac Runoff= 0.18 cfs 0.009 af

Subcatchment D: vegetated final cover system
Tc=20.1 min CN=74 Area=5.131 ac Runoff= 3.20 cfs 0.272 af

Subcatchment DDR: vegetated final cover system
Tc=7.6 min CN=74 Area=0.860 ac Runoff= 0.86 cfs 0.046 af

Subcatchment E: vegetated final cover system
Tc=19.7 min CN=74 Area=5.092 ac Runoff= 3.21 cfs 0.270 af

Subcatchment EE: open space with good grass cover
Tc=25.4 min CN=77 Area=0.925 ac Runoff= 0.63 cfs 0.059 af

Subcatchment F: vegetated final cover system
Tc=19.7 min CN=74 Area=5.053 ac Runoff= 3.19 cfs 0.268 af

Subcatchment FFR: vegetated final cover system
Tc=17.6 min CN=74 Area=2.410 ac Runoff= 1.63 cfs 0.128 af

Subcatchment G: vegetated final cover system
Tc=19.8 min CN=74 Area=5.309 ac Runoff= 3.34 cfs 0.282 af

Subcatchment GGR: open space with good grass cover
Tc=28.3 min CN=67 Area=2.350 ac Runoff= 0.53 cfs 0.074 af

Subcatchment HH: open space with good grass cover
Tc=13.9 min CN=79 Area=0.548 ac Runoff= 0.62 cfs 0.040 af

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Subcatchment HR: vegetated final cover system
Tc=17.7 min CN=74 Area=4.590 ac Runoff= 3.10 cfs 0.243 af

Subcatchment II: open space with good grass cover
Tc=23.0 min CN=68 Area=1.669 ac Runoff= 0.50 cfs 0.057 af

Subcatchment IR: vegetated final cover
Tc=7.3 min CN=74 Area=0.600 ac Runoff= 0.61 cfs 0.032 af

Subcatchment JJ: open space with good grass cover
Tc=41.9 min CN=62 Area=0.914 ac Runoff= 0.07 cfs 0.018 af

Subcatchment JR: vegetated final cover
Tc=20.8 min CN=74 Area=2.520 ac Runoff= 1.54 cfs 0.134 af

Subcatchment K1R: open space with good grass cover
Tc=4.9 min CN=74 Area=0.382 ac Runoff= 0.42 cfs 0.020 af

Subcatchment K2R: open space with good grass cover
Tc=33.4 min CN=66 Area=0.530 ac Runoff= 0.09 cfs 0.015 af

Subcatchment KK: open space with good grass cover
Tc=36.4 min CN=64 Area=5.893 ac Runoff= 0.70 cfs 0.141 af

Subcatchment L: open space with good grass cover
Tc=15.4 min CN=76 Area=1.683 ac Runoff= 1.45 cfs 0.102 af

Subcatchment LL: open space with good grass cover
Tc=28.1 min CN=61 Area=7.049 ac Runoff= 0.54 cfs 0.124 af

Subcatchment M: open space with good grass cover
Tc=12.1 min CN=79 Area=1.000 ac Runoff= 1.20 cfs 0.073 af

Subcatchment MM: open space with good grass cover
Tc=9.9 min CN=61 Area=1.943 ac Runoff= 0.29 cfs 0.034 af

Subcatchment N: direct runon to pond
Tc=1.0 min CN=98 Area=7.818 ac Runoff= 31.03 cfs 1.512 af

Subcatchment NN: open space with good grass cover
Tc=1.4 min CN=66 Area=1.274 ac Runoff= 0.73 cfs 0.037 af

Subcatchment O: open space with good grass cover
Tc=1.3 min CN=79 Area=1.317 ac Runoff= 2.25 cfs 0.096 af

Subcatchment OO: open space with good grass cover
Tc=5.4 min CN=66 Area=0.399 ac Runoff= 0.19 cfs 0.012 af

Subcatchment P: open space with good grass cover
Tc=33.7 min CN=75 Area=5.238 ac Runoff= 2.50 cfs 0.297 af

Subcatchment PP: open space with good grass cover
Tc=79.5 min CN=64 Area=40.964 ac Runoff= 3.01 cfs 0.983 af

Subcatchment Q: open space with good grass cover
Tc=31.8 min CN=72 Area=7.700 ac Runoff= 2.89 cfs 0.356 af

Subcatchment R: open space with good grass cover
Tc=21.6 min CN=74 Area=2.612 ac Runoff= 1.55 cfs 0.139 af

Subcatchment S: open space with good grass cover
Tc=27.9 min CN=78 Area=0.402 ac Runoff= 0.28 cfs 0.027 af

Subcatchment TR: open space with good grass cover
Tc=3.7 min CN=74 Area=0.040 ac Runoff= 0.05 cfs 0.002 af

Subcatchment U: open space with good grass cover
Tc=32.3 min CN=72 Area=4.149 ac Runoff= 1.54 cfs 0.192 af

Subcatchment V: direct runon to pond
Tc=1.0 min CN=98 Area=0.274 ac Runoff= 1.09 cfs 0.053 af

Subcatchment W: open space with good grass cover
Tc=12.6 min CN=72 Area=10.593 ac Runoff= 7.22 cfs 0.490 af

Subcatchment X: open space with good grass cover
Tc=33.4 min CN=71 Area=11.853 ac Runoff= 3.87 cfs 0.510 af

Subcatchment Y: open space with good grass cover
Tc=36.8 min CN=73 Area=6.522 ac Runoff= 2.43 cfs 0.323 af

Subcatchment Z: open space with good grass cover
Tc=23.7 min CN=72 Area=1.606 ac Runoff= 0.74 cfs 0.074 af

Reach 1: east drainage channel — Inflow= 2.09 cfs 0.167 af
Length= 420.0' Max Vel= 1.3 fps Capacity= 754.76 cfs Outflow= 1.79 cfs 0.167 af

[illegible]R: (new node) — Inflow= 0.54 cfs 0.124 af
Length= 100.0' Max Vel= 2.6 fps Capacity= 1,101.12 cfs Outflow= 0.54 cfs 0.124 af

Reach 2: east drainage channel — Inflow= 4.96 cfs 0.443 af
Length= 420.0' Max Vel= 1.8 fps Capacity= 1,205.98 cfs Outflow= 4.62 cfs 0.443 af

Reach 2R: (new node) — Inflow= 0.29 cfs 0.034 af
Length= 100.0' Max Vel= 2.1 fps Capacity= 1,101.12 cfs Outflow= 0.27 cfs 0.034 af

Reach 3: east drainage channel — Inflow= 7.06 cfs 0.715 af
Length= 420.0' Max Vel= 2.1 fps Capacity= 1,563.67 cfs Outflow= 6.83 cfs 0.715 af

Reach 3R: (new node) — Inflow= 0.73 cfs 0.037 af
Length= 100.0' Max Vel= 2.7 fps Capacity= 1,101.12 cfs Outflow= 0.67 cfs 0.037 af

Reach 4: east drainage channel — Inflow= 8.67 cfs 0.985 af
Length= 420.0' Max Vel= 2.2 fps Capacity= 1,106.53 cfs Outflow= 8.51 cfs 0.985 af

Reach 5: east drainage channel — Inflow= 9.97 cfs 1.253 af
Length= 440.0' Max Vel= 2.2 fps Capacity= 182.58 cfs Outflow= 9.82 cfs 1.253 af

Reach 6: east drainage channel — Inflow= 11.07 cfs 1.535 af
Length= 480.0' Max Vel= 2.9 fps Capacity= 258.21 cfs Outflow= 10.99 cfs 1.535 af

Reach 7R: runoff diversion channel — Inflow= 11.82 cfs 1.779 af
Length= 400.0' Max Vel= 2.9 fps Capacity= 1,632.24 cfs Outflow= 11.75 cfs 1.779 af

Reach 8R: runoff diversion channel — Inflow= 12.13 cfs 1.906 af
Length= 220.0' Max Vel= 2.0 fps Capacity= 1,597.49 cfs Outflow= 12.07 cfs 1.906 af

Reach 9R: runoff diversion channel — Inflow= 12.17 cfs 1.954 af
Length= 120.0' Max Vel= 2.2 fps Capacity= 462.89 cfs Outflow= 12.14 cfs 1.954 af

Reach 10AR: runoff diversion channel — Inflow= 12.23 cfs 2.006 af
Length= 365.0' Max Vel= 2.0 fps Capacity= 646.10 cfs Outflow= 12.17 cfs 2.006 af

Reach 10BR: (new node) — Inflow= 12.54 cfs 2.155 af
Length= 179.0' Max Vel= 1.7 fps Capacity= 202.01 cfs Outflow= 12.50 cfs 2.155 af

Reach 11: new CMP arch — Inflow= 12.72 cfs 2.229 af
Length= 40.0' Max Vel= 3.9 fps Capacity= 522.31 cfs Outflow= 12.72 cfs 2.229 af

Reach 12R: runoff diversion channel — Inflow= 12.72 cfs 2.229 af
Length= 240.0' Max Vel= 2.0 fps Capacity= 317.79 cfs Outflow= 12.67 cfs 2.229 af

Reach 13R: runoff diversion channel — Inflow= 23.36 cfs 5.232 af
Length= 450.0' Max Vel= 2.2 fps Capacity= 346.63 cfs Outflow= 23.26 cfs 5.231 af

Reach 14: east runon channel — Inflow= 0.18 cfs 0.009 af
Length= 420.0' Max Vel= 0.7 fps Capacity= 22.78 cfs Outflow= 0.11 cfs 0.009 af

Reach 15: east runon channel — Inflow= 1.04 cfs 0.064 af
Length= 420.0' Max Vel= 1.3 fps Capacity= 61.62 cfs Outflow= 0.88 cfs 0.064 af

Reach 16: east runon channel — Inflow= 2.68 cfs 0.208 af
Length= 420.0' Max Vel= 1.9 fps Capacity= 25[illegible] cfs Outflow= 2.47 cfs 0.208 af

Reach 17: east runon channel — Inflow= 3.20 cfs 0.282 af
Length= 420.0' Max Vel= 2.3 fps Capacity= 436.18 cfs Outflow= 3.08 cfs 0.282 af

Reach 18: east runon channel — Inflow= 5.48 cfs 0.605 af
Length= 440.0' Max Vel= 2.6 fps Capacity= 169.20 cfs Outflow= 5.35 cfs 0.605 af

Reach 19: east runon channel — Inflow= 9.08 cfs 1.115 af
Length= 470.0' Max Vel= 1.9 fps Capacity= 911.12 cfs Outflow= 8.71 cfs 1.115 af

Reach 20: east runon channel — Inflow= 10.07 cfs 1.605 af
Length= 75.0' Max Vel= 2.9 fps Capacity= 153.84 cfs Outflow= 10.03 cfs 1.605 af

Reach 21: east runon channel — Inflow= 7.74 cfs 1.817 af
Length= 65.0' Max Vel= 2.9 fps Capacity= 169.20 cfs Outflow= 7.74 cfs 1.817 af

Reach 22: east runon channel — Inflow= 7.81 cfs 1.844 af
Length= 190.0' Max Vel= 2.9 fps Capacity= 364.40 cfs Outflow= 7.80 cfs 1.844 af

Reach 23: new CMP culverts — Inflow= 8.22 cfs 2.042 af
Length= 92.0' Max Vel= 3.2 fps Capacity= 468.67 cfs Outflow= 8.21 cfs 2.042 af

Reach 24: runon channel — Inflow= 9.31 cfs 2.398 af
Length= 160.0' Max Vel= 2.2 fps Capacity= 153.54 cfs Outflow= 9.29 cfs 2.397 af

Reach 25: new CMP arch — Inflow= 10.27 cfs 2.694 af
Length= 53.0' Max Vel= 3.4 fps Capacity= 475.34 cfs Outflow= 10.27 cfs 2.694 af

Reach 26: runon channel — Inflow= 10.27 cfs 2.694 af
Length= 300.0' Max Vel= 2.8 fps Capacity= 90.11 cfs Outflow= 10.24 cfs 2.694 af

Reach 27: new CMP arch — Inflow= 10.41 cfs 2.795 af
Length= 106.0' Max Vel= 3.0 fps Capacity= 398.58 cfs Outflow= 10.40 cfs 2.795 af

Reach 28R: new CMP culverts — Inflow= 12.56 cfs 2.155 af
Length= 140.0' Max Vel= 3.4 fps Capacity= 427.00 cfs Outflow= 12.54 cfs 2.155 af

Reach 29: east runon channel — Inflow= 7.95 cfs 1.904 af
Length= 230.0' Max Vel= 2.9 fps Capacity= 255.23 cfs Outflow= 7.93 cfs 1.903 af

Reach 30: east runon channel — Inflow= 7.74 cfs 1.817 af
Length= 30.0' Max Vel= 2.9 fps Capacity= 104.05 cfs Outflow= 7.74 cfs 1.817 af

Reach 31: culvert — Inflow= 2.25 cfs 0.096 af
Length= 80.0' Max Vel= 3.7 fps Capacity= 1,025.91 cfs Outflow= 2.20 cfs 0.096 af

Pond 1P: (new node) — Peak Storage= 1.082 af Inflow= 11.25 cfs 1.850 af
Primary= 7.74 cfs 1.817 af Outflow= 7.74 cfs 1.817 af

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Pond 3P: Borrow Area Basin — Peak Storage= 7.954 af Inflow= 31.84 cfs 7.954 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

Runoff Area = 171.154 ac Volume = 8.184 af Average Depth = 0.57"

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Subcatchment A: vegetated final cover system

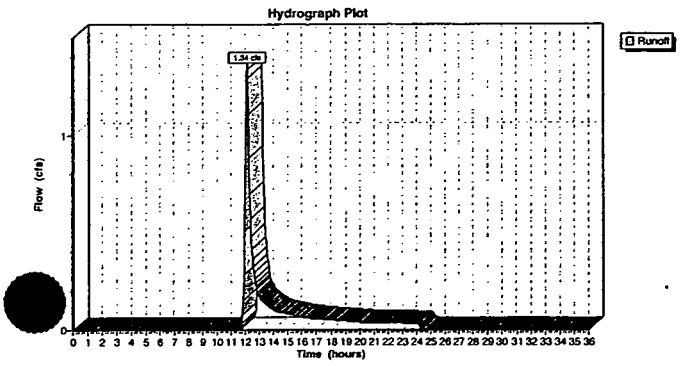
Runoff = 1.34 cfs @ 12.12 hrs, Volume= 0.104 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.964	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	80	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
17.3	380	Total			

Subcatchment A: vegetated final cover system



Subcatchment AA: open space with good grass cover

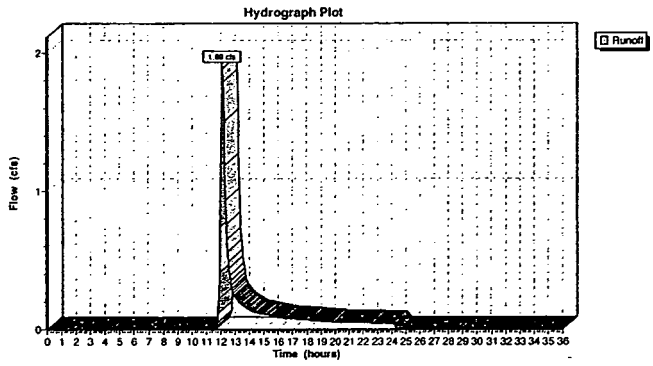
Runoff = 1.89 cfs @ 12.11 hrs, Volume= 0.144 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.708	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0	300	0.0800	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.6	170	0.0800	4.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.2	300	0.0070	4.0	48.01	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
16.8	770	Total			

Subcatchment AA: open space with good grass cover



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Subcatchment B: vegetated final cover system

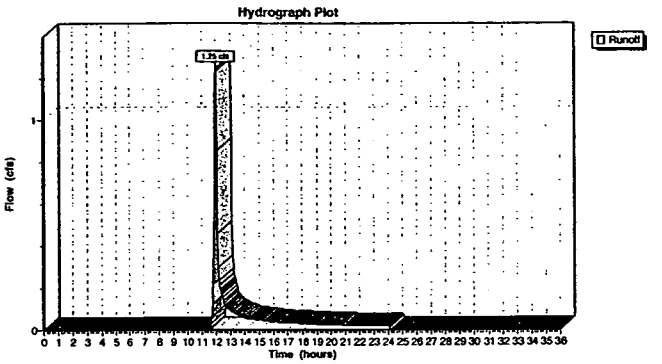
Runoff = 1.25 cfs @ 11.99 hrs, Volume= 0.063 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.179	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	50	0.1800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.6	450	0.0045	2.1	9.75	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.02' Z= 6.0 & 3.0 '/' n= 0.030
6.2	500	Total			

Subcatchment B: vegetated final cover system



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Subcatchment BB: open space with good grass cover

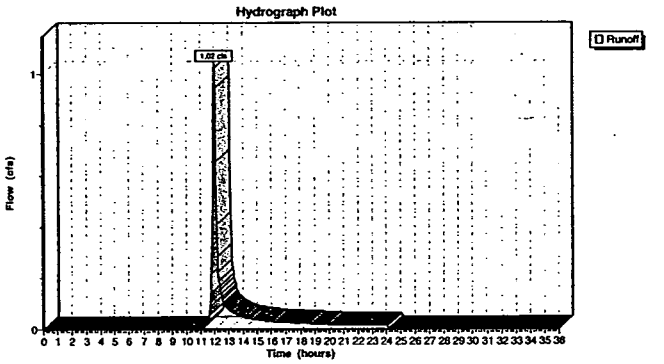
Runoff = 1.02 cfs @ 12.01 hrs, Volume= 0.055 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.761	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	110	0.0800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.4	360	0.0040	2.5	22.78	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.50' Z= 3.0 & 5.0 '/' n= 0.030
9.1	470	Total			

Subcatchment BB: open space with good grass cover



Subcatchment C: vegetated final cover system

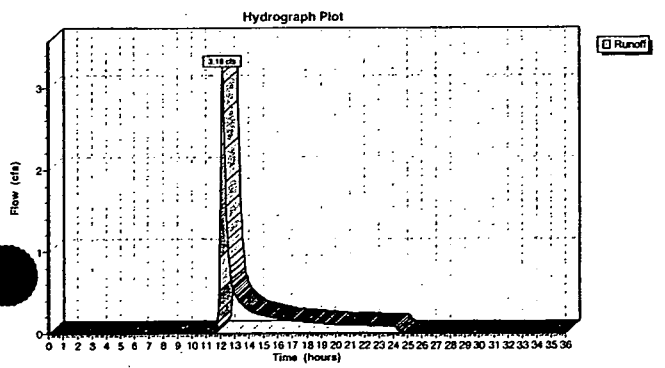
Runoff = 3.18 cfs @ 12.16 hrs, Volume= 0.276 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.209	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
3.2	400	0.0045	2.1	10.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.02' Z= 6.0 & 4.0 '/' n= 0.030
20.7	870	Total			

Subcatchment C: vegetated final cover system



Subcatchment CC: open space with good grass cover

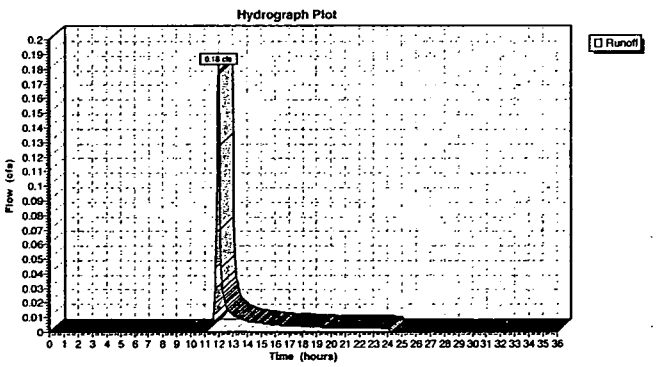
Runoff = 0.18 cfs @ 11.99 hrs, Volume= 0.009 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.121	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	110	0.0800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment CC: open space with good grass cover



Subcatchment D: vegetated final cover system

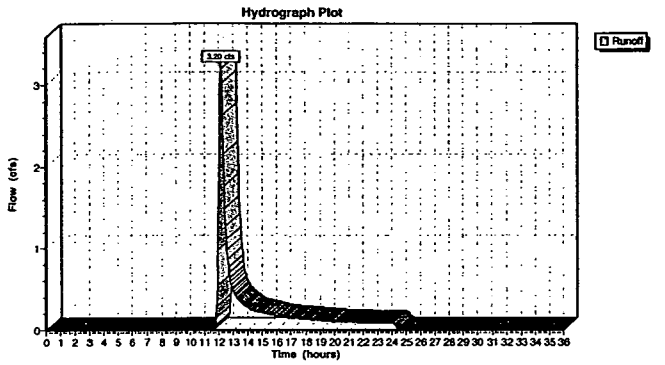
Runoff = 3.20 cfs @ 12.15 hrs, Volume= 0.272 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.131	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.7	250	0.0045	2.4	16.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.29' Z= 5.0 & 3.0 '/' n= 0.030
0.9	150	0.0050	2.9	25.90	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.59' Z= 4.0 & 3.0 '/' n= 0.030
20.1	870	Total			

Subcatchment D: vegetated final cover system



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Subcatchment DDR: vegetated final cover system

Runoff = 0.86 cfs @ 12.00 hrs, Volume= 0.046 af

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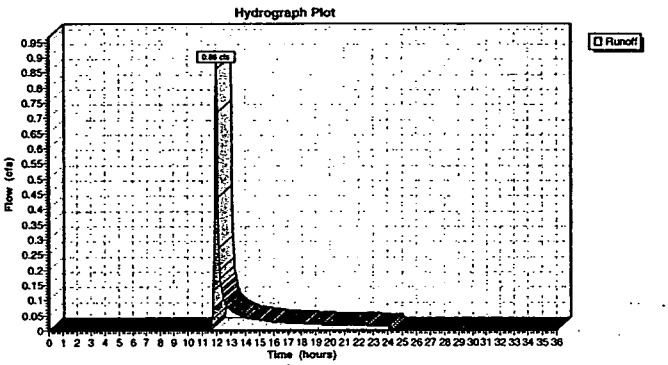
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.860	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.6	480	Total			

Subcatchment DDR: vegetated final cover system



Subcatchment E: vegetated final cover system

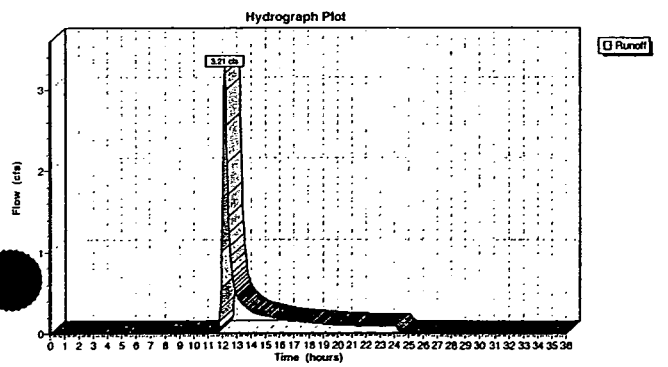
Runoff = 3.21 cfs @ 12.15 hrs, Volume= 0.270 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.092	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	380	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	850	Total			

Subcatchment E: vegetated final cover system



Subcatchment EE: open space with good grass cover

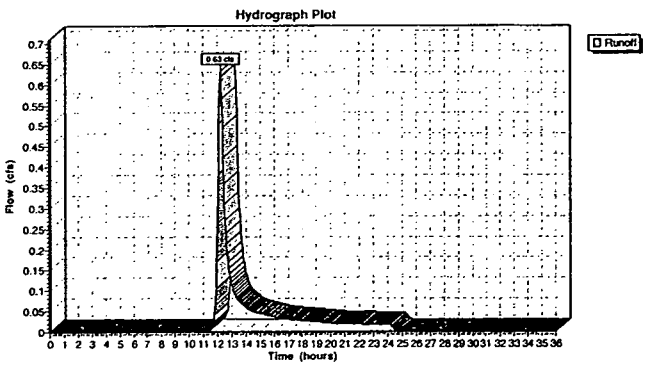
Runoff = 0.63 cfs @ 12.21 hrs, Volume= 0.059 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.925	77	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.8	300	0.0230	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	80	0.0230	2.4		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	40	0.0100	7.6	364.40	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 3.0 '/' n= 0.030
25.4	420	Total			

Subcatchment EE: open space with good grass cover



Subcatchment F: vegetated final cover system

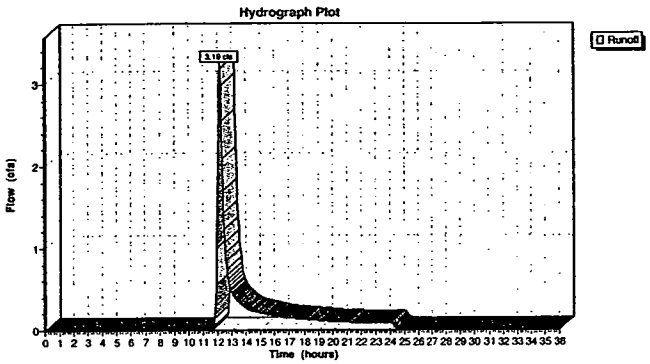
Runoff = 3.19 cfs @ 12.15 hrs, Volume= 0.268 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.053	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	390	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	860	Total			

Subcatchment F: vegetated final cover system



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Subcatchment FFR: vegetated final cover system

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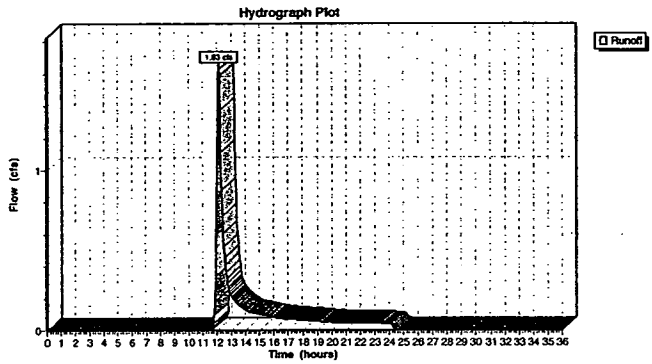
Runoff = 1.63 cfs @ 12.12 hrs, Volume= 0.128 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.410	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	85	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	365	0.0050	6.7	914.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.030
17.6	810	Total			

Subcatchment FFR: vegetated final cover system



Subcatchment G: vegetated final cover system

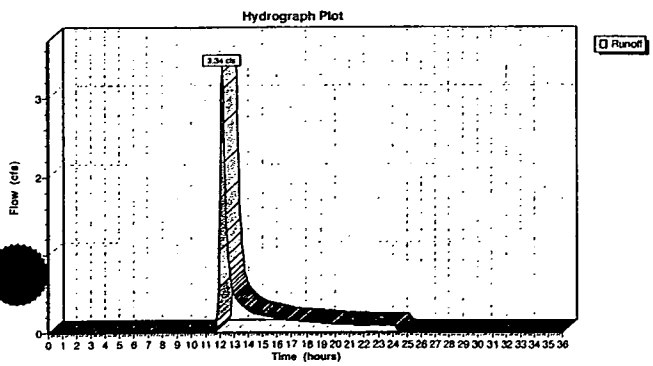
Runoff = 3.34 cfs @ 12.15 hrs, Volume= 0.282 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.309	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	410	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.8	880	Total			

Subcatchment G: vegetated final cover system



Subcatchment GGR: open space with good grass cover

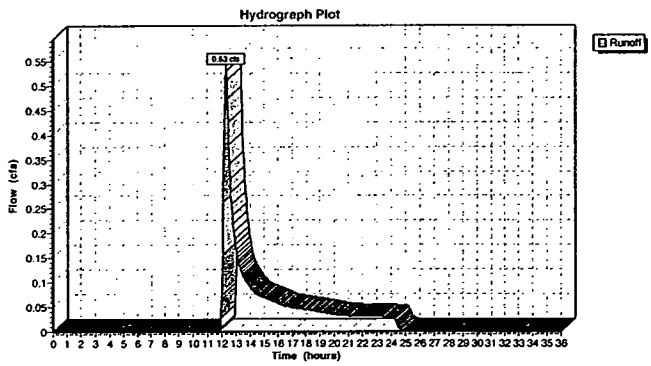
Runoff = 0.53 cfs @ 12.30 hrs, Volume= 0.074 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.350	67	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.2	300	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.3	590	Total			

Subcatchment GGR: open space with good grass cover



Subcatchment HH: open space with good grass cover

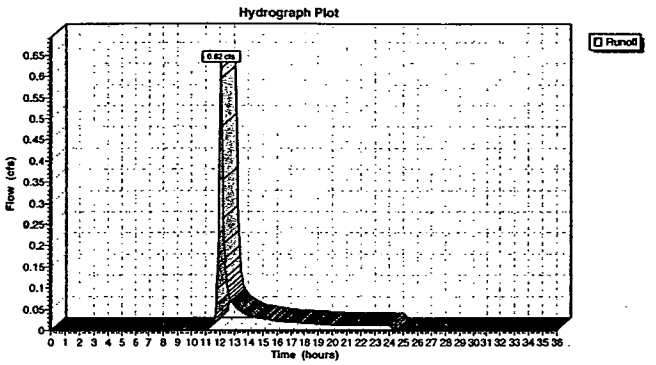
Runoff = 0.62 cfs @ 12.07 hrs, Volume= 0.040 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.548	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	90	0.0100	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.7	230	0.0045	5.1	352.87	**Trap/Vee/Rect Channel Flow,** Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
13.9	320	Total			

Subcatchment HH: open space with good grass cover



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Subcatchment HR: vegetated final cover system

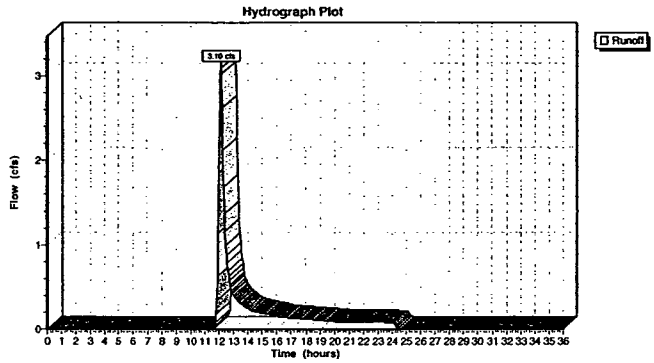
Runoff = 3.10 cfs @ 12.12 hrs, Volume= 0.243 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
4.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.7	400	0.0100	9.8	1,429.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=5.70' Z= 6.0 & 3.0 '/' n= 0.030
17.7	850	Total			

Subcatchment HR: vegetated final cover system



Subcatchment II: open space with good grass cover

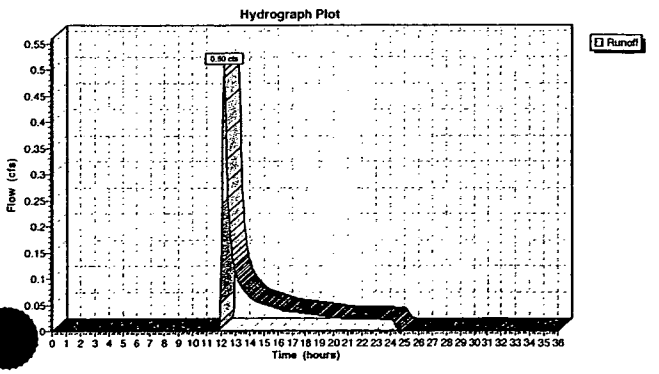
Runoff = 0.50 cfs @ 12.21 hrs, Volume= 0.057 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.669	68	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.9	210	0.0400	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	70	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
7.9	380	0.0025	0.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
23.0	660	Total			

Subcatchment II: open space with good grass cover



Subcatchment IR: vegetated final cover

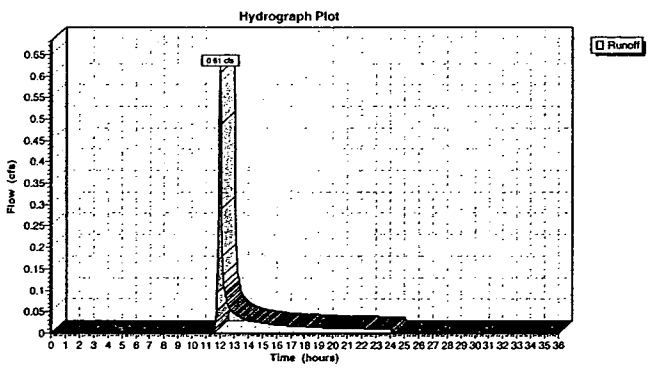
Runoff = 0.61 cfs @ 12.00 hrs, Volume= 0.032 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.600	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.6	220	0.1500	6.2		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
7.3	370	Total			

Subcatchment IR: vegetated final cover



Subcatchment JJ: open space with good grass cover

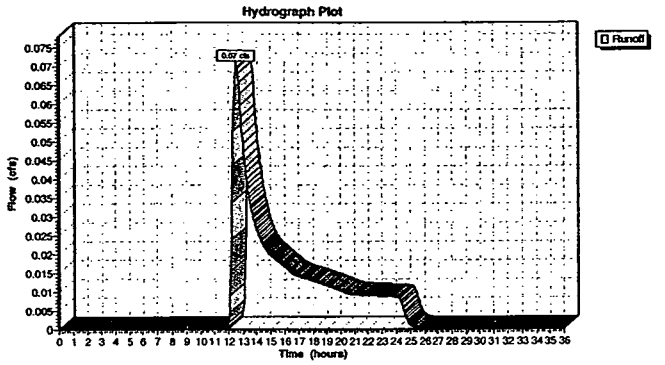
Runoff = 0.07 cfs @ 12.58 hrs, Volume= 0.018 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.914	62	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.9	300	0.0250	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.3	40	0.0250	2.5		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
17.4	840	0.0025	0.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
41.9	1,290	Total			

Subcatchment JJ: open space with good grass cover



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Subcatchment JR: vegetated final cover

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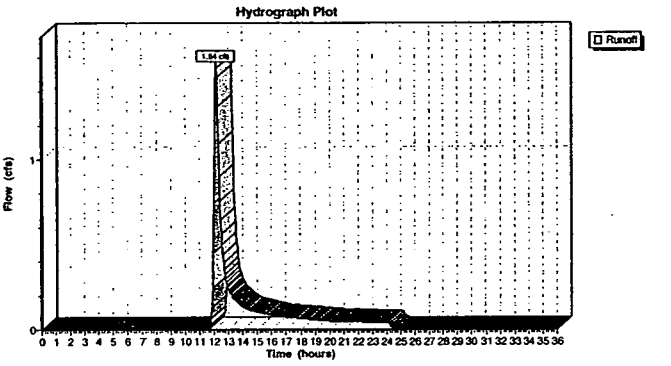
Runoff = 1.54 cfs @ 12.16 hrs, Volume= 0.134 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.520	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	80	0.0176	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
4.1	60	0.0830	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.2	80	0.0050	6.1	646.98	**Trap/Vee/Rect Channel Flow,** Bot.W=10.12' D=3.85' Z= 6.0 & 3.0 '/' n= 0.030
20.8	560	Total			

Subcatchment JR: vegetated final cover



Subcatchment K1R: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

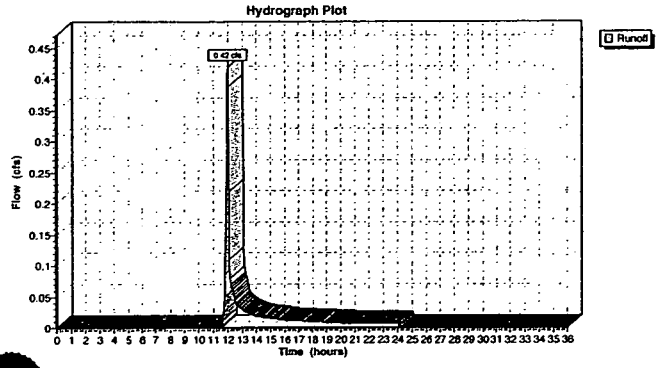
Runoff = 0.42 cfs @ 11.97 hrs, Volume= 0.020 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.382	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	33	0.0160	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment K1R: open space with good grass cover



Subcatchment K2R: open space with good grass cover

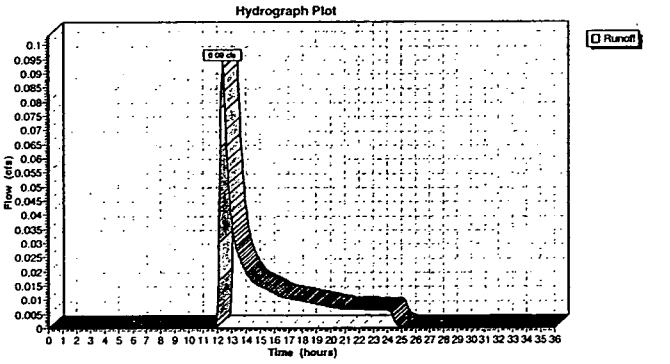
Runoff = 0.09 cfs @ 12.38 hrs, Volume= 0.015 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.530	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.2	300	0.0110	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.2	23	0.0110	1.7		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
33.4	323	Total			

Subcatchment K2R: open space with good grass cover



Subcatchment KK: open space with good grass cover

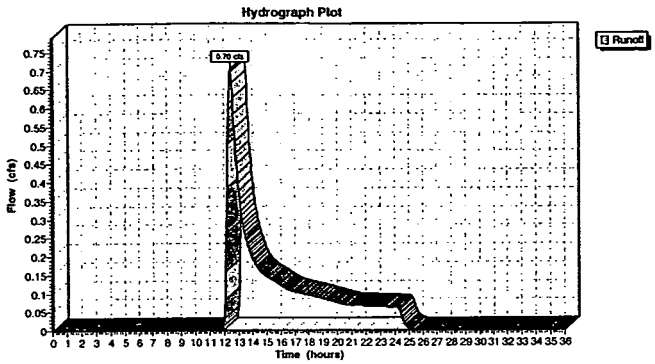
Runoff = 0.70 cfs @ 12.45 hrs, Volume= 0.141 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.893	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	300	0.0280	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.3	150	0.0140	1.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
11.9	630	0.0030	0.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
36.4	1,190	Total			

Subcatchment KK: open space with good grass cover



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Subcatchment L: open space with good grass cover

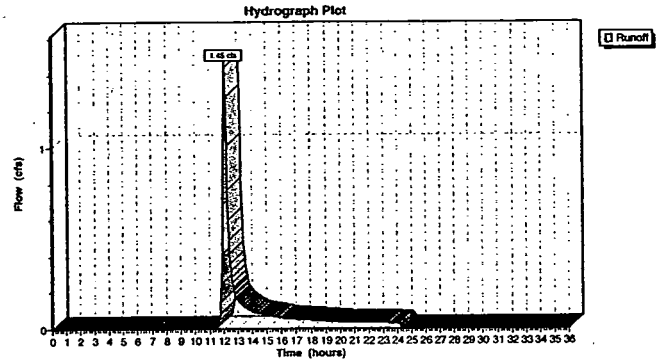
Runoff = 1.45 cfs @ 12.09 hrs, Volume= 0.102 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.683	76	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2	140	0.0200	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.2	290	0.0075	4.1	49.70	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
15.4	430	Total			

Subcatchment L: open space with good grass cover



Subcatchment LL: open space with good grass cover

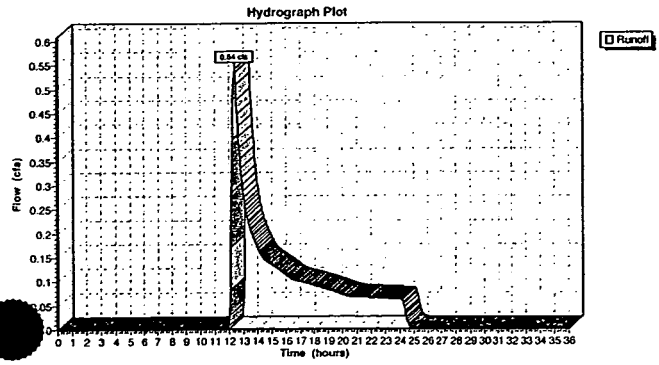
Runoff = 0.54 cfs @ 12.36 hrs, Volume= 0.124 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
7.049	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.3	300	0.0240	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.3	200	0.0240	2.5		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
2.5	900	0.0090	5.9	160.52	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
28.1	1,400	Total			

Subcatchment LL: open space with good grass cover



Subcatchment M: open space with good grass cover

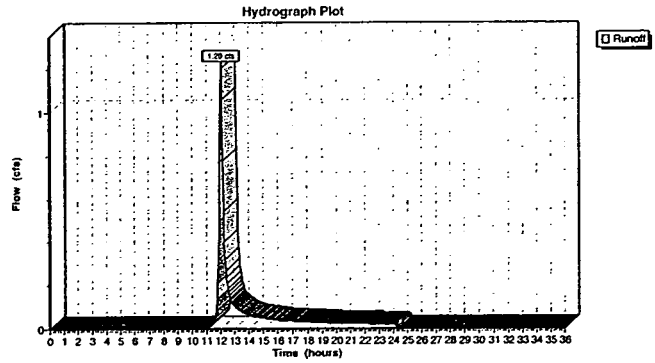
Runoff = 1.20 cfs @ 12.05 hrs, Volume= 0.073 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.000	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5	170	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.6	200	0.0045	5.1	352.87	**Trap/Vee/Rect Channel Flow,** Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
12.1	370	Total			

Subcatchment M: open space with good grass cover



Subcatchment MM: open space with good grass cover

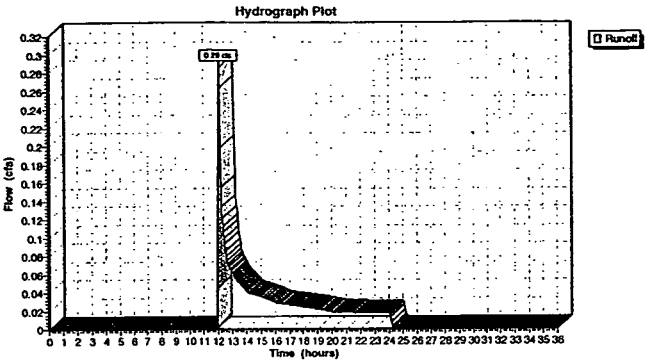
Runoff = 0.29 cfs @ 12.07 hrs, Volume= 0.034 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.943	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	100	0.0700	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.3	980	0.0060	4.9	200.34	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 5.0 & 4.0 '/' n= 0.030
9.9	1,080	Total			

Subcatchment MM: open space with good grass cover



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Subcatchment N: direct runon to pond

[49] Hint: Tc<2dt may require smaller dt

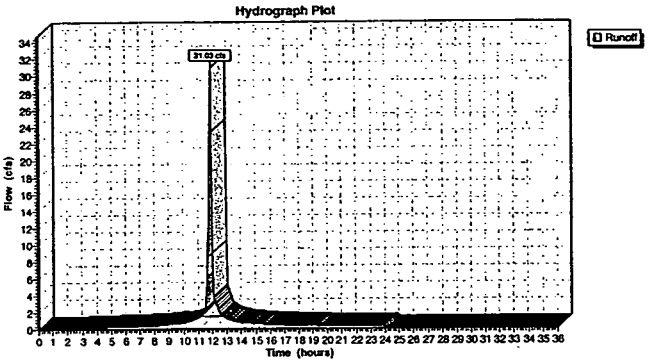
Runoff = 31.03 cfs @ 11.90 hrs, Volume= 1.512 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
7.818	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					**Direct Entry,**

Subcatchment N: direct runon to pond



Subcatchment NN: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

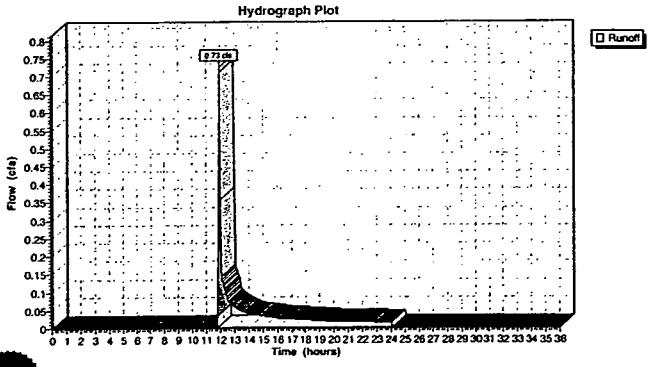
Runoff = 0.73 cfs @ 11.94 hrs, Volume= 0.037 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.274	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	600	0.0130	7.1	192.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030

Subcatchment NN: open space with good grass cover



Subcatchment O: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

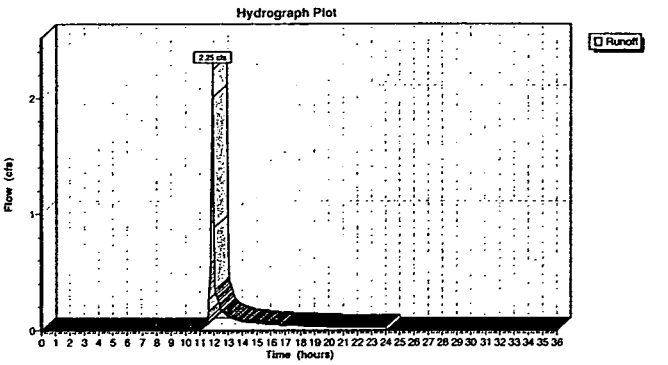
Runoff = 2.25 cfs @ 11.91 hrs, Volume= 0.096 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.317	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	230	0.0086	2.9	14.28	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 5.0 '/' n= 0.030

Subcatchment O: open space with good grass cover



Subcatchment OO: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

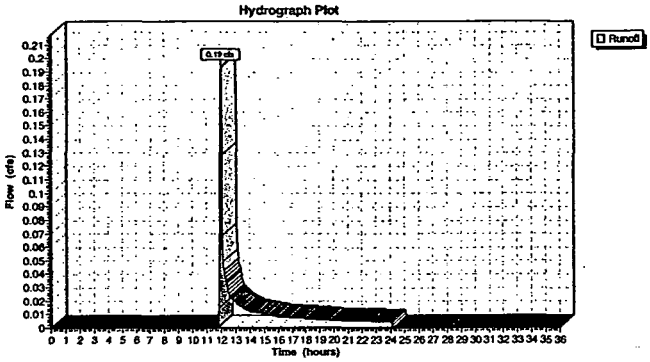
Runoff = 0.19 cfs @ 11.99 hrs, Volume= 0.012 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.399	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	120	0.1660	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment OO: open space with good grass cover



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Subcatchment P: open space with good grass cover

Runoff = 2.50 cfs @ 12.32 hrs, Volume= 0.297 af

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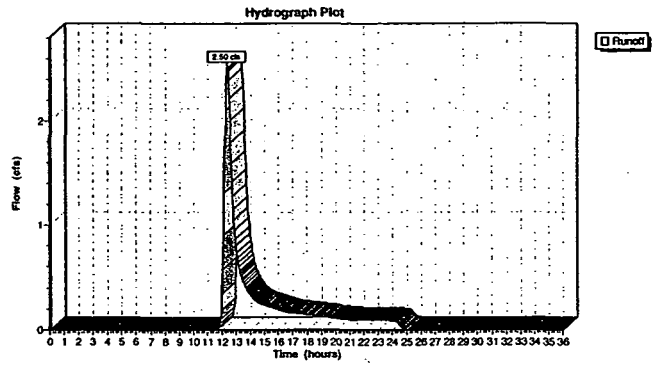
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.238	75	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.4	300	0.0150	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
4.3	350	0.0070	1.3		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
33.7	650	Total			

Subcatchment P: open space with good grass cover



Subcatchment PP: open space with good grass cover

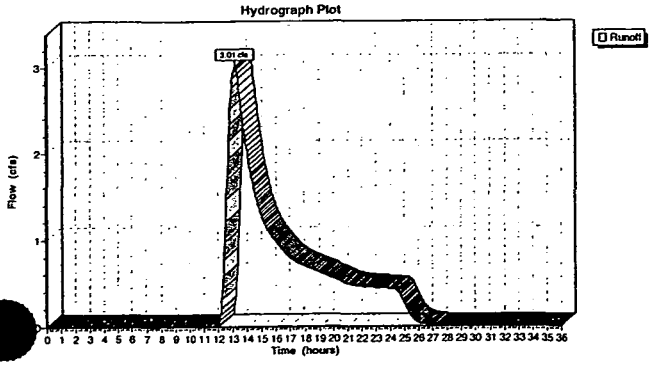
Runoff = 3.01 cfs @ 13.15 hrs, Volume= 0.983 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
40.964	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	150	0.1660	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 0.26"
34.5	150	0.0025	0.1		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
24.6	1,190	0.0025	0.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
79.5	1,490	Total			

Subcatchment PP: open space with good grass cover



Subcatchment Q: open space with good grass cover

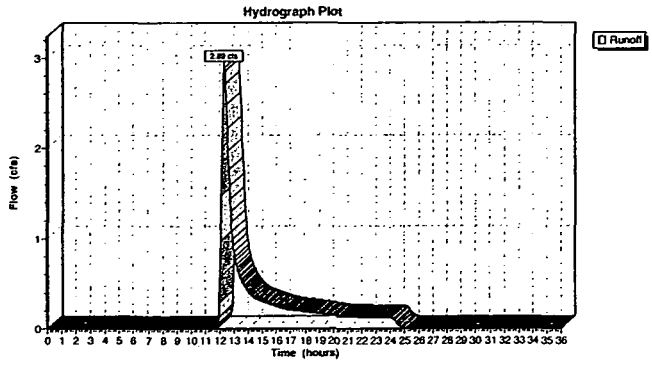
Runoff = 2.89 cfs @ 12.32 hrs, Volume= 0.356 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
7.700	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.6	300	0.0260	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
8.2	1,280	0.0260	2.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
31.8	1,580	Total			

Subcatchment Q: open space with good grass cover



Subcatchment R: open space with good grass cover

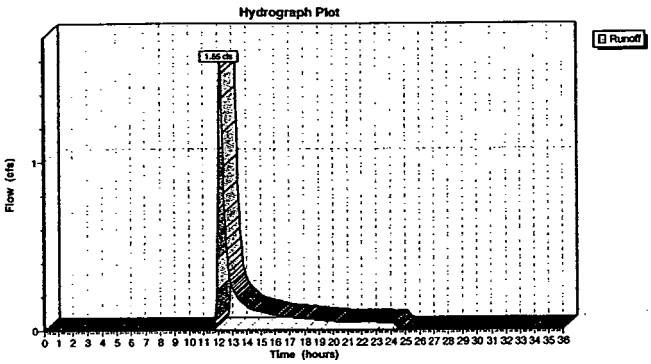
Runoff = 1.55 cfs @ 12.17 hrs, Volume= 0.139 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.612	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.8	300	0.0400	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.8	350	0.0400	3.2		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
21.6	650	Total			

Subcatchment R: open space with good grass cover



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Subcatchment S: open space with good grass cover

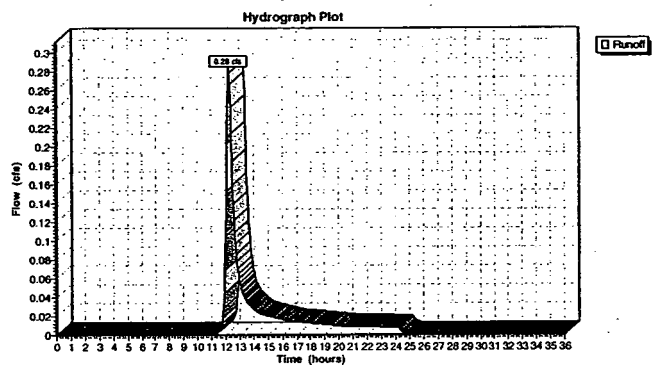
Runoff = 0.28 cfs @ 12.24 hrs, Volume= 0.027 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.402	78	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.8	280	0.0150	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.1	30	0.0100	6.3	169.20	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
27.9	310	Total			

Subcatchment S: open space with good grass cover



Subcatchment TR: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

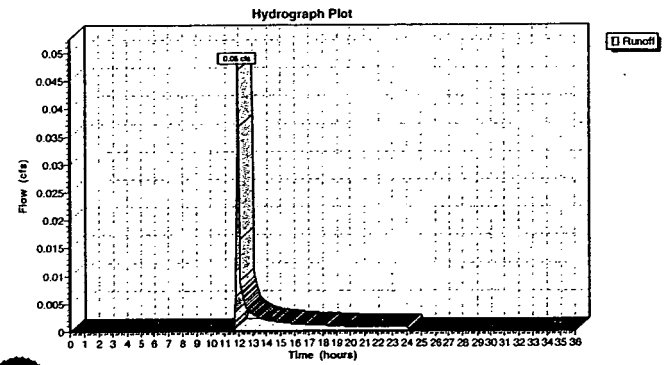
Runoff = 0.05 cfs @ 11.95 hrs, Volume= 0.002 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.040	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	40	0.0460	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment TR: open space with good grass cover



Subcatchment U: open space with good grass cover

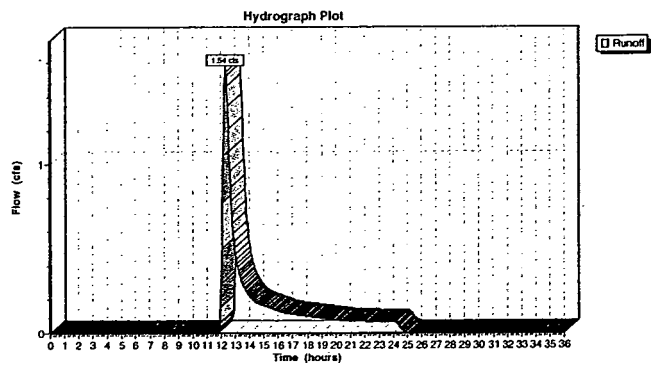
Runoff = 1.54 cfs @ 12.32 hrs, Volume= 0.192 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
4.149	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.2	300	0.0140	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
2.1	240	0.0140	1.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
32.3	540	Total			

Subcatchment U: open space with good grass cover



Subcatchment V: direct runon to pond

[49] Hint: Tc<2dt may require smaller dt

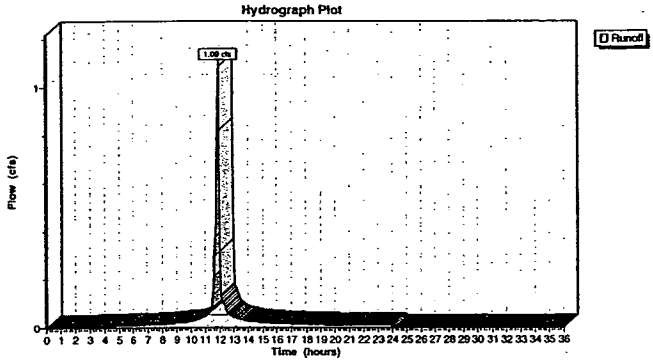
Runoff = 1.09 cfs @ 11.90 hrs, Volume= 0.053 af

y SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.274	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment V: direct runon to pond



Subcatchment W: open space with good grass cover

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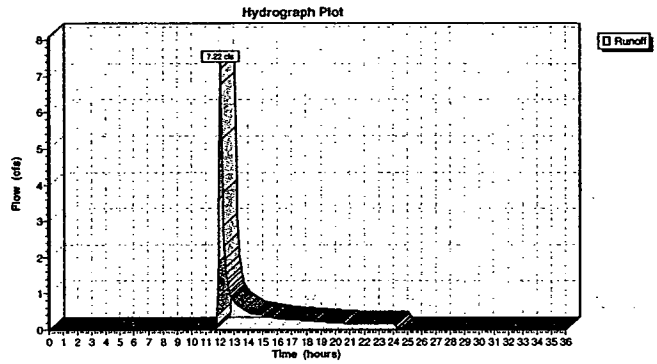
Runoff = 7.22 cfs @ 12.06 hrs, Volume= 0.490 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
10.593	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	300	0.1780	0.5		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.0	400	0.1780	6.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	270	0.0114	6.7	180.66	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
12.6	970	Total			

Subcatchment W: open space with good grass cover



Subcatchment X: open space with good grass cover

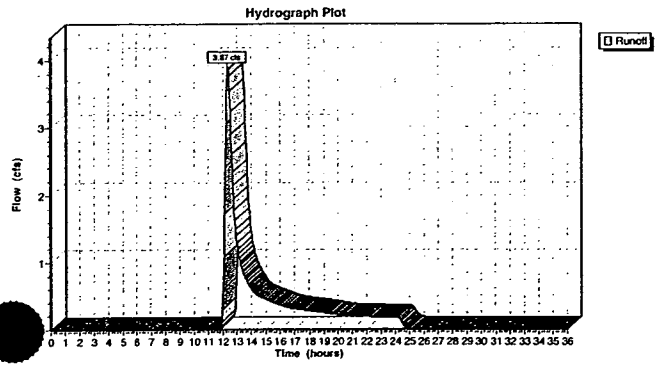
Runoff = 3.87 cfs @ 12.34 hrs, Volume= 0.510 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
11.853	71	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7	300	0.0190	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
5.5	730	0.0190	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	330	0.0100	4.8	57.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
33.4	1,360	Total			

Subcatchment X: open space with good grass cover



Subcatchment Y: open space with good grass cover

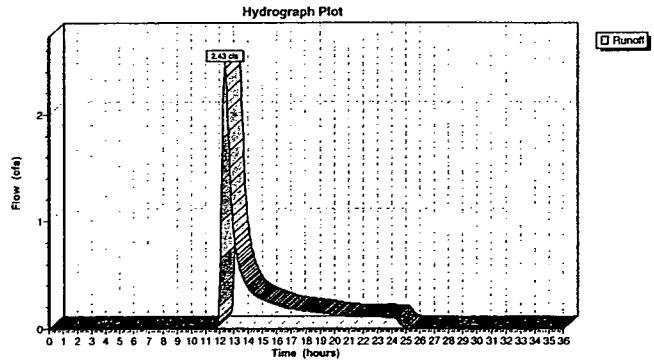
Runoff = 2.43 cfs @ 12.38 hrs, Volume= 0.323 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
6.522	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.1	300	0.0130	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.6	510	0.0130	1.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.1	340	0.0110	5.1	92.00	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
36.8	1,150	Total			

Subcatchment Y: open space with good grass cover



Subcatchment Z: open space with good grass cover

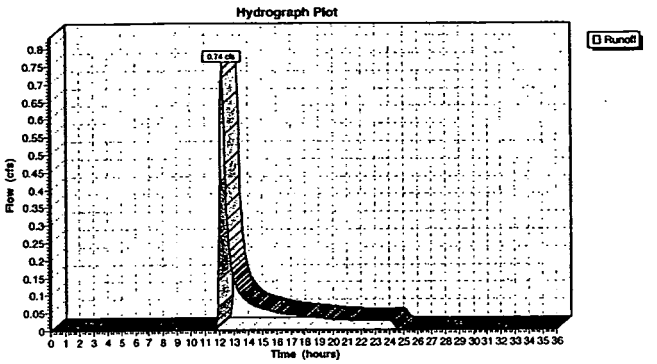
Runoff = 0.74 cfs @ 12.21 hrs, Volume= 0.074 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
[illegible] 24-hr Rainfall=2.55"

[illegible] (ac)	CN	Description
[illegible] 1.606	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.0	300	0.0310	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.5	250	0.0310	2.8		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.2	50	0.0070	4.1	73.39	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
23.7	600	Total			

Subcatchment Z: open space with good grass cover



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Reach 1: east drainage channel

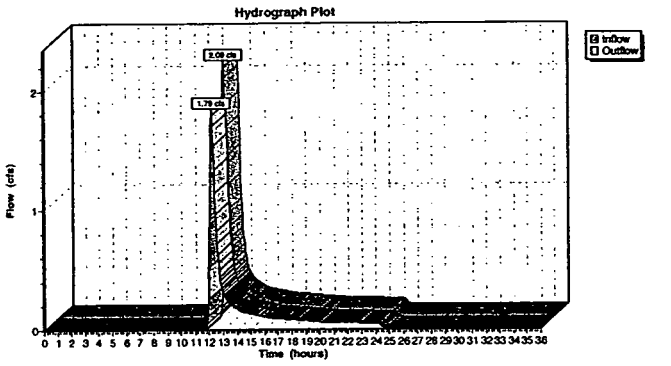
[65] Warning: Inlet elevation not specified

Inflow = 2.09 cfs @ 12.02 hrs, Volume= 0.167 af
Outflow = 1.79 cfs @ 12.20 hrs, Volume= 0.167 af, Atten= 14%, Lag= 10.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.3 fps, Min. Travel Time= 5.2 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 11.6 min

Peak Depth= 0.52'
Capacity at bank full= 754.76 cfs
0.00' x 5.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: east drainage channel



Reach 1R: (new node)

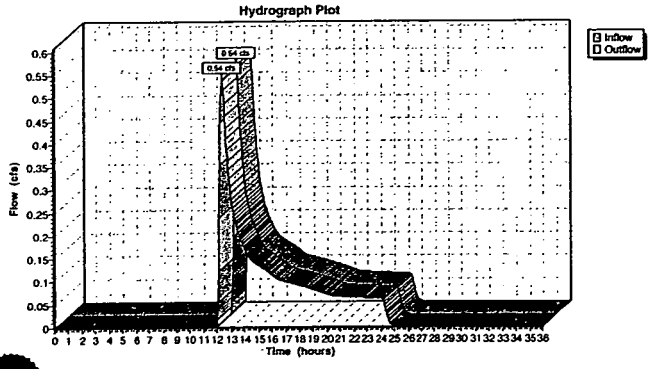
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 0.54 cfs @ 12.36 hrs, Volume= 0.124 af
Outflow = 0.54 cfs @ 12.38 hrs, Volume= 0.124 af, Atten= 1%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.9 min

Peak Depth= 0.10'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 1R: (new node)



Reach 2: east drainage channel

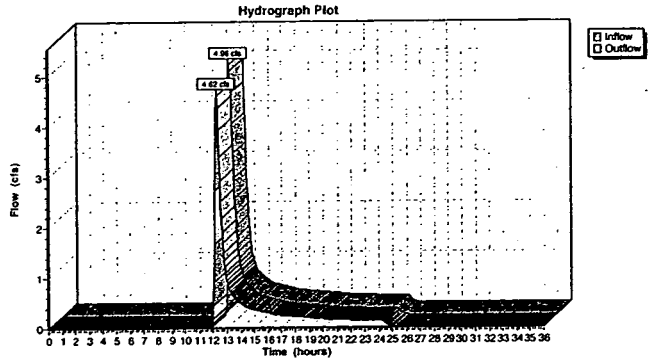
[65] Warning: Inlet elevation not specified

Inflow = 4.96 cfs @ 12.17 hrs, Volume= 0.443 af
Outflow = 4.62 cfs @ 12.30 hrs, Volume= 0.443 af, Atten= 7%, Lag= 7.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.8 fps, Min. Travel Time= 3.9 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 8.9 min

Peak Depth= 0.81'
Capacity at bank full= 1,205.98 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 2: east drainage channel



Reach 2R: (new node)

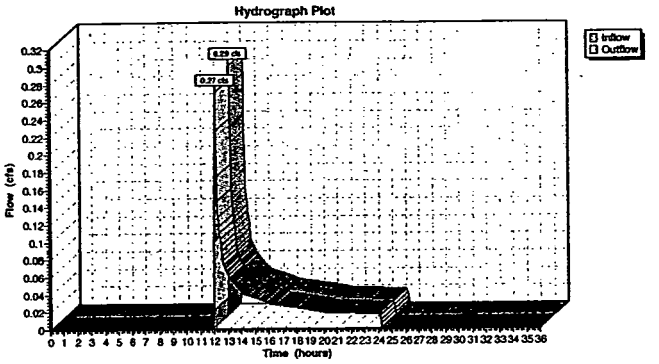
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	0.29 cfs @	12.07 hrs, Volume=	0.034 af	
[illegible]	=	0.27 cfs @	12.10 hrs, Volume=	0.034 af, Atten= 5%, Lag= 1.8 min	

[illegible]g by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 1.0 min

Peak Depth= 0.07'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 2R: (new node)



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Reach 3: east drainage channel

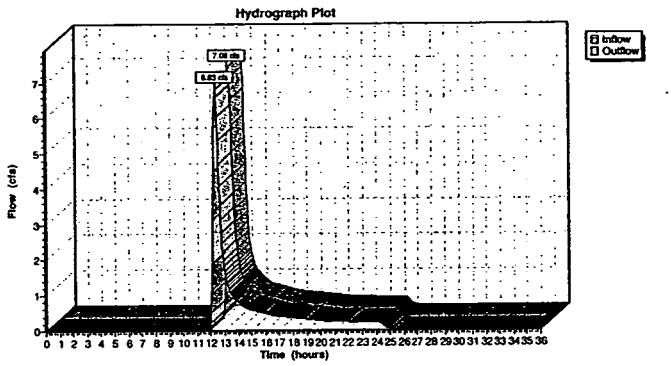
[65] Warning: Inlet elevation not specified

Inflow	=	7.06 cfs @	12.25 hrs, Volume=	0.715 af	
Outflow	=	6.83 cfs @	12.35 hrs, Volume=	0.715 af, Atten= 3%, Lag= 6.1 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 7.5 min

Peak Depth= 0.97'
Capacity at bank full= 1,563.67 cfs
0.00' x 7.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 3: east drainage channel



Reach 3R: (new node)

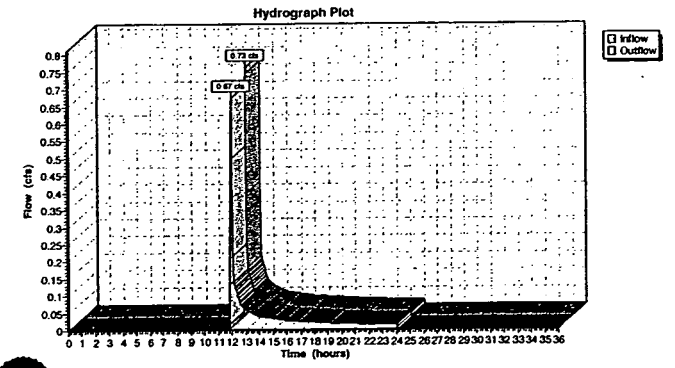
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	0.73 cfs @	11.94 hrs, Volume=	0.037 af	
Outflow	=	0.67 cfs @	11.95 hrs, Volume=	0.037 af, Atten= 7%, Lag= 0.9 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 1.0 min

Peak Depth= 0.12'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 3R: (new node)



Reach 4: east drainage channel

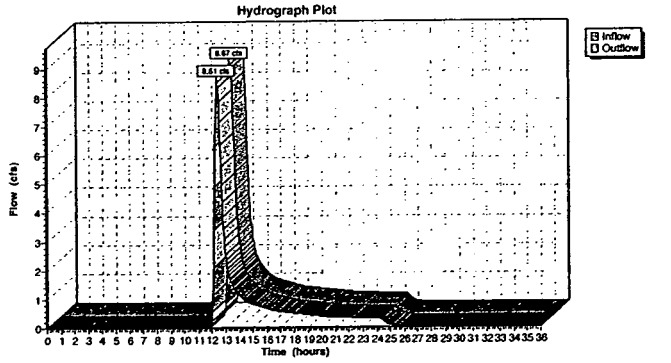
[65] Warning: Inlet elevation not specified

Inflow	=	8.67 cfs @	12.31 hrs, Volume=	0.985 af	
Outflow	=	8.51 cfs @	12.41 hrs, Volume=	0.985 af, Atten= 2%, Lag= 5.7 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 3.2 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 7.2 min

Peak Depth= 1.05'
Capacity at bank full= 1,106.53 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 4: east drainage channel



Reach 5: east drainage channel

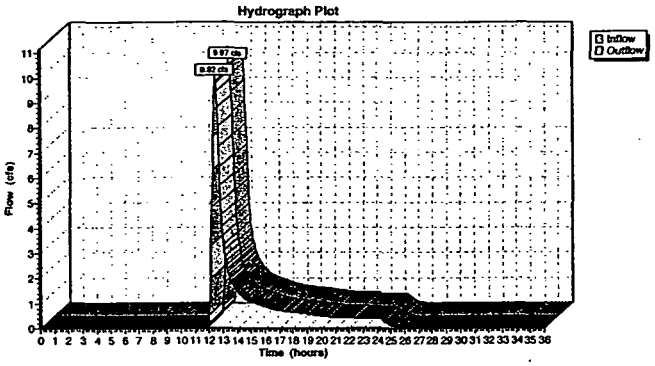
[65] Warning: Inlet elevation not specified

Inflow = 9.97 cfs @ 12.38 hrs, Volume= 1.253 af
Outflow = 9.82 cfs @ 12.48 hrs, Volume= 1.253 af, Atten= 2%, Lag= 5.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 8.1 min

Peak Depth= 1.00'
Capacity at bank full= 182.58 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 5: east drainage channel



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Reach 6: east drainage channel

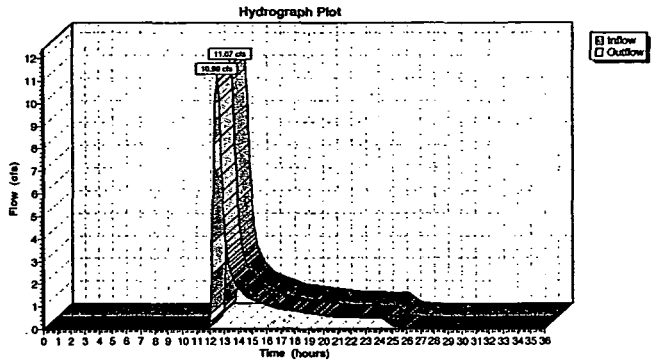
[65] Warning: Inlet elevation not specified

Inflow = 11.07 cfs @ 12.45 hrs, Volume= 1.535 af
Outflow = 10.99 cfs @ 12.53 hrs, Volume= 1.535 af, Atten= 1%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 6.6 min

Peak Depth= 0.92'
Capacity at bank full= 258.21 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 480.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 6: east drainage channel



Reach 7R: runoff diversion channel

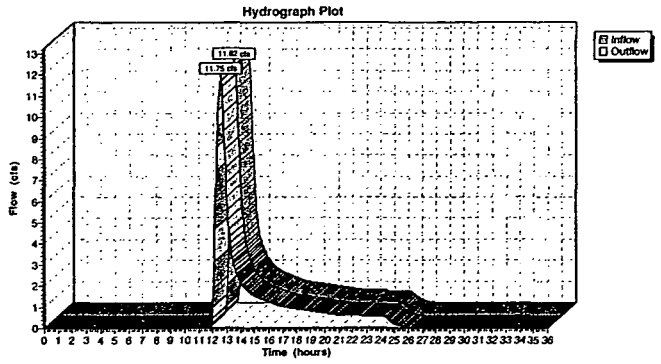
[65] Warning: Inlet elevation not specified

Inflow = 11.82 cfs @ 12.51 hrs, Volume= 1.779 af
Outflow = 11.75 cfs @ 12.58 hrs, Volume= 1.779 af, Atten= 1%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.1 min

Peak Depth= 0.94'
Capacity at bank full= 1,632.24 cfs
0.00' x 5.99' deep channel, n= 0.030 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 7R: runoff diversion channel



Reach 8R: runoff diversion channel

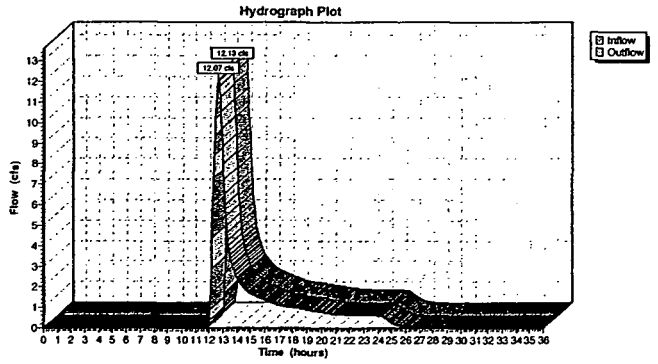
[65] Warning: Inlet elevation not specified

Inflow = 12.13 cfs @ 12.57 hrs, Volume= 1.906 af
Outflow = 12.07 cfs @ 12.62 hrs, Volume= 1.906 af, Atten= 0%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.0 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 4.3 min

Peak Depth= 0.88'
Capacity at bank full= 1,597.49 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
0.00' x 5.47' deep channel, n= 0.030 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: runoff diversion channel



Reach 9R: runoff diversion channel

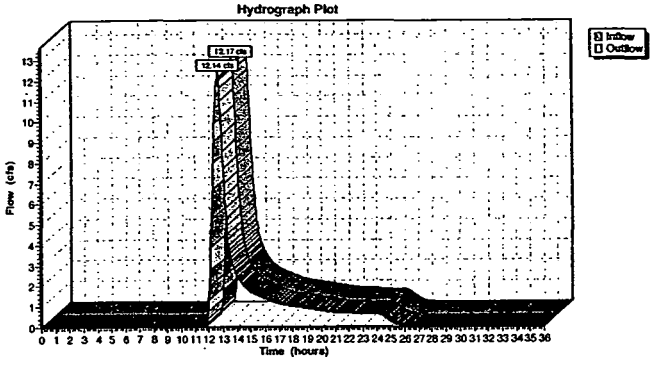
[65] Warning: Inlet elevation not specified

Inflow = 12.17 cfs @ 12.62 hrs, Volume= 1.954 af
Outflow = 12.14 cfs @ 12.65 hrs, Volume= 1.954 af, Atten= 0%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 2.3 min

Peak Depth= 0.72'
Capacity at bank full= 462.89 cfs
4.35' x 3.80' deep channel, n= 0.030 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: runoff diversion channel



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Reach 10AR: runoff diversion channel

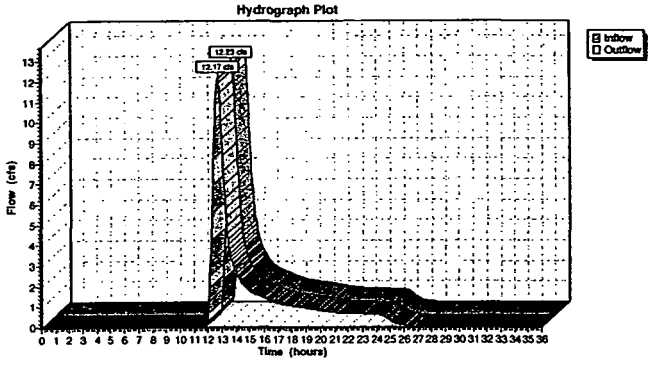
[65] Warning: Inlet elevation not specified

Inflow = 12.23 cfs @ 12.64 hrs, Volume= 2.006 af
Outflow = 12.17 cfs @ 12.73 hrs, Volume= 2.006 af, Atten= 0%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.0 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 8.3 min

Peak Depth= 0.50'
Capacity at bank full= 646.10 cfs
10.12' x 3.85' deep channel, n= 0.030 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 10AR: runoff diversion channel



Reach 10BR: (new node)

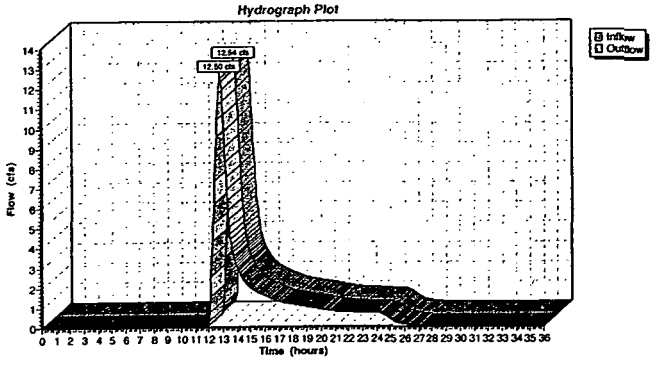
[65] Warning: Inlet elevation not specified

Inflow = 12.54 cfs @ 12.74 hrs, Volume= 2.155 af
Outflow = 12.50 cfs @ 12.79 hrs, Volume= 2.155 af, Atten= 0%, Lag= 2.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.7 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 5.1 min

Peak Depth= 0.60'
Capacity at bank full= 202.01 cfs
10.21' x 2.62' deep channel, n= 0.030 Length= 179.0' Slope= 0.0029 '/'
Side Slope Z-value= 3.0 4.6 '/'

Reach 10BR: (new node)



Reach 11: new CMP arch

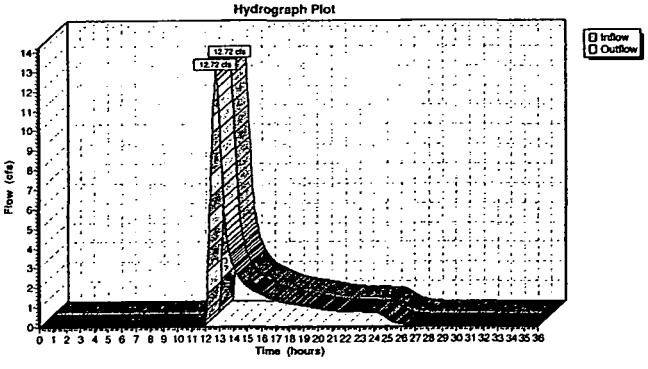
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 12.72 cfs @ 12.79 hrs, Volume= 2.229 af
Outflow = 12.72 cfs @ 12.79 hrs, Volume= 2.229 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.9 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.65'
Capacity at bank full= 522.31 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 40.0' Slope= 0.0022 '/'

Reach 11: new CMP arch



Reach 12R: runoff diversion channel

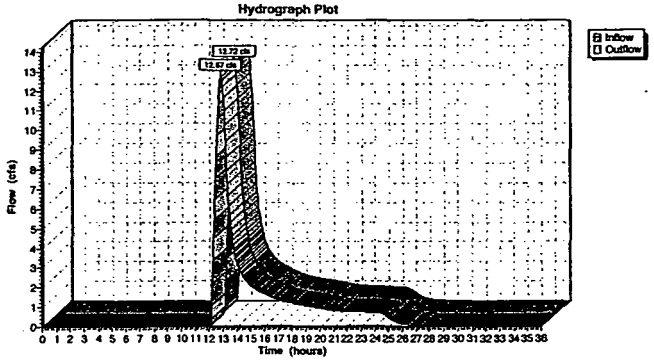
[65] Warning: Inlet elevation not specified

Inflow = 12.72 cfs @ 12.79 hrs, Volume= 2.229 af
Outflow = 12.67 cfs @ 12.84 hrs, Volume= 2.229 af, Atten= 0%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.0 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 5.7 min

Peak Depth= 0.41'
Capacity at bank full= 317.79 cfs
14.00' x 2.45' deep channel, n= 0.030 Length= 240.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 4.3 '/'

Reach 12R: runoff diversion channel



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Reach 13R: runoff diversion channel

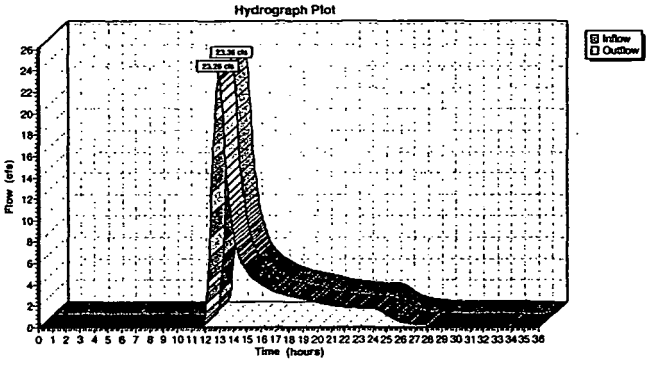
[65] Warning: Inlet elevation not specified

Inflow = 23.36 cfs @ 12.86 hrs, Volume= 5.232 af
Outflow = 23.26 cfs @ 12.95 hrs, Volume= 5.231 af, Atten= 0%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 11.7 min

Peak Depth= 0.43'
Capacity at bank full= 346.63 cfs
23.11' x 2.06' deep channel, n= 0.030 Length= 450.0' Slope= 0.0067 '/'
Side Slope Z-value= 2.3 4.0 '/'

Reach 13R: runoff diversion channel



Reach 14: east runon channel

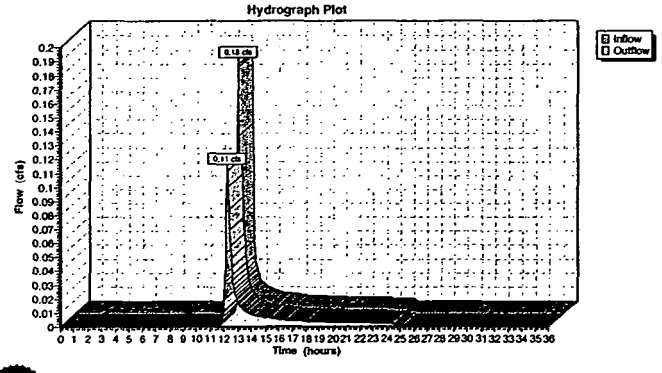
[65] Warning: Inlet elevation not specified

Inflow = 0.18 cfs @ 11.99 hrs, Volume= 0.009 af
Outflow = 0.11 cfs @ 12.24 hrs, Volume= 0.009 af, Atten= 38%, Lag= 15.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.7 fps, Min. Travel Time= 10.4 min
Avg. Velocity = 0.3 fps, Avg. Travel Time= 25.8 min

Peak Depth= 0.21'
Capacity at bank full= 22.78 cfs
0.00' x 1.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0040 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 14: east runon channel



Reach 15: east runon channel

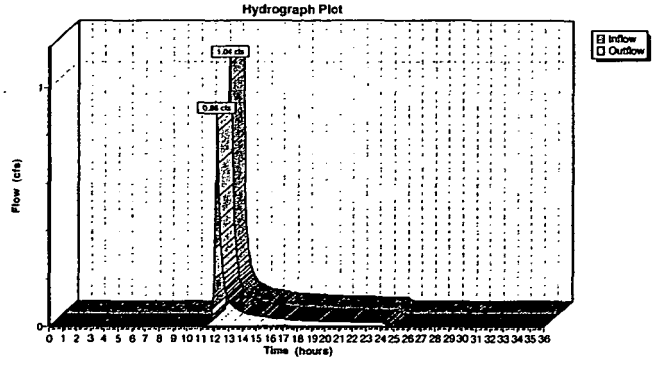
[65] Warning: Inlet elevation not specified

Inflow = 1.04 cfs @ 12.01 hrs, Volume= 0.064 af
Outflow = 0.86 cfs @ 12.16 hrs, Volume= 0.064 af, Atten= 17%, Lag= 8.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.3 fps, Min. Travel Time= 5.3 min
Avg. Velocity = 0.5 fps, Avg. Travel Time= 14.0 min

Peak Depth= 0.41'
Capacity at bank full= 61.62 cfs
0.00' x 2.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 15: east runon channel



Reach 16: east runon channel

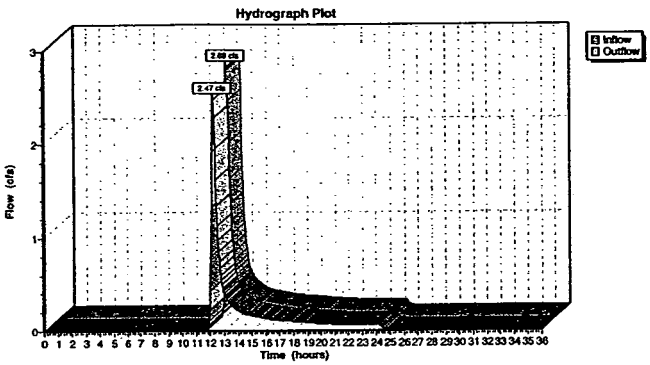
[65] Warning: Inlet elevation not specified

Inflow = 2.68 cfs @ 12.13 hrs, Volume= 0.208 af
Outflow = 2.47 cfs @ 12.24 hrs, Volume= 0.208 af, Atten= 8%, Lag= 6.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.9 fps, Min. Travel Time= 3.8 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 9.7 min

Peak Depth= 0.60'
Capacity at bank full= 256.58 cfs
0.00' x 3.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0074 '/'
Side Slope Z-value= 2.5 5.0 '/'

Reach 16: east runon channel



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Reach 17: east runon channel

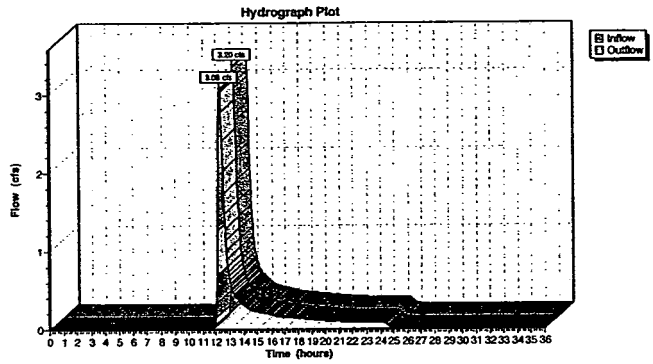
[65] Warning: Inlet elevation not specified

Inflow = 3.20 cfs @ 12.24 hrs, Volume= 0.282 af
Outflow = 3.08 cfs @ 12.33 hrs, Volume= 0.282 af, Atten= 4%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.3 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 7.6 min

Peak Depth= 0.55'
Capacity at bank full= 436.18 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 5.0 '/'

Reach 17: east runon channel



Reach 18: east runon channel

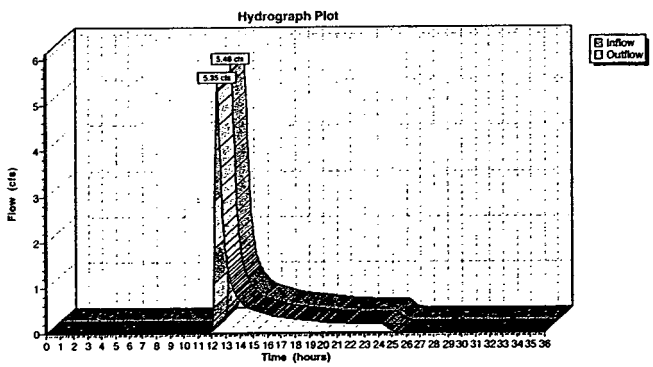
[65] Warning: Inlet elevation not specified

Inflow = 5.48 cfs @ 12.34 hrs, Volume= 0.605 af
Outflow = 5.35 cfs @ 12.43 hrs, Volume= 0.605 af, Atten= 2%, Lag= 5.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.9 min

Peak Depth= 0.82'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 18: east runon channel



Reach 19: east runon channel

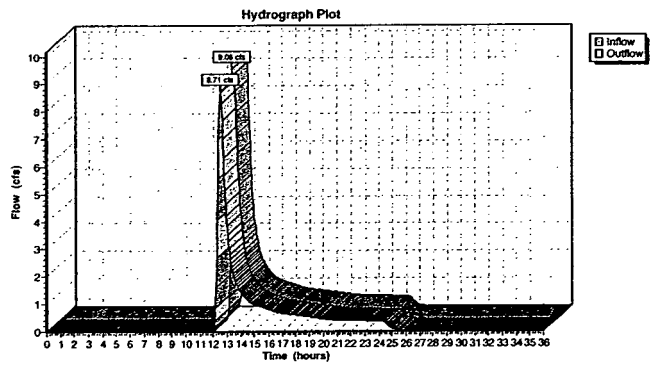
[65] Warning: Inlet elevation not specified

Inflow = 9.08 cfs @ 12.41 hrs, Volume= 1.115 af
Outflow = 8.71 cfs @ 12.53 hrs, Volume= 1.115 af, Atten= 4%, Lag= 7.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.9 fps, Min. Travel Time= 4.1 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 9.7 min

Peak Depth= 0.53'
Capacity at bank full= 911.12 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 470.0' Slope= 0.0090 '/'
Side Slope Z-value= 3.0 30.0 '/'

Reach 19: east runon channel



Reach 20: east runon channel

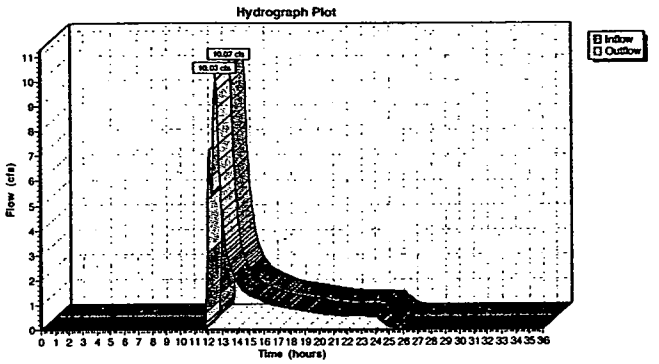
[65] Warning: Inlet elevation not specified

Inflow = 10.07 cfs @ 12.52 hrs, Volume= 1.605 af
Outflow = 10.03 cfs @ 12.53 hrs, Volume= 1.605 af, Atten= 0%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.08'
Capacity at bank full= 153.84 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 75.0' Slope= 0.0083 '/'
Side Slope Z-value= 3.0 '/'

Reach 20: east runon channel



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Reach 21: east runon channel

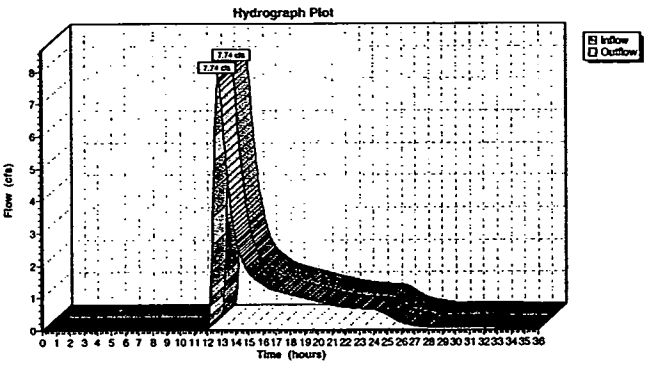
[65] Warning: Inlet elevation not specified

Inflow = 7.74 cfs @ 12.79 hrs, Volume= 1.817 af
Outflow = 7.74 cfs @ 12.80 hrs, Volume= 1.817 af, Atten= 0%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 1.0 min

Peak Depth= 0.94'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 65.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 21: east runon channel



Reach 22: east runon channel

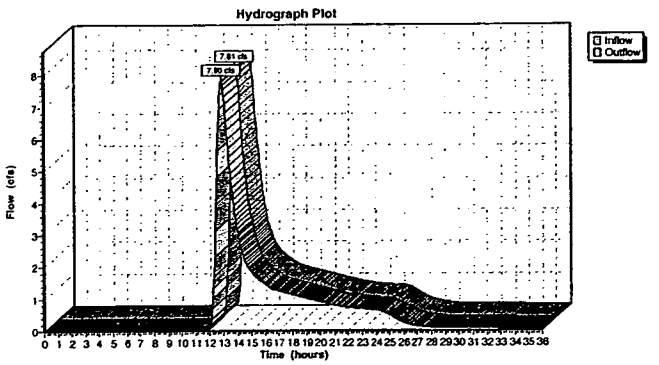
[65] Warning: Inlet elevation not specified

Inflow = 7.81 cfs @ 12.80 hrs, Volume= 1.844 af
Outflow = 7.80 cfs @ 12.83 hrs, Volume= 1.844 af, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 2.8 min

Peak Depth= 0.95'
Capacity at bank full= 364.40 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 190.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 22: east runon channel



Reach 23: new CMP culverts

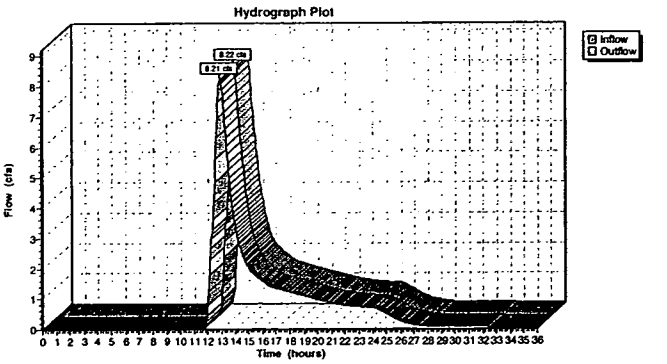
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 8.22 cfs @ 12.85 hrs, Volume= 2.042 af
Outflow = 8.21 cfs @ 12.87 hrs, Volume= 2.042 af, Atten= 0%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.3 min

Peak Depth= 0.55'
Capacity at bank full= 468.67 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 92.0' Slope= 0.0059 '/'

Reach 23: new CMP culverts



Reach 24: runon channel

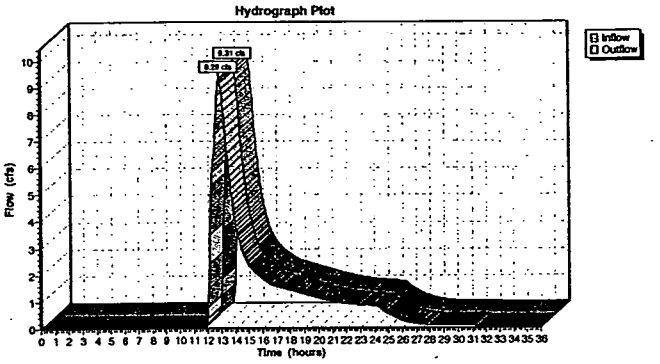
[65] Warning: Inlet elevation not specified

Inflow = 9.31 cfs @ 12.82 hrs, Volume= 2.398 af
Outflow = 9.29 cfs @ 12.86 hrs, Volume= 2.397 af, Atten= 0%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 3.9 min

Peak Depth= 0.43'
Capacity at bank full= 153.54 cfs
8.50' x 2.00' deep channel, n= 0.030 Length= 160.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 24: runon channel



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Reach 25: new CMP arch

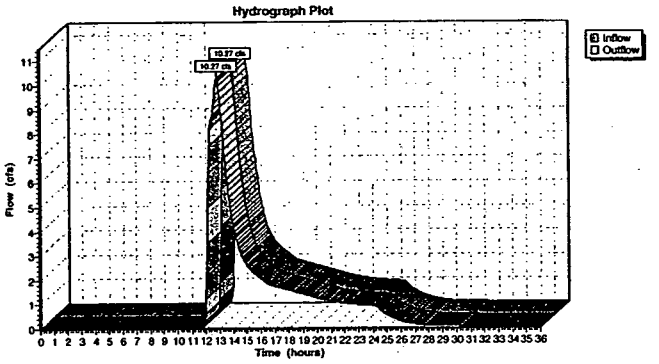
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 10.27 cfs @ 12.82 hrs, Volume= 2.694 af
Outflow = 10.27 cfs @ 12.82 hrs, Volume= 2.694 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.61'
Capacity at bank full= 475.34 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 53.0' Slope= 0.0060 '/'

Reach 25: new CMP arch



Reach 26: runon channel

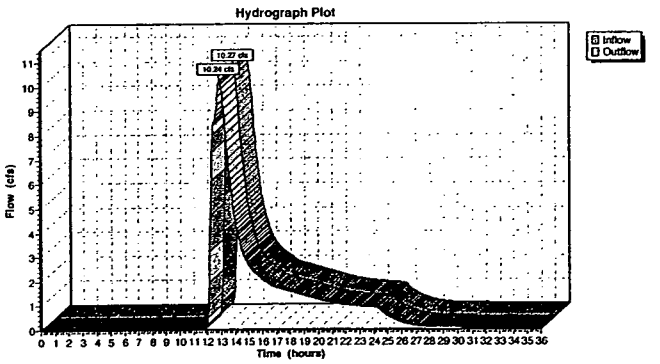
[65] Warning: Inlet elevation not specified

Inflow = 10.27 cfs @ 12.82 hrs, Volume= 2.694 af
Outflow = 10.24 cfs @ 12.88 hrs, Volume= 2.694 af, Atten= 0%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 4.6 min

Peak Depth= 1.11'
Capacity at bank full= 90.11 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 300.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 26: runon channel



Reach 27: new CMP arch

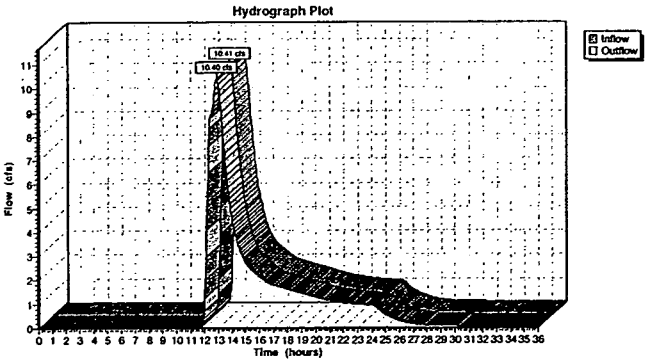
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 10.41 cfs @ 12.87 hrs, Volume= 2.795 af
Outflow = 10.40 cfs @ 12.89 hrs, Volume= 2.795 af, Atten= 0%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.5 min

Peak Depth= 0.67'
Capacity at bank full= 398.58 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 106.0' Slope= 0.0042 '/'

Reach 27: new CMP arch



Reach 28R: new CMP culverts

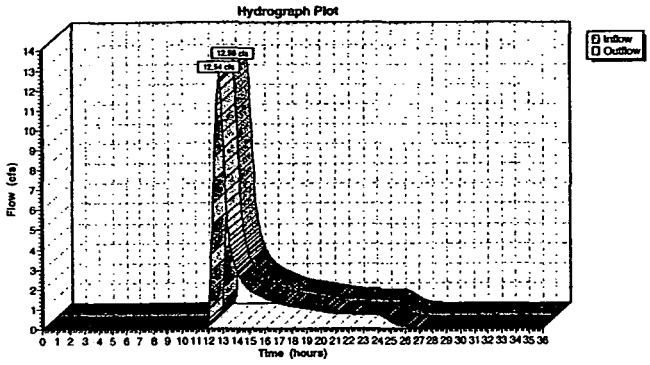
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	12.56 cfs @	12.72 hrs, Volume=	2.155 af	
[illegible]	=	12.54 cfs @	12.74 hrs, Volume=	2.155 af, Atten= 0%, Lag= 1.1 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.7 min

Peak Depth= 0.71'
Capacity at bank full= 427.00 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.019 Length= 140.0' Slope= 0.0054 '/'

Reach 28R: new CMP culverts



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Reach 29: east runon channel

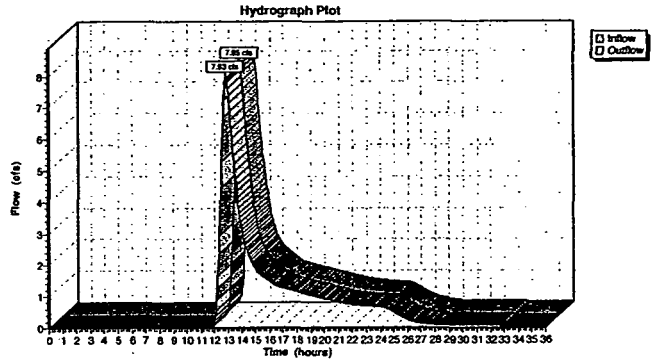
[65] Warning: Inlet elevation not specified

Inflow	=	7.95 cfs @	12.82 hrs, Volume=	1.904 af	
Outflow	=	7.93 cfs @	12.86 hrs, Volume=	1.903 af, Atten= 0%, Lag= 2.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 3.4 min

Peak Depth= 0.95'
Capacity at bank full= 255.23 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 230.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 29: east runon channel



Reach 30: east runon channel

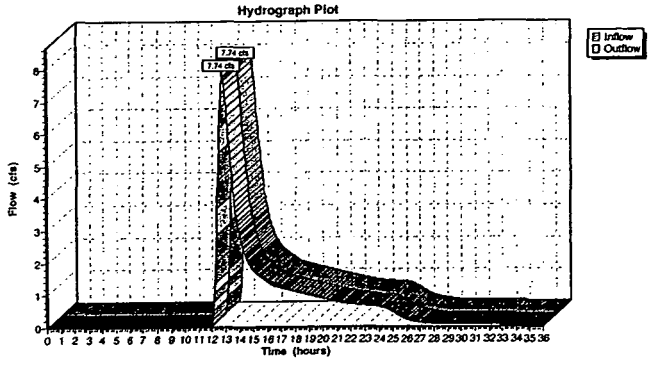
[65] Warning: Inlet elevation not specified

Inflow	=	7.74 cfs @	12.78 hrs, Volume=	1.817 af	
Outflow	=	7.74 cfs @	12.79 hrs, Volume=	1.817 af, Atten= 0%, Lag= 0.3 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.94'
Capacity at bank full= 104.05 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 30.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 30: east runon channel



Reach 31: culvert

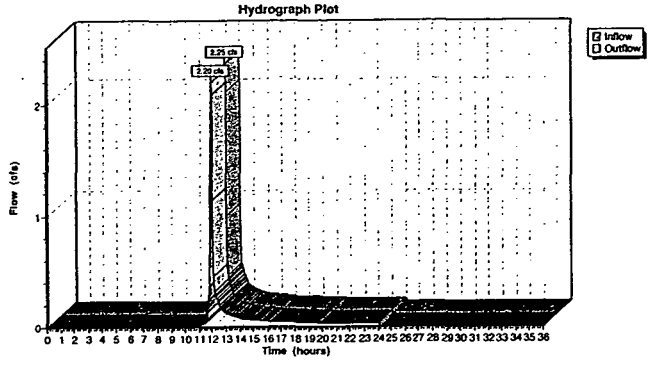
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	2.25 cfs @	11.91 hrs, Volume=	0.096 af	
Outflow	=	2.20 cfs @	11.93 hrs, Volume=	0.096 af, Atten= 2%, Lag= 0.8 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.20'
Capacity at bank full= 1,025.91 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.012 Length= 80.0' Slope= 0.0125 '/'

Reach 31: culvert



Pond 1P: (new node)

Inflow	=	11.25 cfs @	12.51 hrs,	Volume=	1.850 af
Outflow	=	7.74 cfs @	12.78 hrs,	Volume=	1.817 af, Atten= 31%, Lag= 16.0 min
Primary	=	7.74 cfs @	12.78 hrs,	Volume=	1.817 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Starting Elev= 592.00' Storage= 0.691 af
Peak Elev= 592.98' Storage= 1.082 af (0.391 af above starting storage)
Plug-Flow detention time= 348.7 min calculated for 1.124 af (61% of inflow)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
589.30	0.186	0.000	0.000	0.186
590.00	0.210	0.139	0.139	0.211
591.00	0.278	0.243	0.382	0.279
592.00	0.342	0.309	0.691	0.344
593.00	0.463	0.401	1.092	0.465
594.00	0.624	0.542	1.634	0.627

Primary OutFlow (Free Discharge)
└─1=Special (user-defined)

#	Routing	Invert	Outlet Devices
1	Primary	592.00'	**Special (user-defined)** Head (feet) 0.00 0.01 0.18 0.51 1.01 1.34 1.67 2.00 Disch. (cfs) 0.00 0.00 0.08 1.33 8.21 17.57 31.73 51.47

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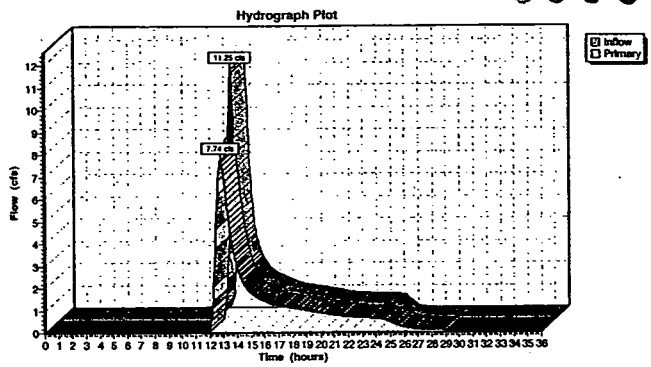
Pond 1P: (new node)

Hydrograph Plot



Pond 3P: Borrow Area Basin

Inflow	=	31.84 cfs @	11.90 hrs,	Volume=	7.954 af
Outflow	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af, Atten= 100%, Lag= 0.0 min
Primary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 571.21' Storage= 7.954 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

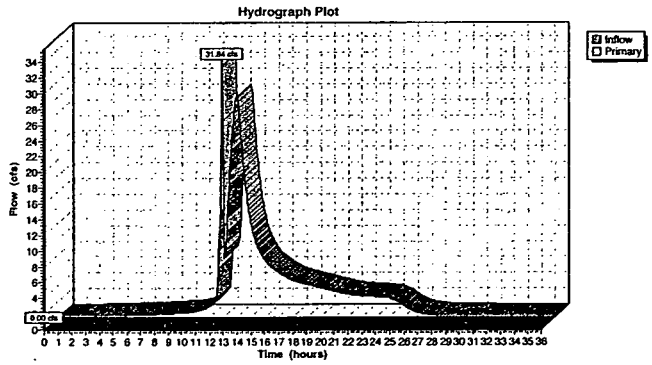
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.00	6.391	0.000	0.000	6.391
571.00	6.687	6.538	6.538	6.690
572.00	7.017	6.851	13.390	7.023
573.00	7.290	7.153	20.543	7.300
574.00	7.613	7.451	27.994	7.626
575.00	7.921	7.766	35.760	7.938

Primary OutFlow (Free Discharge)
├─2=Culvert
│ └─1=Orifice/Grate
└─3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.30'	**48.0" Horiz. Orifice/Grate X 2.00** Limited to weir flow C= 0.600
2	Primary	569.80'	**48.0" x 200.0' long Culvert X 2.00** Ke= 0.700 Outlet Invert= 569.00' S= 0.0040 '/' n= 0.024 Cc= 0.900
3	Primary	578.00'	**20.0' long Broad-Crested Rectangular Weir** Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00 Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 3P: Borrow Area Basin

Hydrograph Plot



EAST OSDF POST-DEVELOPMENT DESIGN SCENARIO
25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover system
Tc=17.3 min CN=74 Area=1.964 ac Runoff= 4.98 cfs 0.348 af

Subcatchment AA: open space with good grass cover
Tc=16.8 min CN=74 Area=2.708 ac Runoff= 6.97 cfs 0.480 af

Subcatchment B: vegetated final cover system
Tc=6.2 min CN=74 Area=1.179 ac Runoff= 4.35 cfs 0.209 af

Subcatchment BB: open space with good grass cover
Tc=9.1 min CN=79 Area=0.761 ac Runoff= 3.03 cfs 0.161 af

Subcatchment C: vegetated final cover system
Tc=20.7 min CN=74 Area=5.209 ac Runoff= 11.92 cfs 0.923 af

Subcatchment CC: open space with good grass cover
Tc=6.7 min CN=79 Area=0.121 ac Runoff= 0.52 cfs 0.026 af

Subcatchment D: vegetated final cover system
Tc=20.1 min CN=74 Area=5.131 ac Runoff= 11.93 cfs 0.910 af

Subcatchment DDR: vegetated final cover system
Tc=7.6 min CN=74 Area=0.860 ac Runoff= 3.04 cfs 0.152 af

Subcatchment E: vegetated final cover system
Tc=19.7 min CN=74 Area=5.092 ac Runoff= 11.98 cfs 0.903 af

Subcatchment EE: open space with good grass cover
Tc=25.4 min CN=77 Area=0.925 ac Runoff= 2.10 cfs 0.183 af

Subcatchment F: vegetated final cover system
Tc=19.7 min CN=74 Area=5.053 ac Runoff= 11.89 cfs 0.896 af

Subcatchment FFR: vegetated final cover system
Tc=17.6 min CN=74 Area=2.410 ac Runoff= 6.05 cfs 0.427 af

Subcatchment G: vegetated final cover system
Tc=19.8 min CN=74 Area=5.309 ac Runoff= 12.45 cfs 0.941 af

Subcatchment GGR: open space with good grass cover
Tc=28.3 min CN=67 Area=2.350 ac Runoff= 3.18 cfs 0.313 af

Subcatchment HH: open space with good grass cover
Tc=13.9 min CN=79 Area=0.548 ac Runoff= 1.86 cfs 0.116 af

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Subcatchment HR: vegetated final cover system
Tc=17.7 min CN=74 Area=4.590 ac Runoff= 11.49 cfs 0.814 af

Subcatchment II: open space with good grass cover
Tc=23.0 min CN=68 Area=1.669 ac Runoff= 2.73 cfs 0.232 af

Subcatchment IR: vegetated final cover
Tc=7.3 min CN=74 Area=0.600 ac Runoff= 2.14 cfs 0.106 af

Subcatchment JJ: open space with good grass cover
Tc=41.9 min CN=62 Area=0.914 ac Runoff= 0.69 cfs 0.096 af

Subcatchment JR: vegetated final cover
Tc=20.8 min CN=74 Area=2.520 ac Runoff= 5.75 cfs 0.447 af

Subcatchment K1R: open space with good grass cover
Tc=4.9 min CN=74 Area=0.382 ac Runoff= 1.47 cfs 0.068 af

Subcatchment K2R: open space with good grass cover
Tc=33.4 min CN=66 Area=0.530 ac Runoff= 0.61 cfs 0.067 af

Subcatchment KK: open space with good grass cover
Tc=36.4 min CN=64 Area=5.893 ac Runoff= 5.63 cfs 0.682 af

Subcatchment L: open space with good grass cover
Tc=15.4 min CN=76 Area=1.683 ac Runoff= 4.88 cfs 0.321 af

Subcatchment LL: open space with good grass cover
Tc=28.1 min CN=61 Area=7.049 ac Runoff= 6.61 cfs 0.701 af

Subcatchment M: open space with good grass cover
Tc=12.1 min CN=79 Area=1.000 ac Runoff= 3.60 cfs 0.212 af

Subcatchment MM: open space with good grass cover
Tc=9.9 min CN=61 Area=1.943 ac Runoff= 3.30 cfs 0.193 af

Subcatchment N: direct runon to pond
Tc=1.0 min CN=98 Area=7.818 ac Runoff= 57.89 cfs 2.908 af

Subcatchment NN: open space with good grass cover
Tc=1.4 min CN=66 Area=1.274 ac Runoff= 3.78 cfs 0.162 af

Subcatchment O: open space with good grass cover
Tc=1.3 min CN=79 Area=1.317 ac Runoff= 6.54 cfs 0.279 af

Subcatchment OO: open space with good grass cover
Tc=5.4 min CN=66 Area=0.399 ac Runoff= 1.06 cfs 0.051 af

Subcatchment P: open space with good grass cover
Tc=33.7 min CN=75 Area=5.238 ac Runoff= 9.16 cfs 0.964 af

Subcatchment PP: open space with good grass cover
Tc=79.5 min CN=64 Area=40.964 ac Runoff= 22.00 cfs 4.742 af

Subcatchment Q: open space with good grass cover
Tc=31.8 min CN=72 Area=7.700 ac Runoff= 12.29 cfs 1.264 af

Subcatchment R: open space with good grass cover
Tc=21.6 min CN=74 Area=2.612 ac Runoff= 5.83 cfs 0.463 af

Subcatchment S: open space with good grass cover
Tc=27.9 min CN=78 Area=0.402 ac Runoff= 0.89 cfs 0.082 af

Subcatchment TR: open space with good grass cover
Tc=3.7 min CN=74 Area=0.040 ac Runoff= 0.16 cfs 0.007 af

Subcatchment U: open space with good grass cover
Tc=32.3 min CN=72 Area=4.149 ac Runoff= 6.57 cfs 0.681 af

Subcatchment V: direct runon to pond
Tc=1.0 min CN=98 Area=0.274 ac Runoff= 2.03 cfs 0.102 af

Subcatchment W: open space with good grass cover
Tc=12.6 min CN=72 Area=10.593 ac Runoff= 28.88 cfs 1.739 af

Subcatchment X: open space with good grass cover
Tc=33.4 min CN=71 Area=11.853 ac Runoff= 17.50 cfs 1.869 af

Subcatchment Y: open space with good grass cover
Tc=36.8 min CN=73 Area=6.522 ac Runoff= 9.84 cfs 1.113 af

Subcatchment Z: open space with good grass cover
Tc=23.7 min CN=72 Area=1.606 ac Runoff= 3.11 cfs 0.264 af

Reach 1: east drainage channel — Inflow= 7.87 cfs 0.557 af
Length= 420.0' Max Vel= 1.9 fps Capacity= 754.76 cfs Outflow= 7.20 cfs 0.557 af

Reach 1R: (new node) — Inflow= 6.61 cfs 0.701 af
Length= 100.0' Max Vel= 5.4 fps Capacity= 1,101.12 cfs Outflow= 6.59 cfs 0.701 af

Reach 2: east drainage channel — Inflow= 19.04 cfs 1.481 af
Length= 420.0' Max Vel= 2.5 fps Capacity= 1,205.98 cfs Outflow= 18.52 cfs 1.481 af

Reach 2R: (new node) — Inflow= 3.30 cfs 0.193 af
Length= 100.0' Max Vel= 4.3 fps Capacity= 1,101.12 cfs Outflow= 3.25 cfs 0.193 af

Reach 3: east drainage channel — Inflow= 29.26 cfs 2.390 af
Length= 420.0' Max Vel= 3.0 fps Capacity= 1,563.67 cfs Outflow= 28.56 cfs 2.390 af

Reach 3R: (new node) — Inflow= 3.78 cfs 0.162 af
Length= 100.0' Max Vel= 4.5 fps Capacity= 1,101.12 cfs Outflow= 3.72 cfs 0.162 af

Reach 4: east drainage channel — Inflow= 37.70 cfs 3.293 af
Length= 420.0' Max Vel= 3.2 fps Capacity= 1,106.53 cfs Outflow= 36.99 cfs 3.293 af

Reach 5: east drainage channel — Inflow= 44.86 cfs 4.189 af
Length= 440.0' Max Vel= 3.2 fps Capacity= 182.58 cfs Outflow= 44.12 cfs 4.189 af

Reach 6: east drainage channel — Inflow= 51.10 cfs 5.130 af
Length= 480.0' Max Vel= 4.2 fps Capacity= 258.21 cfs Outflow= 50.57 cfs 5.130 af

Reach 7R: runoff diversion channel — Inflow= 55.14 cfs 5.944 af
Length= 400.0' Max Vel= 4.3 fps Capacity= 1,632.24 cfs Outflow= 54.73 cfs 5.944 af

Reach 8R: runoff diversion channel — Inflow= 56.86 cfs 6.371 af
Length= 220.0' Max Vel= 2.9 fps Capacity= 1,597.49 cfs Outflow= 56.55 cfs 6.371 af

Reach 9R: runoff diversion channel — Inflow= 56.94 cfs 6.531 af
Length= 120.0' Max Vel= 3.3 fps Capacity= 462.89 cfs Outflow= 56.77 cfs 6.531 af

Reach 10AR: runoff diversion channel — Inflow= 57.17 cfs 6.705 af
Length= 365.0' Max Vel= 3.2 fps Capacity= 648.10 cfs Outflow= 56.79 cfs 6.705 af

Reach 10BR: (new node) — Inflow= 59.15 cfs 7.219 af
Length= 179.0' Max Vel= 2.7 fps Capacity= 202.01 cfs Outflow= 58.90 cfs 7.219 af

Reach 11: new CMP arch — Inflow= 60.72 cfs 7.532 af
Length= 40.0' Max Vel= 6.2 fps Capacity= 522.31 cfs Outflow= 60.69 cfs 7.532 af

Reach 12R: runoff diversion channel — Inflow= 60.69 cfs 7.532 af
Length= 240.0' Max Vel= 3.4 fps Capacity= 317.79 cfs Outflow= 60.45 cfs 7.532 af

Reach 13R: runoff diversion channel — Inflow= 126.44 cfs 17.814 af
Length= 450.0' Max Vel= 4.1 fps Capacity= 348.63 cfs Outflow= 125.93 cfs 17.812 af

Reach 14: east runon channel — Inflow= 0.52 cfs 0.026 af
Length= 420.0' Max Vel= 0.9 fps Capacity= 22.78 cfs Outflow= 0.38 cfs 0.026 af

Reach 15: east runon channel — Inflow= 3.20 cfs 0.187 af
Length= 420.0' Max Vel= 1.8 fps Capacity= 61.62 cfs Outflow= 2.82 cfs 0.187 af

Reach 16: east runon channel — Inflow= 9.76 cfs 0.667 af
Length= 420.0' Max Vel= 2.6 fps Capacity= [illegible] cfs Outflow= 9.33 cfs 0.667 af

Reach 17: east runon channel Inflow= 12.43 cfs 0.931 af
Length= 420.0' Max Vel= 3.2 fps Capacity= 436.18 cfs Outflow= 12.07 cfs 0.931 af

Reach 18: east runon channel Inflow= 21.43 cfs 2.044 af
Length= 440.0' Max Vel= 3.7 fps Capacity= 169.20 cfs Outflow= 20.99 cfs 2.044 af

Reach 19: east runon channel Inflow= 38.43 cfs 3.913 af
Length= 470.0' Max Vel= 2.8 fps Capacity= 911.12 cfs Outflow= 37.75 cfs 3.913 af

Reach 20: east runon channel Inflow= 43.35 cfs 5.652 af
Length= 75.0' Max Vel= 4.2 fps Capacity= 153.84 cfs Outflow= 43.26 cfs 5.652 af

Reach 21: east runon channel Inflow= 45.96 cfs 6.399 af
Length= 65.0' Max Vel= 4.5 fps Capacity= 169.20 cfs Outflow= 45.90 cfs 6.399 af

Reach 22: east runon channel Inflow= 46.39 cfs 6.481 af
Length= 190.0' Max Vel= 4.5 fps Capacity= 364.40 cfs Outflow= 46.24 cfs 6.481 af

Reach 23: new CMP culverts Inflow= 48.82 cfs 7.127 af
Length= 92.0' Max Vel= 5.4 fps Capacity= 468.67 cfs Outflow= 48.75 cfs 7.127 af

Reach 24: runon channel Inflow= 57.21 cfs 8.390 af
Length= 160.0' Max Vel= 4.0 fps Capacity= 153.54 cfs Outflow= 57.10 cfs 8.390 af

Reach 25: new CMP arch Inflow= 64.32 cfs 9.354 af
Length= 53.0' Max Vel= 5.9 fps Capacity= 475.34 cfs Outflow= 64.29 cfs 9.354 af

Reach 26: runon channel Inflow= 64.29 cfs 9.354 af
Length= 300.0' Max Vel= 4.4 fps Capacity= 90.11 cfs Outflow= 64.13 cfs 9.353 af

Reach 27: new CMP arch Inflow= 65.08 cfs 9.674 af
Length= 106.0' Max Vel= 5.2 fps Capacity= 398.58 cfs Outflow= 65.02 cfs 9.674 af

Reach 28R: new CMP culverts Inflow= 59.26 cfs 7.219 af
Length= 140.0' Max Vel= 5.3 fps Capacity= 427.00 cfs Outflow= 59.15 cfs 7.219 af

Reach 29: east runon channel Inflow= 47.16 cfs 6.664 af
Length= 230.0' Max Vel= 4.6 fps Capacity= 255.23 cfs Outflow= 46.97 cfs 6.664 af

Reach 30: east runon channel Inflow= 45.98 cfs 6.399 af
Length= 30.0' Max Vel= 4.5 fps Capacity= 104.05 cfs Outflow= 45.96 cfs 6.399 af

Reach 31: culvert Inflow= 6.54 cfs 0.279 af
Length= 80.0' Max Vel= 5.1 fps Capacity= 1,025.91 cfs Outflow= 6.34 cfs 0.279 af

Pond 1P: (new node) Peak Storage= 1.584 af Inflow= 49.32 cfs 6.434 af
Primary= 45.98 cfs 6.399 af Outflow= 45.98 cfs 6.399 af

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Pond 3P: Borrow Area Basin Peak Storage= 26.523 af Inflow= 150.77 cfs 26.523 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

Runoff Area = 171.154 ac Volume = 27.618 af Average Depth = 1.94"

Subcatchment A: vegetated final cover system

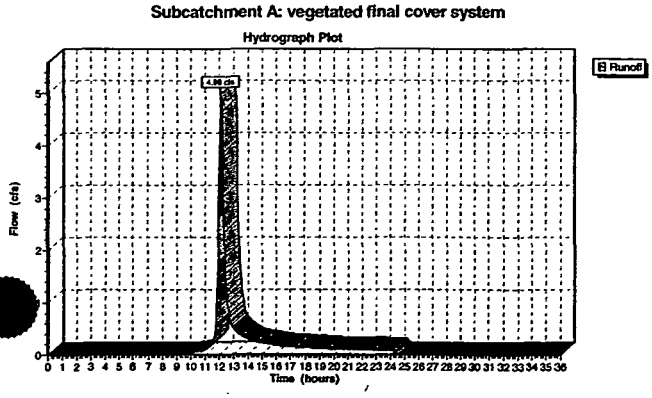
Runoff = 4.98 cfs @ 12.10 hrs, Volume= 0.348 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.964	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.2	80	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
17.3	380	Total			

Subcatchment A: vegetated final cover system



Subcatchment AA: open space with good grass cover

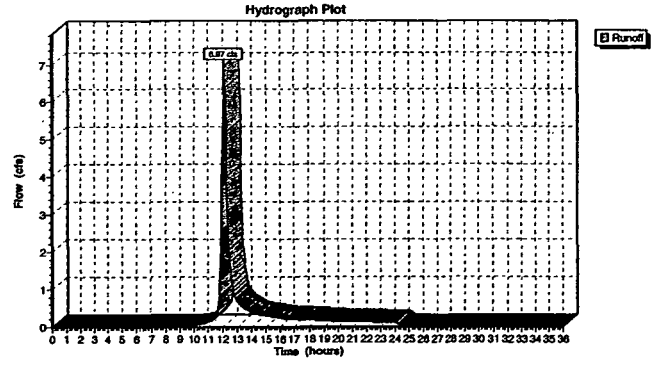
Runoff = 6.97 cfs @ 12.10 hrs, Volume= 0.480 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.708	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0	300	0.0800	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.6	170	0.0800	4.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	300	0.0070	4.0	48.01	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
16.8	770	Total			

Subcatchment AA: open space with good grass cover



Subcatchment B: vegetated final cover system

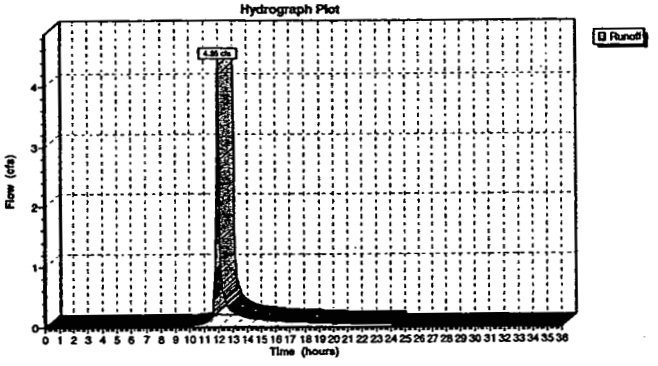
Runoff = 4.35 cfs @ 11.98 hrs, Volume= 0.209 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.179	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	50	0.1800	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.6	450	0.0045	2.1	9.75	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.02' Z= 6.0 & 3.0 '/' n= 0.030
6.2	500	Total			

Subcatchment B: vegetated final cover system



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Subcatchment BB: open space with good grass cover

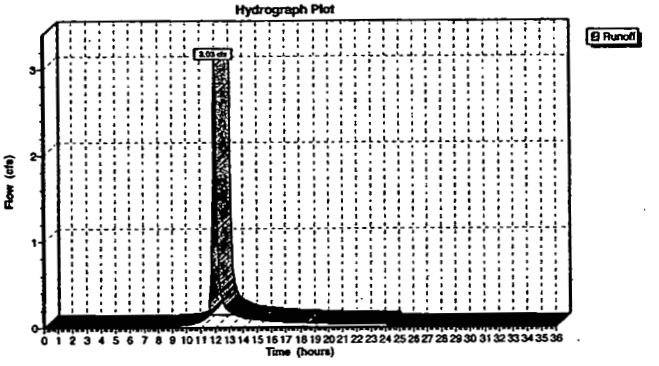
Runoff = 3.03 cfs @ 12.01 hrs, Volume= 0.161 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.761	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	110	0.0800	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
2.4	360	0.0040	2.5	22.78	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.50' Z= 3.0 & 5.0 '/' n= 0.030
9.1	470	Total			

Subcatchment BB: open space with good grass cover



Subcatchment C: vegetated final cover system

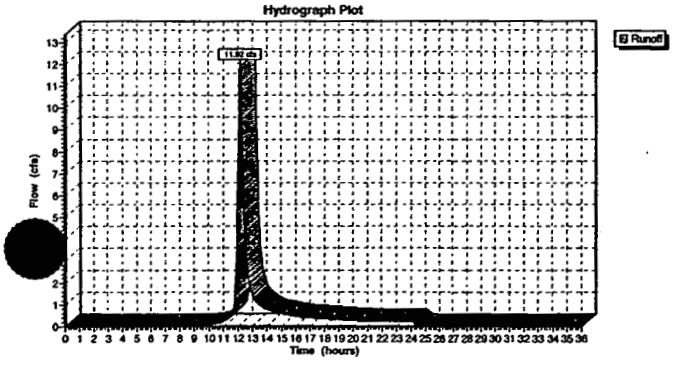
Runoff = 11.92 cfs @ 12.14 hrs, Volume= 0.923 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.209	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
3.2	400	0.0045	2.1	10.88	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.02' Z= 6.0 & 4.0 '/' n= 0.030
20.7	870	Total			

Subcatchment C: vegetated final cover system



Subcatchment CC: open space with good grass cover

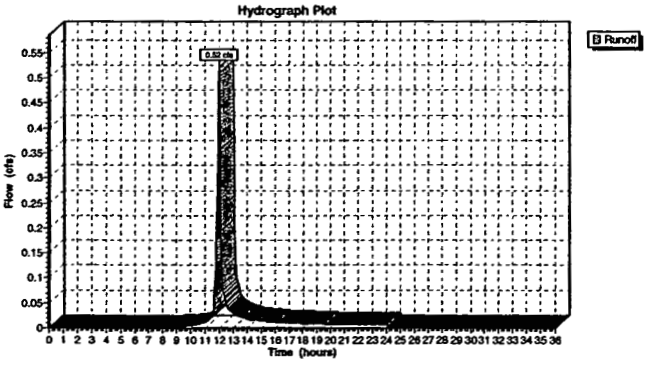
Runoff = 0.52 cfs @ 11.98 hrs, Volume= 0.026 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.121	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	110	0.0800	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment CC: open space with good grass cover



Subcatchment D: vegetated final cover system

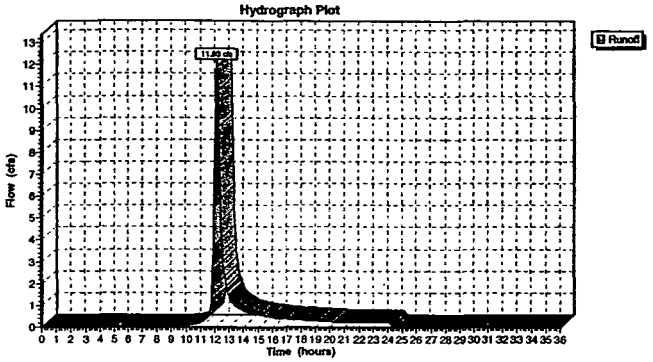
Runoff = 11.93 cfs @ 12.13 hrs, Volume= 0.910 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.131	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.7	250	0.0045	2.4	16.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.29' Z= 5.0 & 3.0 '/' n= 0.030
0.9	150	0.0050	2.9	25.90	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.59' Z= 4.0 & 3.0 '/' n= 0.030
20.1	870	Total			

Subcatchment D: vegetated final cover system



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Subcatchment DDR: vegetated final cover system

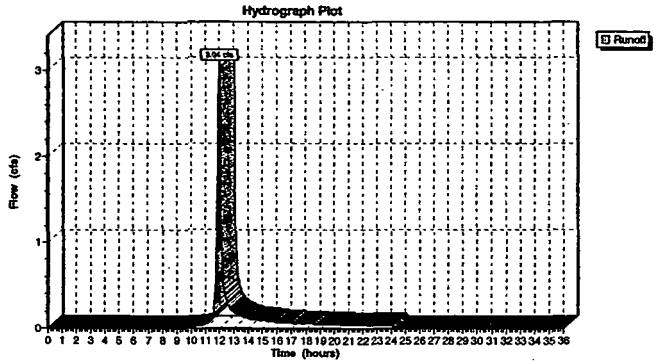
Runoff = 3.04 cfs @ 11.99 hrs, Volume= 0.152 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.860	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.6	480	Total			

Subcatchment DDR: vegetated final cover system



Subcatchment E: vegetated final cover system

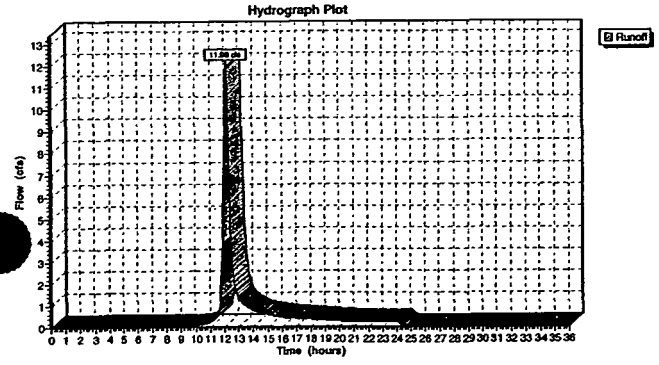
Runoff = 11.98 cfs @ 12.13 hrs, Volume= 0.903 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.092	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	380	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	850	Total			

Subcatchment E: vegetated final cover system



Subcatchment EE: open space with good grass cover

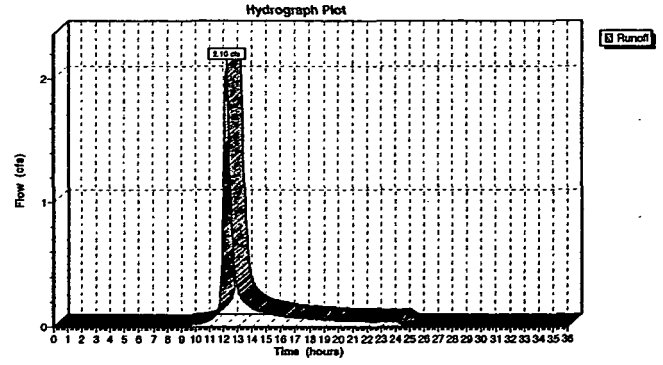
Runoff = 2.10 cfs @ 12.19 hrs, Volume= 0.183 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.925	77	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.8	300	0.0230	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	80	0.0230	2.4		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	40	0.0100	7.6	364.40	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 3.0 '/' n= 0.030
25.4	420	Total			

Subcatchment EE: open space with good grass cover



Subcatchment F: vegetated final cover system

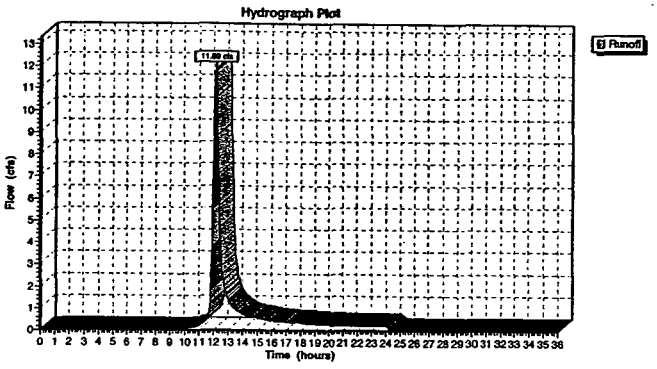
Runoff = 11.89 cfs @ 12.13 hrs, Volume= 0.896 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.053	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.2	390	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.7	860	Total			

Subcatchment F: vegetated final cover system



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Subcatchment FFR: vegetated final cover system

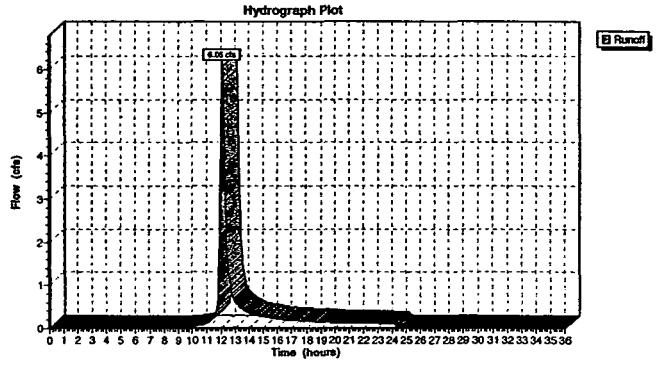
Runoff = 6.05 cfs @ 12.11 hrs, Volume= 0.427 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.410	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	85	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	365	0.0050	6.7	914.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.030
17.6	810	Total			

Subcatchment FFR: vegetated final cover system



Subcatchment G: vegetated final cover system

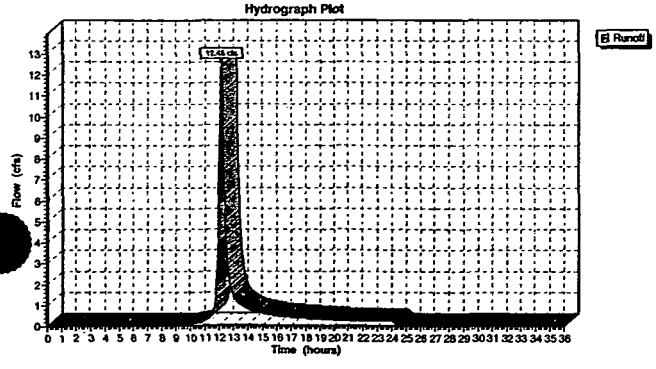
Runoff = 12.45 cfs @ 12.13 hrs, Volume= 0.941 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.309	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	410	0.0050	2.9	26.33	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.60' Z= 4.0 & 3.0 '/' n= 0.030
19.8	880	Total			

Subcatchment G: vegetated final cover system



Subcatchment GGR: open space with good grass cover

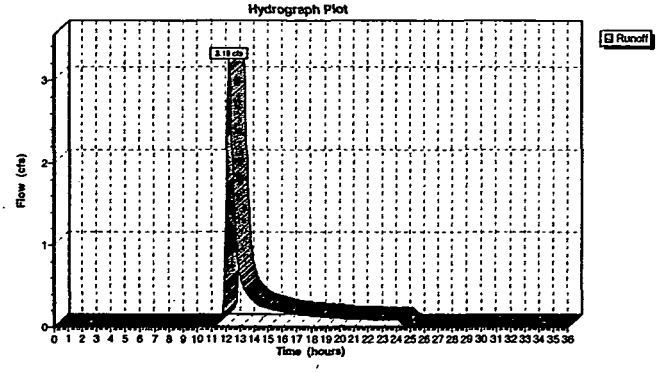
Runoff = 3.18 cfs @ 12.24 hrs, Volume= 0.313 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.350	67	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.2	300	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.3	590	Total			

Subcatchment GGR: open space with good grass cover



Subcatchment HH: open space with good grass cover

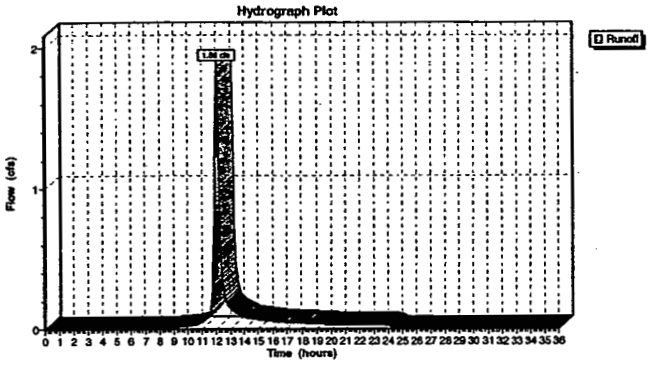
Runoff = 1.86 cfs @ 12.06 hrs, Volume= 0.116 af

[illegible] by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
[illegible] 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.548	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	90	0.0100	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.7	230	0.0045	5.1	352.87	Trap/Vee/Rect Channel Flow, Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
13.9	320	Total			

Subcatchment HH: open space with good grass cover



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Subcatchment HR: vegetated final cover system

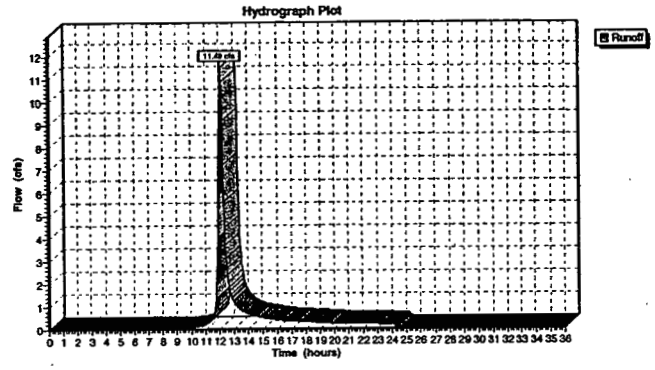
Runoff = 11.49 cfs @ 12.11 hrs, Volume= 0.814 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
4.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	400	0.0100	9.8	1,429.92	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.70' Z= 6.0 & 3.0 '/' n= 0.030
17.7	850	Total			

Subcatchment HR: vegetated final cover system



Subcatchment II: open space with good grass cover

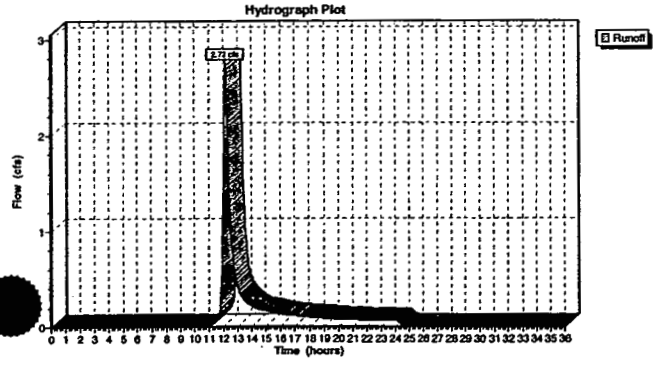
Runoff = 2.73 cfs @ 12.17 hrs, Volume= 0.232 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.669	68	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.9	210	0.0400	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.2	70	0.1660	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.9	380	0.0025	0.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
23.0	660	Total			

Subcatchment II: open space with good grass cover



Subcatchment IR: vegetated final cover

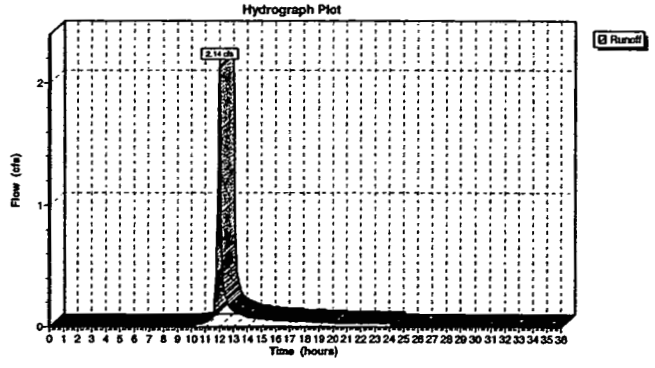
Runoff = 2.14 cfs @ 11.99 hrs, Volume= 0.106 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.600	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.6	220	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.3	370	Total			

Subcatchment IR: vegetated final cover



Subcatchment JJ: open space with good grass cover

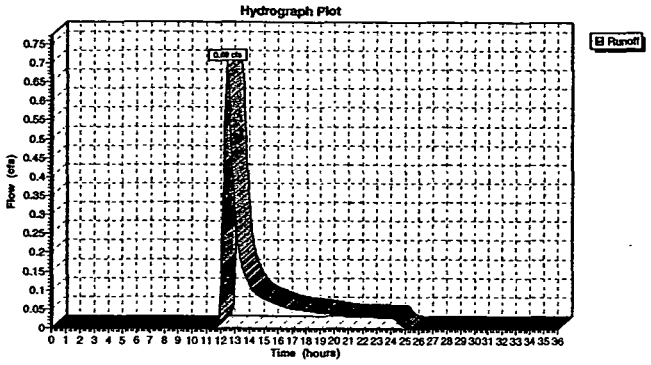
Runoff = 0.69 cfs @ 12.44 hrs, Volume= 0.096 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.914	62	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.9	300	0.0250	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.3	40	0.0250	2.5		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
17.4	840	0.0025	0.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
41.9	1,290	Total			

Subcatchment JJ: open space with good grass cover



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Subcatchment JR: vegetated final cover

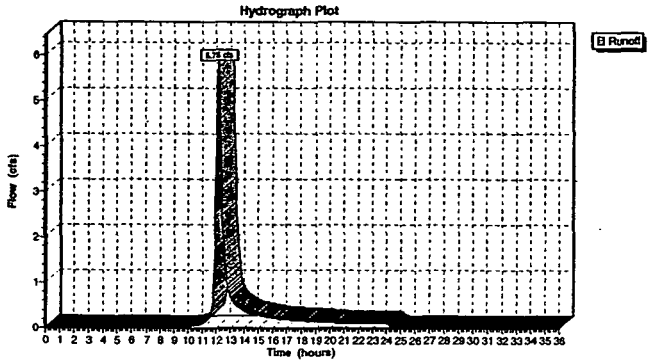
Runoff = 5.75 cfs @ 12.14 hrs, Volume= 0.447 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.520	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	80	0.0176	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.1	60	0.0830	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	80	0.0050	6.1	646.98	Trap/Vee/Rect Channel Flow, Bot.W=10.12' D=3.85' Z= 6.0 & 3.0 '/' n= 0.030
20.8	560	Total			

Subcatchment JR: vegetated final cover



Subcatchment K1R: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

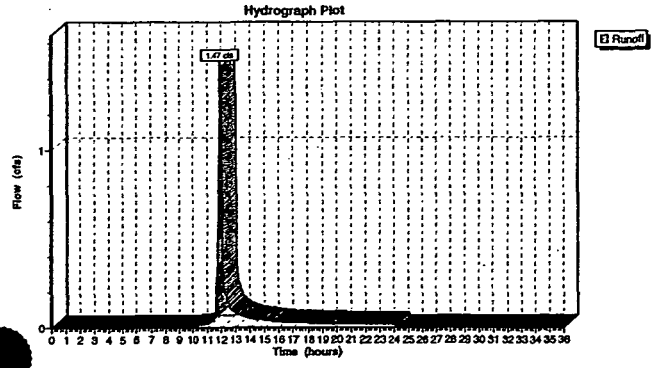
Runoff = 1.47 cfs @ 11.96 hrs, Volume= 0.068 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.382	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	33	0.0160	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment K1R: open space with good grass cover



Subcatchment K2R: open space with good grass cover

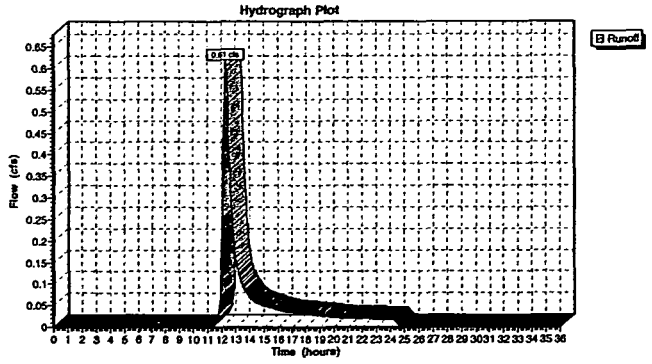
Runoff = 0.61 cfs @ 12.31 hrs, Volume= 0.067 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.530	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.2	300	0.0110	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.2	23	0.0110	1.7		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
33.4	323	Total			

Subcatchment K2R: open space with good grass cover



Subcatchment KK: open space with good grass cover

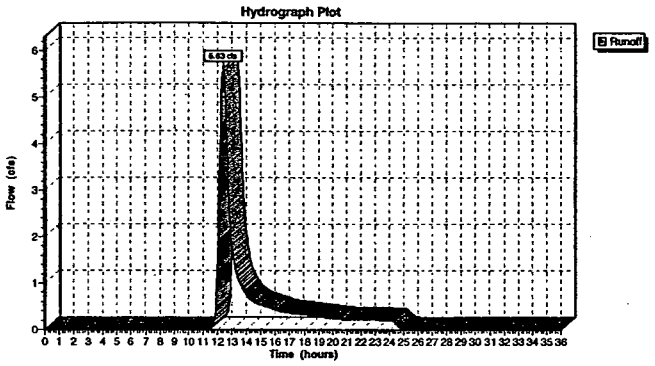
Runoff = 5.63 cfs @ 12.36 hrs, Volume= 0.682 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.893	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	300	0.0280	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.3	150	0.0140	1.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.3	110	0.1660	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
11.9	630	0.0030	0.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
36.4	1,190	Total			

Subcatchment KK: open space with good grass cover



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Subcatchment L: open space with good grass cover

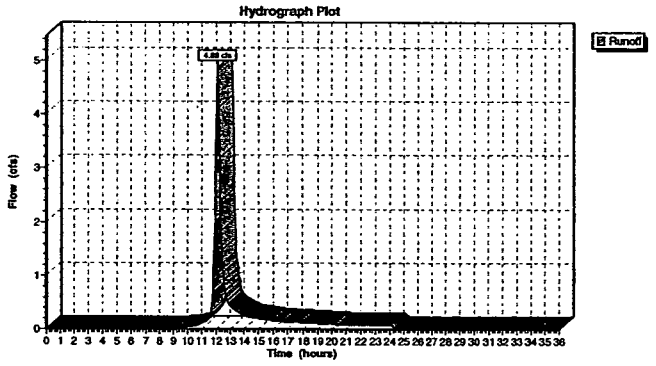
Runoff = 4.88 cfs @ 12.08 hrs, Volume= 0.321 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.683	76	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2	140	0.0200	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.2	290	0.0075	4.1	49.70	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
15.4	430	Total			

Subcatchment L: open space with good grass cover



Subcatchment LL: open space with good grass cover

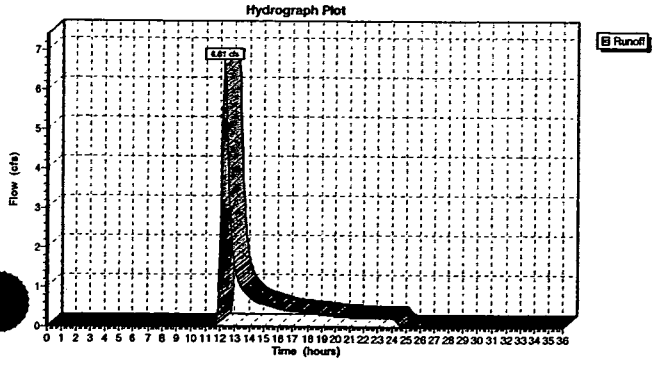
Runoff = 6.61 cfs @ 12.25 hrs, Volume= 0.701 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.049	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.3	300	0.0240	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
1.3	200	0.0240	2.5		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
2.5	900	0.0090	5.9	160.52	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
28.1	1,400	Total			

Subcatchment LL: open space with good grass cover



Subcatchment M: open space with good grass cover

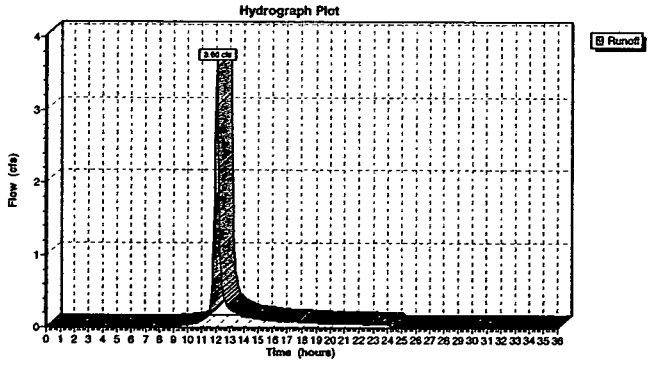
Runoff = 3.60 cfs @ 12.04 hrs, Volume= 0.212 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.000	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5	170	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.6	200	0.0045	5.1	352.87	**Trap/Vee/Rect Channel Flow,** Bot.W=20.00' D=2.50' Z= 3.0 '/' n= 0.030
12.1	370	Total			

Subcatchment M: open space with good grass cover



Subcatchment MM: open space with good grass cover

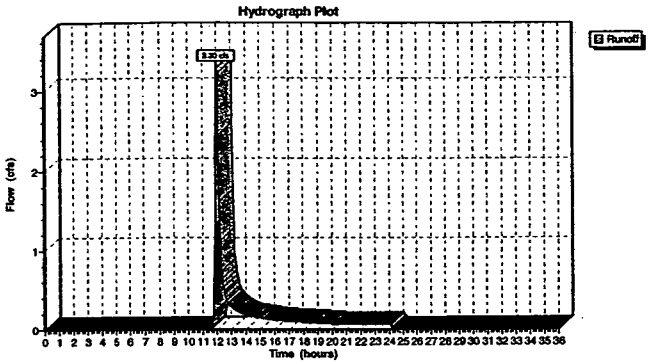
Runoff = 3.30 cfs @ 12.03 hrs, Volume= 0.193 af

ff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.943	61	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	100	0.0700	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.3	980	0.0060	4.9	200.34	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 5.0 & 4.0 '/' n= 0.030
9.9	1,080	Total			

Subcatchment MM: open space with good grass cover



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Subcatchment N: direct runon to pond

[49] Hint: Tc<2dt may require smaller dt

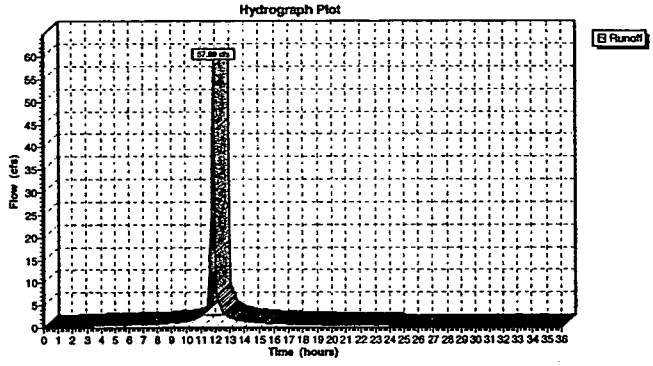
Runoff = 57.89 cfs @ 11.90 hrs, Volume= 2.908 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.818	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					**Direct Entry,**

Subcatchment N: direct runon to pond



Subcatchment NN: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

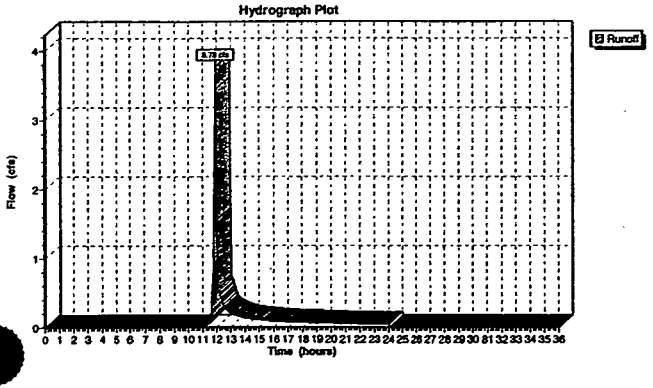
Runoff = 3.78 cfs @ 11.92 hrs, Volume= 0.162 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.274	66	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	600	0.0130	7.1	192.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030

Subcatchment NN: open space with good grass cover



Subcatchment O: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

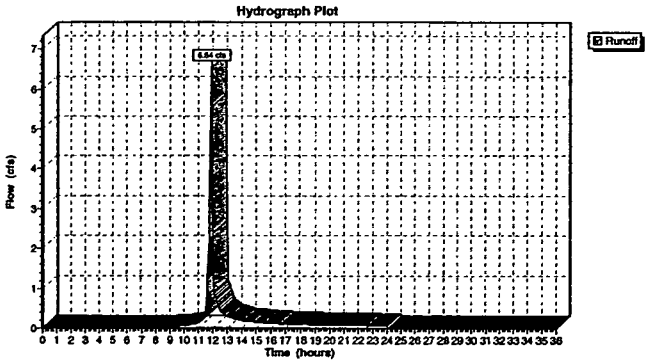
Runoff = 6.54 cfs @ 11.91 hrs, Volume= 0.279 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.317	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	230	0.0086	2.9	14.28	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 5.0 '/' n= 0.030

Subcatchment O: open space with good grass cover



Subcatchment OO: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

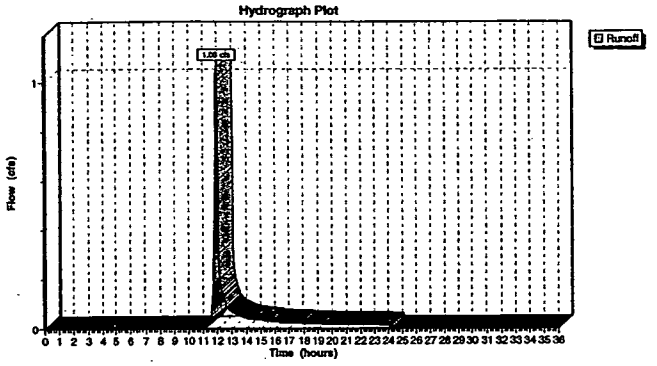
Runoff = 1.06 cfs @ 11.97 hrs, Volume= 0.051 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.399	68	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	120	0.1660	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment OO: open space with good grass cover



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Subcatchment P: open space with good grass cover

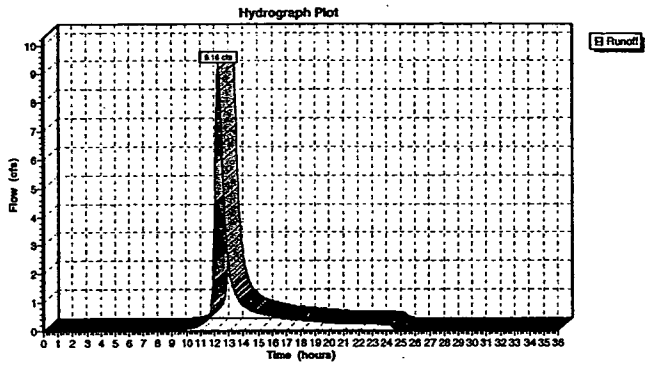
Runoff = 9.16 cfs @ 12.30 hrs, Volume= 0.964 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.238	75	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.4	300	0.0150	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.3	350	0.0070	1.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
33.7	650	Total			

Subcatchment P: open space with good grass cover



Subcatchment PP: open space with good grass cover

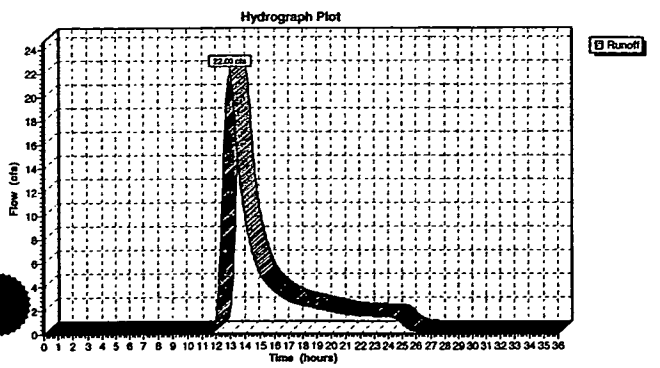
Runoff = 22.00 cfs @ 12.97 hrs, Volume= 4.742 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
40.964	64	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	150	0.1660	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 0.26"
34.5	150	0.0025	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
24.6	1,190	0.0025	0.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
79.5	1,490	Total			

Subcatchment PP: open space with good grass cover



Subcatchment Q: open space with good grass cover

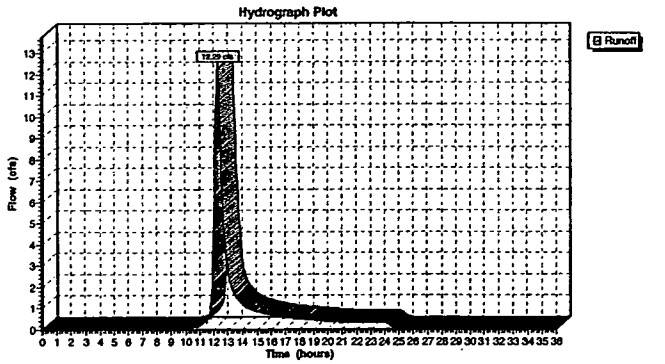
Runoff = 12.29 cfs @ 12.28 hrs, Volume= 1.264 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
7.700	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.6	300	0.0260	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
8.2	1,280	0.0260	2.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
31.8	1,580	Total			

Subcatchment Q: open space with good grass cover



Subcatchment R: open space with good grass cover

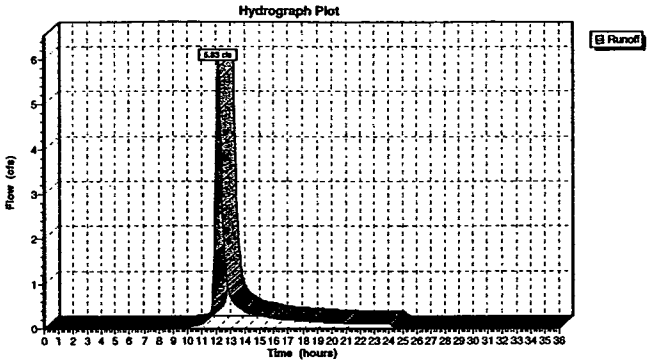
Runoff = 5.83 cfs @ 12.15 hrs, Volume= 0.463 af

ff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
d 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.612	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.8	300	0.0400	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.8	350	0.0400	3.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
21.6	650	Total			

Subcatchment R: open space with good grass cover



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Subcatchment S: open space with good grass cover

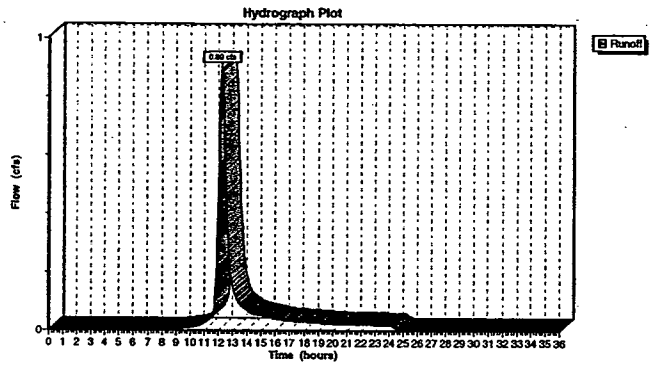
Runoff = 0.89 cfs @ 12.22 hrs, Volume= 0.082 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.402	78	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.8	280	0.0150	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.1	30	0.0100	6.3	169.20	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
27.9	310	Total			

Subcatchment S: open space with good grass cover



Subcatchment TR: open space with good grass cover

[49] Hint: Tc<2dt may require smaller dt

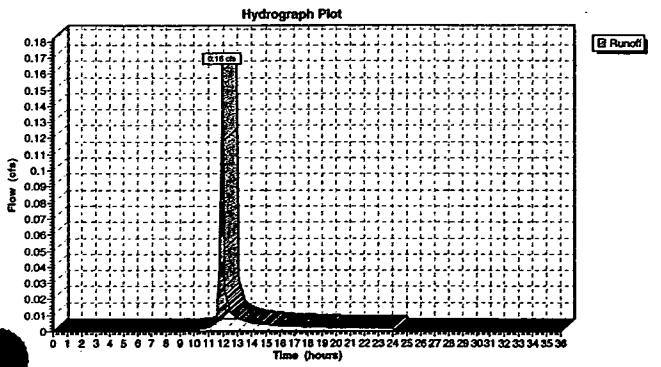
Runoff = 0.16 cfs @ 11.95 hrs, Volume= 0.007 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.040	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	40	0.0460	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment TR: open space with good grass cover



Subcatchment U: open space with good grass cover

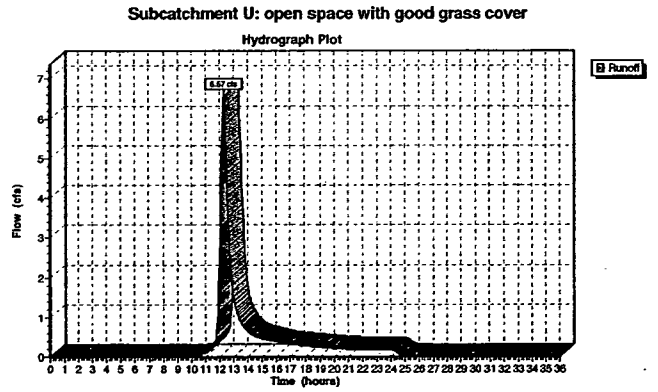
Runoff = 6.57 cfs @ 12.28 hrs, Volume= 0.681 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
4.149	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.2	300	0.0140	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	240	0.0140	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
32.3	540	Total			

Subcatchment U: open space with good grass cover



Subcatchment V: direct runon to pond

[49] Hint: Tc<2dt may require smaller dt

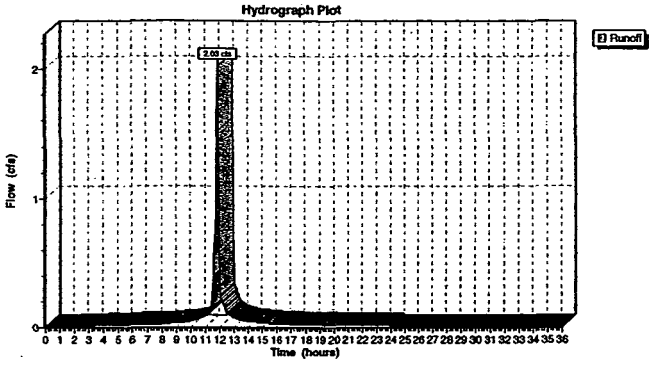
Runoff = 2.03 cfs @ 11.90 hrs, Volume= 0.102 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.274	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment V: direct runon to pond



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Subcatchment W: open space with good grass cover

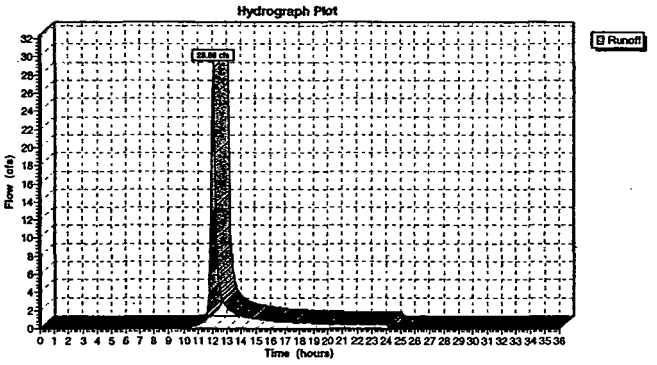
Runoff = 28.88 cfs @ 12.05 hrs, Volume= 1.739 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
10.593	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	300	0.1780	0.5		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.0	400	0.1780	6.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	270	0.0114	6.7	180.66	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.00' Z= 3.0 '/' n= 0.030
12.6	970	Total			

Subcatchment W: open space with good grass cover



Subcatchment X: open space with good grass cover

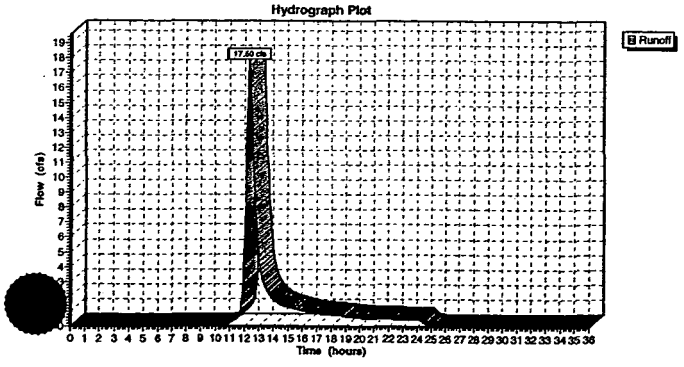
Runoff = 17.50 cfs @ 12.30 hrs, Volume= 1.869 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
11.853	71	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7	300	0.0190	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
5.5	730	0.0190	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	330	0.0100	4.8	57.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 '/' n= 0.030
33.4	1,360	Total			

Subcatchment X: open space with good grass cover



Subcatchment Y: open space with good grass cover

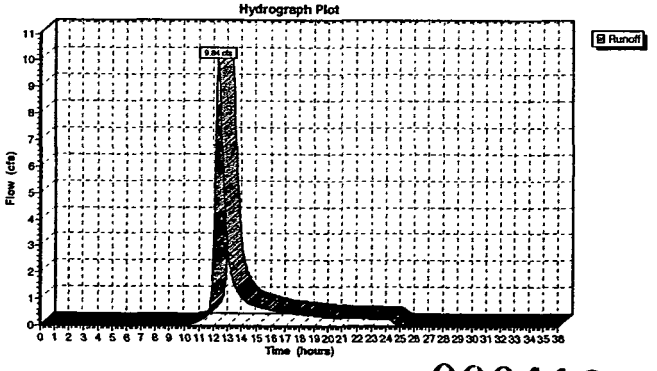
Runoff = 9.84 cfs @ 12.34 hrs, Volume= 1.113 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
6.522	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.1	300	0.0130	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.6	510	0.0130	1.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.1	340	0.0110	5.1	92.00	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
36.8	1,150	Total			

Subcatchment Y: open space with good grass cover



Subcatchment Z: open space with good grass cover

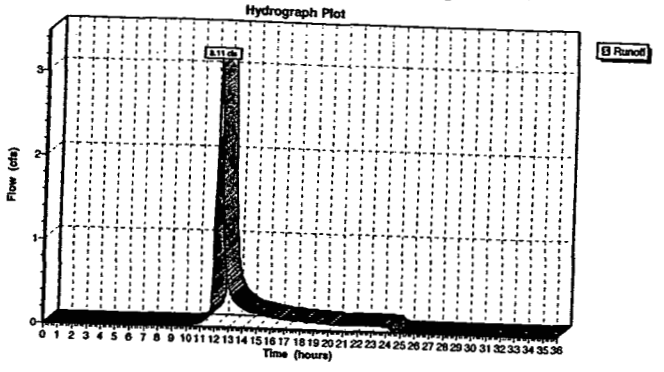
Runoff = 3.11 cfs @ 12.18 hrs, Volume= 0.264 af

[illegible]ff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
[illegible] 24-hr Rainfall=4.70"

[illegible]rea (ac)	CN	Description
1.606	72	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.0	300	0.0310	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.5	250	0.0310	2.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	50	0.0070	4.1	73.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 5.0 & 4.0 '/' n= 0.030
23.7	600	Total			

Subcatchment Z: open space with good grass cover



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Reach 1: east drainage channel

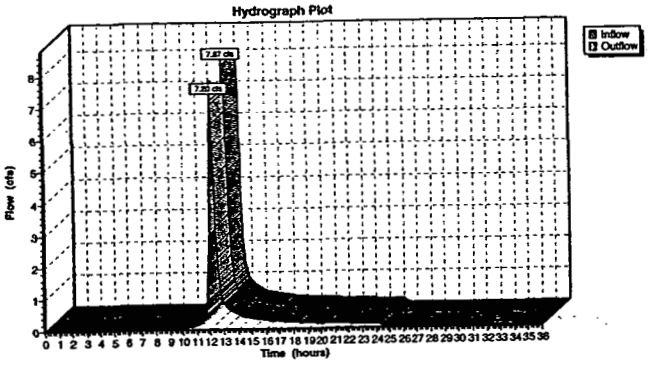
[65] Warning: Inlet elevation not specified

Inflow = 7.87 cfs @ 12.01 hrs, Volume= 0.557 af
Outflow = 7.20 cfs @ 12.12 hrs, Volume= 0.557 af, Atten= 8%, Lag= 6.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.9 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 9.5 min

Peak Depth= 0.88'
Capacity at bank full= 754.76 cfs
0.00' x 5.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: east drainage channel



Reach 1R: (new node)

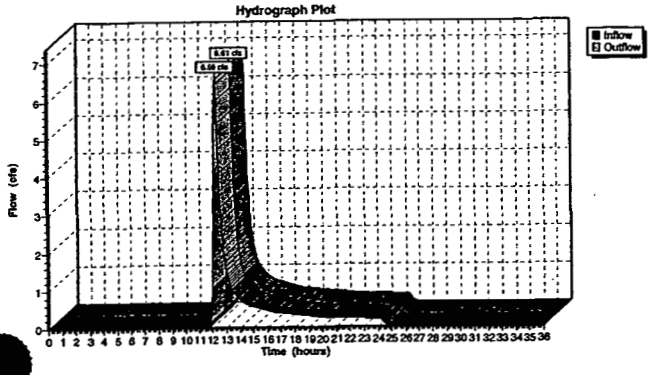
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 6.61 cfs @ 12.25 hrs, Volume= 0.701 af
Outflow = 6.59 cfs @ 12.26 hrs, Volume= 0.701 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.33'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 1R: (new node)



Reach 2: east drainage channel

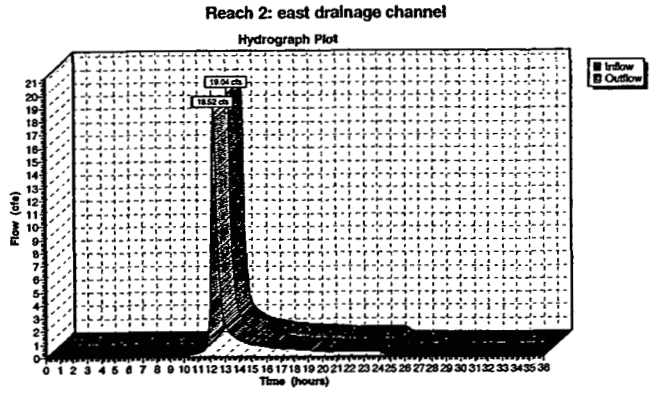
[65] Warning: Inlet elevation not specified

Inflow = 19.04 cfs @ 12.14 hrs, Volume= 1.481 af
Outflow = 18.52 cfs @ 12.22 hrs, Volume= 1.481 af, Atten= 3%, Lag= 5.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 7.3 min

Peak Depth= 1.36'
Capacity at bank full= 1,205.98 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 2: east drainage channel



Reach 2R: (new node)

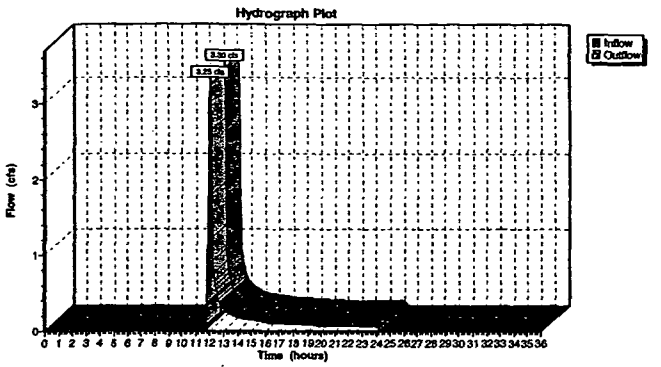
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	3.30 cfs @	12.03 hrs, Volume=	0.193 af	
[illegible]w	=	3.25 cfs @	12.04 hrs, Volume=	0.193 af, Atten= 1%, Lag= 0.7 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 0.9 min

Peak Depth= 0.24'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 2R: (new node)



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Reach 3: east drainage channel

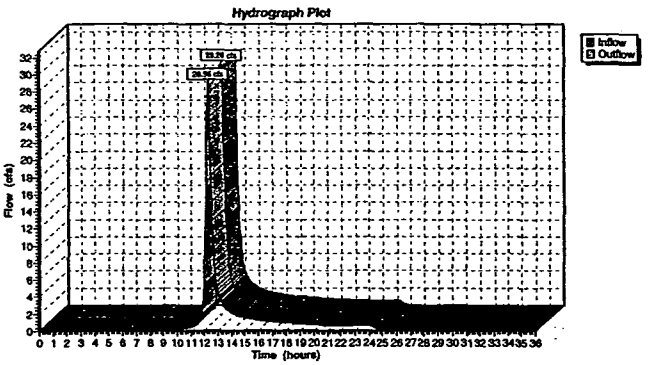
[65] Warning: Inlet elevation not specified

Inflow	=	29.26 cfs @	12.19 hrs, Volume=	2.390 af
Outflow	=	28.56 cfs @	12.26 hrs, Volume=	2.390 af, Atten= 2%, Lag= 4.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.2 min

Peak Depth= 1.65'
Capacity at bank full= 1,563.67 cfs
0.00' x 7.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 3: east drainage channel



Reach 3R: (new node)

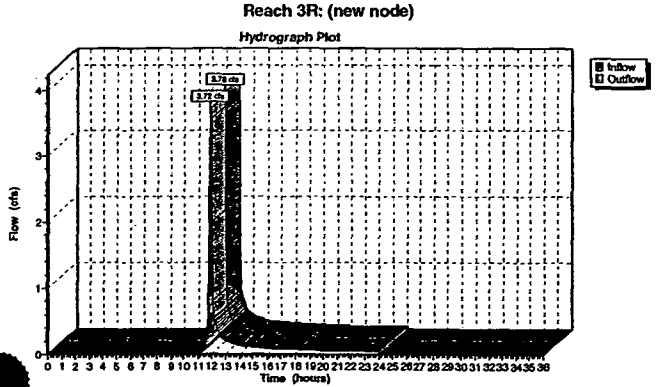
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	3.78 cfs @	11.92 hrs, Volume=	0.162 af
Outflow	=	3.72 cfs @	11.93 hrs, Volume=	0.162 af, Atten= 2%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.9 min

Peak Depth= 0.25'
Capacity at bank full= 1,101.12 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 100.0' Slope= 0.0100 '/'

Reach 3R: (new node)



Reach 4: east drainage channel

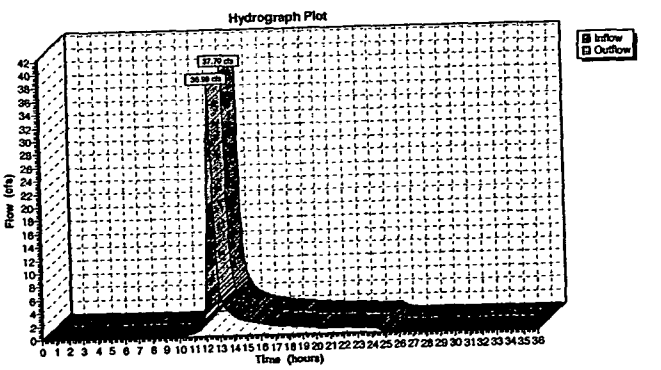
[65] Warning: Inlet elevation not specified

Inflow	=	37.70 cfs @	12.23 hrs, Volume=	3.293 af
Outflow	=	36.99 cfs @	12.29 hrs, Volume=	3.293 af, Atten= 2%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.9 min

Peak Depth= 1.82'
Capacity at bank full= 1,106.53 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 4: east drainage channel



Reach 5: east drainage channel

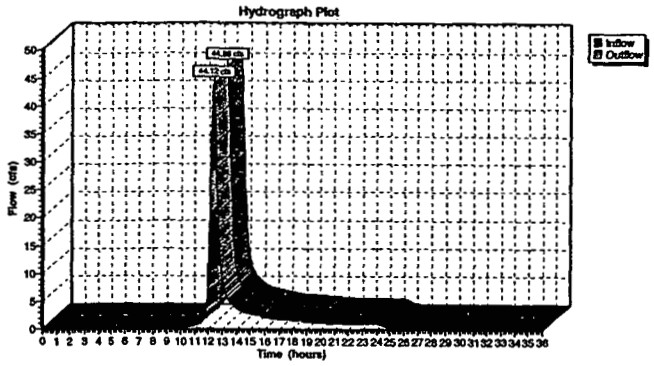
[65] Warning: Inlet elevation not specified

[illegible]	=	44.86 cfs @	12.26 hrs,	Volume=	4.189 af
[illegible]w	=	44.12 cfs @	12.33 hrs,	Volume=	4.189 af, Atten= 2%, Lag= 4.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.6 min

Peak Depth= 1.76'
Capacity at bank full= 182.58 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 5: east drainage channel



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Reach 6: east drainage channel

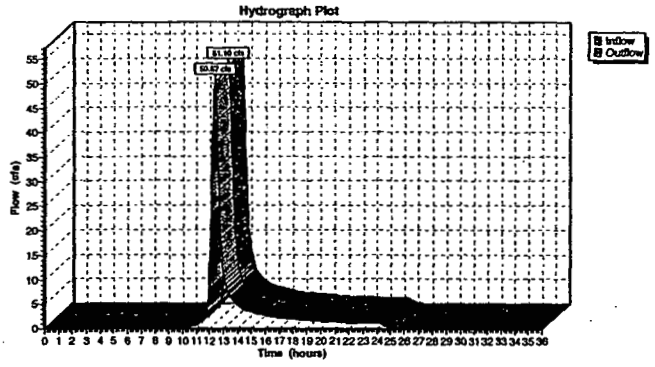
[65] Warning: Inlet elevation not specified

Inflow	=	51.10 cfs @	12.30 hrs,	Volume=	5.130 af
Outflow	=	50.57 cfs @	12.36 hrs,	Volume=	5.130 af, Atten= 1%, Lag= 3.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.2 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 5.3 min

Peak Depth= 1.63'
Capacity at bank full= 258.21 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 480.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 6: east drainage channel



Reach 7R: runoff diversion channel

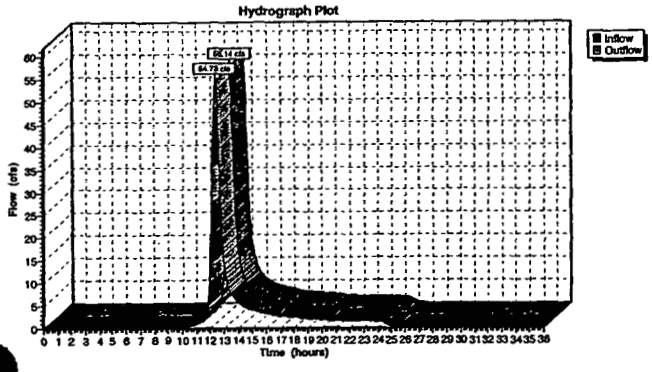
[65] Warning: Inlet elevation not specified

Inflow	=	55.14 cfs @	12.33 hrs,	Volume=	5.944 af
Outflow	=	54.73 cfs @	12.38 hrs,	Volume=	5.944 af, Atten= 1%, Lag= 2.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 4.2 min

Peak Depth= 1.68'
Capacity at bank full= 1,632.24 cfs
0.00' x 5.99' deep channel, n= 0.030 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 7R: runoff diversion channel



Reach 8R: runoff diversion channel

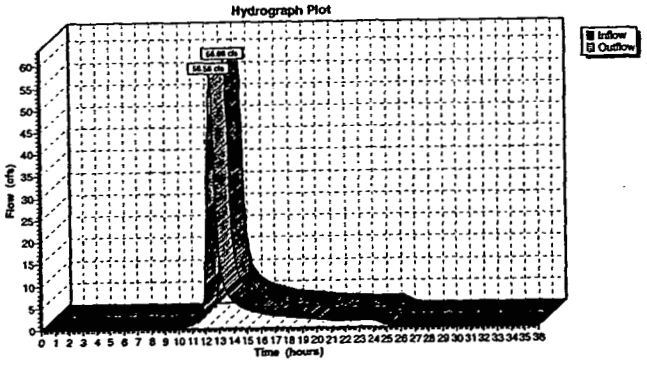
[65] Warning: Inlet elevation not specified

Inflow	=	56.86 cfs @	12.37 hrs,	Volume=	6.371 af
Outflow	=	56.55 cfs @	12.41 hrs,	Volume=	6.371 af, Atten= 1%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 3.5 min

Peak Depth= 1.56'
Capacity at bank full= 1,597.49 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
0.00' x 5.47' deep channel, n= 0.030 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: runoff diversion channel



Reach 9R: runoff diversion channel

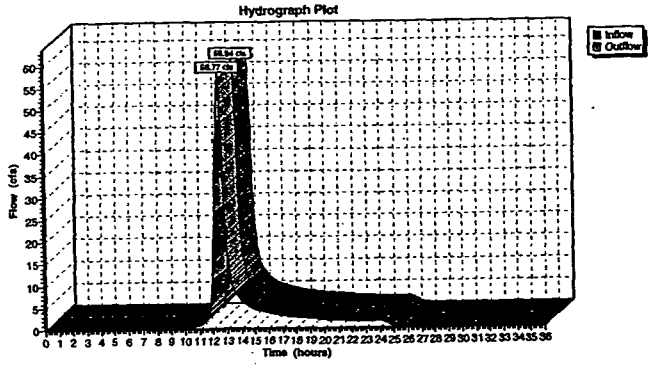
[65] Warning: Inlet elevation not specified

[illegible]	=	56.94 cfs @	12.40 hrs, Volume=	6.531 af	
[illegible]w	=	56.77 cfs @	12.42 hrs, Volume=	6.531 af, Atten= 0%, Lag= 1.0 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 1.8 min

Peak Depth= 1.52'
Capacity at bank full= 462.89 cfs
4.35' x 3.80' deep channel, n= 0.030 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: runoff diversion channel



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Reach 10AR: runoff diversion channel

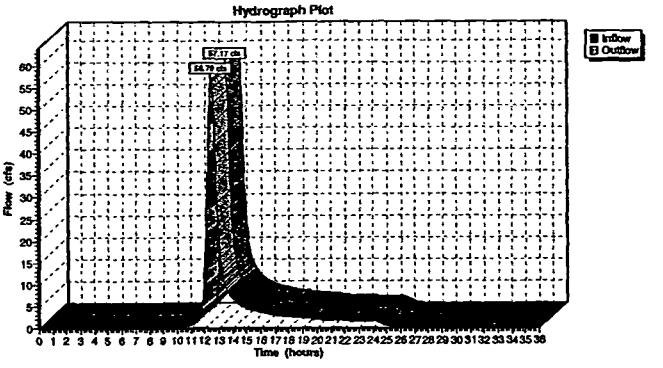
[65] Warning: Inlet elevation not specified

Inflow	=	57.17 cfs @	12.42 hrs, Volume=	6.705 af	
Outflow	=	56.79 cfs @	12.48 hrs, Volume=	6.705 af, Atten= 1%, Lag= 3.3 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.3 min

Peak Depth= 1.17'
Capacity at bank full= 646.10 cfs
10.12' x 3.85' deep channel, n= 0.030 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 10AR: runoff diversion channel



Reach 10BR: (new node)

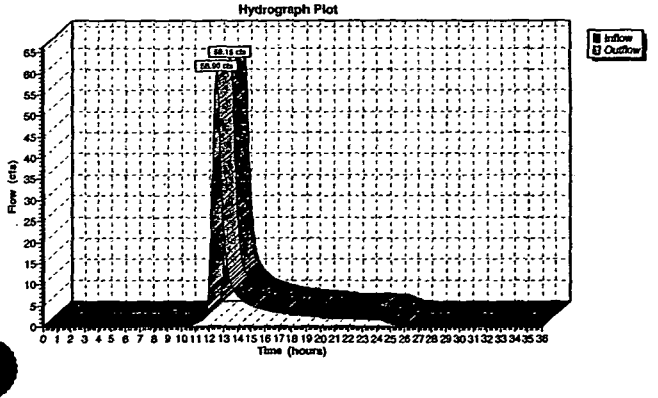
[65] Warning: Inlet elevation not specified

Inflow	=	59.15 cfs @	12.48 hrs, Volume=	7.219 af	
Outflow	=	58.90 cfs @	12.51 hrs, Volume=	7.219 af, Atten= 0%, Lag= 1.9 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 3.8 min

Peak Depth= 1.40'
Capacity at bank full= 202.01 cfs
10.21' x 2.62' deep channel, n= 0.030 Length= 179.0' Slope= 0.0029 '/'
Side Slope Z-value= 3.0 4.6 '/'

Reach 10BR: (new node)



Reach 11: new CMP arch

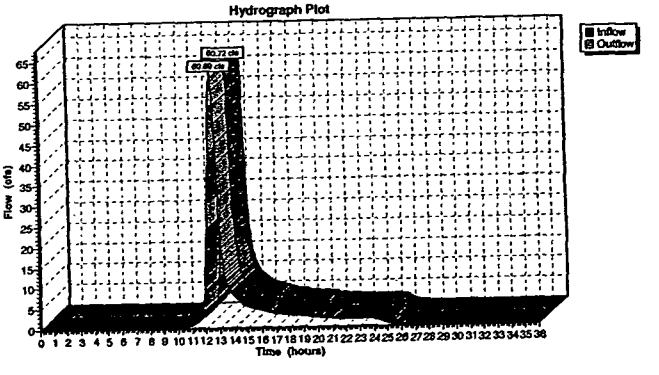
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	60.72 cfs @	12.50 hrs, Volume=	7.532 af	
Outflow	=	60.69 cfs @	12.50 hrs, Volume=	7.532 af, Atten= 0%, Lag= 0.2 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.2 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.38'
Capacity at bank full= 522.31 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 40.0' Slope= 0.0022 '/'

Reach 11: new CMP arch



Reach 12R: runoff diversion channel

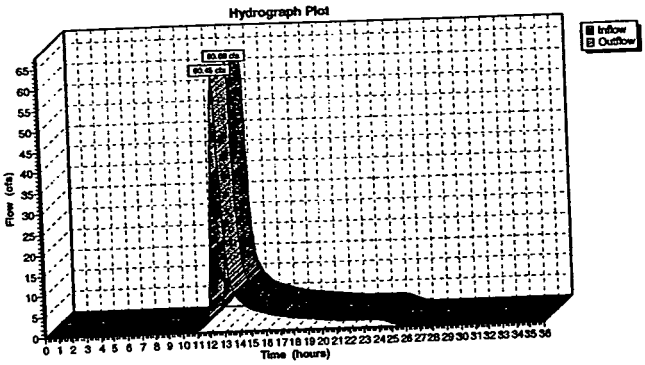
[65] Warning: Inlet elevation not specified

Inflow = 60.69 cfs @ 12.50 hrs, Volume= 7.532 af
Outflow = 60.45 cfs @ 12.54 hrs, Volume= 7.532 af, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 4.2 min

Peak Depth= 1.00'
Capacity at bank full= 317.79 cfs
14.00' x 2.45' deep channel, n= 0.030 Length= 240.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 4.3 '/'

Reach 12R: runoff diversion channel



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Reach 13R: runoff diversion channel

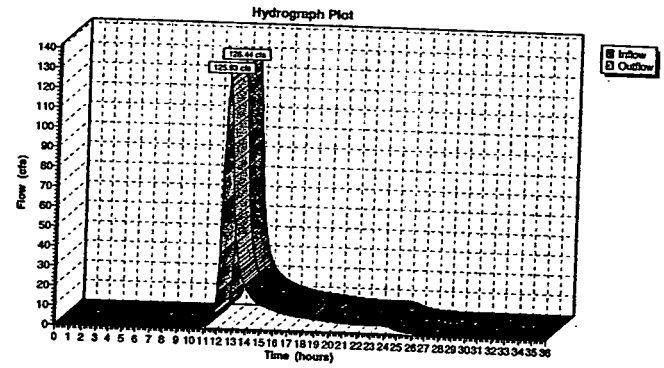
[65] Warning: Inlet elevation not specified

Inflow = 126.44 cfs @ 12.52 hrs, Volume= 17.814 af
Outflow = 125.93 cfs @ 12.57 hrs, Volume= 17.812 af, Atten= 0%, Lag= 3.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 8.6 min

Peak Depth= 1.16'
Capacity at bank full= 346.63 cfs
23.11' x 2.06' deep channel, n= 0.030 Length= 450.0' Slope= 0.0067 '/'
Side Slope Z-value= 2.3 4.0 '/'

Reach 13R: runoff diversion channel



Reach 14: east runon channel

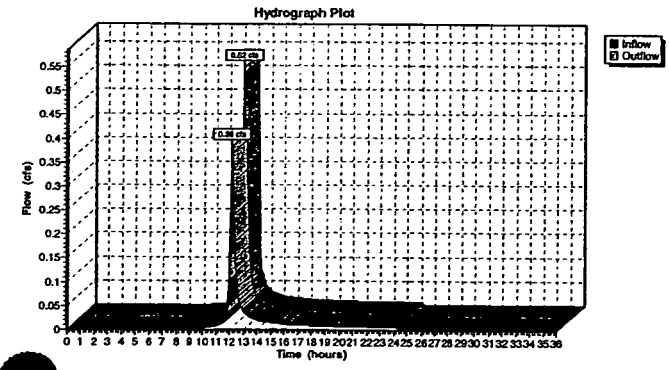
[65] Warning: Inlet elevation not specified

Inflow = 0.52 cfs @ 11.98 hrs, Volume= 0.026 af
Outflow = 0.38 cfs @ 12.17 hrs, Volume= 0.026 af, Atten= 27%, Lag= 11.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.9 fps, Min. Travel Time= 7.6 min
Avg. Velocity = 0.3 fps, Avg. Travel Time= 21.6 min

Peak Depth= 0.33'
Capacity at bank full= 22.78 cfs
0.00' x 1.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0040 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 14: east runon channel



Reach 15: east runon channel

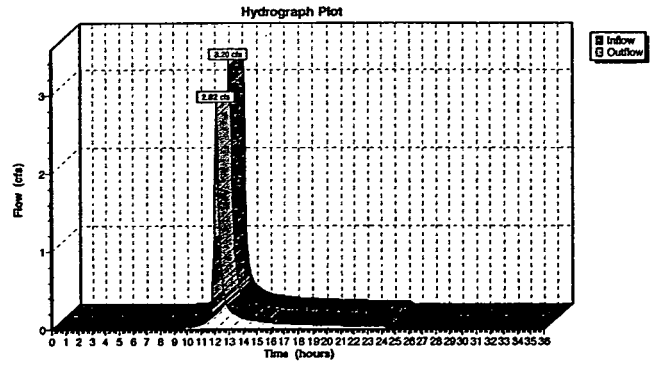
[65] Warning: Inlet elevation not specified

Inflow = 3.20 cfs @ 12.01 hrs, Volume= 0.187 af
Outflow = 2.82 cfs @ 12.12 hrs, Volume= 0.187 af, Atten= 12%, Lag= 6.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.8 fps, Min. Travel Time= 3.9 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 11.6 min

Peak Depth= 0.64'
Capacity at bank full= 61.62 cfs
0.00' x 2.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0063 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 15: east runon channel



Reach 16: east runon channel

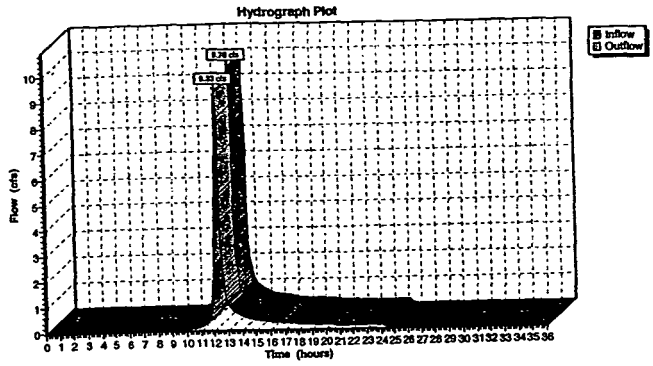
[65] Warning: Inlet elevation not specified

= 9.76 cfs @ 12.10 hrs, Volume= 0.667 af
= 9.33 cfs @ 12.19 hrs, Volume= 0.667 af, Atten= 4%, Lag= 4.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 8.0 min

Peak Depth= 0.98'
Capacity at bank full= 256.58 cfs
0.00' x 3.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0074 '/'
Side Slope Z-value= 2.5 5.0 '/'

Reach 16: east runon channel



Reach 17: east runon channel

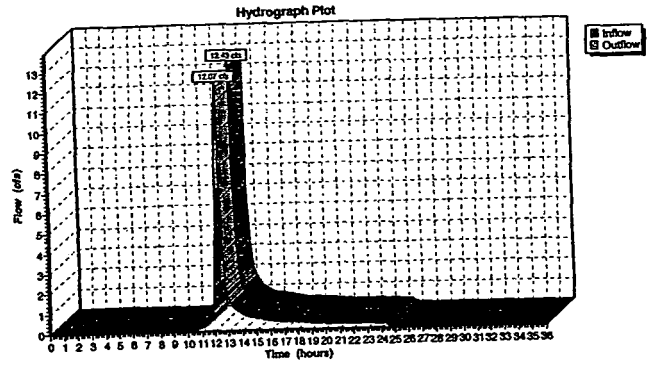
[65] Warning: Inlet elevation not specified

Inflow = 12.43 cfs @ 12.18 hrs, Volume= 0.931 af
Outflow = 12.07 cfs @ 12.25 hrs, Volume= 0.931 af, Atten= 3%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.2 min

Peak Depth= 0.92'
Capacity at bank full= 436.18 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 5.0 '/'

Reach 17: east runon channel



Reach 18: east runon channel

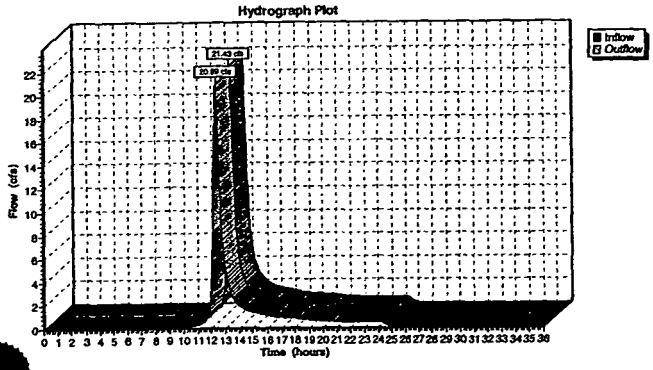
[65] Warning: Inlet elevation not specified

Inflow = 21.43 cfs @ 12.27 hrs, Volume= 2.044 af
Outflow = 20.99 cfs @ 12.33 hrs, Volume= 2.044 af, Atten= 2%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.6 min

Peak Depth= 1.38'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 440.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 18: east runon channel



Reach 19: east runon channel

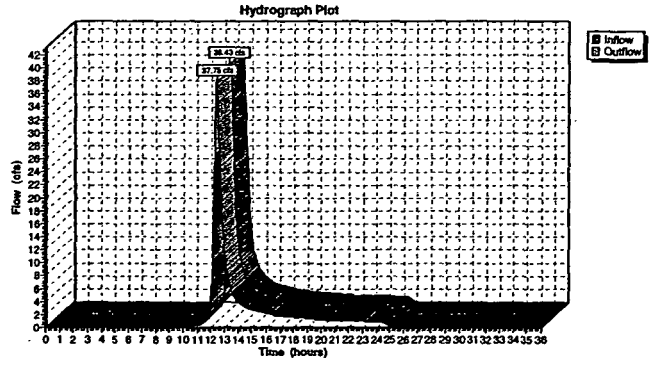
[65] Warning: Inlet elevation not specified

Inflow = 38.43 cfs @ 12.32 hrs, Volume= 3.913 af
Outflow = 37.75 cfs @ 12.41 hrs, Volume= 3.913 af, Atten= 2%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 8.0 min

Peak Depth= 0.91'
Capacity at bank full= 911.12 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 470.0' Slope= 0.0090 '/'
Side Slope Z-value= 3.0 30.0 '/'

Reach 19: east runon channel



Reach 20: east runon channel

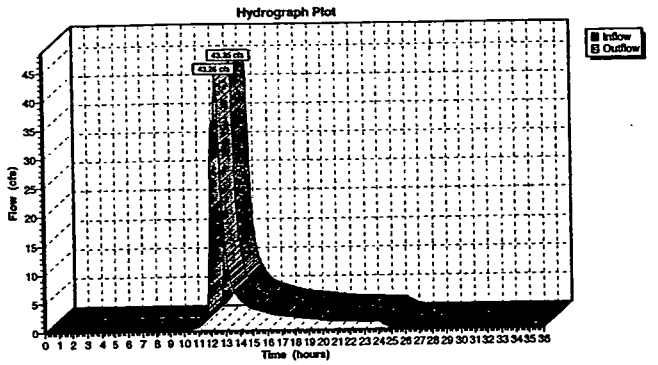
[65] Warning: Inlet elevation not specified

[illegible]	=	43.35 cfs @	12.39 hrs, Volume=	5.652 af	
[illegible]w	=	43.26 cfs @	12.40 hrs, Volume=	5.652 af, Atten= 0%, Lag= 0.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.8 min

Peak Depth= 1.87'
Capacity at bank full= 153.84 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 75.0' Slope= 0.0083 '/'
Side Slope Z-value= 3.0 '/'

Reach 20: east runon channel



Reach 21: east runon channel

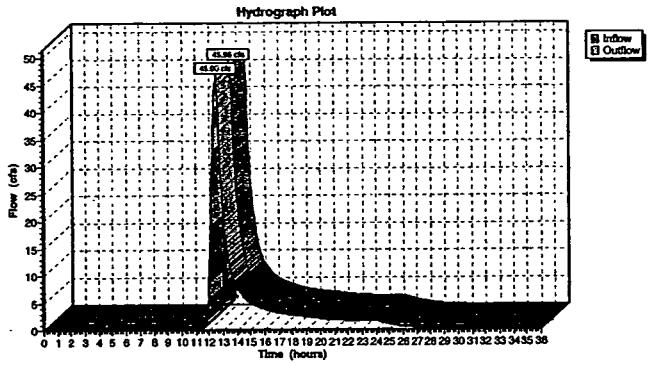
[65] Warning: Inlet elevation not specified

Inflow	=	45.96 cfs @	12.48 hrs, Volume=	6.399 af
Outflow	=	45.90 cfs @	12.49 hrs, Volume=	6.399 af, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 0.8 min

Peak Depth= 1.84'
Capacity at bank full= 169.20 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 65.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 21: east runon channel



Reach 22: east runon channel

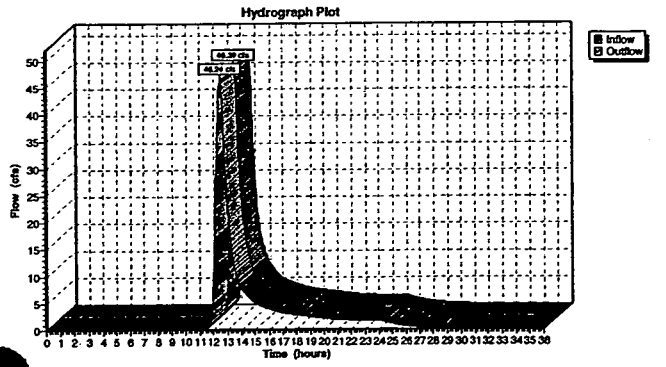
[65] Warning: Inlet elevation not specified

Inflow	=	46.39 cfs @	12.49 hrs, Volume=	6.481 af
Outflow	=	46.24 cfs @	12.51 hrs, Volume=	6.481 af, Atten= 0%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 2.3 min

Peak Depth= 1.85'
Capacity at bank full= 364.40 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 190.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 22: east runon channel



Reach 23: new CMP culverts

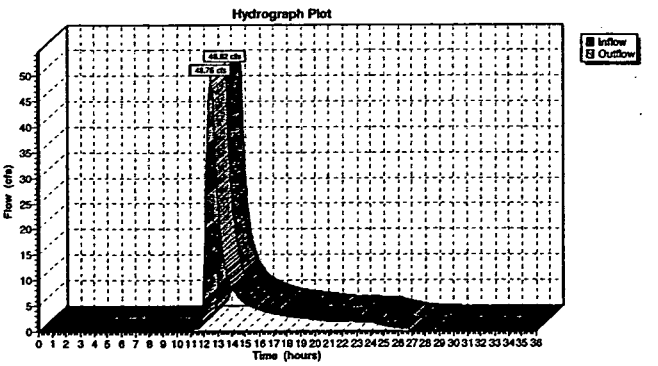
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	48.82 cfs @	12.52 hrs, Volume=	7.127 af
Outflow	=	48.75 cfs @	12.52 hrs, Volume=	7.127 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.31'
Capacity at bank full= 468.67 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 92.0' Slope= 0.0059 '/'

Reach 23: new CMP culverts



Reach 24: runon channel

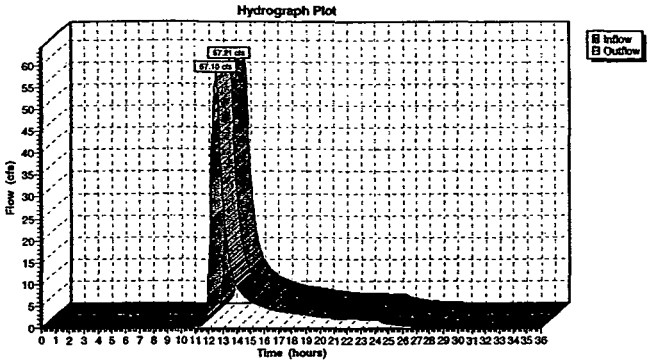
[65] Warning: Inlet elevation not specified

[illegible]	=	57.21 cfs @ 12.48 hrs, Volume=	8.390 af	
[illegible]w	=	57.10 cfs @ 12.49 hrs, Volume=	8.390 af, Atten= 0%, Lag= 1.1 min	

[illegible]uting by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.0 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 2.8 min

Peak Depth= 1.19'
Capacity at bank full= 153.54 cfs
8.50' x 2.00' deep channel, n= 0.030 Length= 160.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 24: runon channel



Reach 25: new CMP arch

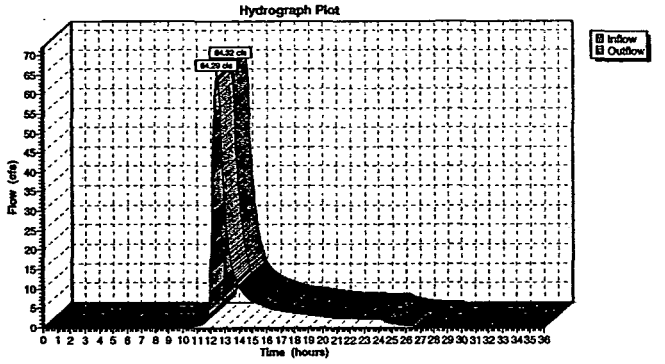
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	64.32 cfs @ 12.45 hrs, Volume=	9.354 af
Outflow	=	64.29 cfs @ 12.46 hrs, Volume=	9.354 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.9 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.5 min

Peak Depth= 1.49'
Capacity at bank full= 475.34 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 53.0' Slope= 0.0060 '/'

Reach 25: new CMP arch



Reach 26: runon channel

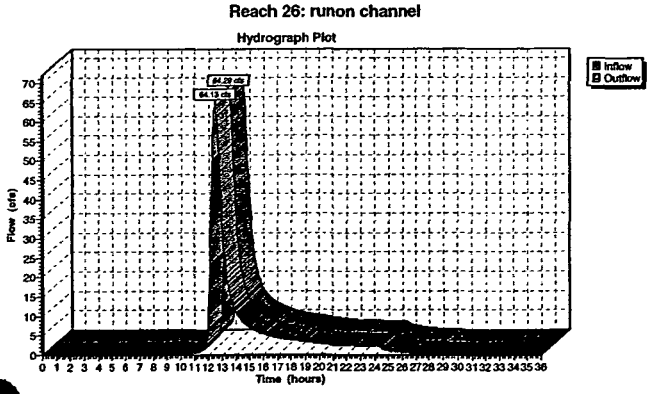
[65] Warning: Inlet elevation not specified

Inflow	=	64.29 cfs @ 12.46 hrs, Volume=	9.354 af
Outflow	=	64.13 cfs @ 12.49 hrs, Volume=	9.353 af, Atten= 0%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.4 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 3.7 min

Peak Depth= 2.20'
Capacity at bank full= 90.11 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 300.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 '/'

Reach 26: runon channel



Reach 27: new CMP arch

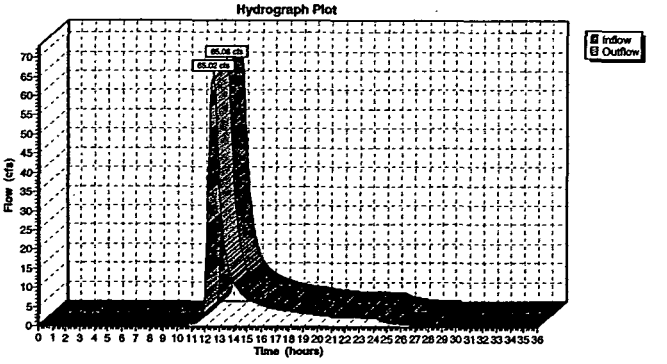
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	65.08 cfs @ 12.48 hrs, Volume=	9.674 af
Outflow	=	65.02 cfs @ 12.49 hrs, Volume=	9.674 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 1.2 min

Peak Depth= 1.64'
Capacity at bank full= 398.58 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 106.0' Slope= 0.0042 '/'

Reach 27: new CMP arch



Reach 28R: new CMP culverts

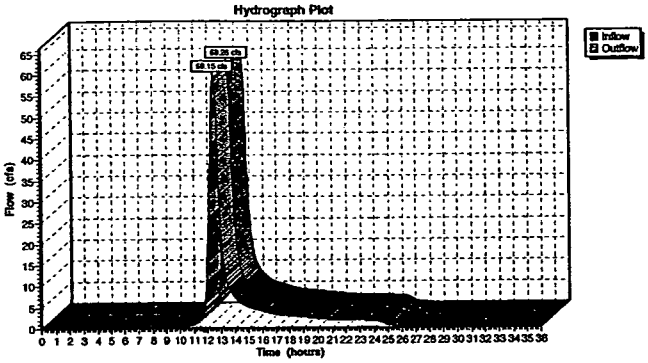
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]	=	59.26 cfs @	12.46 hrs, Volume=	7.219 af	
[illegible]ow	=	59.15 cfs @	12.48 hrs, Volume=	7.219 af, Atten= 0%, Lag= 0.8 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 1.3 min

Peak Depth= 1.51'
Capacity at bank full= 427.00 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.019 Length= 140.0' Slope= 0.0054 '/'

Reach 28R: new CMP culverts



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Reach 29: east runon channel

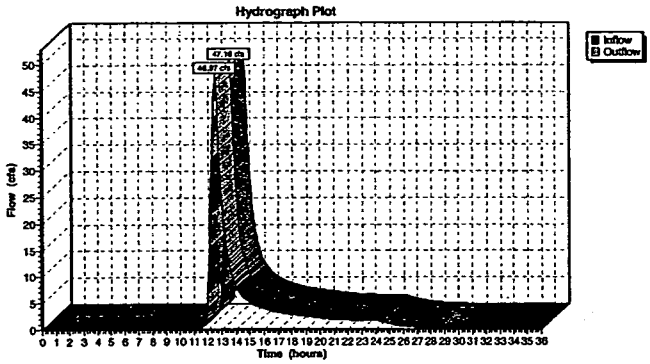
[65] Warning: Inlet elevation not specified

Inflow	=	47.16 cfs @	12.50 hrs, Volume=	6.664 af	
Outflow	=	46.97 cfs @	12.53 hrs, Volume=	6.664 af, Atten= 0%, Lag= 1.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 2.7 min

Peak Depth= 1.86'
Capacity at bank full= 255.23 cfs
0.00' x 3.50' deep channel, n= 0.030 Length= 230.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 29: east runon channel



Reach 30: east runon channel

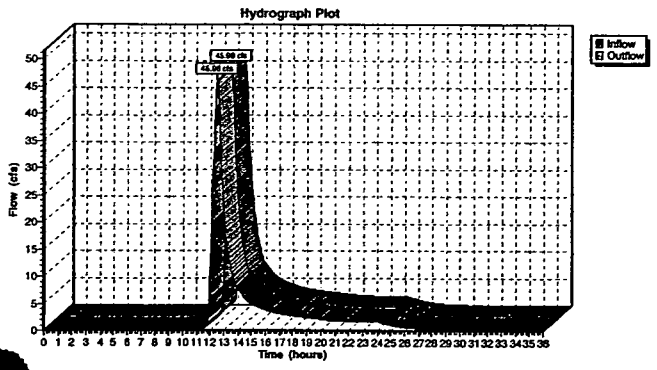
[65] Warning: Inlet elevation not specified

Inflow	=	45.98 cfs @	12.48 hrs, Volume=	6.399 af	
Outflow	=	45.96 cfs @	12.48 hrs, Volume=	6.399 af, Atten= 0%, Lag= 0.3 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 0.4 min

Peak Depth= 1.84'
Capacity at bank full= 104.05 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 30.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 '/'

Reach 30: east runon channel



Reach 31: culvert

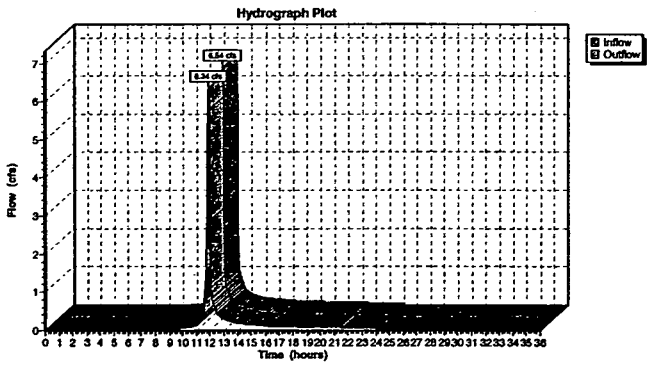
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	6.54 cfs @	11.91 hrs, Volume=	0.279 af	
Outflow	=	6.34 cfs @	11.91 hrs, Volume=	0.279 af, Atten= 3%, Lag= 0.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.1 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.34'
Capacity at bank full= 1,025.91 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.012 Length= 80.0' Slope= 0.0125 '/'

Reach 31: culvert



Pond 1P: (new node)

Inflow = 49.32 cfs @ 12.39 hrs, Volume= 6.434 af
Outflow = 45.98 cfs @ 12.48 hrs, Volume= 6.399 af, Atten= 7%, Lag= 5.4 min
Primary = 45.98 cfs @ 12.48 hrs, Volume= 6.399 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

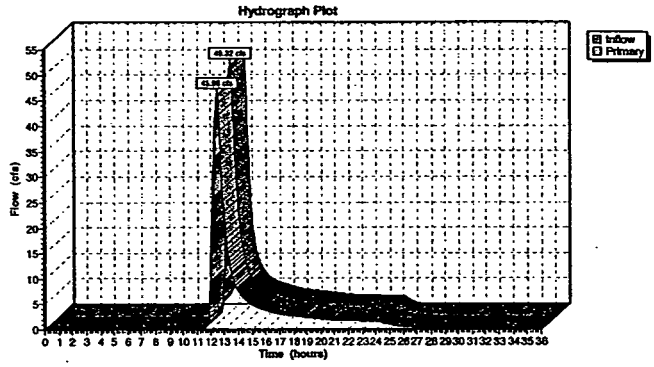
Starting Elev= 592.00' Storage= 0.691 af
Peak Elev= 593.91' Storage= 1.584 af (0.893 af above starting storage)
Plug-Flow detention time= 115.9 min calculated for 5.700 af (89% of inflow)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
589.30	0.186	0.000	0.000	0.186
590.00	0.210	0.139	0.139	0.211
591.00	0.278	0.243	0.382	0.279
592.00	0.342	0.309	0.691	0.344
593.00	0.463	0.401	1.092	0.465
594.00	0.624	0.542	1.634	0.627

Primary OutFlow (Free Discharge)
└─1=Special (user-defined)

#	Routing	Invert	Outlet Devices
1	Primary	592.00'	**Special (user-defined)** Head (feet) 0.00 0.01 0.18 0.51 1.01 1.34 1.67 2.00 Disch. (cfs) 0.00 0.00 0.08 1.33 8.21 17.57 31.73 51.47

Pond 1P: (new node)



Pond 3P: Borrow Area Basin

Inflow = 150.77 cfs @ 12.59 hrs, Volume= 26.523 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

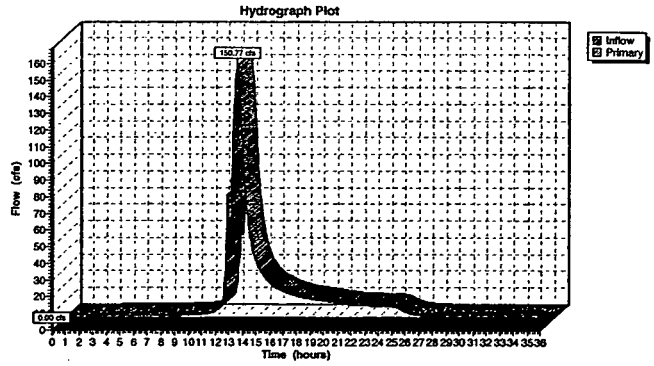
Peak Elev= 573.80' Storage= 26.523 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.00	6.391	0.000	0.000	6.391
571.00	6.687	6.538	6.538	6.690
572.00	7.017	6.851	13.390	7.023
573.00	7.290	7.153	20.543	7.300
574.00	7.613	7.451	27.994	7.626
575.00	7.921	7.766	35.760	7.938

Primary OutFlow (Free Discharge)
├─2=Culvert
│ └─1=Orifice/Grate
└─3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.30'	**48.0" Horiz. Orifice/Grate X 2.00 Limited to weir flow C= 0.600**
2	Primary	569.80'	**48.0" x 200.0' long Culvert X 2.00 Ke= 0.700** Outlet Invert= 569.00' S= 0.0040 '/' n= 0.024 Cc= 0.900
3	Primary	578.00'	**20.0' long Broad-Crested Rectangular Weir** Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00 Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 3P: Borrow Area Basin



ATTACHMENT C-1D

HydroCAD™ OUTPUT REPORTS

WEST OSDF POST-DEVELOPMENT DESIGN SCENARIO

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

WEST OSDF POST-DEVELOPMENT DESIGN SCENARIO
2-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=2.55"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=18.3 min CN=74 Area=2.730 ac Runoff= 1.80 cfs 0.144 af

Subcatchment B: vegetated final cover
Tc=19.0 min CN=74 Area=5.342 ac Runoff= 3.44 cfs 0.281 af

Subcatchment C: vegetated final cover
Tc=19.0 min CN=74 Area=5.399 ac Runoff= 3.48 cfs 0.284 af

Subcatchment D: vegetated final cover
Tc=19.0 min CN=74 Area=5.530 ac Runoff= 3.56 cfs 0.291 af

Subcatchment ER: vegetated final cover
Tc=18.8 min CN=74 Area=5.320 ac Runoff= 3.45 cfs 0.280 af

Subcatchment F1R: vegetated final cover
Tc=17.5 min CN=74 Area=0.918 ac Runoff= 0.62 cfs 0.048 af

Subcatchment F2R: (new node)
Tc=17.3 min CN=74 Area=1.550 ac Runoff= 1.06 cfs 0.082 af

Subcatchment FR: vegetated final cover/construction laydown
Tc=13.4 min CN=74 Area=1.853 ac Runoff= 1.46 cfs 0.098 af

Subcatchment GR: (new node)
Tc=7.7 min CN=75 Area=0.366 ac Runoff= 0.39 cfs 0.021 af

Subcatchment HR: non-vegetated final cover area
Tc=9.5 min CN=79 Area=0.092 ac Runoff= 0.12 cfs 0.007 af

Subcatchment J1R: grass area
Tc=2.8 min CN=74 Area=0.312 ac Runoff= 0.38 cfs 0.017 af

Subcatchment J2R: grass area
Tc=6.2 min CN=74 Area=0.854 ac Runoff= 0.90 cfs 0.045 af

Subcatchment KR: runon north of borrow area
Tc=11.8 min CN=76 Area=2.370 ac Runoff= 2.34 cfs 0.143 af

Subcatchment LR: grass area
Tc=28.6 min CN=74 Area=2.287 ac Runoff= 1.12 cfs 0.120 af

Subcatchment MR: runon north of borrow area
Tc=2.8 min CN=79 Area=0.675 ac Runoff= 1.15 cfs 0.049 af

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Subcatchment N: grass area
Tc=15.2 min CN=74 Area=1.043 ac Runoff= 0.77 cfs 0.055 af

Subcatchment O: pond
Tc=1.0 min CN=98 Area=2.252 ac Runoff= 8.94 cfs 0.435 af

Subcatchment P1R: grass area
Tc=7.0 min CN=74 Area=0.666 ac Runoff= 0.68 cfs 0.035 af

Subcatchment P2R: grass area
Tc=8.3 min CN=74 Area=0.214 ac Runoff= 0.21 cfs 0.011 af

Subcatchment QN: runon north of borrow area
Tc=11.8 min CN=79 Area=0.127 ac Runoff= 0.15 cfs 0.009 af

Reach 1: west channel — Inflow= 1.80 cfs 0.144 af
Length= 400.0' Max Vel= 1.7 fps Capacity= 424.60 cfs Outflow= 1.66 cfs 0.143 af

Reach 2: west channel — Inflow= 4.73 cfs 0.424 af
Length= 400.0' Max Vel= 2.1 fps Capacity= 424.60 cfs Outflow= 4.58 cfs 0.423 af

Reach 3: west channel — Inflow= 7.32 cfs 0.707 af
Length= 400.0' Max Vel= 2.4 fps Capacity= 424.60 cfs Outflow= 7.14 cfs 0.704 af

Reach 4: west channel — Inflow= 9.52 cfs 0.995 af
Length= 90.0' Max Vel= 2.6 fps Capacity= 426.17 cfs Outflow= 9.45 cfs 0.995 af

Reach 5: culvert — Inflow= 9.45 cfs 0.995 af
Length= 100.0' Max Vel= 2.9 fps Capacity= 397.33 cfs Outflow= 9.41 cfs 0.994 af

Reach 6: west channel — Inflow= 9.41 cfs 0.994 af
Length= 380.0' Max Vel= 2.5 fps Capacity= 424.60 cfs Outflow= 9.26 cfs 0.990 af

Reach 7AR: Haul Road Culvert 1 — Inflow= 10.91 cfs 1.270 af
Length= 81.5' Max Vel= 3.3 fps Capacity= 166.63 cfs Outflow= 10.88 cfs 1.270 af

Reach 7BR: Channel between GIS 14 & 15 — Inflow= 10.92 cfs 1.286 af
Length= 100.0' Max Vel= 1.7 fps Capacity= 200.78 cfs Outflow= 10.85 cfs 1.284 af

Reach 7CR: Rimia Parking Lot Culvert — Inflow= 11.09 cfs 1.333 af
Length= 296.0' Max Vel= 5.0 fps Capacity= 296.41 cfs Outflow= 11.03 cfs 1.331 af

Reach 7DR: Runoff Drainage Channel south of Rimia — Inflow= 11.15 cfs 1.376 af
Length= 237.0' Max Vel= 2.1 fps Capacity= 599.79 cfs Outflow= 11.05 cfs 1.372 af

Reach 8AR: west channel — Inflow= 13.08 cfs 1.754 af
Length= 220.0' Max Vel= 1.9 fps Capacity= 389.11 cfs Outflow= 13.00 cfs 1.748 af

Reach 8BR: Culvert at Sed Basin 2 entrance — Inflow= 13.00 cfs 1.748 af
Length= 30.0' Max Vel= 4.0 fps Capacity= 535.70 cfs Outflow= 12.99 cfs 1.747 af

Reach 8CR: Channel into Sed Basin 2 — Inflow= 13.02 cfs 1.759 af
Length= 62.7' Max Vel= 4.1 fps Capacity= 728.12 cfs Outflow= 13.00 cfs 1.758 af

Reach 9AR: Extended Drainge Channel South of Cell 8 — Inflow= 2.34 cfs 0.143 af
Length= 197.0' Max Vel= 3.0 fps Capacity= 267.67 cfs Outflow= 2.23 cfs 0.142 af

Reach 9BR: (new node) — Inflow= 2.23 cfs 0.142 af
Length= 88.0' Max Vel= 3.5 fps Capacity= 353.53 cfs Outflow= 2.21 cfs 0.142 af

Reach 9R: Channel U/S of 30" Culvert — Inflow= 2.29 cfs 0.149 af
Length= 27.3' Max Vel= 3.0 fps Capacity= 1,695.60 cfs Outflow= 2.28 cfs 0.149 af

Reach 10AR: (new node) — Inflow= 1.06 cfs 0.082 af
Length= 71.4' Max Vel= 2.4 fps Capacity= 243.75 cfs Outflow= 1.04 cfs 0.082 af

Reach 10BR: (new node) — Inflow= 1.04 cfs 0.082 af
Length= 38.0' Max Vel= 2.7 fps Capacity= 343.51 cfs Outflow= 1.04 cfs 0.082 af

Reach 10R: access road diversion channel — Inflow= 2.40 cfs 0.179 af
Length= 320.0' Max Vel= 1.2 fps Capacity= 172.90 cfs Outflow= 2.18 cfs 0.178 af

Reach 11AR: (new node) — Inflow= 2.24 cfs 0.198 af
Length= 60.0' Max Vel= 1.2 fps Capacity= 170.32 cfs Outflow= 2.21 cfs 0.198 af

Reach 11R: culvert — Inflow= 2.18 cfs 0.178 af
Length= 48.6' Max Vel= 2.8 fps Capacity= 264.80 cfs Outflow= 2.16 cfs 0.178 af

Reach 12: Culvert from F Street Drainage Channel — Inflow= 3.70 cfs 0.347 af
Length= 104.8' Max Vel= 2.3 fps Capacity= 413.70 cfs Outflow= 3.66 cfs 0.347 af

Reach 13: (new node) — Inflow= 1.12 cfs 0.120 af
Length= 120.0' Max Vel= 3.0 fps Capacity= 386.61 cfs Outflow= 1.11 cfs 0.120 af

Reach 14: Culvert from North Entrance Road channel — Inflow= 1.00 cfs 0.058 af
Length= 112.0' Max Vel= 2.5 fps Capacity= 822.56 cfs Outflow= 0.97 cfs 0.058 af

Reach 15N: Culvert adjacent to North Entrance Road — Inflow= 0.15 cfs 0.009 af
Length= 55.0' Max Vel= 1.8 fps Capacity= 406.62 cfs Outflow= 0.15 cfs 0.009 af

Reach 16N: Channel east of North Entrance Road — Inflow= 1.23 cfs 0.058 af
Length= 382.0' Max Vel= 1.7 fps Capacity= 71.46 cfs Outflow= 1.00 cfs 0.058 af

Pond 1P: Sedimentation Basin 2 — Peak Storage= 2.425 af Inflow= 14.72 cfs 2.426 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

Runoff Area = 39.900 ac Volume = 2.456 af Average Depth = 0.74"

Subcatchment A: vegetated final cover

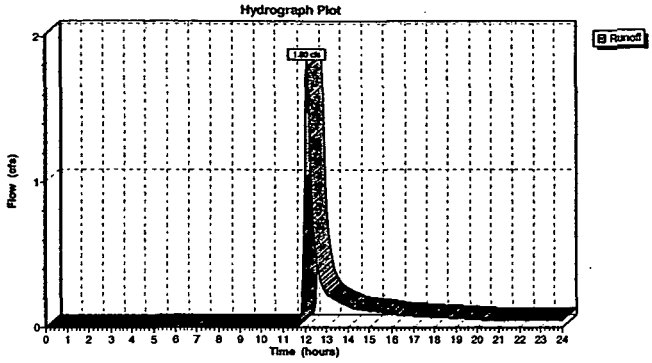
Runoff = 1.80 cfs @ 12.13 hrs, Volume= 0.144 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.730	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.7	180	0.0075	4.2	75.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
18.3	670	Total			

Subcatchment A: vegetated final cover



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Subcatchment B: vegetated final cover

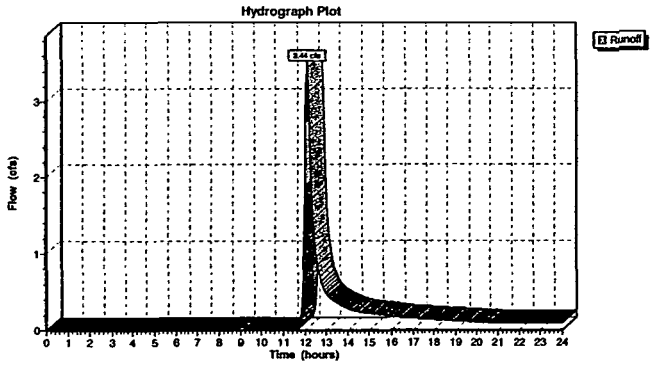
Runoff = 3.44 cfs @ 12.14 hrs, Volume= 0.281 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.342	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	200	0.0075	6.6	424.60	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

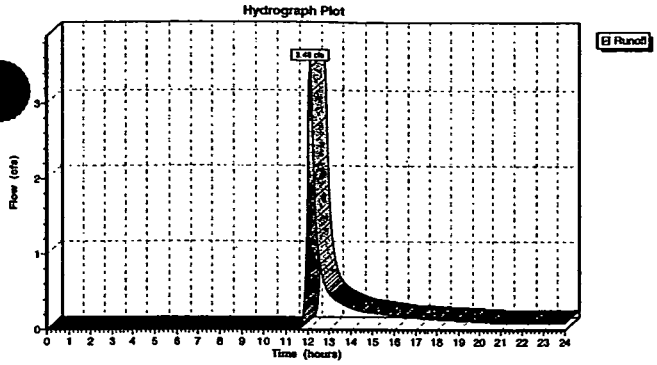
Runoff = 3.48 cfs @ 12.14 hrs, Volume= 0.284 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.399	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	945	Total			

Subcatchment C: vegetated final cover



Subcatchment D: vegetated final cover

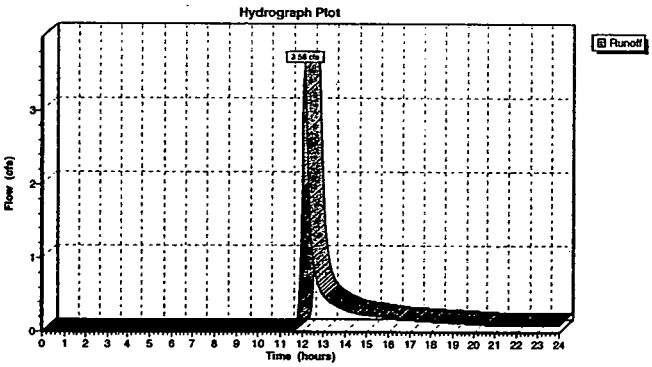
Runoff = 3.56 cfs @ 12.14 hrs, Volume= 0.291 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.530	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	205	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment D: vegetated final cover



Subcatchment ER: vegetated final cover

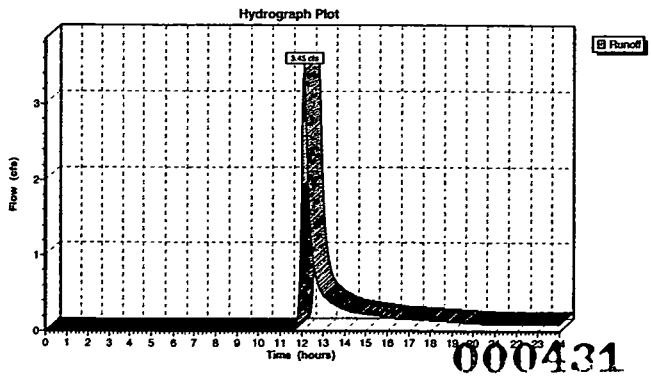
Runoff = 3.45 cfs @ 12.14 hrs, Volume= 0.280 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
5.320	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	110	0.0625	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
2.9	45	0.1110	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.4	510	0.0075	6.1	337.31	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.50' Z= 3.0 & 6.0 '/' n= 0.030
0.2	85	0.0029	8.1	228.07	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
18.8	1,100	Total			

Subcatchment ER: vegetated final cover



Subcatchment F1R: vegetated final cover

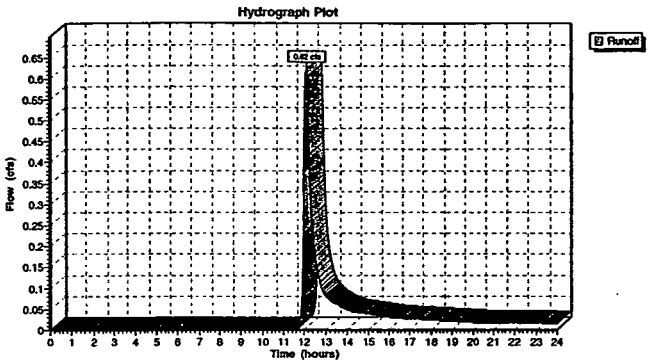
Runoff = 0.62 cfs @ 12.12 hrs, Volume= 0.048 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.918	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	90	0.0530	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
6.5	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.5	200	0.1670	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	160	0.0075	6.1	337.31	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.50' Z= 6.0 & 3.0 '/' n= 0.030
0.0	53	0.0580	36.1	1,019.94	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
17.5	703	Total			

Subcatchment F1R: vegetated final cover



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Subcatchment F2R: (new node)

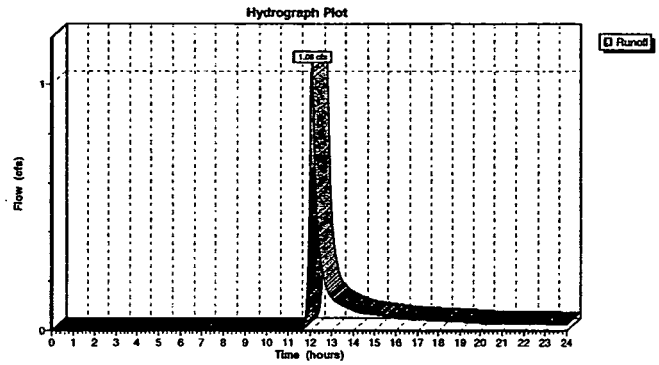
Runoff = 1.06 cfs @ 12.12 hrs, Volume= 0.082 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.550	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.5	55	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1667	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1667	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
17.3	495	Total			

Subcatchment F2R: (new node)



Subcatchment FR: vegetated final cover/construction laydown

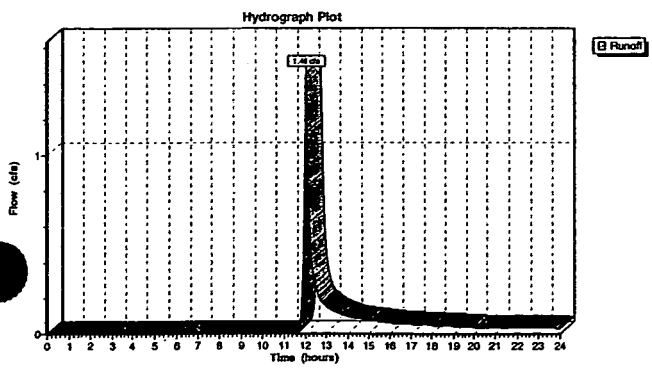
Runoff = 1.46 cfs @ 12.07 hrs, Volume= 0.098 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.853	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	30	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.5	55	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	30	0.3300	9.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
13.4	445	Total			

Subcatchment FR: vegetated final cover/construction laydown



Subcatchment GR: (new node)

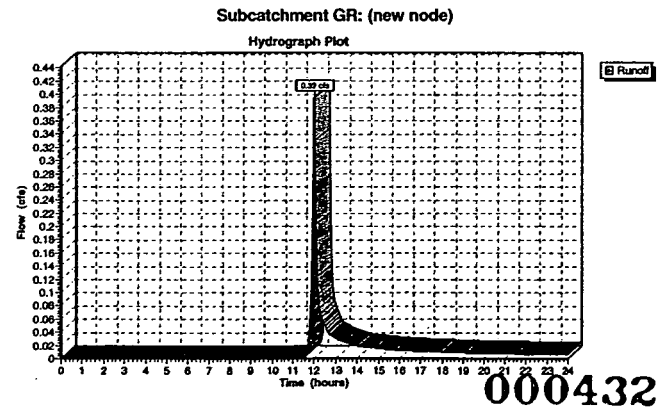
Runoff = 0.39 cfs @ 12.00 hrs, Volume= 0.021 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.262	74	
0.035	79	
0.069	79	
0.366	75	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.7	270	0.1670	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.5	60	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.7	480	Total			

Subcatchment GR: (new node)



Subcatchment HR: non-vegetated final cover area

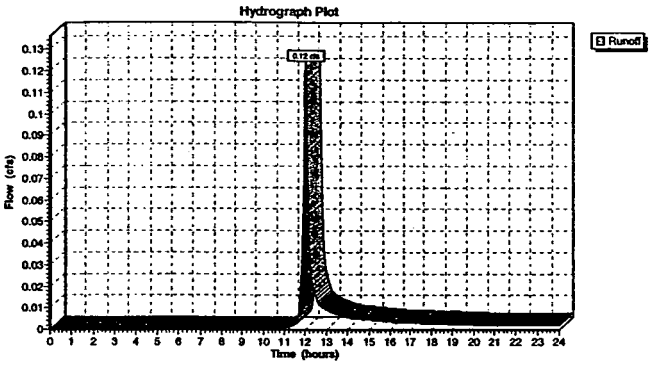
Runoff = 0.12 cfs @ 12.02 hrs, Volume= 0.007 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.092	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	80	0.0180	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment HR: non-vegetated final cover area



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Subcatchment J1R: grass area

[49] Hint: Tc<2dt may require smaller dt

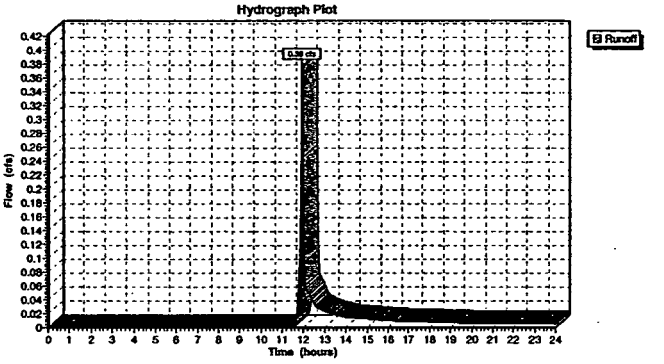
Runoff = 0.38 cfs @ 11.94 hrs, Volume= 0.017 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.312	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	54	0.1670	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J1R: grass area



Subcatchment J2R: grass area

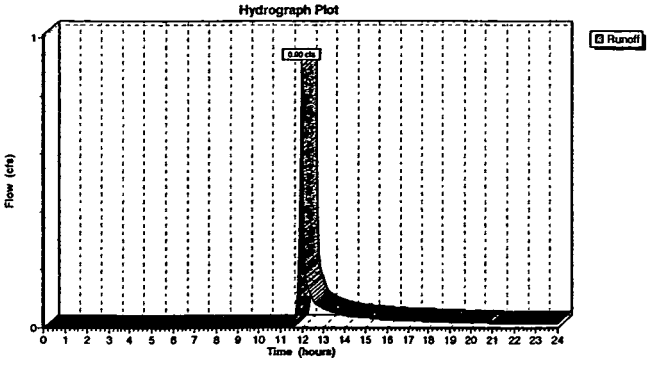
Runoff = 0.90 cfs @ 11.99 hrs, Volume= 0.045 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.854	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	72	0.0427	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J2R: grass area



Subcatchment KR: runon north of borrow area

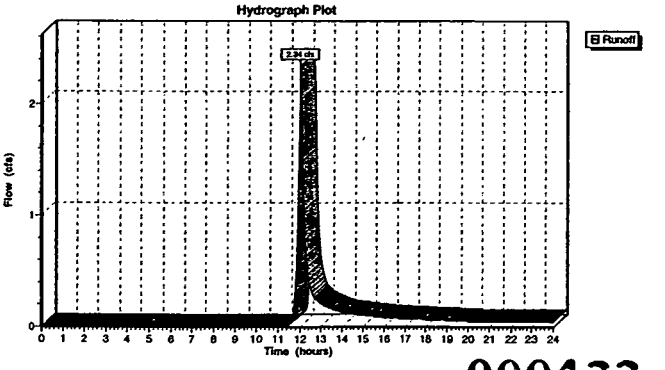
Runoff = 2.34 cfs @ 12.05 hrs, Volume= 0.143 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.469	74	
0.792	79	
0.109	79	
2.370	76	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	70	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	155	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	95	0.0180	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
11.8	470	Total			

Subcatchment KR: runon north of borrow area



Subcatchment LR: grass area

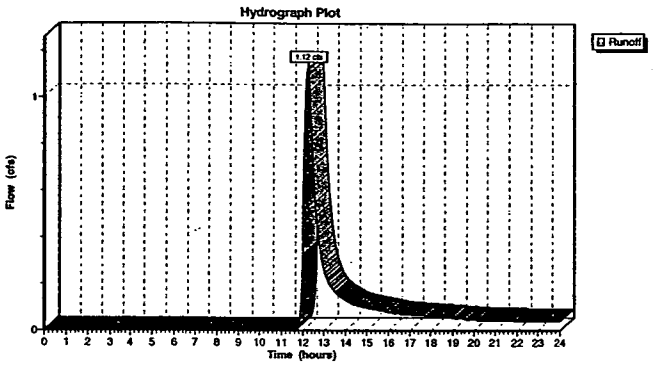
Runoff = 1.12 cfs @ 12.26 hrs, Volume= 0.120 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.287	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0167	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	65	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.6	365	Total			

Subcatchment LR: grass area



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Subcatchment MR: runon north of borrow area

[49] Hint: Tc<2dt may require smaller dt

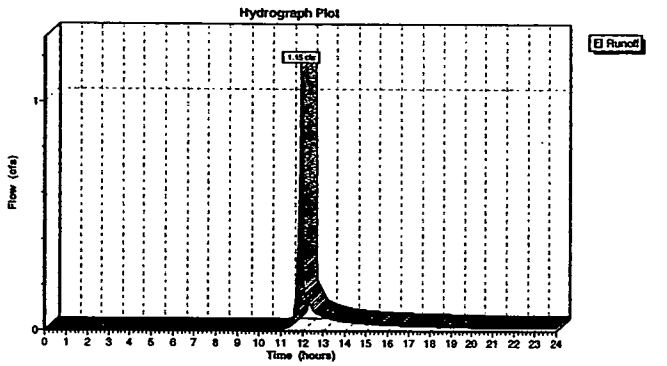
Runoff = 1.15 cfs @ 11.94 hrs, Volume= 0.049 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.675	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	40	0.0985	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment MR: runon north of borrow area



Subcatchment N: grass area

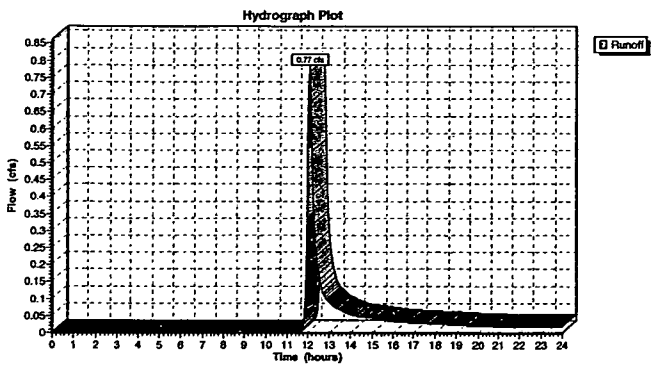
Runoff = 0.77 cfs @ 12.09 hrs, Volume= 0.055 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
1.043	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2	170	0.0250	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment N: grass area



Subcatchment O: pond

[49] Hint: Tc<2dt may require smaller dt

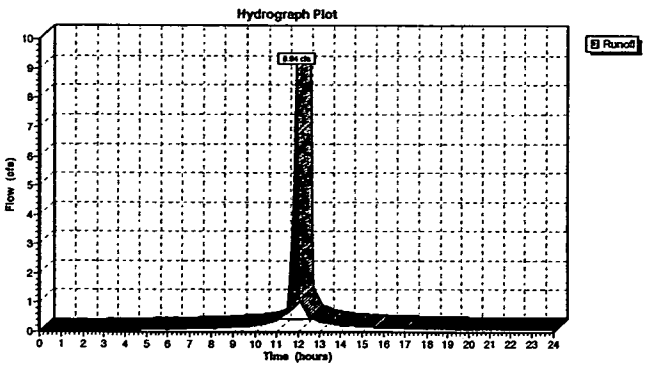
Runoff = 8.94 cfs @ 11.90 hrs, Volume= 0.435 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
2.252	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment O: pond



Subcatchment P1R: grass area

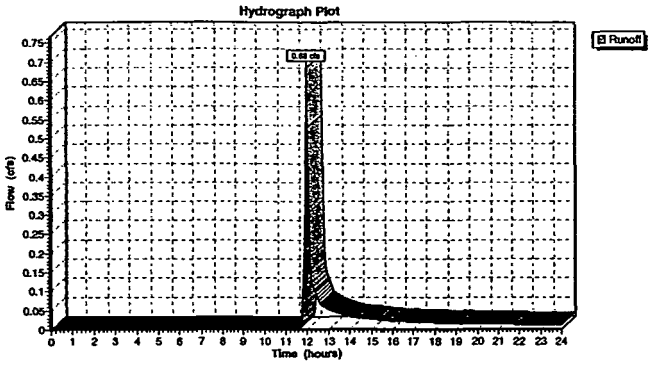
Runoff = 0.68 cfs @ 12.00 hrs, Volume= 0.035 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.666	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	80	0.0385	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P1R: grass area



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Subcatchment P2R: grass area

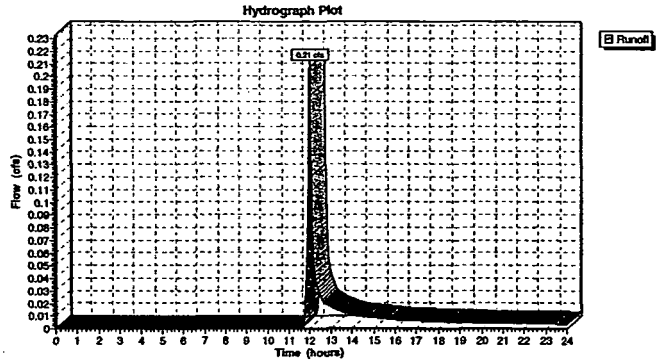
Runoff = 0.21 cfs @ 12.01 hrs, Volume= 0.011 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.214	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	110	0.0473	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P2R: grass area



Subcatchment QN: runon north of borrow area

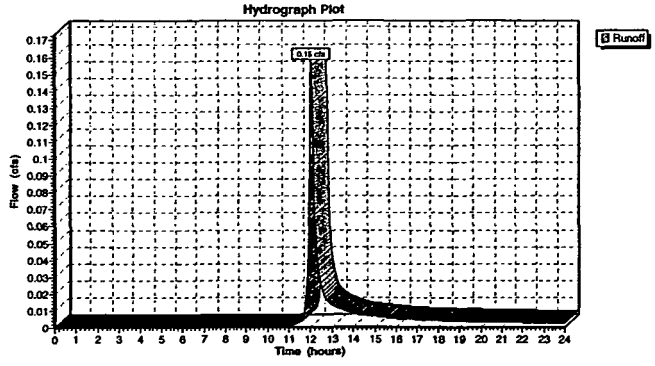
Runoff = 0.15 cfs @ 12.05 hrs, Volume= 0.009 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=2.55"

Area (ac)	CN	Description
0.127	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	100	0.0167	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"

Subcatchment QN: runon north of borrow area



Reach 1: west channel

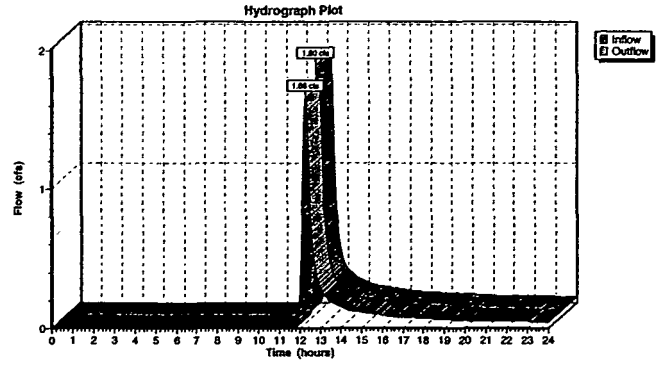
[65] Warning: Inlet elevation not specified

Inflow = 1.80 cfs @ 12.13 hrs, Volume= 0.144 af
Outflow = 1.66 cfs @ 12.25 hrs, Volume= 0.143 af, Atten= 8%, Lag= 7.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.7 fps, Min. Travel Time= 4.0 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 8.2 min

Peak Depth= 0.50'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 1: west channel



Reach 2: west channel

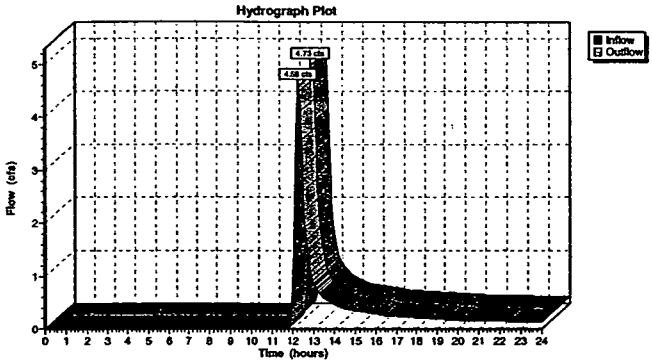
[65] Warning: Inlet elevation not specified

Inflow = 4.73 cfs @ 12.18 hrs, Volume= 0.424 af
Outflow = 4.58 cfs @ 12.27 hrs, Volume= 0.423 af, Atten= 3%, Lag= 5.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.3 min

Peak Depth= 0.73'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 2: west channel



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Reach 3: west channel

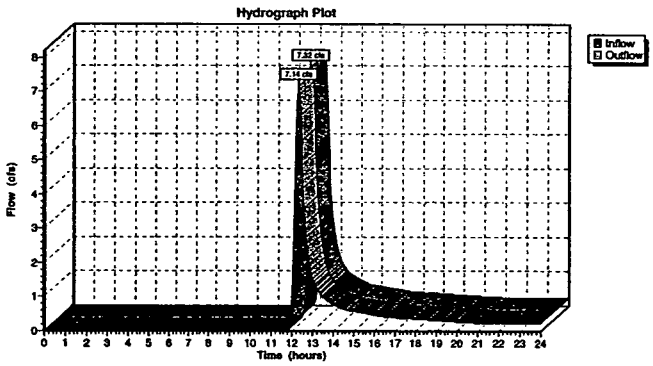
[65] Warning: Inlet elevation not specified

Inflow = 7.32 cfs @ 12.22 hrs, Volume= 0.707 af
Outflow = 7.14 cfs @ 12.31 hrs, Volume= 0.704 af, Atten= 2%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.6 min

Peak Depth= 0.86'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 3: west channel



Reach 4: west channel

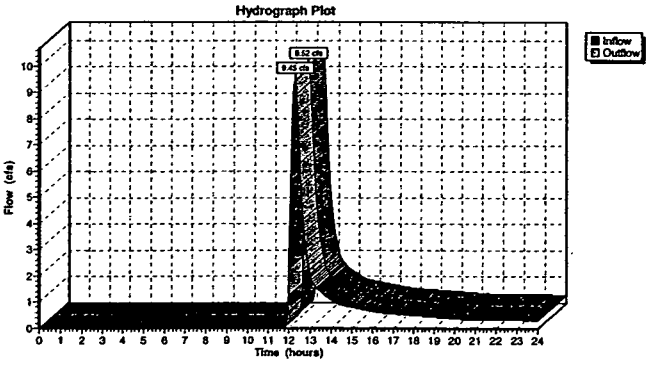
[65] Warning: Inlet elevation not specified

Inflow = 9.52 cfs @ 12.26 hrs, Volume= 0.995 af
Outflow = 9.45 cfs @ 12.28 hrs, Volume= 0.995 af, Atten= 1%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.96'
Capacity at bank full= 426.17 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 90.0' Slope= 0.0076 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 4: west channel



Reach 5: culvert

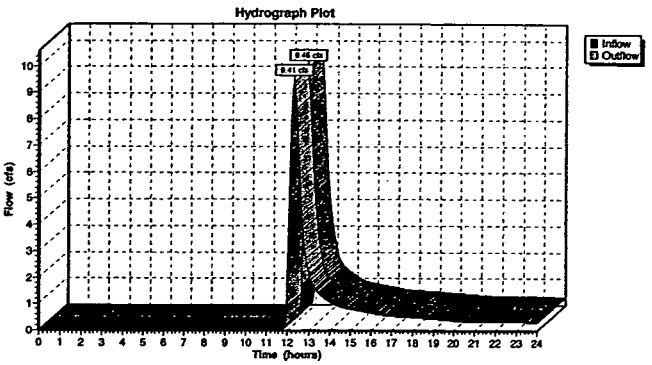
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 9.45 cfs @ 12.28 hrs, Volume= 0.995 af
Outflow = 9.41 cfs @ 12.30 hrs, Volume= 0.994 af, Atten= 0%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 1.3 min

Peak Depth= 0.64'
Capacity at bank full= 397.33 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 100.0' Slope= 0.0075 '/'

Reach 5: culvert



Reach 6: west channel

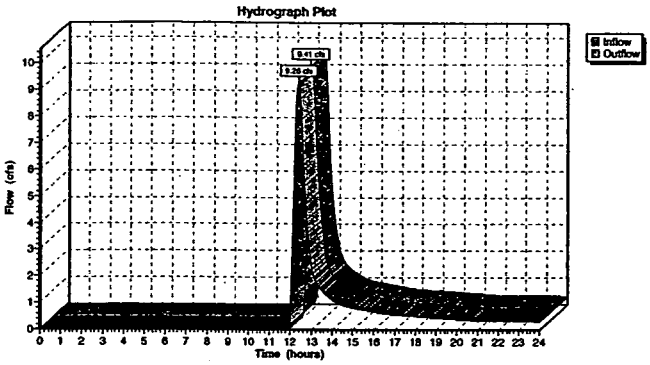
[65] Warning: Inlet elevation not specified

Inflow = 9.41 cfs @ 12.30 hrs, Volume= 0.994 af
Outflow = 9.26 cfs @ 12.37 hrs, Volume= 0.990 af, Atten= 2%, Lag= 4.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 4.8 min

Peak Depth= 0.95'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 380.0' Slope= 0.0075 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 6: west channel



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Reach 7AR: Haul Road Culvert 1

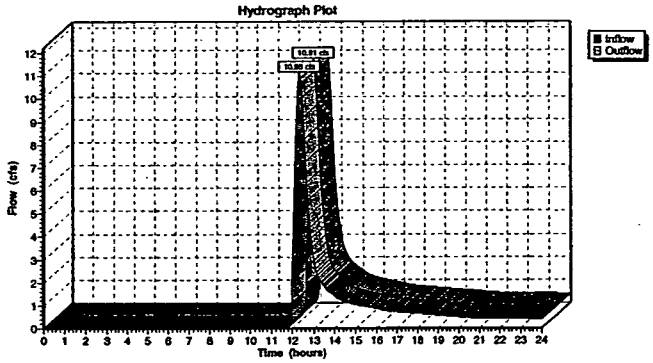
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 10.91 cfs @ 12.34 hrs, Volume= 1.270 af
Outflow = 10.88 cfs @ 12.36 hrs, Volume= 1.270 af, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.9 min

Peak Depth= 1.04'
Capacity at bank full= 166.63 cfs
72.0" Diameter Pipe n= 0.024 Length= 81.5' Slope= 0.0053 '/'

Reach 7AR: Haul Road Culvert 1



Reach 7BR: Channel between GIS 14 & 15

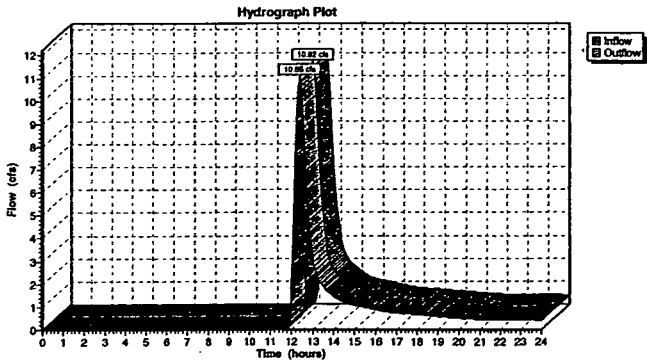
[65] Warning: Inlet elevation not specified

Inflow = 10.92 cfs @ 12.36 hrs, Volume= 1.286 af
Outflow = 10.85 cfs @ 12.38 hrs, Volume= 1.284 af, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.7 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 1.9 min

Peak Depth= 1.26'
Capacity at bank full= 200.78 cfs
0.00' x 3.77' deep channel, n= 0.030 Length= 100.0' Slope= 0.0023 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 7BR: Channel between GIS 14 & 15



Reach 7CR: Rimia Parking Lot Culvert

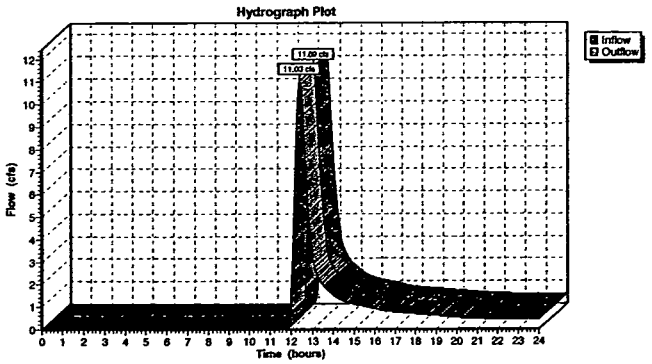
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 11.09 cfs @ 12.38 hrs, Volume= 1.333 af
Outflow = 11.03 cfs @ 12.41 hrs, Volume= 1.331 af, Atten= 1%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 2.1 min

Peak Depth= 0.79'
Capacity at bank full= 296.41 cfs
72.0" Diameter Pipe n= 0.013 Length= 296.0' Slope= 0.0049 '/'

Reach 7CR: Rimia Parking Lot Culvert



Reach 7DR: Runoff Drainage Channel south of Rimia

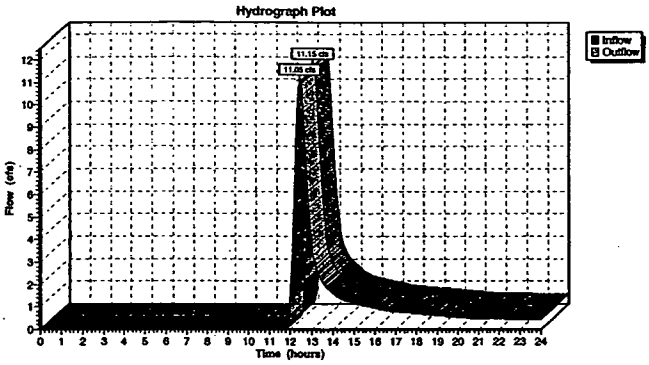
[65] Warning: Inlet elevation not specified

Inflow = 11.15 cfs @ 12.41 hrs, Volume= 1.376 af
Outflow = 11.05 cfs @ 12.46 hrs, Volume= 1.372 af, Atten= 1%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 3.7 min

Peak Depth= 0.86'
Capacity at bank full= 599.79 cfs
2.56' x 4.71' deep channel, n= 0.030 Length= 237.0' Slope= 0.0042 '/'
Side Slope Z-value= 4.3 3.9 '/'

Reach 7DR: Runoff Drainage Channel south of Rimia



5316 251/344

Reach 8AR: west channel

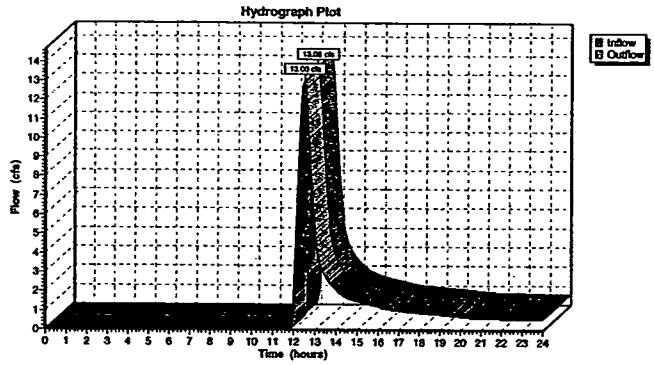
[65] Warning: Inlet elevation not specified

Inflow = 13.08 cfs @ 12.42 hrs, Volume= 1.754 af
Outflow = 13.00 cfs @ 12.48 hrs, Volume= 1.748 af, Atten= 1%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.9 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 4.8 min

Peak Depth= 0.46'
Capacity at bank full= 389.11 cfs
13.28' x 3.00' deep channel, n= 0.030 Length= 220.0' Slope= 0.0048 '/'
Side Slope Z-value= 4.2 2.6 '/'

Reach 8AR: west channel



Reach 8BR: Culvert at Sed Basin 2 entrance

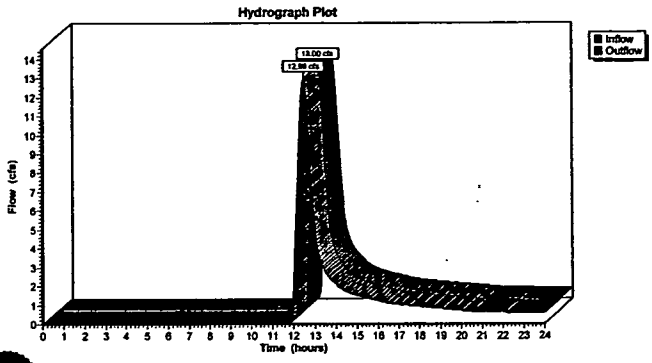
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 13.00 cfs @ 12.48 hrs, Volume= 1.748 af
Outflow = 12.99 cfs @ 12.48 hrs, Volume= 1.747 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.0 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 0.3 min

Peak Depth= 0.64'
Capacity at bank full= 535.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 30.0' Slope= 0.0040 '/'

Reach 8BR: Culvert at Sed Basin 2 entrance



Reach 8CR: Channel into Sed Basin 2

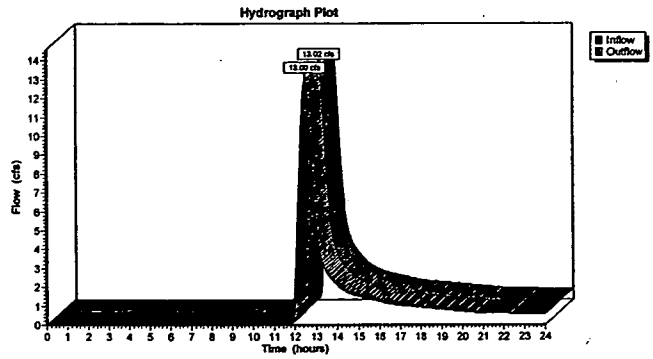
[65] Warning: Inlet elevation not specified

Inflow = 13.02 cfs @ 12.48 hrs, Volume= 1.759 af
Outflow = 13.00 cfs @ 12.49 hrs, Volume= 1.758 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 0.5 min

Peak Depth= 0.94'
Capacity at bank full= 728.12 cfs
1.17' x 5.00' deep channel, n= 0.030 Length= 62.7' Slope= 0.0159 '/'
Side Slope Z-value= 2.4 2.3 '/'

Reach 8CR: Channel into Sed Basin 2



Reach 9AR: Extended Drainge Channel South of Cell 8

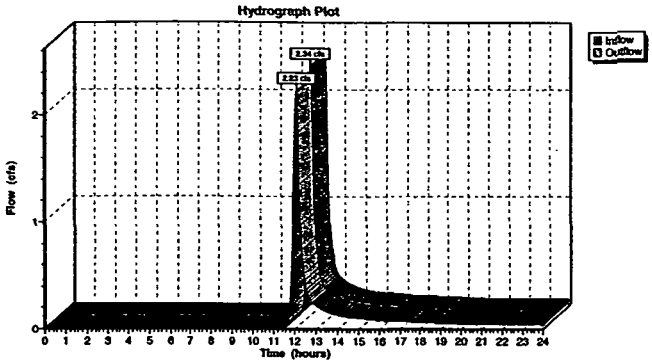
[65] Warning: Inlet elevation not specified

Inflow = 2.34 cfs @ 12.05 hrs, Volume= 0.143 af
Outflow = 2.23 cfs @ 12.08 hrs, Volume= 0.142 af, Atten= 4%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 2.5 min

Peak Depth= 0.50'
Capacity at bank full= 267.67 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 197.0' Slope= 0.0250 '/'
Side Slope Z-value= 3.0 '/'

Reach 9AR: Extended Drainge Channel South of Cell 8



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Reach 9BR: (new node)

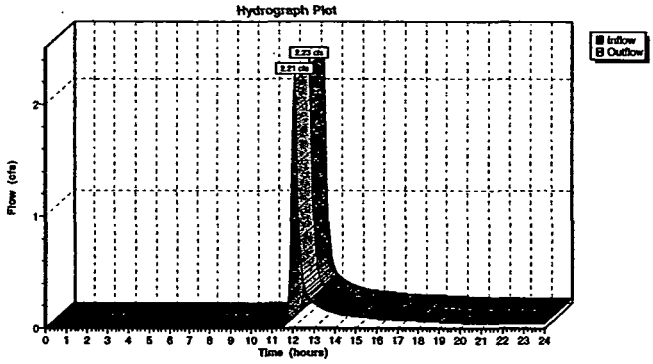
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 2.23 cfs @ 12.08 hrs, Volume= 0.142 af
Outflow = 2.21 cfs @ 12.09 hrs, Volume= 0.142 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.34'
Capacity at bank full= 353.53 cfs
72.0" Diameter Pipe n= 0.024 Length= 88.0' Slope= 0.0237 '/'

Reach 9BR: (new node)



Reach 9R: Channel U/S of 30" Culvert

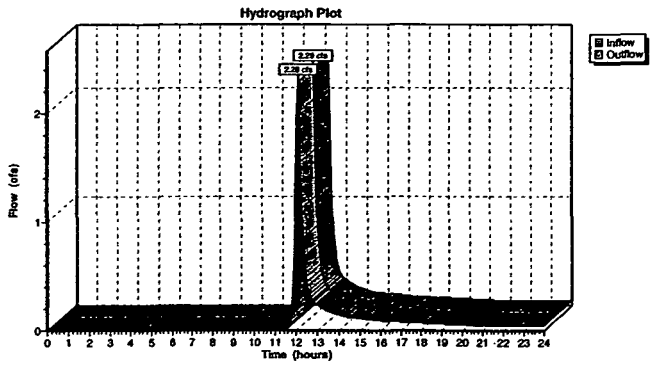
[65] Warning: Inlet elevation not specified

Inflow = 2.29 cfs @ 12.09 hrs, Volume= 0.149 af
Outflow = 2.28 cfs @ 12.10 hrs, Volume= 0.149 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.3 min

Peak Depth= 0.50'
Capacity at bank full= 1,695.60 cfs
0.00' x 8.00' deep channel, n= 0.030 Length= 27.3' Slope= 0.0249 '/'
Side Slope Z-value= 3.0 '/'

Reach 9R: Channel U/S of 30" Culvert



Reach 10AR: (new node)

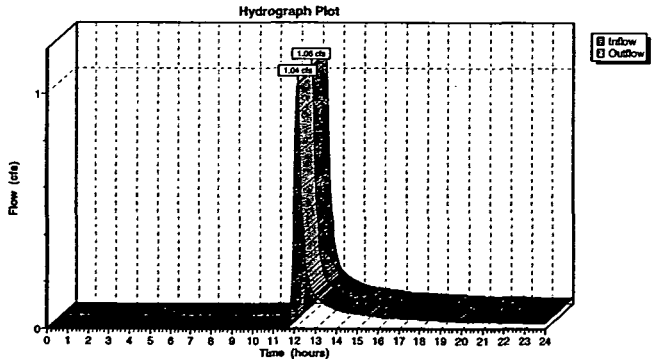
[65] Warning: Inlet elevation not specified

Inflow = 1.06 cfs @ 12.12 hrs, Volume= 0.082 af
Outflow = 1.04 cfs @ 12.13 hrs, Volume= 0.082 af, Atten= 2%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 1.3 min

Peak Depth= 0.09'
Capacity at bank full= 243.75 cfs
5.00' x 1.75' deep channel, n= 0.030 Length= 71.4' Slope= 0.0650 '/'
Side Slope Z-value= 3.0 '/'

Reach 10AR: (new node)



Reach 10BR: (new node)

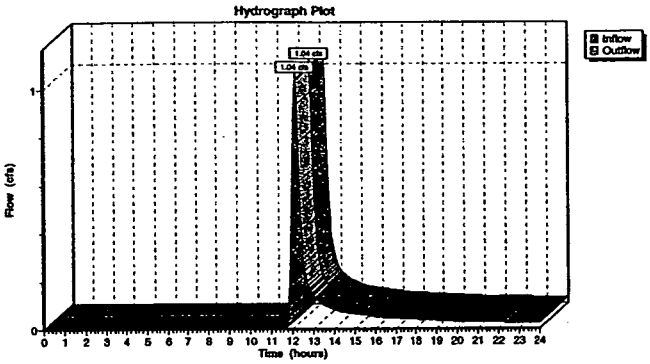
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]w	=	1.04 cfs @	12.13 hrs, Volume=	0.082 af	
[illegible]w	=	1.04 cfs @	12.14 hrs, Volume=	0.082 af, Atten= 0%, Lag= 0.5 min	

[illegible]ting by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 0.5 min

Peak Depth= 0.24'
Capacity at bank full= 343.51 cfs
72.0" Diameter Pipe n= 0.013 Length= 38.0' Slope= 0.0066 '/'

Reach 10BR: (new node)



Reach 10R: access road diversion channel

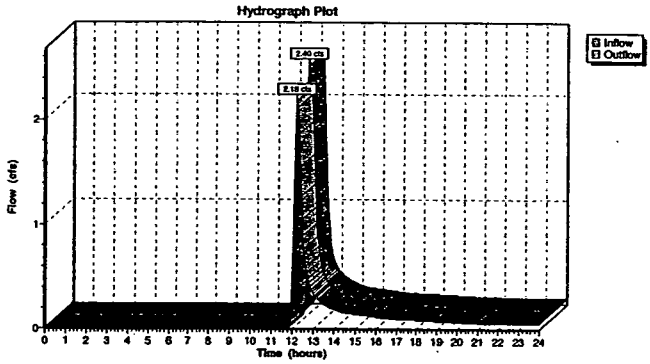
[65] Warning: Inlet elevation not specified

Inflow	=	2.40 cfs @	12.10 hrs, Volume=	0.179 af	
Outflow	=	2.18 cfs @	12.22 hrs, Volume=	0.178 af, Atten= 9%, Lag= 7.4 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.2 fps, Min. Travel Time= 4.3 min
Avg. Velocity = 0.4 fps, Avg. Travel Time= 12.6 min

Peak Depth= 0.23'
Capacity at bank full= 172.90 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 320.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 '/'

Reach 10R: access road diversion channel



Reach 11AR: (new node)

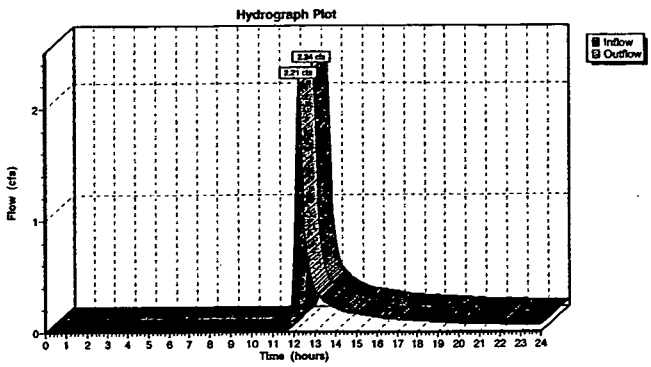
[65] Warning: Inlet elevation not specified

Inflow	=	2.24 cfs @	12.23 hrs, Volume=	0.198 af	
Outflow	=	2.21 cfs @	12.25 hrs, Volume=	0.198 af, Atten= 1%, Lag= 1.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.2 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 0.4 fps, Avg. Travel Time= 2.3 min

Peak Depth= 0.23'
Capacity at bank full= 170.32 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 60.0' Slope= 0.0050 '/'
Side Slope Z-value= 2.8 3.0 '/'

Reach 11AR: (new node)



Reach 11R: culvert

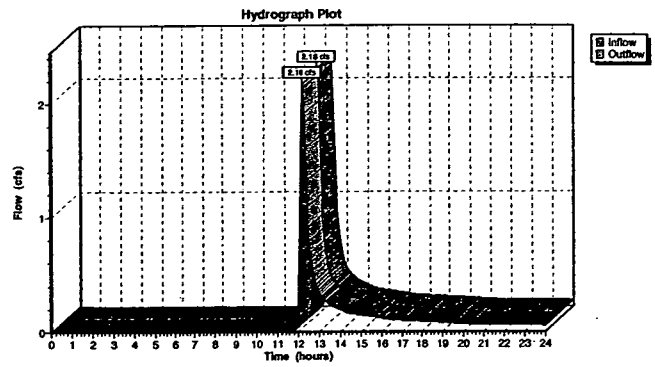
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	2.18 cfs @	12.22 hrs, Volume=	0.178 af	
Outflow	=	2.16 cfs @	12.23 hrs, Volume=	0.178 af, Atten= 1%, Lag= 0.5 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.39'
Capacity at bank full= 264.80 cfs
72.0" Diameter Pipe n= 0.013 Length= 48.6' Slope= 0.0039 '/'

Reach 11R: culvert



Reach 12: Culvert from F Street Drainage Channel

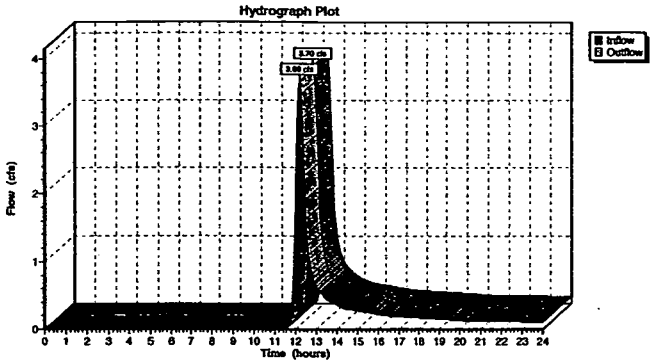
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

[illegible]w	=	3.70 cfs @	12.16 hrs, Volume=	0.347 af	
[illegible]w	=	3.66 cfs @	12.19 hrs, Volume=	0.347 af, Atten= 1%, Lag= 1.4 min	

[illegible]ting by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.3 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 1.8 min

Peak Depth= 0.40'
Capacity at bank full= 413.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 104.8' Slope= 0.0024 '/'

Reach 12: Culvert from F Street Drainage Channel



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Reach 13: (new node)

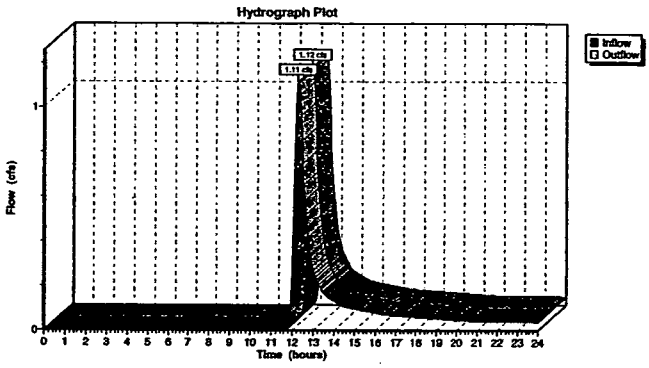
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	1.12 cfs @	12.26 hrs, Volume=	0.120 af	
Outflow	=	1.11 cfs @	12.28 hrs, Volume=	0.120 af, Atten= 1%, Lag= 1.2 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.4 min

Peak Depth= 0.24'
Capacity at bank full= 386.61 cfs
72.0" Diameter Pipe n= 0.013 Length= 120.0' Slope= 0.0083 '/'

Reach 13: (new node)



Reach 14: Culvert from North Entrance Road channel

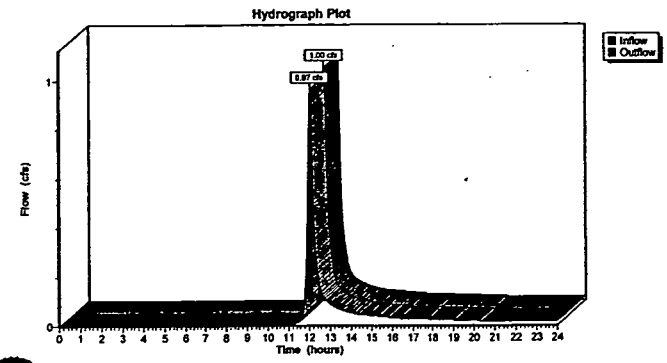
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	1.00 cfs @	12.05 hrs, Volume=	0.058 af	
Outflow	=	0.97 cfs @	12.07 hrs, Volume=	0.058 af, Atten= 4%, Lag= 1.2 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 1.4 min

Peak Depth= 0.15'
Capacity at bank full= 822.56 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 112.0' Slope= 0.0321 '/'

Reach 14: Culvert from North Entrance Road channel



Reach 15N: Culvert adjacent to North Entrance Road

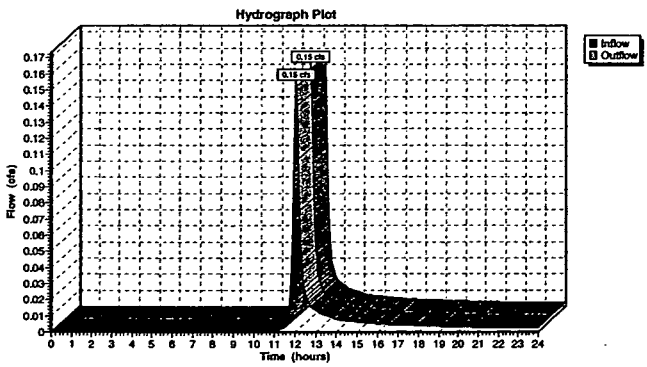
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	0.15 cfs @	12.05 hrs, Volume=	0.009 af	
Outflow	=	0.15 cfs @	12.06 hrs, Volume=	0.009 af, Atten= 2%, Lag= 0.8 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.8 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.09'
Capacity at bank full= 406.62 cfs
72.0" Diameter Pipe n= 0.010 Length= 55.0' Slope= 0.0055 '/'

Reach 15N: Culvert adjacent to North Entrance Road



Reach 16N: Channel east of North Entrance Road

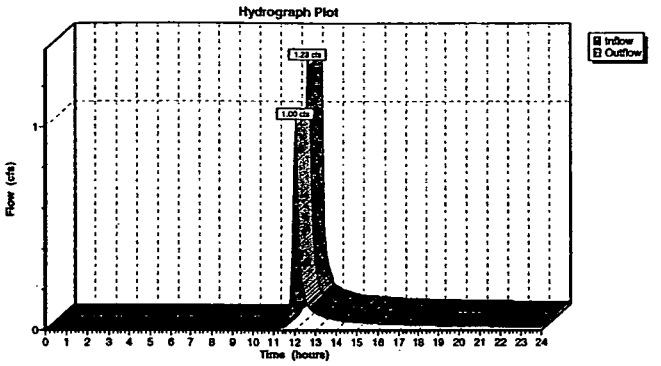
[65] Warning: Inlet elevation not specified

Inflow = 1.23 cfs @ 11.94 hrs, Volume= 0.058 af
Outflow = 1.00 cfs @ 12.05 hrs, Volume= 0.058 af, Atten= 19%, Lag= 6.2 min

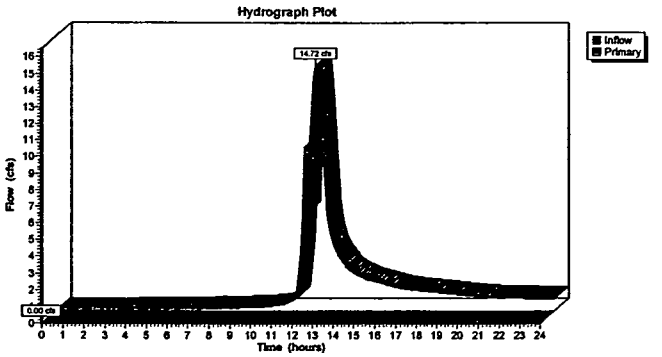
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.7 fps, Min. Travel Time= 3.9 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 9.2 min

Peak Depth= 0.59'
Capacity at bank full= 71.46 cfs
0.00' x 2.88' deep channel, n= 0.030 Length= 382.0' Slope= 0.0069 '/'
Side Slope Z-value= 2.2 1.4 '/'

Reach 16N: Channel east of North Entrance Road



Pond 1P: Sedimentation Basin 2



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Pond 1P: Sedimentation Basin 2

Inflow = 14.72 cfs @ 12.46 hrs, Volume= 2.426 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 572.07' Storage= 2.425 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.50	1.460	0.000	0.000	1.460
571.00	1.512	0.743	0.743	1.513
572.00	1.614	1.563	2.306	1.617
573.00	1.713	1.663	3.969	1.719
574.00	1.819	1.766	5.735	1.827
575.00	1.917	1.868	7.602	1.928
576.00	2.026	1.971	9.574	2.039
577.00	2.162	2.094	11.667	2.177

Primary OutFlow (Free Discharge)
- 2=Culvert
  - 1=Orifice/Grate
- 3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.50'	48.0" Horiz. Orifice/Grate Limited to weir flow C= 0.600
2	Primary	570.78'	36.0" x 680.0' long Culvert Ke= 0.700 Outlet Invert= 563.30' S= 0.0110 '/' n= 0.024 Cc= 0.900
3	Primary	576.00'	20.0' long Broad-Crested Rectangular Weir Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00 Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

WEST OSDF POST-DEVELOPMENT DESIGN SCENARIO 25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=18.3 min CN=74 Area=2.730 ac Runoff= 6.71 cfs 0.482 af

Subcatchment B: vegetated final cover
Tc=19.0 min CN=74 Area=5.342 ac Runoff= 12.85 cfs 0.942 af

Subcatchment C: vegetated final cover
Tc=19.0 min CN=74 Area=5.399 ac Runoff= 12.99 cfs 0.952 af

Subcatchment D: vegetated final cover
Tc=19.0 min CN=74 Area=5.530 ac Runoff= 13.31 cfs 0.975 af

Subcatchment ER: vegetated final cover
Tc=18.8 min CN=74 Area=5.320 ac Runoff= 12.88 cfs 0.938 af

Subcatchment F1R: vegetated final cover
Tc=17.5 min CN=74 Area=0.918 ac Runoff= 2.31 cfs 0.162 af

Subcatchment F2R: (new node)
Tc=17.3 min CN=74 Area=1.550 ac Runoff= 3.93 cfs 0.274 af

Subcatchment FR: vegetated final cover/construction laydown
Tc=13.4 min CN=74 Area=1.853 ac Runoff= 5.33 cfs 0.327 af

Subcatchment GR: (new node)
Tc=7.7 min CN=75 Area=0.368 ac Runoff= 1.34 cfs 0.067 af

Subcatchment HR: non-vegetated final cover area
Tc=9.5 min CN=79 Area=0.092 ac Runoff= 0.36 cfs 0.019 af

Subcatchment J1R: grass area
Tc=2.8 min CN=74 Area=0.312 ac Runoff= 1.29 cfs 0.055 af

Subcatchment J2R: grass area
Tc=6.2 min CN=74 Area=0.854 ac Runoff= 3.15 cfs 0.151 af

Subcatchment KR: runon north of borrow area
Tc=11.8 min CN=76 Area=2.370 ac Runoff= 7.76 cfs 0.451 af

Subcatchment LR: grass area
Tc=28.6 min CN=74 Area=2.287 ac Runoff= 4.28 cfs 0.402 af

Subcatchment MR: runon north of borrow area
Tc=2.8 min CN=79 Area=0.675 ac Runoff= 3.30 cfs 0.143 af

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Subcatchment N: grass area
Tc=15.2 min CN=74 Area=1.043 ac Runoff= 2.82 cfs 0.184 af

Subcatchment O: pond
Tc=1.0 min CN=98 Area=2.252 ac Runoff= 16.67 cfs 0.838 af

Subcatchment P1R: grass area
Tc=7.0 min CN=74 Area=0.666 ac Runoff= 2.40 cfs 0.118 af

Subcatchment P2R: grass area
Tc=8.3 min CN=74 Area=0.214 ac Runoff= 0.74 cfs 0.038 af

Subcatchment QN: runon north of borrow area
Tc=11.8 min CN=79 Area=0.127 ac Runoff= 0.46 cfs 0.027 af

Reach 1: west channel
Inflow= 6.71 cfs 0.482 af
Length= 400.0' Max Vel= 2.3 fps Capacity= 424.60 cfs Outflow= 6.46 cfs 0.480 af

Reach 2: west channel
Inflow= 18.66 cfs 1.422 af
Length= 400.0' Max Vel= 3.0 fps Capacity= 424.60 cfs Outflow= 18.15 cfs 1.418 af

Reach 3: west channel
Inflow= 29.58 cfs 2.371 af
Length= 400.0' Max Vel= 3.4 fps Capacity= 424.60 cfs Outflow= 28.95 cfs 2.365 af

Reach 4: west channel
Inflow= 39.78 cfs 3.340 af
Length= 90.0' Max Vel= 3.7 fps Capacity= 426.17 cfs Outflow= 39.58 cfs 3.339 af

Reach 5: culvert
Inflow= 39.58 cfs 3.339 af
Length= 100.0' Max Vel= 4.5 fps Capacity= 397.33 cfs Outflow= 39.39 cfs 3.337 af

Reach 6: west channel
Inflow= 39.39 cfs 3.337 af
Length= 380.0' Max Vel= 3.7 fps Capacity= 424.60 cfs Outflow= 38.66 cfs 3.330 af

Reach 7AR: Haul Road Culvert 1
Inflow= 47.24 cfs 4.268 af
Length= 81.5' Max Vel= 5.1 fps Capacity= 168.63 cfs Outflow= 47.12 cfs 4.267 af

Reach 7BR: Channel between GIS 14 & 15
Inflow= 47.27 cfs 4.322 af
Length= 100.0' Max Vel= 2.5 fps Capacity= 200.78 cfs Outflow= 46.97 cfs 4.319 af

Reach 7CR: Rimia Parking Lot Culvert
Inflow= 48.27 cfs 4.481 af
Length= 296.0' Max Vel= 7.7 fps Capacity= 296.41 cfs Outflow= 47.95 cfs 4.477 af

Reach 7DR: Runoff Drainage Channel south of Rimia
Inflow= 48.38 cfs 4.628 af
Length= 237.0' Max Vel= 3.1 fps Capacity= 599.79 cfs Outflow= 47.93 cfs 4.621 af

Reach 8AR: west channel
Inflow= 57.22 cfs 5.872 af
Length= 220.0' Max Vel= 3.1 fps Capacity= 389.11 cfs Outflow= 56.84 cfs 5.861 af

Reach 8BR: Culvert at Sed Basin 2 entrance
Inflow= 56.84 cfs 5.861 af
Length= 30.0' Max Vel= 6.2 fps Capacity= 535.70 cfs Outflow= 56.81 cfs 5.861 af

Reach 8CR: Channel into Sed Basin 2
Inflow= 56.92 cfs 5.899 af
Length= 62.7' Max Vel= 6.0 fps Capacity= 728.12 cfs Outflow= 56.81 cfs 5.897 af

Reach 9AR: Extended Drainge Channel South of Cell 8
Inflow= 7.76 cfs 0.451 af
Length= 197.0' Max Vel= 4.1 fps Capacity= 267.67 cfs Outflow= 7.54 cfs 0.451 af

Reach 9BR: (new node)
Inflow= 7.54 cfs 0.451 af
Length= 88.0' Max Vel= 5.0 fps Capacity= 353.53 cfs Outflow= 7.45 cfs 0.450 af

Reach 9R: Channel U/S of 30" Culvert
Inflow= 7.76 cfs 0.470 af
Length= 27.3' Max Vel= 4.1 fps Capacity= 1,695.60 cfs Outflow= 7.72 cfs 0.470 af

Reach 10AR: (new node)
Inflow= 3.93 cfs 0.274 af
Length= 71.4' Max Vel= 3.8 fps Capacity= 243.75 cfs Outflow= 3.90 cfs 0.273 af

Reach 10BR: (new node)
Inflow= 3.90 cfs 0.273 af
Length= 38.0' Max Vel= 4.1 fps Capacity= 343.51 cfs Outflow= 3.89 cfs 0.273 af

Reach 10R: access road diversion channel
Inflow= 8.94 cfs 0.601 af
Length= 320.0' Max Vel= 2.0 fps Capacity= 172.90 cfs Outflow= 8.64 cfs 0.598 af

Reach 11AR: (new node)
Inflow= 8.96 cfs 0.665 af
Length= 60.0' Max Vel= 2.0 fps Capacity= 170.32 cfs Outflow= 8.86 cfs 0.664 af

Reach 11R: culvert
Inflow= 8.64 cfs 0.598 af
Length= 48.6' Max Vel= 4.3 fps Capacity= 264.80 cfs Outflow= 8.60 cfs 0.598 af

Reach 12: Culvert from F Street Drainage Channel
Inflow= 15.42 cfs 1.134 af
Length= 104.8' Max Vel= 3.5 fps Capacity= 413.70 cfs Outflow= 15.28 cfs 1.133 af

Reach 13: (new node)
Inflow= 4.28 cfs 0.402 af
Length= 120.0' Max Vel= 4.5 fps Capacity= 386.61 cfs Outflow= 4.26 cfs 0.402 af

Reach 14: Culvert from North Entrance Road channel
Inflow= 3.20 cfs 0.169 af
Length= 112.0' Max Vel= 3.5 fps Capacity= 822.56 cfs Outflow= 3.11 cfs 0.169 af

15N: Culvert adjacent to North Entrance Road
Inflow= 0.46 cfs 0.027 af
Length= 55.0' Max Vel= 2.4 fps Capacity= 406.62 cfs Outflow= 0.46 cfs 0.027 af

Reach 16N: Channel east of North Entrance Road
Inflow= 3.58 cfs 0.170 af
Length= 382.0' Max Vel= 2.2 fps Capacity= 71.46 cfs Outflow= 3.20 cfs 0.169 af

Pond 1P: Sedimentation Basin 2
Peak Storage= 7.487 af Inflow= 63.87 cfs 7.491 af
Primary= 0.00 cfs 0.000 af Outflow= 0.00 cfs 0.000 af

Runoff Area = 39.900 ac Volume = 7.547 af Average Depth = 2.27"

Subcatchment A: vegetated final cover

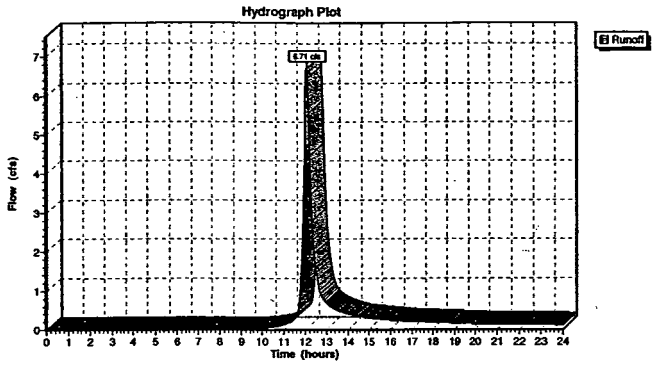
Runoff = 6.71 cfs @ 12.11 hrs, Volume= 0.482 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.730	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	180	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
18.3	670	Total			

Subcatchment A: vegetated final cover



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Subcatchment B: vegetated final cover

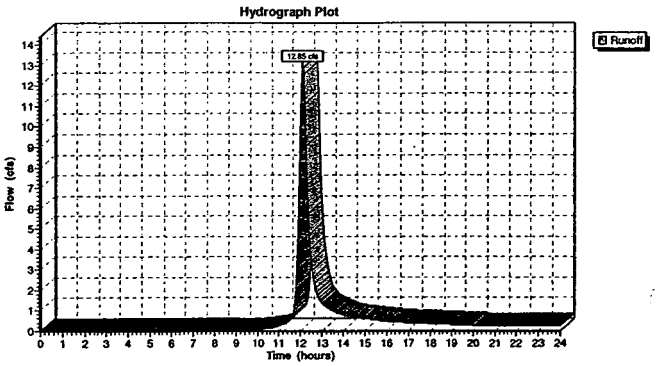
Runoff = 12.85 cfs @ 12.12 hrs, Volume= 0.942 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.342	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	200	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

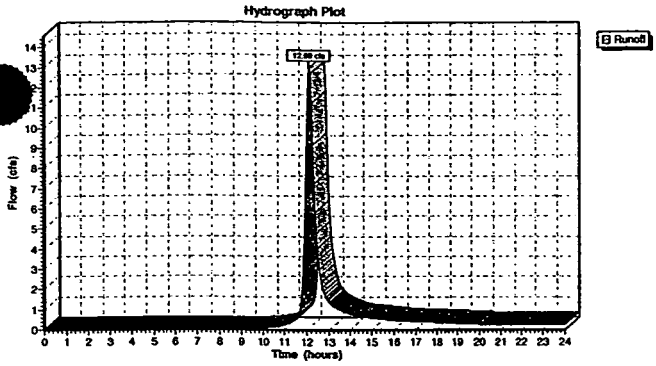
Runoff = 12.99 cfs @ 12.12 hrs, Volume= 0.952 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.399	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	945	Total			

Subcatchment C: vegetated final cover



Subcatchment D: vegetated final cover

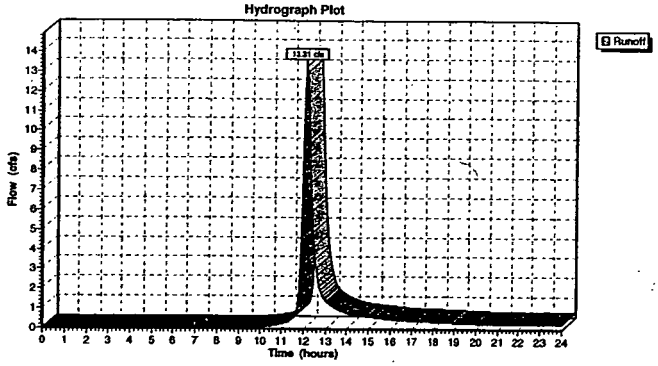
Runoff = 13.31 cfs @ 12.12 hrs, Volume= 0.975 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.530	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	205	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment D: vegetated final cover



Subcatchment ER: vegetated final cover

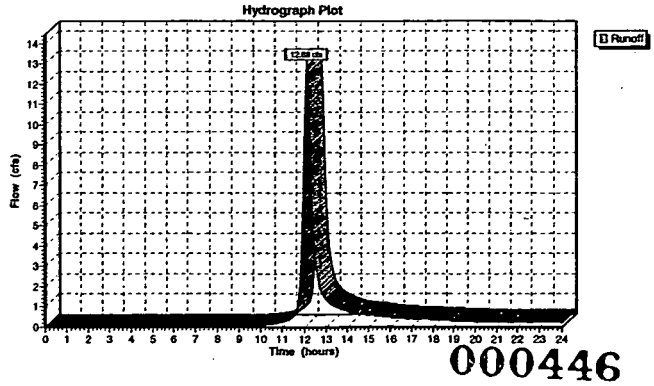
Runoff = 12.88 cfs @ 12.12 hrs, Volume= 0.938 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.320	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	110	0.0625	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
2.9	45	0.1110	0.3		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.4	510	0.0075	6.1	337.31	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.50' Z= 3.0 & 6.0 '/' n= 0.030
0.2	85	0.0029	8.1	228.07	**Circular Channel (pipe),** Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
18.8	1,100	Total			

Subcatchment ER: vegetated final cover



Subcatchment F1R: vegetated final cover

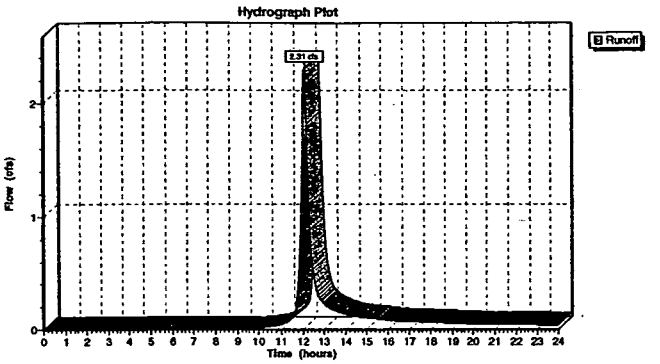
Runoff = 2.31 cfs @ 12.10 hrs, Volume= 0.162 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.918	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	90	0.0530	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
6.5	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.5	200	0.1670	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	160	0.0075	6.1	337.31	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.50' Z= 6.0 & 3.0 '/' n= 0.030
0.0	53	0.0580	36.1	1,019.94	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
17.5	703	Total			

Subcatchment F1R: vegetated final cover



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Subcatchment F2R: (new node)

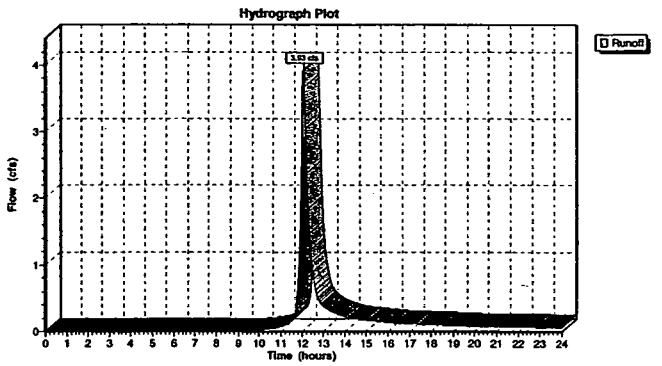
Runoff = 3.93 cfs @ 12.10 hrs, Volume= 0.274 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.550	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.5	55	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1667	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1667	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
17.3	495	Total			

Subcatchment F2R: (new node)



Subcatchment FR: vegetated final cover/construction laydown

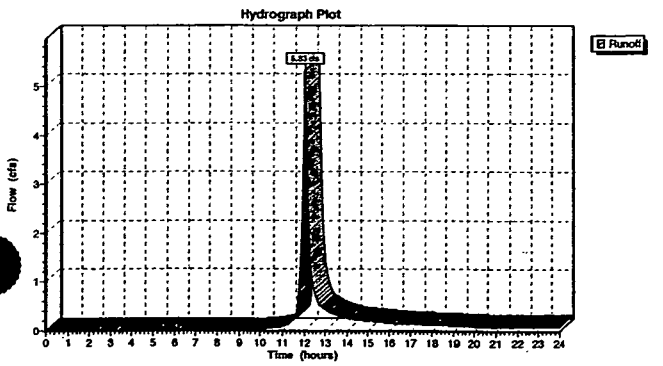
Runoff = 5.33 cfs @ 12.06 hrs, Volume= 0.327 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.853	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	30	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.5	55	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	30	0.3300	9.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
13.4	445	Total			

Subcatchment FR: vegetated final cover/construction laydown



Subcatchment GR: (new node)

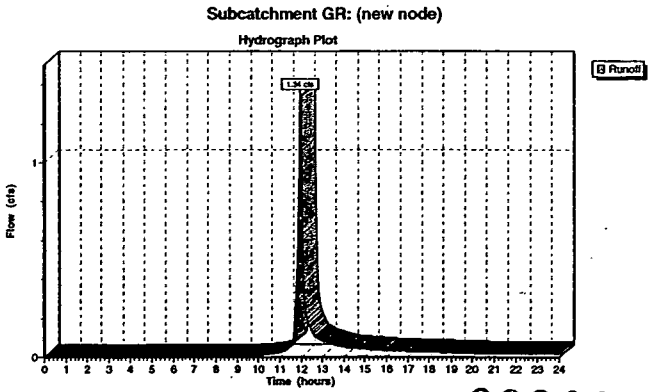
Runoff = 1.34 cfs @ 11.99 hrs, Volume= 0.067 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.262	74	
0.035	79	
0.069	79	
0.366	75	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	150	0.1670	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.7	270	0.1670	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.5	60	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.7	480	Total			

Subcatchment GR: (new node)



Subcatchment HR: non-vegetated final cover area

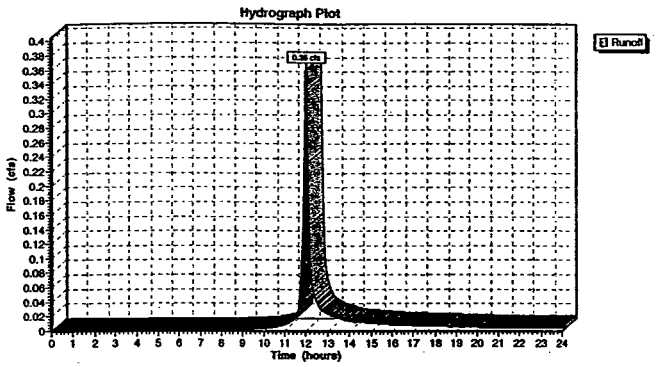
Runoff = 0.36 cfs @ 12.01 hrs, Volume= 0.019 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.092	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	80	0.0180	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment HR: non-vegetated final cover area



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Subcatchment J1R: grass area

[49] Hint: Tc<2dt may require smaller dt

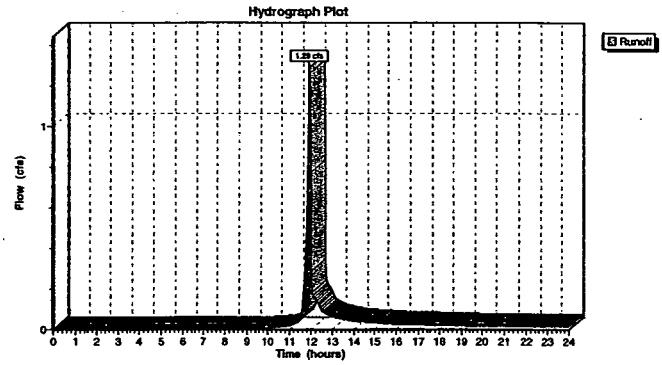
Runoff = 1.29 cfs @ 11.94 hrs, Volume= 0.055 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.312	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	54	0.1670	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J1R: grass area



Subcatchment J2R: grass area

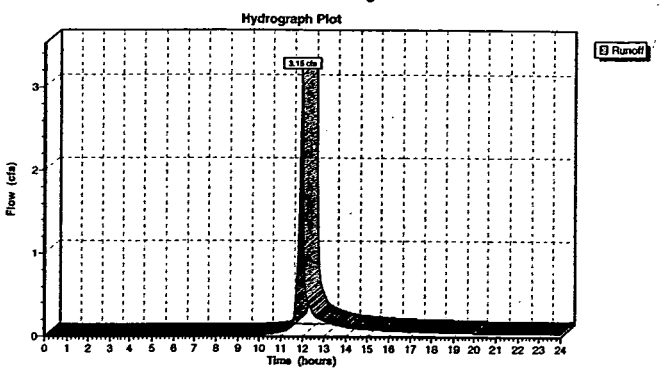
Runoff = 3.15 cfs @ 11.98 hrs, Volume= 0.151 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.854	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	72	0.0427	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment J2R: grass area



Subcatchment KR: runon north of borrow area

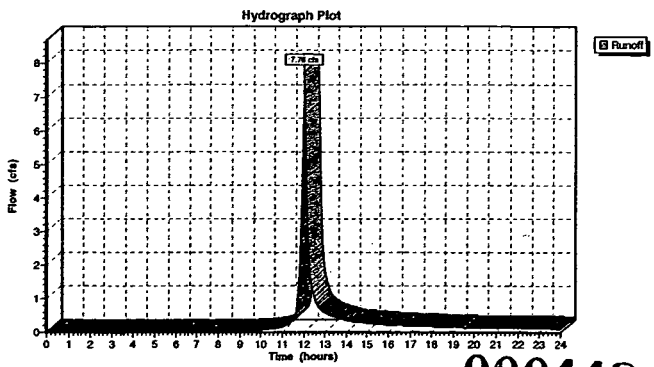
Runoff = 7.76 cfs @ 12.04 hrs, Volume= 0.451 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.469	74	
0.792	79	
0.109	79	
2.370	76	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	70	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	155	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	95	0.0180	2.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
11.8	470	Total			

Subcatchment KR: runon north of borrow area



Subcatchment LR: grass area

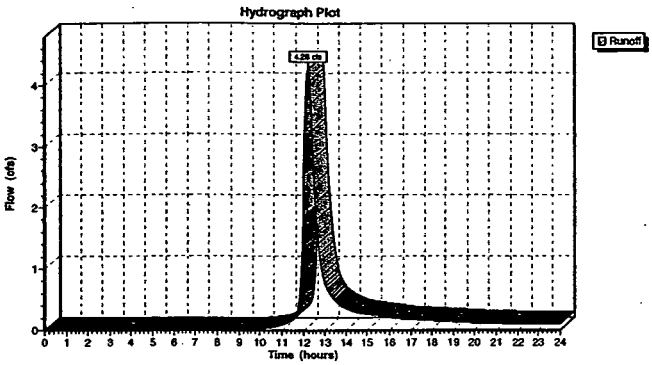
Runoff = 4.28 cfs @ 12.24 hrs, Volume= 0.402 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.287	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0167	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"
0.5	65	0.0167	2.1		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
28.6	365	Total			

Subcatchment LR: grass area



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Subcatchment MR: runon north of borrow area

[49] Hint: Tc<2dt may require smaller dt

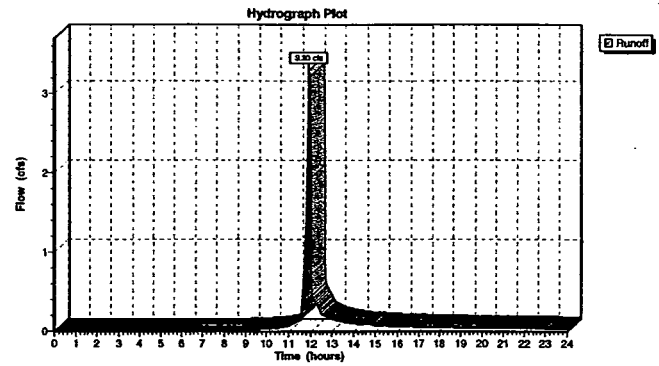
Runoff = 3.30 cfs @ 11.93 hrs, Volume= 0.143 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.675	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	40	0.0985	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment MR: runon north of borrow area



Subcatchment N: grass area

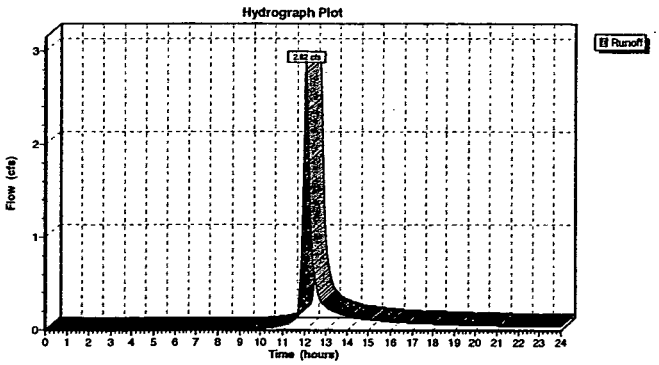
Runoff = 2.82 cfs @ 12.08 hrs, Volume= 0.184 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.043	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2	170	0.0250	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.60"

Subcatchment N: grass area



Subcatchment O: pond

[49] Hint: Tc<2dt may require smaller dt

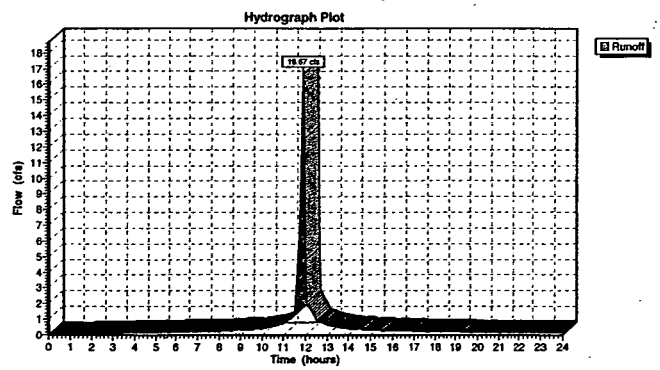
Runoff = 16.67 cfs @ 11.90 hrs, Volume= 0.838 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.252	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					**Direct Entry,**

Subcatchment O: pond



Subcatchment P1R: grass area

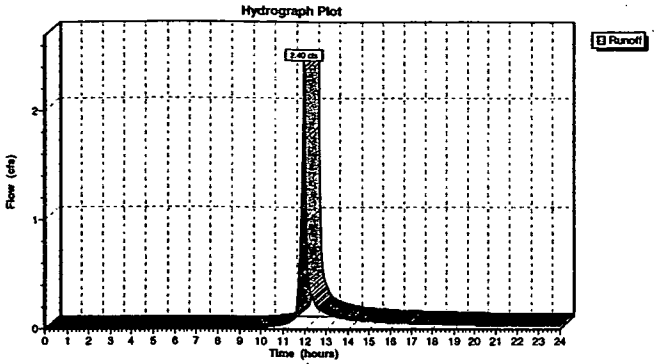
Runoff = 2.40 cfs @ 11.99 hrs, Volume= 0.118 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.666	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	80	0.0385	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P1R: grass area



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Subcatchment P2R: grass area

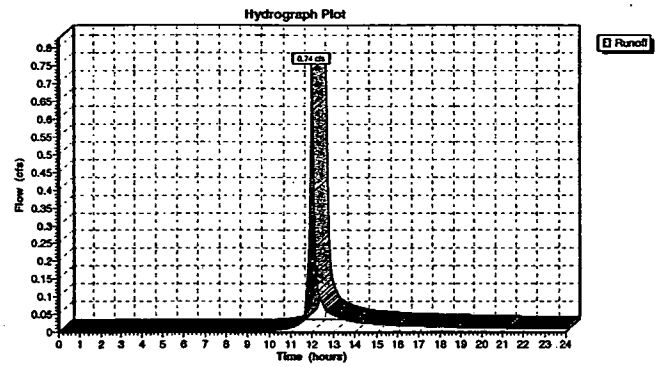
Runoff = 0.74 cfs @ 12.00 hrs, Volume= 0.038 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.214	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	110	0.0473	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment P2R: grass area



Subcatchment QN: runon north of borrow area

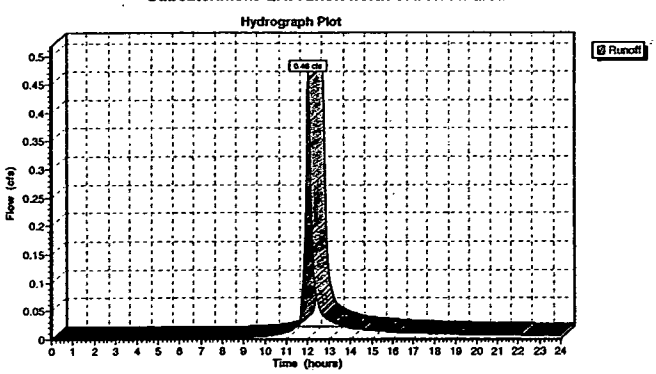
Runoff = 0.46 cfs @ 12.04 hrs, Volume= 0.027 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.127	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	100	0.0167	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"

Subcatchment QN: runon north of borrow area



Reach 1: west channel

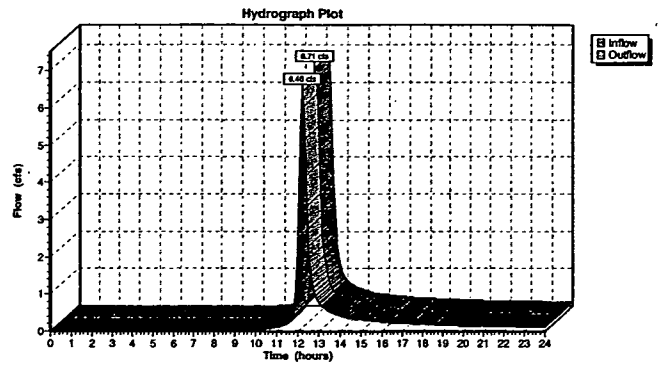
[65] Warning: Inlet elevation not specified

Inflow = 6.71 cfs @ 12.11 hrs, Volume= 0.482 af
Outflow = 6.46 cfs @ 12.20 hrs, Volume= 0.480 af, Atten= 4%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.3 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.7 min

Peak Depth= 0.83'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 1: west channel



Reach 2: west channel

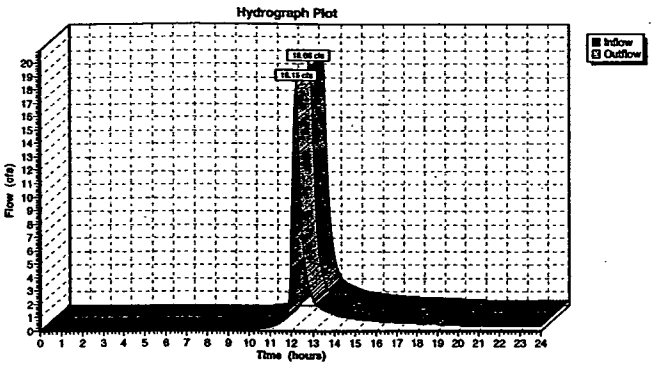
[65] Warning: Inlet elevation not specified

Inflow = 18.66 cfs @ 12.15 hrs, Volume= 1.422 af
Outflow = 18.15 cfs @ 12.21 hrs, Volume= 1.418 af, Atten= 3%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.1 min

Peak Depth= 1.23'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 2: west channel



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Reach 3: west channel

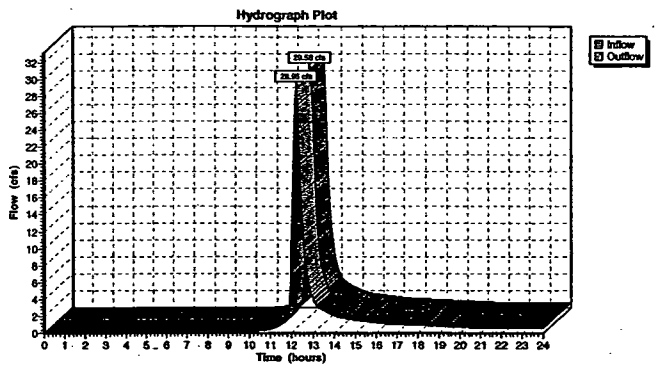
[65] Warning: Inlet elevation not specified

Inflow = 29.58 cfs @ 12.18 hrs, Volume= 2.371 af
Outflow = 28.95 cfs @ 12.24 hrs, Volume= 2.365 af, Atten= 2%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 4.5 min

Peak Depth= 1.47'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 3: west channel



Reach 4: west channel

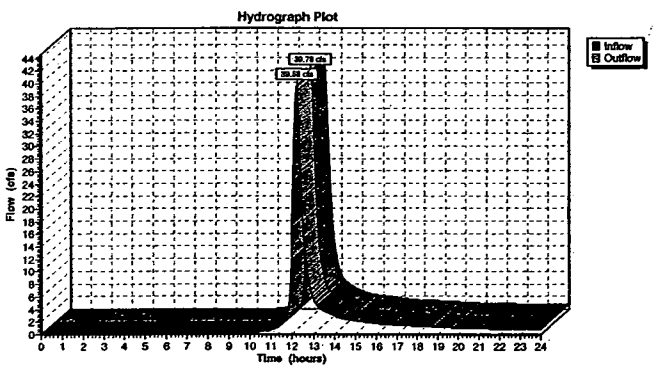
[65] Warning: Inlet elevation not specified

Inflow = 39.78 cfs @ 12.20 hrs, Volume= 3.340 af
Outflow = 39.58 cfs @ 12.21 hrs, Volume= 3.339 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.9 min

Peak Depth= 1.64'
Capacity at bank full= 426.17 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 90.0' Slope= 0.0076 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 4: west channel



Reach 5: culvert

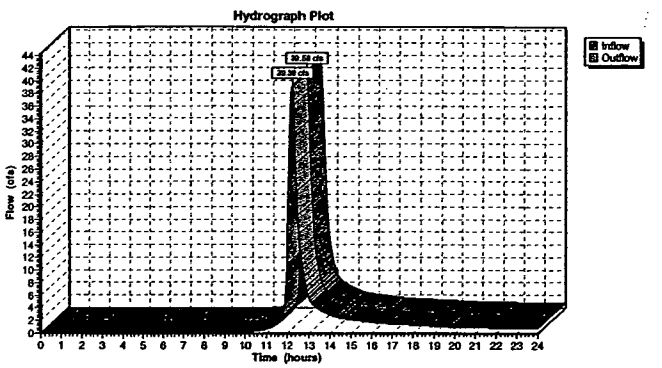
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 39.58 cfs @ 12.21 hrs, Volume= 3.339 af
Outflow = 39.39 cfs @ 12.22 hrs, Volume= 3.337 af, Atten= 0%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.28'
Capacity at bank full= 397.33 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 100.0' Slope= 0.0075 '/'

Reach 5: culvert



Reach 6: west channel

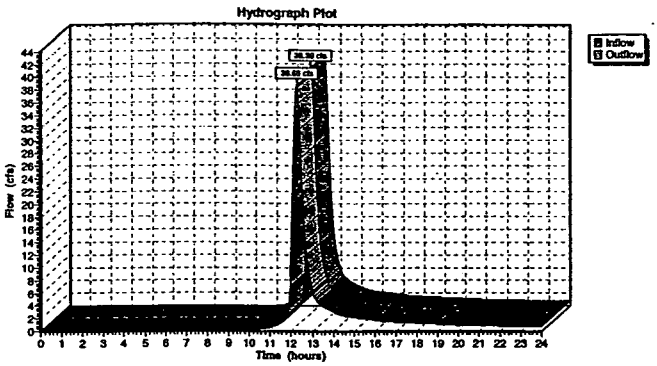
[65] Warning: Inlet elevation not specified

Inflow = 39.39 cfs @ 12.22 hrs, Volume= 3.337 af
Outflow = 38.66 cfs @ 12.28 hrs, Volume= 3.330 af, Atten= 2%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 1.7 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 3.9 min

Peak Depth= 1.63'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 380.0' Slope= 0.0075 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 6: west channel



Reach 7AR: Haul Road Culvert 1

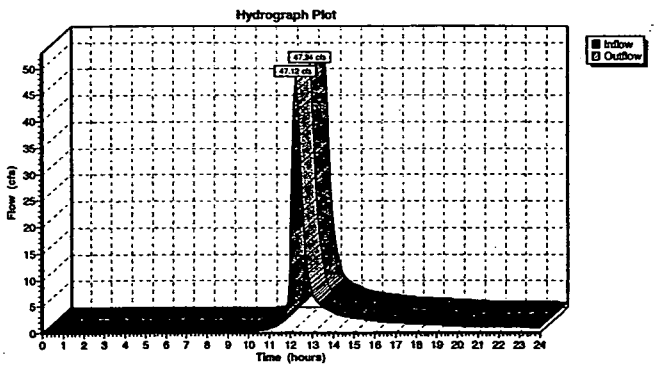
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 47.24 cfs @ 12.24 hrs, Volume= 4.268 af
Outflow = 47.12 cfs @ 12.25 hrs, Volume= 4.267 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.1 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 0.7 min

Peak Depth= 2.19'
Capacity at bank full= 166.63 cfs
72.0" Diameter Pipe n= 0.024 Length= 81.5' Slope= 0.0053 '/'

Reach 7AR: Haul Road Culvert 1



Reach 7BR: Channel between GIS 14 & 15

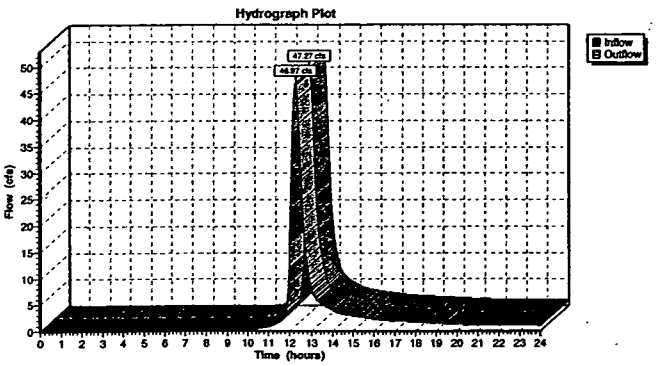
[65] Warning: Inlet elevation not specified

Inflow = 47.27 cfs @ 12.25 hrs, Volume= 4.322 af
Outflow = 46.97 cfs @ 12.27 hrs, Volume= 4.319 af, Atten= 1%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 1.5 min

Peak Depth= 2.19'
Capacity at bank full= 200.78 cfs
0.00' x 3.77' deep channel, n= 0.030 Length= 100.0' Slope= 0.0023 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 7BR: Channel between GIS 14 & 15



Reach 7CR: Rimla Parking Lot Culvert

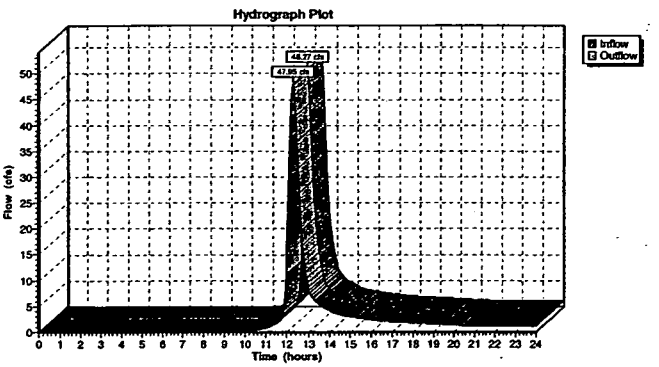
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 48.27 cfs @ 12.27 hrs, Volume= 4.481 af
Outflow = 47.95 cfs @ 12.29 hrs, Volume= 4.477 af, Atten= 1%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.7 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 3.0 fps, Avg. Travel Time= 1.6 min

Peak Depth= 1.64'
Capacity at bank full= 296.41 cfs
72.0" Diameter Pipe n= 0.013 Length= 296.0' Slope= 0.0049 '/'

Reach 7CR: Rimla Parking Lot Culvert



Reach 7DR: Runoff Drainage Channel south of Rimia

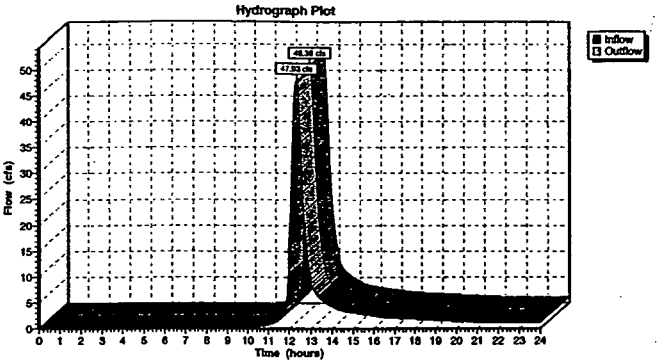
[65] Warning: Inlet elevation not specified

Inflow = 48.38 cfs @ 12.29 hrs, Volume= 4.628 af
Outflow = 47.93 cfs @ 12.32 hrs, Volume= 4.621 af, Atten= 1%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.1 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 3.0 min

Peak Depth= 1.66'
Capacity at bank full= 599.79 cfs
2.56' x 4.71' deep channel, n= 0.030 Length= 237.0' Slope= 0.0042 '/'
Side Slope Z-value= 4.3 3.9 '/'

Reach 7DR: Runoff Drainage Channel south of Rimia



Reach 8AR: west channel

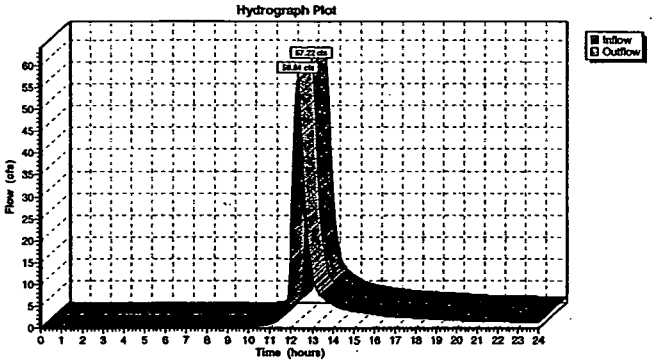
[65] Warning: Inlet elevation not specified

Inflow = 57.22 cfs @ 12.29 hrs, Volume= 5.872 af
Outflow = 56.84 cfs @ 12.32 hrs, Volume= 5.861 af, Atten= 1%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.1 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 3.6 min

Peak Depth= 1.08'
Capacity at bank full= 389.11 cfs
13.28' x 3.00' deep channel, n= 0.030 Length= 220.0' Slope= 0.0048 '/'
Side Slope Z-value= 4.2 2.6 '/'

Reach 8AR: west channel



Reach 8BR: Culvert at Sed Basin 2 entrance

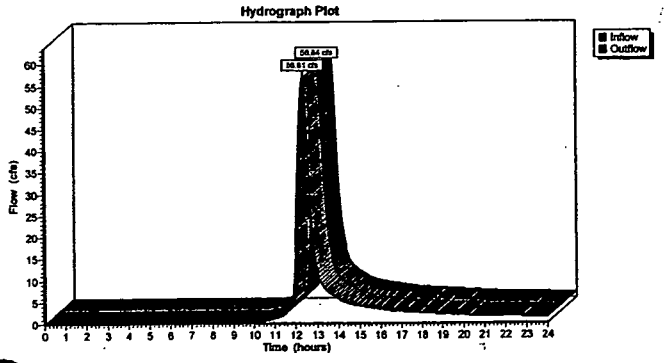
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 56.84 cfs @ 12.32 hrs, Volume= 5.861 af
Outflow = 56.81 cfs @ 12.32 hrs, Volume= 5.861 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.2 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.32'
Capacity at bank full= 535.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 30.0' Slope= 0.0040 '/'

Reach 8BR: Culvert at Sed Basin 2 entrance



Reach 8CR: Channel Into Sed Basin 2

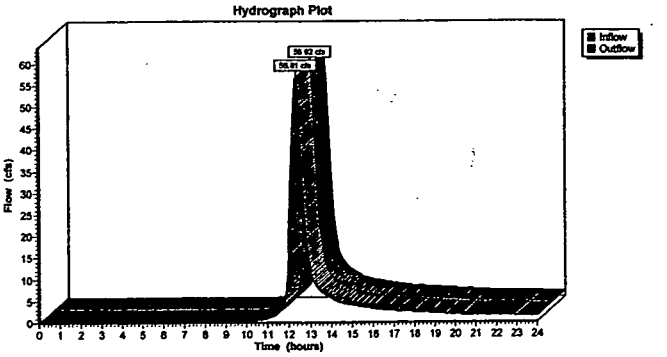
[65] Warning: Inlet elevation not specified

Inflow = 56.92 cfs @ 12.32 hrs, Volume= 5.899 af
Outflow = 56.81 cfs @ 12.33 hrs, Volume= 5.897 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.0 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 0.4 min

Peak Depth= 1.78'
Capacity at bank full= 728.12 cfs
1.17' x 5.00' deep channel, n= 0.030 Length= 62.7' Slope= 0.0159 '/'
Side Slope Z-value= 2.4 2.3 '/'

Reach 8CR: Channel Into Sed Basin 2



Reach 9AR: Extended Drainge Channel South of Cell 8

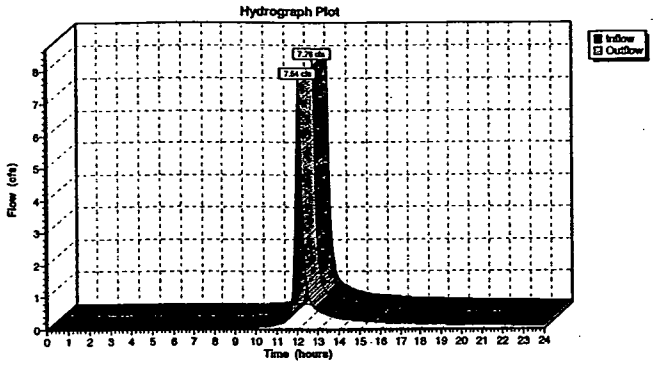
[65] Warning: Inlet elevation not specified

Inflow = 7.76 cfs @ 12.04 hrs, Volume= 0.451 af
Outflow = 7.54 cfs @ 12.06 hrs, Volume= 0.451 af, Atten= 3%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 2.0 min

Peak Depth= 0.79'
Capacity at bank full= 267.67 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 197.0' Slope= 0.0250 '/'
Side Slope Z-value= 3.0 '/'

Reach 9AR: Extended Drainge Channel South of Cell 8



Reach 9BR: (new node)

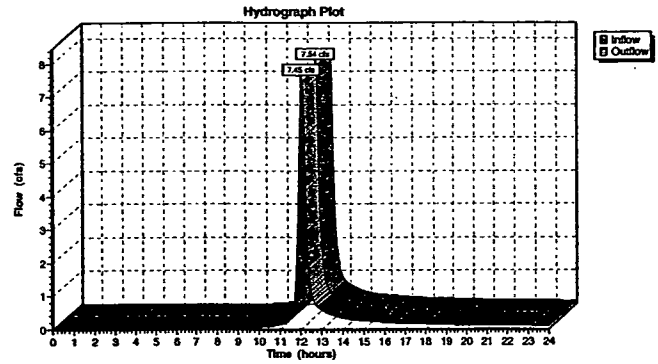
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 7.54 cfs @ 12.06 hrs, Volume= 0.451 af
Outflow = 7.45 cfs @ 12.07 hrs, Volume= 0.450 af, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.61'
Capacity at bank full= 353.53 cfs
72.0" Diameter Pipe n= 0.024 Length= 88.0' Slope= 0.0237 '/'

Reach 9BR: (new node)



Reach 9R: Channel U/S of 30" Culvert

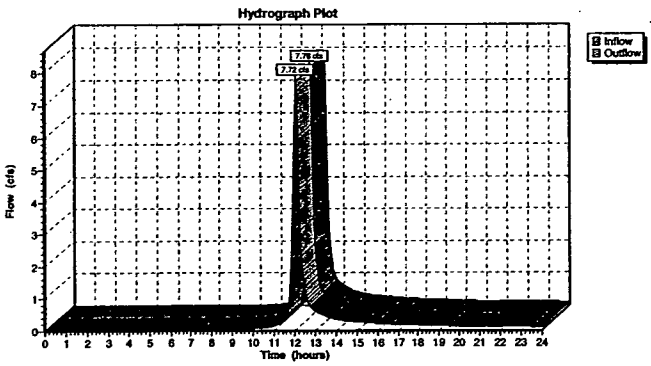
[65] Warning: Inlet elevation not specified

Inflow = 7.76 cfs @ 12.07 hrs, Volume= 0.470 af
Outflow = 7.72 cfs @ 12.07 hrs, Volume= 0.470 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 0.3 min

Peak Depth= 0.80'
Capacity at bank full= 1,695.60 cfs
0.00' x 6.00' deep channel, n= 0.030 Length= 27.3' Slope= 0.0249 '/'
Side Slope Z-value= 3.0 '/'

Reach 9R: Channel U/S of 30" Culvert



Reach 10AR: (new node)

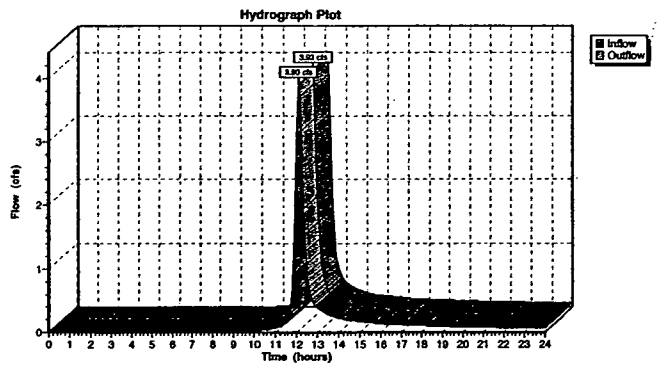
[65] Warning: Inlet elevation not specified

Inflow = 3.93 cfs @ 12.10 hrs, Volume= 0.274 af
Outflow = 3.90 cfs @ 12.11 hrs, Volume= 0.273 af, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.8 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.18'
Capacity at bank full= 243.75 cfs
5.00' x 1.75' deep channel, n= 0.030 Length= 71.4' Slope= 0.0650 '/'
Side Slope Z-value= 3.0 '/'

Reach 10AR: (new node)



Reach 10BR: (new node)

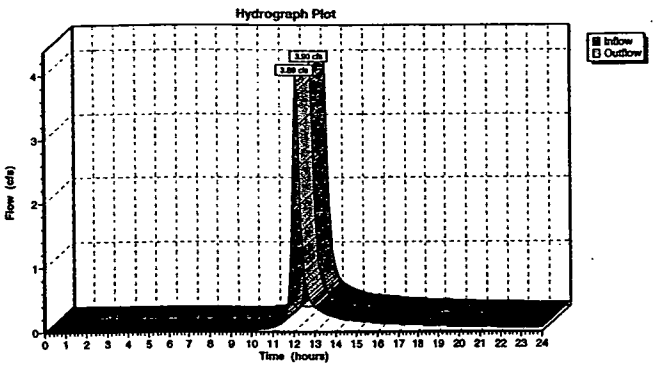
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 3.90 cfs @ 12.11 hrs, Volume= 0.273 af
Outflow = 3.89 cfs @ 12.11 hrs, Volume= 0.273 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.45'
Capacity at bank full= 343.51 cfs
72.0" Diameter Pipe n= 0.013 Length= 38.0' Slope= 0.0066 '/'

Reach 10BR: (new node)



Reach 10R: access road diversion channel

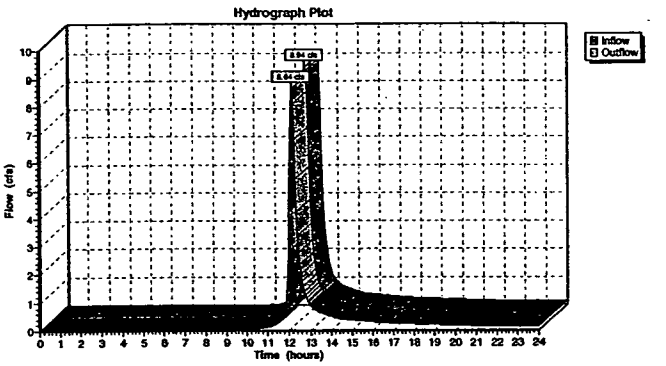
[65] Warning: Inlet elevation not specified

Inflow = 8.94 cfs @ 12.08 hrs, Volume= 0.601 af
Outflow = 8.64 cfs @ 12.16 hrs, Volume= 0.598 af, Atten= 3%, Lag= 4.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.0 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 9.1 min

Peak Depth= 0.51'
Capacity at bank full= 172.90 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 320.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 '/'

Reach 10R: access road diversion channel



Reach 11AR: (new node)

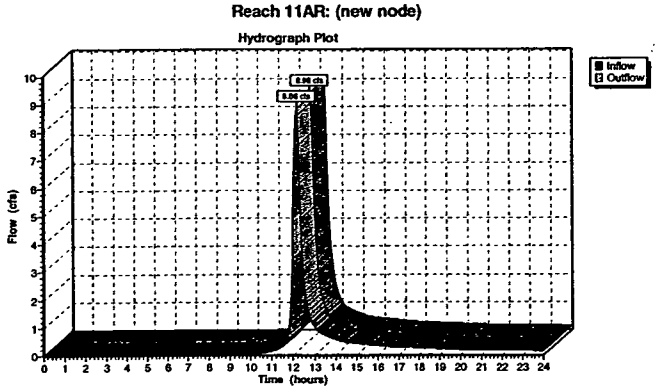
[65] Warning: Inlet elevation not specified

Inflow = 8.96 cfs @ 12.15 hrs, Volume= 0.665 af
Outflow = 8.86 cfs @ 12.17 hrs, Volume= 0.664 af, Atten= 1%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.0 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 1.7 min

Peak Depth= 0.52'
Capacity at bank full= 170.32 cfs
7.00' x 2.50' deep channel, n= 0.030 Length= 60.0' Slope= 0.0050 '/'
Side Slope Z-value= 2.8 3.0 '/'

Reach 11AR: (new node)



Reach 11R: culvert

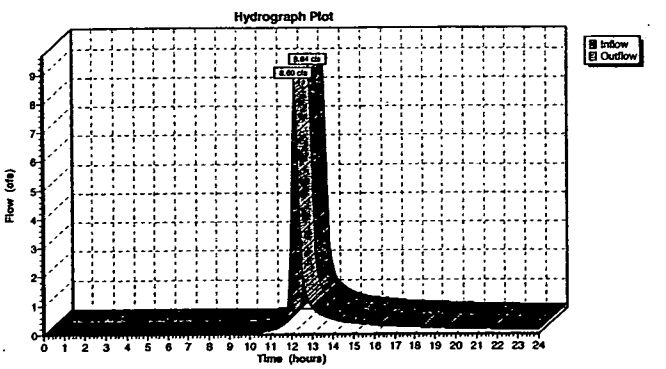
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 8.64 cfs @ 12.16 hrs, Volume= 0.598 af
Outflow = 8.60 cfs @ 12.16 hrs, Volume= 0.598 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.5 min

Peak Depth= 0.74'
Capacity at bank full= 264.80 cfs
72.0" Diameter Pipe n= 0.013 Length= 48.6' Slope= 0.0039 '/'

Reach 11R: culvert



Reach 12: Culvert from F Street Drainage Channel

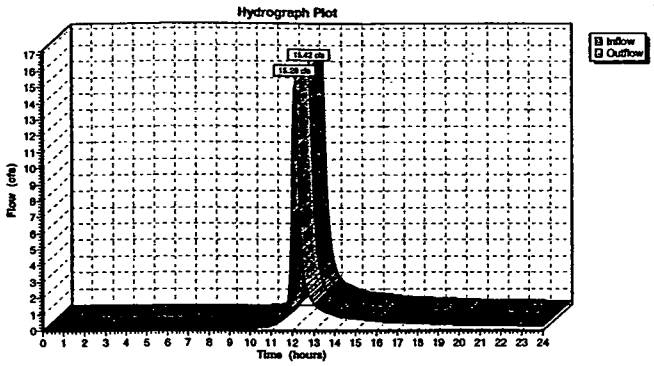
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	15.42 cfs @	12.11 hrs, Volume=	1.134 af	
Outflow	=	15.28 cfs @	12.12 hrs, Volume=	1.133 af, Atten= 1%, Lag= 0.9 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.4 min

Peak Depth= 0.79'
Capacity at bank full= 413.70 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.013 Length= 104.8' Slope= 0.0024 '/'

Reach 12: Culvert from F Street Drainage Channel



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Reach 13: (new node)

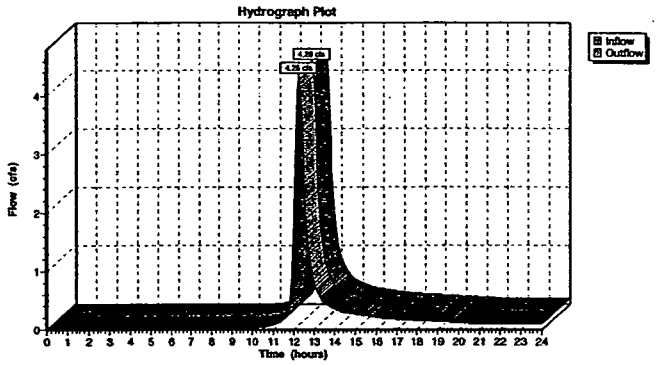
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	4.28 cfs @	12.24 hrs, Volume=	0.402 af	
Outflow	=	4.26 cfs @	12.25 hrs, Volume=	0.402 af, Atten= 0%, Lag= 0.8 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.44'
Capacity at bank full= 386.61 cfs
72.0" Diameter Pipe n= 0.013 Length= 120.0' Slope= 0.0083 '/'

Reach 13: (new node)



Reach 14: Culvert from North Entrance Road channel

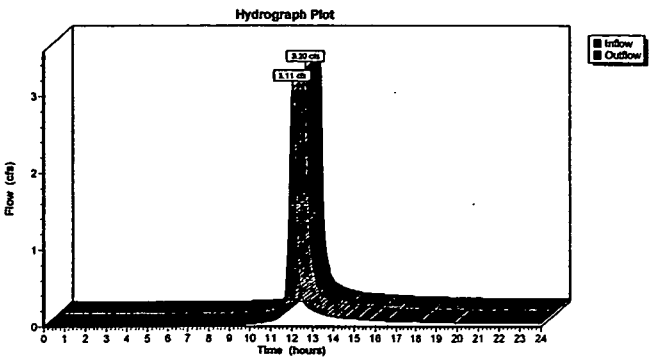
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	3.20 cfs @	12.01 hrs, Volume=	0.169 af	
Outflow	=	3.11 cfs @	12.03 hrs, Volume=	0.169 af, Atten= 3%, Lag= 1.0 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.5 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 1.3 min

Peak Depth= 0.27'
Capacity at bank full= 822.56 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 112.0' Slope= 0.0321 '/'

Reach 14: Culvert from North Entrance Road channel



Reach 15N: Culvert adjacent to North Entrance Road

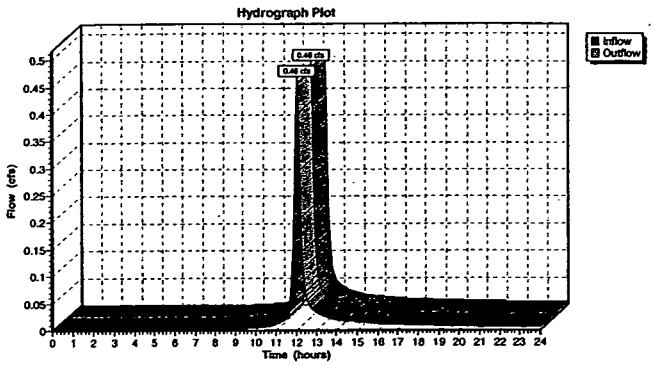
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	0.46 cfs @	12.04 hrs, Volume=	0.027 af	
Outflow	=	0.46 cfs @	12.05 hrs, Volume=	0.027 af, Atten= 1%, Lag= 0.6 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.15'
Capacity at bank full= 406.62 cfs
72.0" Diameter Pipe n= 0.010 Length= 55.0' Slope= 0.0055 '/'

Reach 15N: Culvert adjacent to North Entrance Road



Reach 16N: Channel east of North Entrance Road

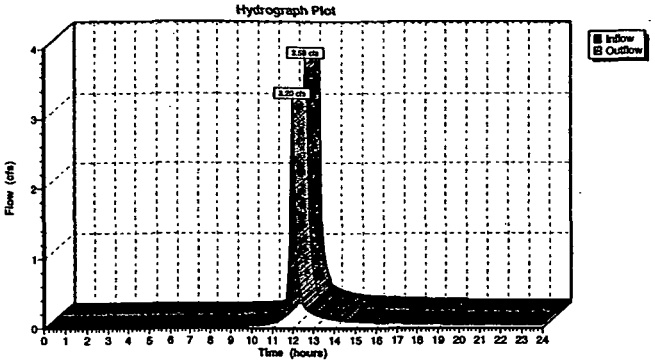
[65] Warning: Inlet elevation not specified

Inflow	=	3.58 cfs @	11.94 hrs, Volume=	0.170 af	
Outflow	=	3.20 cfs @	12.01 hrs, Volume=	0.169 af, Atten= 11%, Lag= 4.6 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 7.7 min

Peak Depth= 0.90'
Capacity at bank full= 71.46 cfs
0.00' x 2.88' deep channel, n= 0.030 Length= 382.0' Slope= 0.0069 '/'
Side Slope Z-value= 2.2 1.4 '/'

Reach 16N: Channel east of North Entrance Road



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Pond 1P: Sedimentation Basin 2

Inflow	=	63.87 cfs @	12.31 hrs, Volume=	7.491 af	
Outflow	=	0.00 cfs @	0.00 hrs, Volume=	0.000 af, Atten= 100%, Lag= 0.0 min	
Primary	=	0.00 cfs @	0.00 hrs, Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

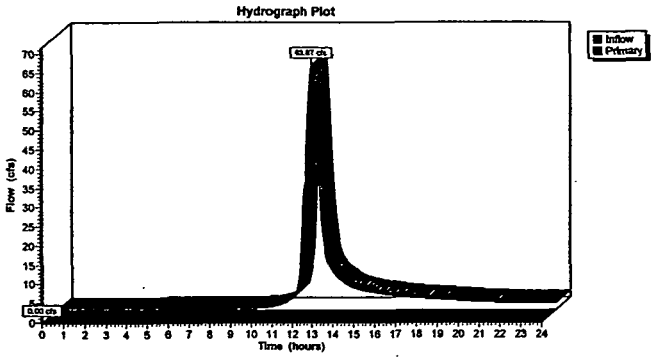
Peak Elev= 574.94' Storage= 7.487 af
Plug-Flow detention time= (not calculated)
Storage and wetted areas determined by Conic sections

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
570.50	1.460	0.000	0.000	1.460
571.00	1.512	0.743	0.743	1.513
572.00	1.614	1.563	2.306	1.617
573.00	1.713	1.663	3.969	1.719
574.00	1.819	1.766	5.735	1.827
575.00	1.917	1.868	7.602	1.928
576.00	2.026	1.971	9.574	2.039
577.00	2.162	2.094	11.667	2.177

Primary OutFlow (Free Discharge)
- 2=Culvert
  - 1=Orifice/Grate
- 3=Broad-Crested Rectangular Weir

#	Routing	Invert	Outlet Devices
1	Device 2	575.50'	48.0" Horiz. Orifice/Grate Limited to weir flow C= 0.600
2	Primary	570.78'	36.0" x 680.0' long Culvert Ke= 0.700
			Outlet Invert= 563.30' S= 0.0110 '/' n= 0.024 Cc= 0.900
3	Primary	576.00'	20.0' long Broad-Crested Rectangular Weir
			Head (feet) 0.50 1.00 1.50 2.00 2.50 3.00 4.00 5.00
			Coef. (English) 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00

Pond 1P: Sedimentation Basin 2



ATTACHMENT C-1E

HydroCAD™ OUTPUT REPORTS

DESIGN CASE "A"

DESIGN CASE "A"

25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: liner runout — Tc=3.4 min CN=89 Area=1.927 ac Runoff= 12.05 cfs 0.559 af

Subcatchment B: construction laydown — Tc=32.9 min CN=82 Area=0.880 ac Runoff= 2.02 cfs 0.205 af

Subcatchment C: construction laydown — Tc=25.9 min CN=82 Area=0.711 ac Runoff= 1.90 cfs 0.166 af

Subcatchment D: construction laydown — Tc=30.7 min CN=82 Area=0.654 ac Runoff= 1.57 cfs 0.152 af

Subcatchment E: construction laydown — Tc=30.8 min CN=82 Area=1.287 ac Runoff= 3.08 cfs 0.299 af

Subcatchment F: construction laydown — Tc=28.3 min CN=82 Area=0.336 ac Runoff= 0.85 cfs 0.078 af

Subcatchment G: construction laydown — Tc=9.8 min CN=82 Area=1.858 ac Runoff= 7.91 cfs 0.435 af

Subcatchment H: construction laydown/pavement — Tc=19.1 min CN=92 Area=0.650 ac Runoff= 2.68 cfs 0.205 af

Reach 1: existing culvert — Inflow= 2.02 cfs 0.205 af
Length= 60.0' Max Vel= 2.7 fps Capacity= 677.07 cfs Outflow= 2.01 cfs 0.204 af

Reach 2: channel — Inflow= 2.01 cfs 0.204 af
Length= 330.0' Max Vel= 2.1 fps Capacity= 352.90 cfs Outflow= 1.99 cfs 0.204 af

Reach 3: existing culverts — Inflow= 8.41 cfs 0.638 af
Length= 55.0' Max Vel= 4.6 fps Capacity= 813.23 cfs Outflow= 8.33 cfs 0.638 af

Reach 4: existing culverts — Inflow= 1.90 cfs 0.166 af
Length= 60.0' Max Vel= 4.7 fps Capacity= 1,557.22 cfs Outflow= 1.89 cfs 0.166 af

Reach 5: channel — Inflow= 12.05 cfs 0.559 af
Length= 170.0' Max Vel= 2.1 fps Capacity= 60.78 cfs Outflow= 10.91 cfs 0.559 af

Reach 6: channel — Inflow= 11.74 cfs 0.724 af
Length= 230.0' Max Vel= 1.8 fps Capacity= 12.79 cfs Outflow= 11.05 cfs 0.723 af

Reach 7: channel — Inflow= 20.18 cfs 1.513 af
Length= 185.0' Max Vel= 4.3 fps Capacity= 138.21 cfs Outflow= 19.74 cfs 1.512 af

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Reach 8: new culverts — Inflow= 24.73 cfs 2.095 af
Length= 49.0' Max Vel= 5.5 fps Capacity= 647.72 cfs Outflow= 24.61 cfs 2.094 af

Runoff Area = 8.303 ac Volume = 2.099 af Average Depth = 3.03"

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Subcatchment A: liner runout

[49] Hint: Tc<2dt may require smaller dt

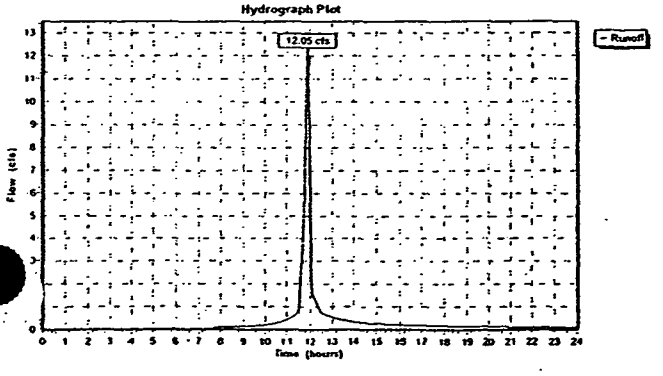
Runoff = 12.05 cfs @ 11.94 hrs, Volume= 0.559 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.927	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0	8	0.6660	3.0		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.3	18	0.0215	0.9		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.2	31	0.2500	2.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
1.2	90	0.0222	1.3		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
1.7	590	0.0100	5.7	949.93	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.50' Z= 3.0 & 50.0 '/' n= 0.030
3.4	737	Total			

Subcatchment A: liner runout



Subcatchment B: construction laydown

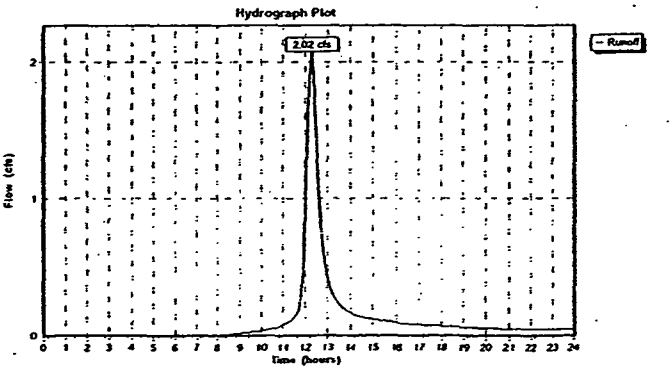
Runoff = 2.02 cfs @ 12.28 hrs, Volume= 0.205 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.880	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.6	300	0.0125	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.3	145	0.0125	1.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
32.9	445	Total			

Subcatchment B: construction laydown



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Subcatchment C: construction laydown

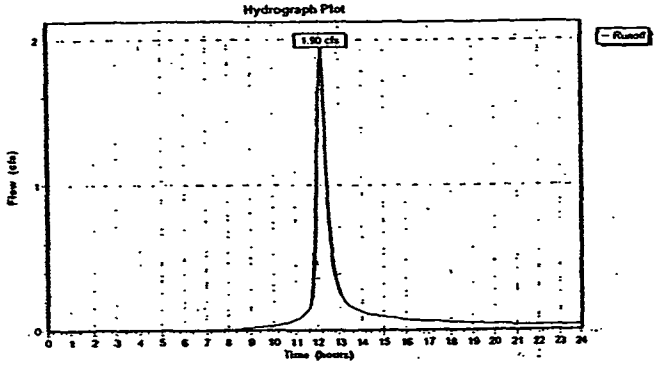
Runoff = 1.90 cfs @ 12.19 hrs, Volume= 0.166 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.711	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
25.9	260	0.0154	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment C: construction laydown



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Subcatchment D: construction laydown

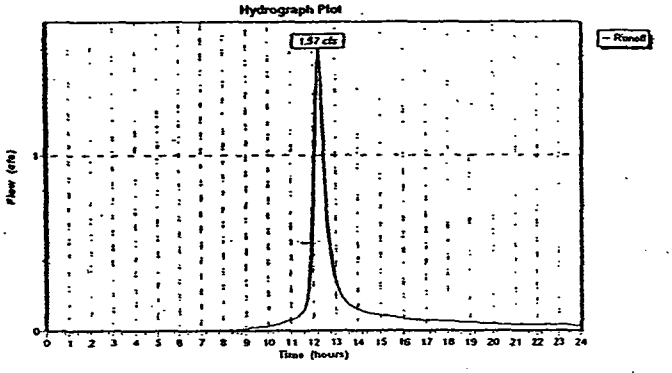
Runoff = 1.57 cfs @ 12.25 hrs, Volume= 0.152 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.654	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	85	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
23.4	215	0.0136	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.3	30	0.0136	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	60	0.0050	2.8	18.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.50' Z= 3.0 '7 n= 0.030
30.7	390	Total			

Subcatchment D: construction laydown



Subcatchment E: construction laydown

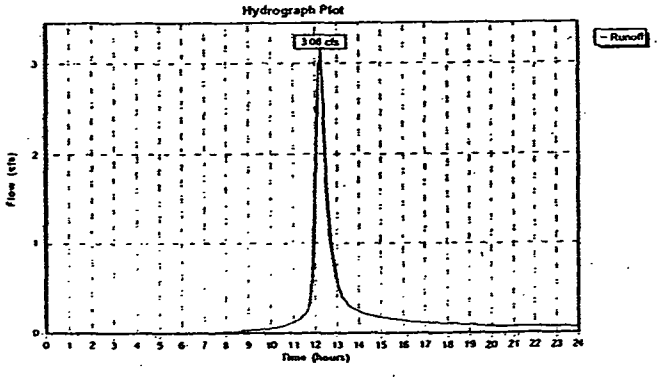
Runoff = 3.08 cfs @ 12.25 hrs, Volume= 0.299 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.287	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.8	300	0.0133	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment E: construction laydown



Subcatchment F: construction laydown

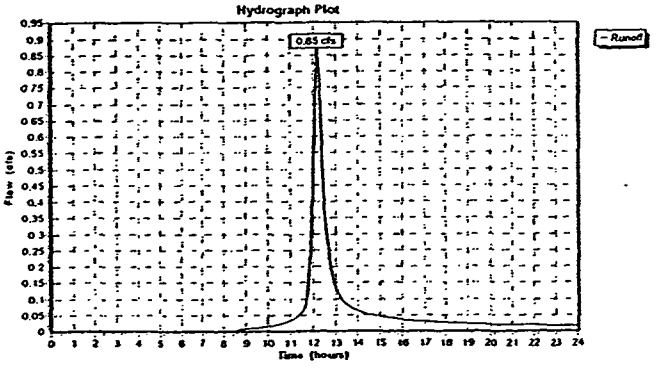
Runoff = 0.85 cfs @ 12.22 hrs, Volume= 0.078 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.336	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.1	20	0.3750	2.9		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
5.0	60	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.3	55	0.0600	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
17.7	165	0.0161	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.2	150	0.0161	2.0		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
28.3	450	Total			

Subcatchment F: construction laydown



Subcatchment G: construction laydown

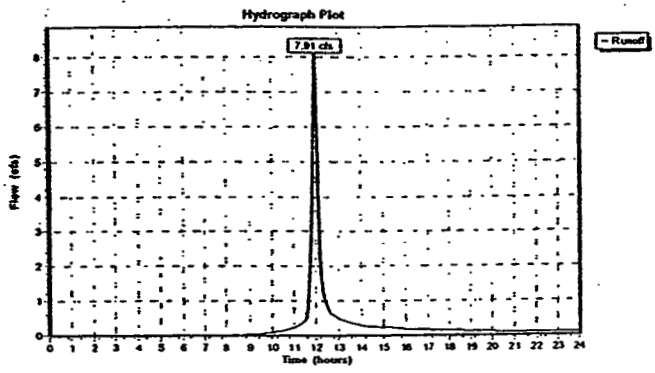
Runoff = 7.91 cfs @ 12.01 hrs, Volume= 0.435 af

SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
hr Rainfall=4.70"

Area (ac)	CN	Description
1.858	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	85	0.0235	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.9	330	0.0150	6.0	119.69	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 4.0 & 6.0 '/' n= 0.030
9.8	415	Total			

Subcatchment G: construction laydown



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Subcatchment H: construction laydown/pavement

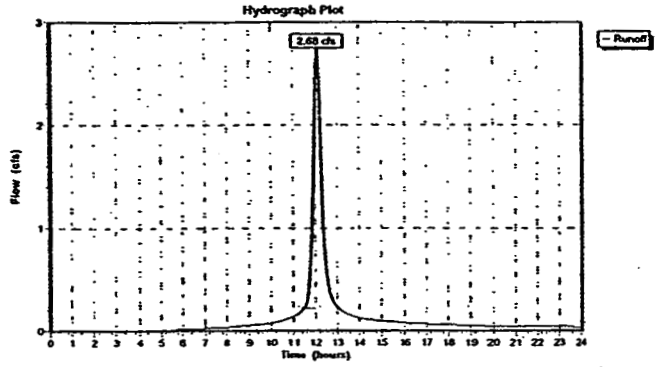
Runoff = 2.68 cfs @ 12.11 hrs, Volume= 0.205 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.650	92	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	165	0.0182	1.3		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
17.0	115	0.0087	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
19.1	280	Total			

Subcatchment H: construction laydown/pavement



Reach 1: existing culvert

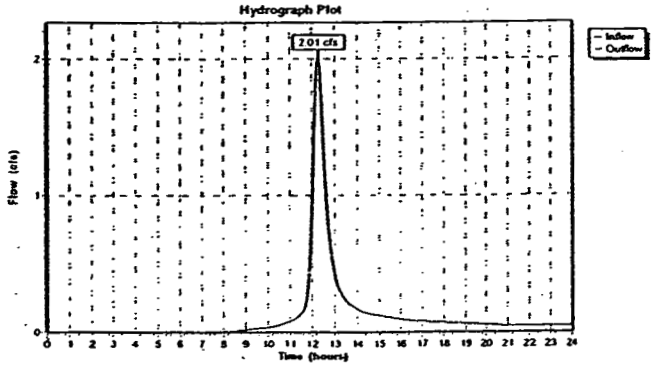
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 2.02 cfs @ 12.28 hrs, Volume= 0.205 af
Outflow = 2.01 cfs @ 12.29 hrs, Volume= 0.204 af, Atten= 0%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.1 min

Peak Depth= 0.24'
Capacity at bank full= 677.07 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 80.0' Slope= 0.0123 '/'

Reach 1: existing culvert



Reach 2: channel

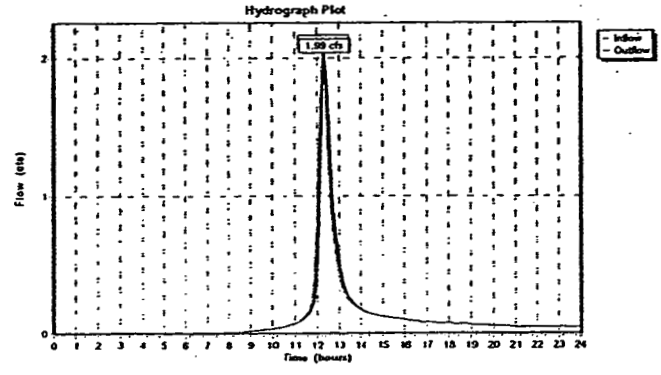
[65] Warning: Inlet elevation not specified

Inflow = 2.01 cfs @ 12.29 hrs, Volume= 0.204 af
Outflow = 1.99 cfs @ 12.37 hrs, Volume= 0.204 af, Atten= 1%, Lag= 4.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 2.6 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 5.8 min

Peak Depth= 0.43'
Capacity at bank full= 352.90 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 330.0' Slope= 0.0150 '/'
Side Slope Z-value= 4.0 6.0 '/'

Reach 2: channel



Reach 3: existing culverts

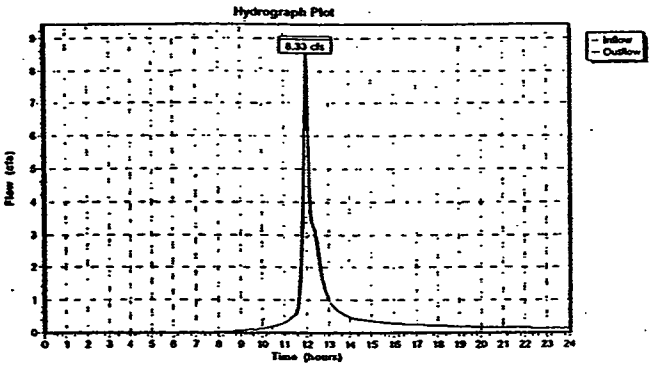
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 8.41 cfs @ 12.02 hrs, Volume= 0.638 af
Outflow = 8.33 cfs @ 12.02 hrs, Volume= 0.638 af, Atten= 1%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 0.5 min

Peak Depth= 0.43'
Capacity at bank full= 813.23 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 55.0' Slope= 0.0055 '/'

Reach 3: existing culverts



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Reach 4: existing culverts

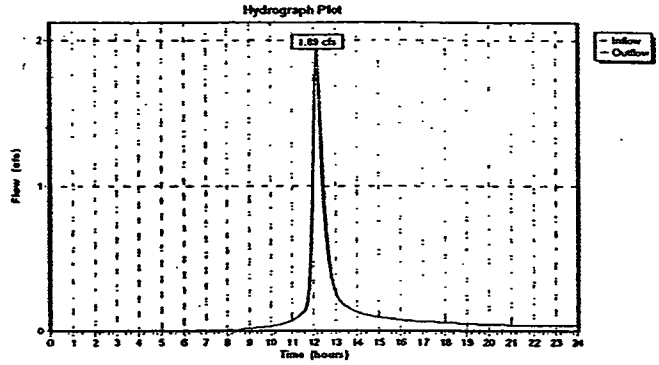
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 1.90 cfs @ 12.19 hrs, Volume= 0.166 af
Outflow = 1.89 cfs @ 12.20 hrs, Volume= 0.166 af, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.16'
Capacity at bank full= 1,557.22 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.010 Length= 60.0' Slope= 0.0200 '/'

Reach 4: existing culverts



Reach 5: channel

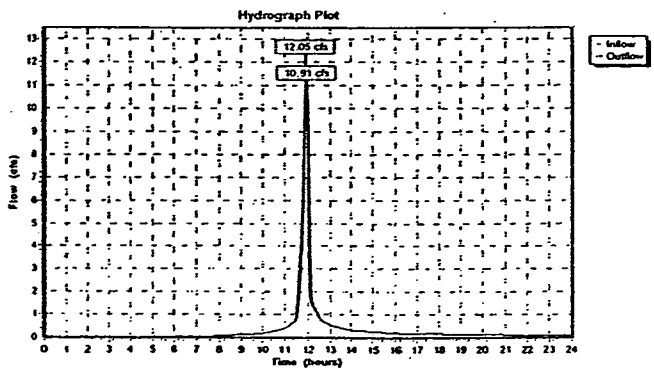
[65] Warning: Inlet elevation not specified

Inflow = 12.05 cfs @ 11.94 hrs, Volume= 0.559 af
Outflow = 10.91 cfs @ 11.97 hrs, Volume= 0.559 af, Atten= 10%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.1 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 3.8 min

Peak Depth= 1.34'
Capacity at bank full= 60.78 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 170.0' Slope= 0.0034 '/'
Side Slope Z-value= 3.0 '/'

Reach 5: channel



Reach 6: channel

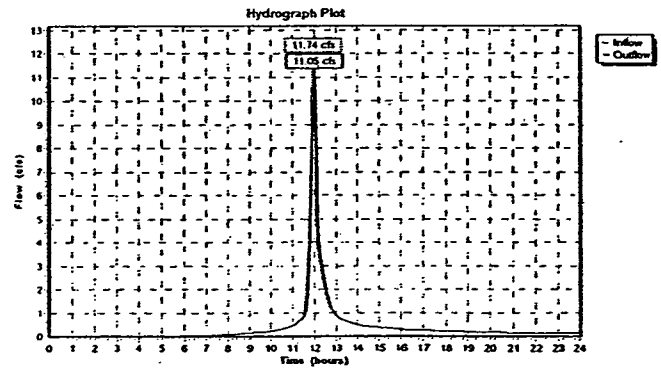
[65] Warning: Inlet elevation not specified

Inflow = 11.74 cfs @ 11.97 hrs, Volume= 0.724 af
Outflow = 11.05 cfs @ 12.03 hrs, Volume= 0.723 af, Atten= 6%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.8 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 5.6 min

Peak Depth= 1.44'
Capacity at bank full= 12.79 cfs
0.00' x 1.50' deep channel, n= 0.030 Length= 230.0' Slope= 0.0023 '/'
Side Slope Z-value= 3.0 '/'

Reach 6: channel



Reach 7: channel

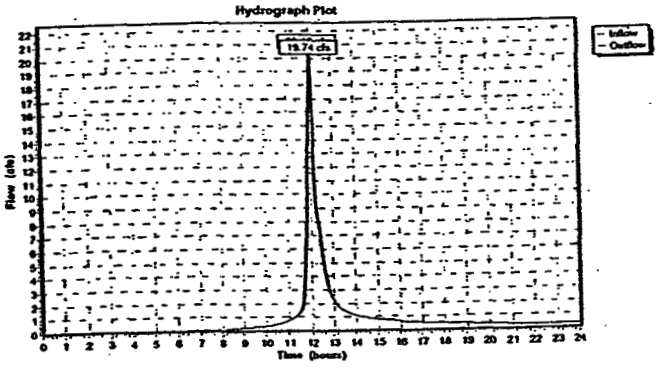
[65] Warning: Inlet elevation not specified

Inflow	=	20.18 cfs @	12.03 hrs, Volume=	1.513 af	
Outflow	=	19.74 cfs @	12.05 hrs, Volume=	1.512 af,	Atten= 2%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 1.9 min

Peak Depth= 0.97'
Capacity at bank full= 138.21 cfs
0.00' x 2.00' deep channel, n= 0.030 Length= 185.0' Slope= 0.0200 '/'
Side Slope Z-value= 4.0 6.0 '/'

Reach 7: channel



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Reach 8: new culverts

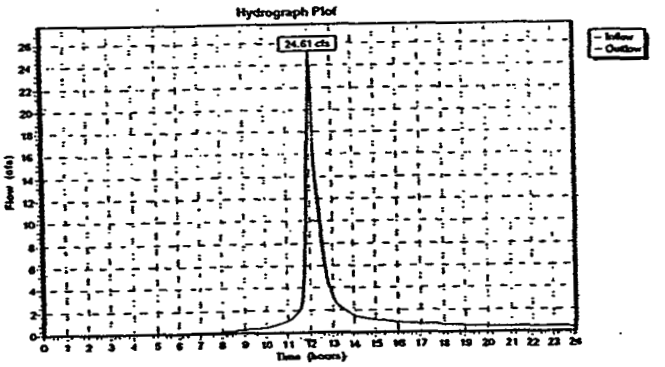
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow	=	24.73 cfs @	12.06 hrs, Volume=	2.095 af	
Outflow	=	24.61 cfs @	12.07 hrs, Volume=	2.094 af,	Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.5 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.80'
Capacity at bank full= 647.72 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.017 Length= 49.0' Slope= 0.0100 '/'

Reach 8: new culverts



ATTACHMENT C-1F

HydroCAD™ OUTPUT REPORTS

DESIGN CASE "B"

ATTACHMENT C-1F

HydroCAD™ OUTPUT REPORTS

DESIGN CASE "B"

DESIGN CASE "B"

25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: Cell 3 Non Veg Final Cover
Tc=2.6 min CN=89 Area=5.131 ac Runoff= 32.36 cfs 1.490 af

Subcatchment B: Cell 4 Non Veg Final Cover
Tc=2.6 min CN=89 Area=5.092 ac Runoff= 32.11 cfs 1.479 af

Subcatchment C: Cell 5 Subgrade
Tc=0.8 min CN=87 Area=1.190 ac Runoff= 7.51 cfs 0.326 af

Subcatchment D: Cell 6 Subgrade
Tc=0.8 min CN=87 Area=1.190 ac Runoff= 7.51 cfs 0.326 af

Subcatchment E: Cell 7 Subgrade
Tc=0.8 min CN=87 Area=1.760 ac Runoff= 11.10 cfs 0.482 af

Subcatchment F1: Construction Support South of Haul Road
Tc=5.7 min CN=82 Area=0.241 ac Runoff= 1.17 cfs 0.056 af

Subcatchment F2: Construction Support South of Haul Road
Tc=5.5 min CN=82 Area=0.510 ac Runoff= 2.49 cfs 0.119 af

Subcatchment G: Cell 7 Subgrade South of Inner Cell Berm
Tc=1.0 min CN=87 Area=2.190 ac Runoff= 13.70 cfs 0.600 af

Subcatchment H: Cell 7 Subgrade/Construction Support
Tc=12.4 min CN=85 Area=0.500 ac Runoff= 2.13 cfs 0.128 af

Subcatchment I: Construction Support South of Runoff Diversion Channel
Tc=30.8 min CN=82 Area=1.450 ac Runoff= 3.47 cfs 0.337 af

Subcatchment J: Construction Support South of Runoff Diversion Channel
Tc=19.6 min CN=82 Area=0.744 ac Runoff= 2.34 cfs 0.174 af

Subcatchment K: Cell 1 Vegetated Final Cover
Tc=2.4 min CN=83 Area=1.964 ac Runoff= 10.77 cfs 0.475 af

Subcatchment L: Cell 2 Vegetated Final Cover
Tc=14.4 min CN=83 Area=1.683 ac Runoff= 6.37 cfs 0.406 af

Subcatchment M: Cell 1 Vegetated Final Cover
Tc=3.9 min CN=83 Area=1.179 ac Runoff= 6.31 cfs 0.285 af

Reach 1: Runoff Diversion Channel Cell 3 Inflow= 45.68 cfs 2.653 af
Length= 420.0' Max Vel= 3.1 fps Capacity= 1,205.98 cfs Outflow= 42.00 cfs 2.647 af

Reach 2: Runoff Diversion Channel Cell 4 Inflow= 66.65 cfs 4.125 af
Length= 420.0' Max Vel= 3.7 fps Capacity= 1,563.67 cfs Outflow= 62.42 cfs 4.117 af

Reach 3: Runoff Diversion Channel Cell 5 Inflow= 64.14 cfs 4.443 af
Length= 420.0' Max Vel= 3.6 fps Capacity= 1,106.53 cfs Outflow= 61.84 cfs 4.435 af

Reach 4: Runoff Diversion Channel Cell 6 Inflow= 62.72 cfs 4.761 af
Length= 400.0' Max Vel= 3.4 fps Capacity= 182.58 cfs Outflow= 60.87 cfs 4.752 af

Reach 5: Runoff Diversion Channel Cell 7 Inflow= 62.18 cfs 5.234 af
Length= 510.0' Max Vel= 3.4 fps Capacity= 182.58 cfs Outflow= 60.63 cfs 5.221 af

Reach 6A: Runoff Diversion Channel Inflow= 64.11 cfs 5.615 af
Length= 235.0' Max Vel= 3.4 fps Capacity= 242.25 cfs Outflow= 63.08 cfs 5.607 af

Reach 6B: Runoff Diversion Channel Inflow= 65.36 cfs 5.900 af
Length= 318.0' Max Vel= 3.6 fps Capacity= 115.68 cfs Outflow= 64.43 cfs 5.890 af

Reach 7: 2-49x33 Culverts Inflow= 64.43 cfs 5.890 af
Length= 92.0' Max Vel= 5.3 fps Capacity= 413.33 cfs Outflow= 64.20 cfs 5.888 af

Reach 8: Inner Cell Drainage Channel Inflow= 13.70 cfs 0.600 af
Length= 575.0' Max Vel= 3.0 fps Capacity= 37.08 cfs Outflow= 12.04 cfs 0.597 af

Reach 9: Inner Cell Drainage Channel Inflow= 13.96 cfs 0.726 af
Length= 200.0' Max Vel= 3.9 fps Capacity= 127.44 cfs Outflow= 13.29 cfs 0.725 af

Reach 11: Runoff Diversion Channel Cell 2 Inflow= 20.89 cfs 1.166 af
Length= 420.0' Max Vel= 2.4 fps Capacity= 754.76 cfs Outflow= 18.93 cfs 1.163 af

Runoff Area = 24.824 ac Volume = 6.683 af Average Depth = 3.23"

Subcatchment A: Cell 3 Non Veg Final Cover

[49] Hint: Tc<2dt may require smaller dt

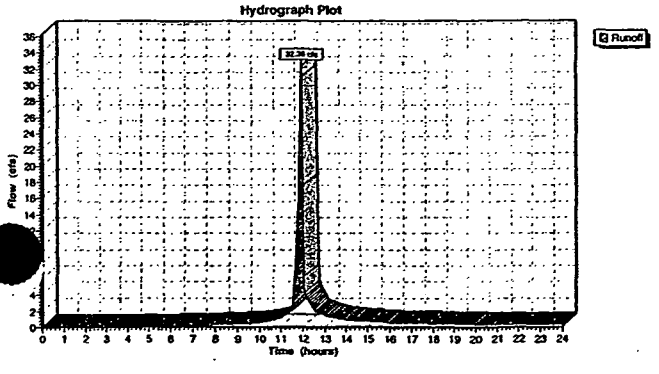
Runoff = 32.36 cfs @ 11.93 hrs, Volume= 1.490 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.131	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	60	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1700	3.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.6	470	Total			

Subcatchment A: Cell 3 Non Veg Final Cover



Subcatchment B: Cell 4 Non Veg Final Cover

[49] Hint: Tc<2dt may require smaller dt

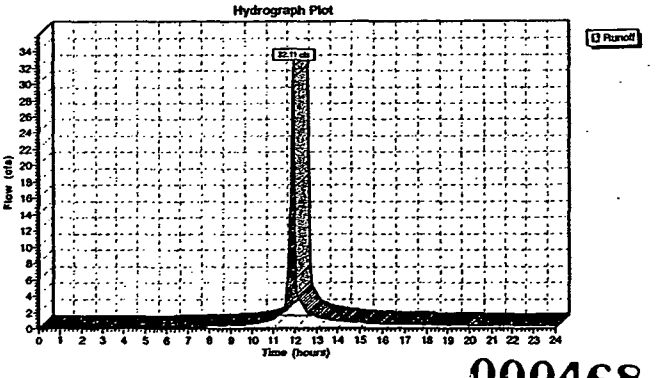
Runoff = 32.11 cfs @ 11.93 hrs, Volume= 1.479 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.092	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	60	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1700	3.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.6	470	Total			

Subcatchment B: Cell 4 Non Veg Final Cover



Subcatchment C: Cell 5 Subgrade

[49] Hint: Tc<2dt may require smaller dt

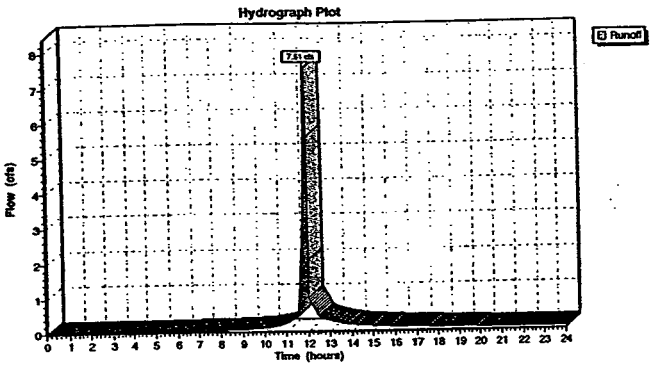
Runoff = 7.51 cfs @ 11.90 hrs, Volume= 0.326 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.190	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	55	0.2000	2.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	50	0.0602	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	105	Total			

Subcatchment C: Cell 5 Subgrade



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Subcatchment D: Cell 6 Subgrade

[49] Hint: Tc<2dt may require smaller dt

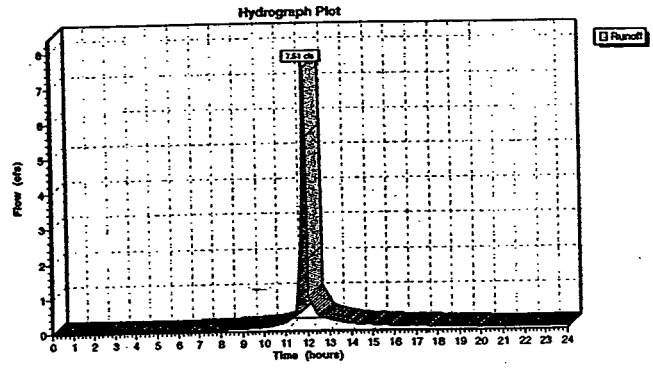
Runoff = 7.51 cfs @ 11.90 hrs, Volume= 0.326 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.190	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	55	0.2000	2.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	50	0.0602	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	105	Total			

Subcatchment D: Cell 6 Subgrade



Subcatchment E: Cell 7 Subgrade

[49] Hint: Tc<2dt may require smaller dt

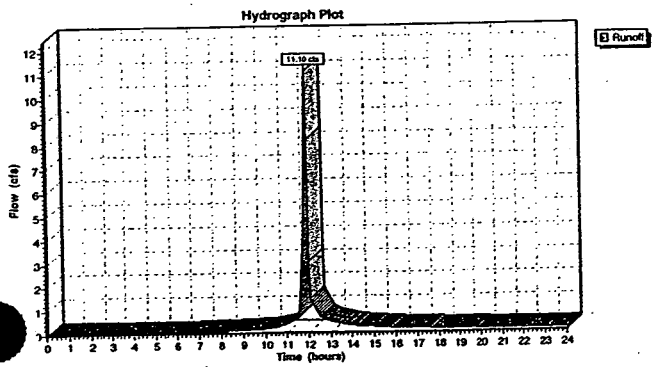
Runoff = 11.10 cfs @ 11.90 hrs, Volume= 0.482 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.760	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	55	0.2000	2.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	50	0.0602	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	105	Total			

Subcatchment E: Cell 7 Subgrade



Subcatchment F1: Construction Support South of Haul Road

[49] Hint: Tc<2dt may require smaller dt

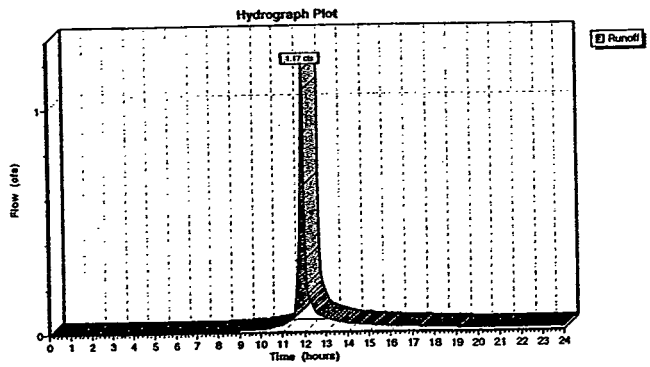
Runoff = 1.17 cfs @ 11.96 hrs, Volume= 0.056 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.241	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	12	0.0100	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.5	8	0.3300	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
2.5	15	0.0180	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
5.7	35	Total			

Subcatchment F1: Construction Support South of Haul Road



Subcatchment F2: Construction Support South of Haul Road

[49] Hint: Tc<2dt may require smaller dt

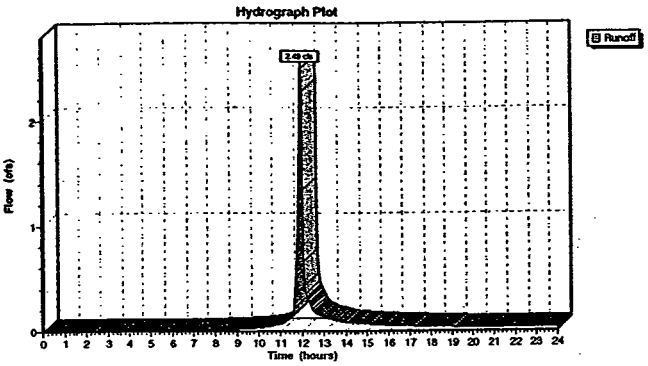
Runoff = 2.49 cfs @ 11.96 hrs, Volume= 0.119 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.510	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	12	0.0100	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
0.7	14	0.3300	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
2.1	21	0.0540	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
5.5	47	Total			

Subcatchment F2: Construction Support South of Haul Road



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Subcatchment G: Cell 7 Subgrade South of Inner Cell Berm

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[49] Hint: Tc<2dt may require smaller dt

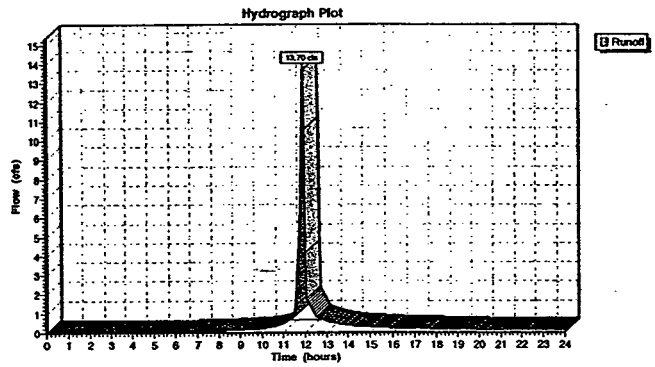
Runoff = 13.70 cfs @ 11.90 hrs, Volume= 0.600 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.190	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	24	0.2500	2.5		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	48	0.0200	1.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
1.0	72	Total			

Subcatchment G: Cell 7 Subgrade South of Inner Cell Berm



Subcatchment H: Cell 7 Subgrade/Construction Support

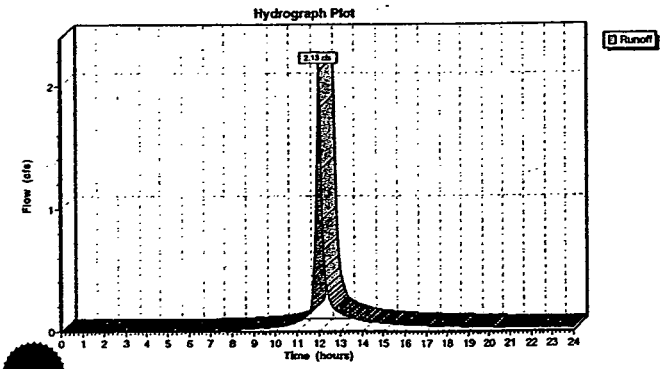
Runoff = 2.13 cfs @ 12.04 hrs, Volume= 0.128 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
0.250	82	
0.250	87	
0.500	85	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	93	0.0127	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"

Subcatchment H: Cell 7 Subgrade/Construction Support



Subcatchment I: Construction Support South of Runoff Diversion Channel

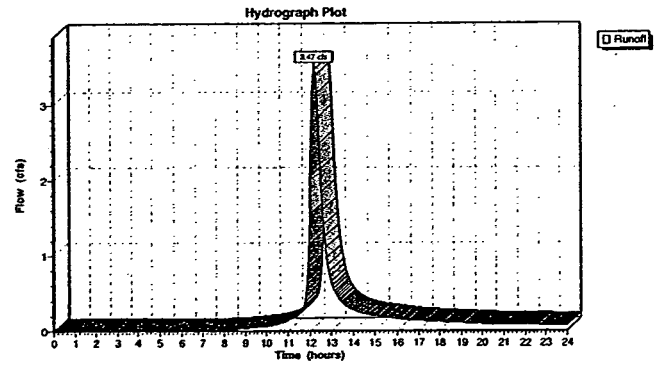
Runoff = 3.47 cfs @ 12.25 hrs, Volume= 0.337 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.450	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.9	150	0.0040	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
1.9	116	0.0040	1.0		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
30.8	266	Total			

Subcatchment I: Construction Support South of Runoff Diversion Channel



Subcatchment J: Construction Support South of Runoff Diversion Channel

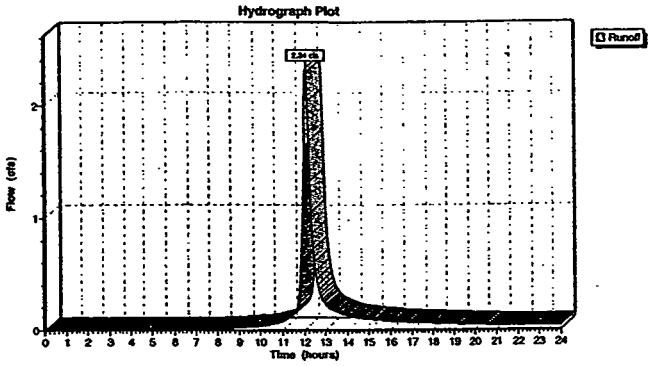
Runoff = 2.34 cfs @ 12.12 hrs, Volume= 0.174 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
T[illegible]4-hr Rainfall=4.70"

[illegible]ac)	CN	Description
[illegible].744	82	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	166	0.0160	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"
1.6	169	0.0120	1.8		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
19.6	335	Total			

Subcatchment J: Construction Support South of Runoff Diversion Channel



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Subcatchment K: Cell 1 Vegetated Final Cover

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[49] Hint: Tc<2dt may require smaller dt

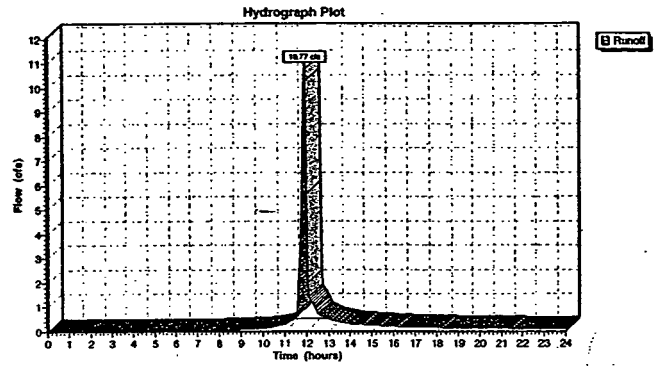
Runoff = 10.77 cfs @ 11.93 hrs, Volume= 0.475 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.964	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.7		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.5	60	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.8	150	0.1700	3.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
0.2	80	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.4	380	Total			

Subcatchment K: Cell 1 Vegetated Final Cover



Subcatchment L: Cell 2 Vegetated Final Cover

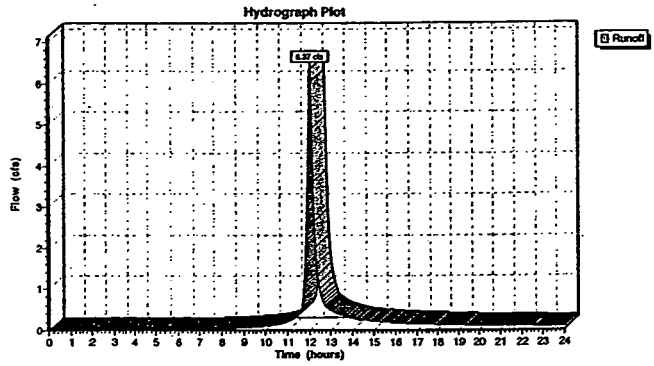
Runoff = 6.37 cfs @ 12.06 hrs, Volume= 0.406 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.683	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.4	140	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.55"

Subcatchment L: Cell 2 Vegetated Final Cover



Subcatchment M: Cell 1 Vegetated Final Cover

[49] Hint: Tc<2dt may require smaller dt

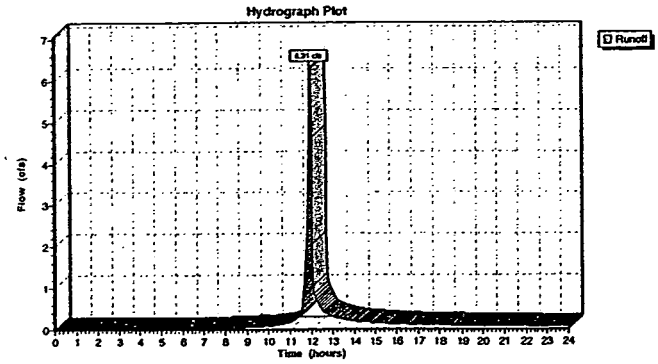
Runoff = 6.31 cfs @ 11.94 hrs, Volume= 0.285 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
1.179	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	50	0.1800	2.6		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.55"
3.6	450	0.0045	2.1	9.75	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.02' Z= 3.0 & 6.0 '/' n= 0.030
3.9	500	Total			

Subcatchment M: Cell 1 Vegetated Final Cover



Reach 1: Runoff Diversion Channel Cell 3

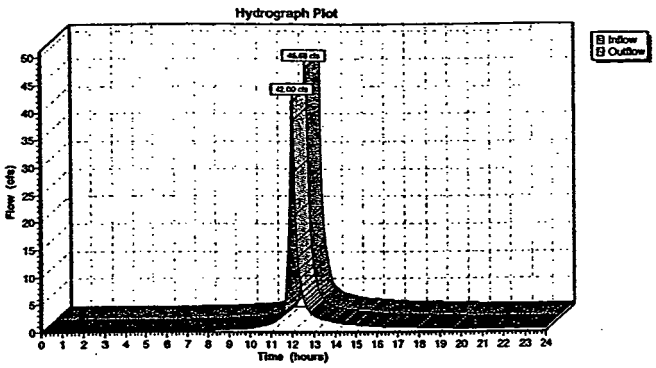
[65] Warning: Inlet elevation not specified

Inflow = 45.68 cfs @ 11.94 hrs, Volume= 2.653 af
Outflow = 42.00 cfs @ 12.01 hrs, Volume= 2.647 af, Atten= 8%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.1 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.2 min

Peak Depth= 1.86'
Capacity at bank full= 1,205.98 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 5.0 3.0 '/'

Reach 1: Runoff Diversion Channel Cell 3



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Reach 2: Runoff Diversion Channel Cell 4

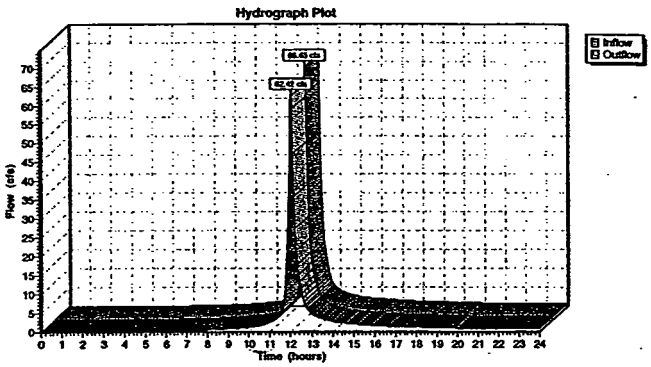
[65] Warning: Inlet elevation not specified

Inflow = 66.65 cfs @ 11.95 hrs, Volume= 4.125 af
Outflow = 62.42 cfs @ 12.01 hrs, Volume= 4.117 af, Atten= 6%, Lag= 3.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 5.2 min

Peak Depth= 2.23'
Capacity at bank full= 1,563.67 cfs
0.00' x 7.40' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 2: Runoff Diversion Channel Cell 4



Reach 3: Runoff Diversion Channel Cell 5

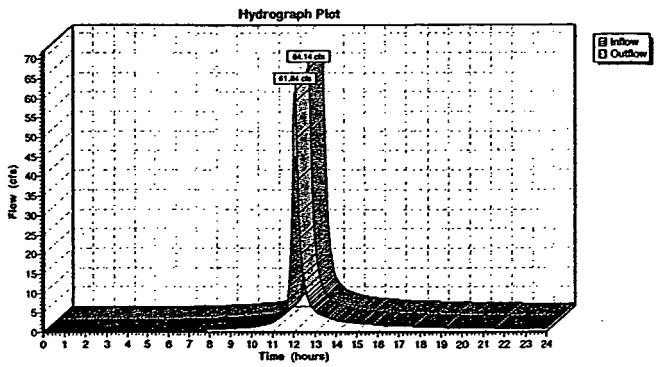
[65] Warning: Inlet elevation not specified

Inflow = 64.14 cfs @ 12.00 hrs, Volume= 4.443 af
Outflow = 61.84 cfs @ 12.06 hrs, Volume= 4.435 af, Atten= 4%, Lag= 3.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.6 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 5.1 min

Peak Depth= 2.22'
Capacity at bank full= 1,106.53 cfs
0.00' x 6.50' deep channel, n= 0.030 Length= 420.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 4.0 '/'

Reach 3: Runoff Diversion Channel Cell 5



Reach 4: Runoff Diversion Channel Cell 6

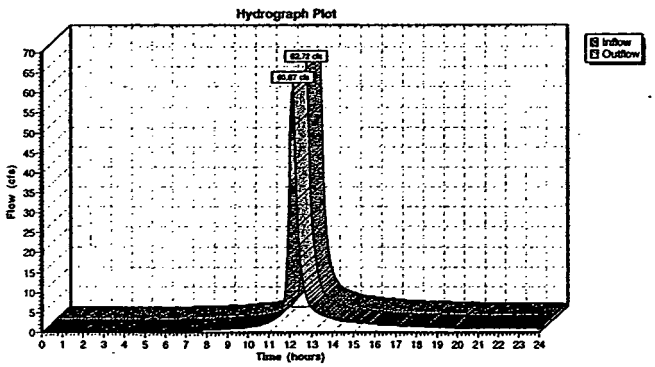
[65] Warning: Inlet elevation not specified

Inflow = 62.72 cfs @ 12.06 hrs, Volume= 4.761 af
Outflow = 60.87 cfs @ 12.11 hrs, Volume= 4.752 af, Atten= 3%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.0 min

Peak Depth= 2.00'
Capacity at bank full= 182.58 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 4: Runoff Diversion Channel Cell 6



Reach 5: Runoff Diversion Channel Cell 7

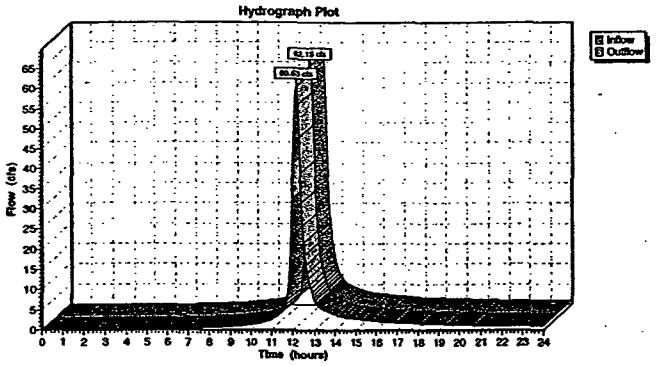
[65] Warning: Inlet elevation not specified

Inflow = 62.18 cfs @ 12.11 hrs, Volume= 5.234 af
Outflow = 60.63 cfs @ 12.18 hrs, Volume= 5.221 af, Atten= 3%, Lag= 4.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 6.2 min

Peak Depth= 1.99'
Capacity at bank full= 182.58 cfs
0.00' x 3.00' deep channel, n= 0.030 Length= 510.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 5: Runoff Diversion Channel Cell 7



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Reach 6A: Runoff Diversion Channel

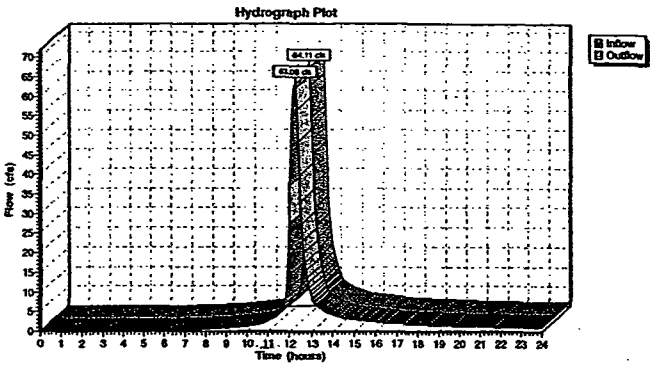
[65] Warning: Inlet elevation not specified

Inflow = 64.11 cfs @ 12.19 hrs, Volume= 5.615 af
Outflow = 63.08 cfs @ 12.22 hrs, Volume= 5.607 af, Atten= 2%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 3.4 min

Peak Depth= 1.49'
Capacity at bank full= 242.25 cfs
5.73' x 2.75' deep channel, n= 0.030 Length= 235.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.2 '/'

Reach 6A: Runoff Diversion Channel



Reach 6B: Runoff Diversion Channel

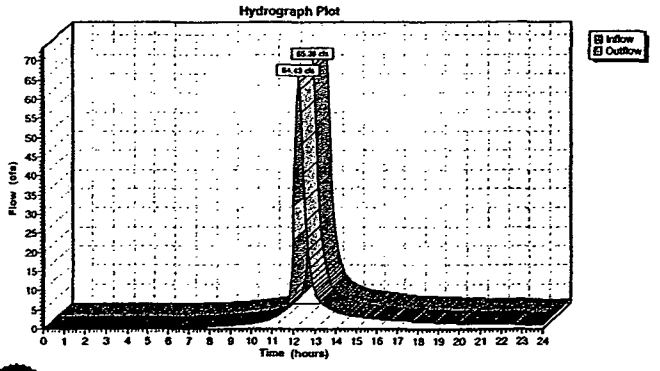
[65] Warning: Inlet elevation not specified

Inflow = 65.36 cfs @ 12.21 hrs, Volume= 5.900 af
Outflow = 64.43 cfs @ 12.25 hrs, Volume= 5.890 af, Atten= 1%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.6 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 4.6 min

Peak Depth= 1.50'
Capacity at bank full= 115.68 cfs
7.10' x 2.00' deep channel, n= 0.030 Length= 318.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.2 3.5 '/'

Reach 6B: Runoff Diversion Channel



Reach 7: 2-49x33 Culverts

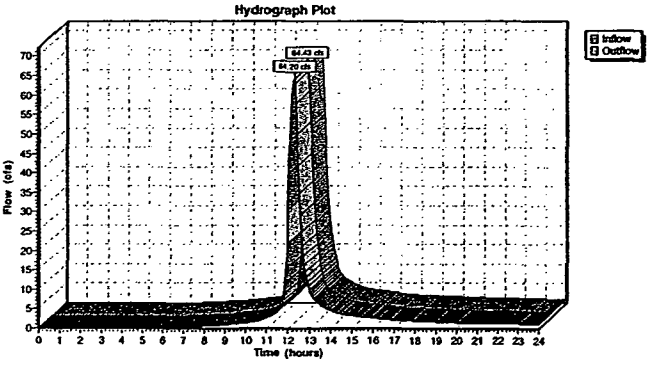
[52] Hint: Inlet conditions not evaluated
[65] Warning: Inlet elevation not specified

Inflow = 64.43 cfs @ 12.25 hrs, Volume= 5.890 af
Outflow = 64.20 cfs @ 12.26 hrs, Volume= 5.888 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 0.8 min

Peak Depth= 1.60'
Capacity at bank full= 413.33 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.018 Length= 92.0' Slope= 0.0046 '/'

Reach 7: 2-49x33 Culverts



Reach 8: Inner Cell Drainage Channel

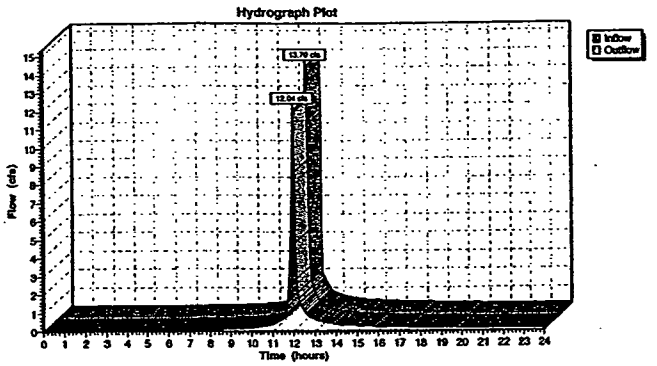
[65] Warning: Inlet elevation not specified

Inflow = 13.70 cfs @ 11.90 hrs, Volume= 0.600 af
Outflow = 12.04 cfs @ 11.99 hrs, Volume= 0.597 af, Atten= 12%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 3.2 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 10.7 min

Peak Depth= 0.79'
Capacity at bank full= 37.08 cfs
2.00' x 1.29' deep channel, n= 0.030 Length= 575.0' Slope= 0.0100 '/'
Side Slope Z-value= 3.0 5.0 '/'

Reach 8: Inner Cell Drainage Channel



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Reach 9: Inner Cell Drainage Channel

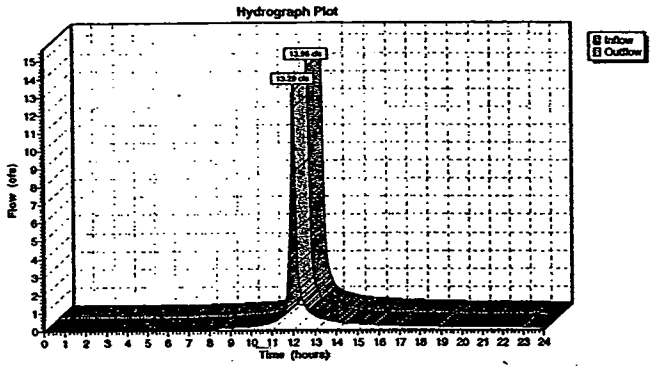
[65] Warning: Inlet elevation not specified

Inflow = 13.96 cfs @ 11.99 hrs, Volume= 0.726 af
Outflow = 13.29 cfs @ 12.01 hrs, Volume= 0.725 af, Atten= 5%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.9 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 2.4 min

Peak Depth= 1.09'
Capacity at bank full= 127.44 cfs
0.00' x 2.50' deep channel, n= 0.030 Length= 200.0' Slope= 0.0150 '/'
Side Slope Z-value= 3.0 '/'

Reach 9: Inner Cell Drainage Channel



Reach 11: Runoff Diversion Channel Cell 2

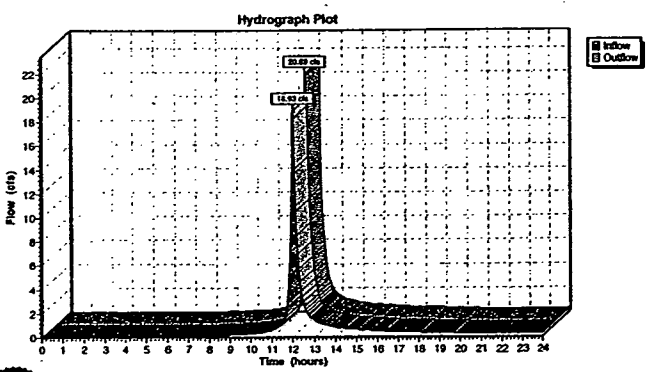
[65] Warning: Inlet elevation not specified

Inflow = 20.89 cfs @ 11.94 hrs, Volume= 1.166 af
Outflow = 18.93 cfs @ 12.02 hrs, Volume= 1.163 af, Atten= 9%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 7.7 min

Peak Depth= 1.26'
Capacity at bank full= 754.76 cfs
0.00' x 5.00' deep channel, n= 0.030 Length= 420.0' Slope= 0.0045 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 11: Runoff Diversion Channel Cell 2



ATTACHMENT C-1G

HydroCAD™ OUTPUT REPORTS

DESIGN CASE "C"

DESIGN CASE "C"

25-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=4.70"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover Tc=18.3 min CN=83 Area=2.730 ac Runoff= 9.20 cfs 0.658 af

Subcatchment B: vegetated final cover Tc=19.0 min CN=83 Area=5.342 ac Runoff= 17.63 cfs 1.287 af

Subcatchment C: vegetated final cover Tc=19.0 min CN=83 Area=5.399 ac Runoff= 17.82 cfs 1.301 af

Subcatchment D: non vegetated final cover Tc=4.1 min CN=89 Area=5.530 ac Runoff= 33.96 cfs 1.605 af

Reach 1: west channel Inflow= 9.20 cfs 0.658 af
Length= 400.0' Max Vel= 2.5 fps Capacity= 424.60 cfs Outflow= 8.87 cfs 0.656 af

Reach 2: west channel Inflow= 25.75 cfs 1.943 af
Length= 400.0' Max Vel= 3.3 fps Capacity= 424.60 cfs Outflow= 25.10 cfs 1.939 af

Reach 3: west channel Inflow= 41.23 cfs 3.240 af
Length= 400.0' Max Vel= 3.7 fps Capacity= 424.60 cfs Outflow= 40.35 cfs 3.234 af

Reach 4: west channel Inflow= 46.28 cfs 4.839 af
Length= 90.0' Max Vel= 3.8 fps Capacity= 426.17 cfs Outflow= 45.14 cfs 4.837 af

Reach 5: culvert Inflow= 45.14 cfs 4.837 af
Length= 95.0' Max Vel= 4.6 fps Capacity= 396.64 cfs Outflow= 44.47 cfs 4.836 af

Runoff Area = 19.001 ac Volume = 4.851 af Average Depth = 3.06"

Subcatchment A: vegetated final cover

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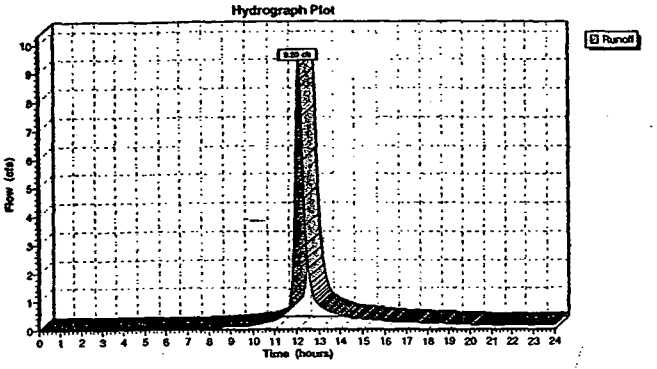
Runoff = 9.20 cfs @ 12.11 hrs, Volume= 0.658 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
2.730	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	180	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
18.3	670	Total			

Subcatchment A: vegetated final cover



Subcatchment B: vegetated final cover

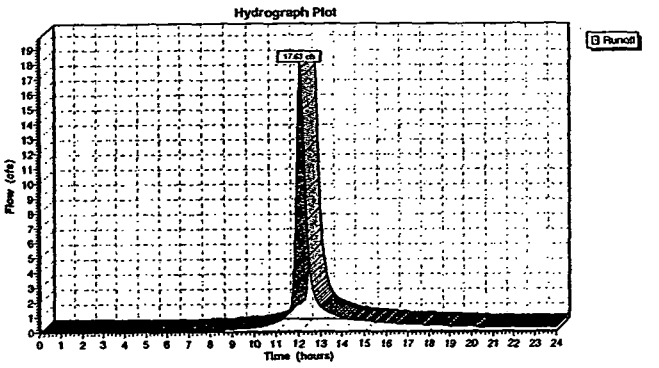
Runoff = 17.63 cfs @ 12.11 hrs, Volume= 1.287 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.342	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	200	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	950	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

Runoff = 17.82 cfs @ 12.11 hrs, Volume= 1.301 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.399	83	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	200	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
19.0	945	Total			

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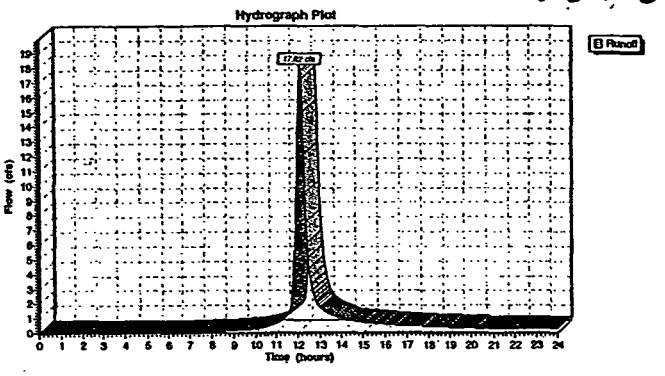
Subcatchment C: vegetated final cover

5316



Subcatchment D: non vegetated final cover

[49] Hint: Tc<2dt may require smaller dt

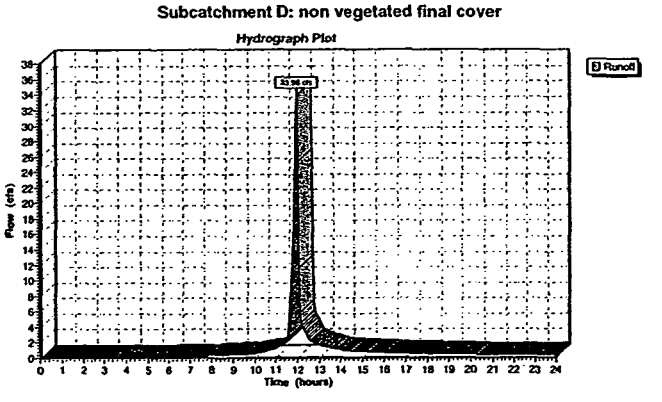
Runoff = 33.96 cfs @ 11.94 hrs, Volume= 1.605 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=4.70"

Area (ac)	CN	Description
5.530	89	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	90	0.0500	1.8		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.5	60	0.1000	2.1		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.8	150	0.1700	3.2		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.5	205	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	190	0.0075	4.2	75.84	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.00' Z= 3.0 & 6.0 '/' n= 0.030
0.1	60	0.0100	15.0	423.51	Circular Channel (pipe), Diam= 72.0" Area= 28.3 sf Perim= 18.8' r= 1.50' n= 0.013
0.5	195	0.0075	6.6	424.60	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.00' Z= 6.0 & 2.0 '/' n= 0.030
4.1	950	Total			

Subcatchment D: non vegetated final cover



Reach 1: west channel

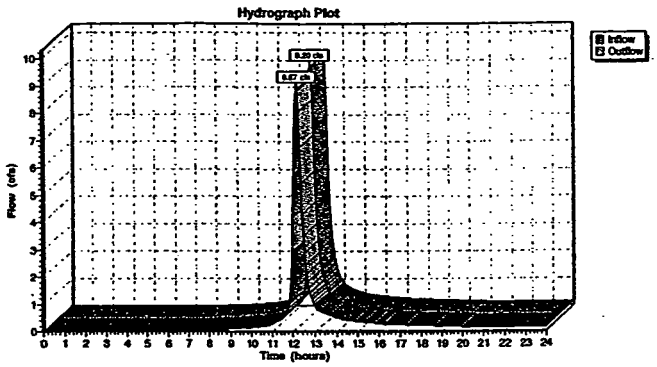
[65] Warning: Inlet elevation not specified

[illegible] = 9.20 cfs @ 12.11 hrs, Volume= 0.658 af
[illegible] = 8.87 cfs @ 12.19 hrs, Volume= 0.656 af, Atten= 4%, Lag= 4.8 min

[illegible] by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Ma[illegible] elocity= 2.5 fps, Min. Travel Time= 2.6 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.6 min

Peak Depth= 0.94'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 1: west channel



5316

Reach 2: west channel

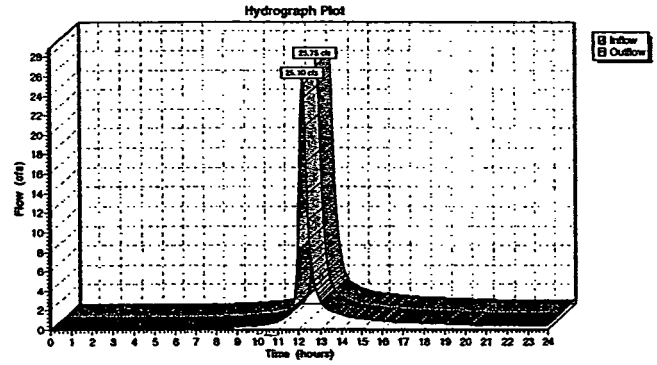
[65] Warning: Inlet elevation not specified

Inflow = 25.75 cfs @ 12.14 hrs, Volume= 1.943 af
Outflow = 25.10 cfs @ 12.20 hrs, Volume= 1.939 af, Atten= 3%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.1 min

Peak Depth= 1.39'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 2: west channel



Reach 3: west channel

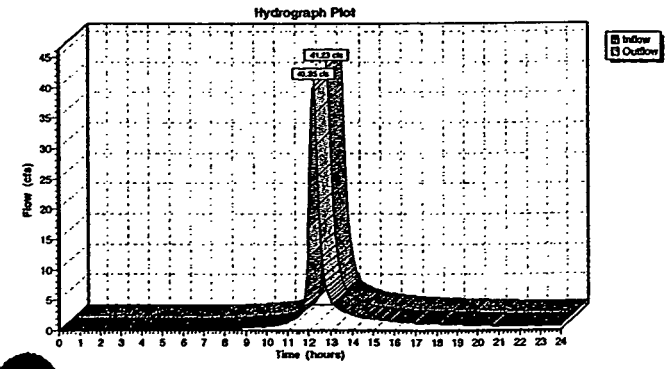
[65] Warning: Inlet elevation not specified

Inflow = 41.23 cfs @ 12.16 hrs, Volume= 3.240 af
Outflow = 40.35 cfs @ 12.22 hrs, Volume= 3.234 af, Atten= 2%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.7 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 4.5 min

Peak Depth= 1.66'
Capacity at bank full= 424.60 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 400.0' Slope= 0.0075 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 3: west channel



Reach 4: west channel

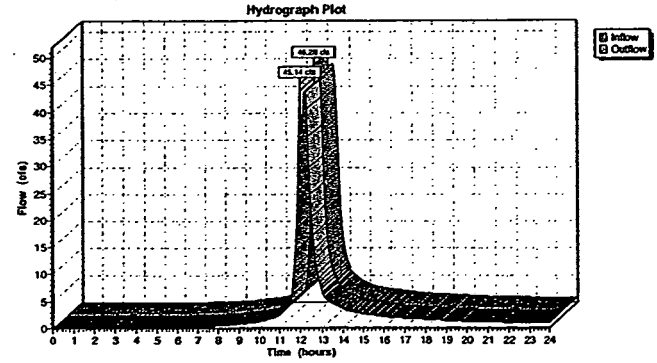
[65] Warning: Inlet elevation not specified

Inflow = 46.28 cfs @ 11.96 hrs, Volume= 4.839 af
Outflow = 45.14 cfs @ 11.97 hrs, Volume= 4.837 af, Atten= 2%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.8 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.74'
Capacity at bank full= 426.17 cfs
0.00' x 4.00' deep channel, n= 0.030 Length= 90.0' Slope= 0.0076 '/'
Side Slope Z-value= 2.0 6.0 '/'

Reach 4: west channel



Reach 5: culvert

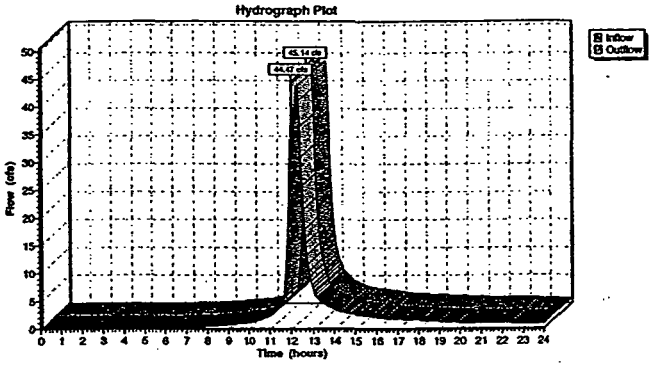
[52] Hint: Inlet conditions not evaluated
[65] Warning: *Inlet elevation not specified*

[illegible] = 45.14 cfs @ 11.97 hrs, Volume= 4.837 af
[illegible] = 44.47 cfs @ 11.99 hrs, Volume= 4.836 af, Atten= 1%, Lag= 0.8 min

[illegible]g by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.36'
Capacity at bank full= 396.64 cfs
A factor of 2.00 has been applied to the supplied storage and discharge data
72.0" Diameter Pipe n= 0.024 Length= 95.0' Slope= 0.0075 '/'

Reach 5: culvert



ATTACHMENT C-2

WEIGHTED CURVE NUMBER CALCULATIONS

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN

East OSDF Construction Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.96	100%	B/C	vegetated final cover	83	83
B	1.18	100%	B/C	vegetated final cover	83	83
C	5.21	100%	B/C	vegetated final cover	83	83
D	5.13	100%	B/C	vegetated final cover	83	83
E	5.09	100%	B/C	vegetated final cover	83	83
F	5.05	100%	B/C	vegetated final cover	83	83
G	5.33	100%	B/C	vegetated final cover	83	83
HR	4.59	100%	B/C	unvegetated final cover	89	89
IR	0.60	100%	B/C	unvegetated final cover	89	89
JR	2.52	100%	B/C	unvegetated final cover	89	89
K1R	0.38	100%	C	construction laydown	82	82
K2R	0.53	65% 35%	B C	construction laydown construction laydown	74 82	77
L	1.68	30% 70%	B C	runoff north of borrow area runoff north of borrow area	69 79	76
M	1.00	100%	C	runoff north of borrow area	79	79
N	7.82	100%	N/A	direct runoff to pond	98	98
O	1.32	100%	C	runoff north of borrow area	79	79
P	5.24	45% 55%	B C	runoff north of borrow area runoff north of borrow area	69 79	75
Q	7.70	70% 30%	B C	runoff north of borrow area runoff north of borrow area	69 79	72
R	2.61	55% 45%	B C	runoff north of borrow area runoff north of borrow area	69 79	74
S	0.40	10% 90%	B C	runoff north of borrow area runoff north of borrow area	69 79	78
TR	0.04	100%	C	construction laydown	82	82
U	4.15	70% 30%	B C	runoff east of OSDF runoff east of OSDF	69 79	72
V	0.27	100%	N/A	direct runoff to pond	98	98
W	10.59	70% 30%	B C	runoff east of OSDF runoff east of OSDF	69 79	72
X	11.85	80% 20%	B C	runoff east of OSDF runoff east of OSDF	69 79	71
Y	6.52	60% 40%	B C	runoff east of OSDF runoff east of OSDF	69 79	73
Z	3.63	70% 30%	B C	runoff east of OSDF runoff east of OSDF	69 79	72
AA	2.71	55% 45%	B C	runoff east of OSDF runoff east of OSDF	69 79	74
BB	0.76	100%	C	runoff east of OSDF	79	79
CC	0.12	100%	C	runoff east of OSDF	79	79
DDR	0.86	100%	B/C	unvegetated final cover	89	89
EE	0.93	20% 80%	B C	runoff north of borrow area runoff north of borrow area	69 79	77
FFR	2.41	100%	B/C	unvegetated final cover	89	89
GGR	2.35	55% 45%	B C	construction laydown construction laydown	74 82	78
HH	0.55	100%	C	runoff north of borrow area	79	79
II	1.67	50% 50%	B C	runoff area to borrow area runoff area to borrow area	61 74	68
JJ	0.91	93% 7%	B C	runoff area to borrow area runoff area to borrow area	61 74	62
KK	5.89	80% 20%	B C	runoff area to borrow area runoff area to borrow area	61 74	64
LL	7.05	100%	B	runoff	61	61
MM	1.93	100%	B	runoff	61	61
NN	1.27	60% 40%	B C	runoff runoff	61 74	66
OO	0.40	65% 35%	B C	runoff area to borrow area runoff area to borrow area	61 74	66
PP	40.96	80% 20%	B C	vegetated borrow area vegetated borrow area	61 74	64

N/A - Not Applicable

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN
East OSDF Post Development Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.96	100%	B/C	vegetated final cover	74	74
B	1.18	100%	B/C	vegetated final cover	74	74
C	5.21	100%	B/C	vegetated final cover	74	74
D	5.13	100%	B/C	vegetated final cover	74	74
E	5.09	100%	B/C	vegetated final cover	74	74
F	5.05	100%	B/C	vegetated final cover	74	74
G	5.31	100%	B/C	vegetated final cover	74	74
HR	4.59	100%	B/C	vegetated final cover	74	74
JR	0.60	100%	B/C	vegetated final cover	74	74
JR	2.52	100%	B/C	vegetated final cover	74	74
KIR	0.38	100%	C	grass area	74	74
KJR	0.53	65% 35%	B C	grass area grass area	61 74	66
L	1.68	30% 70%	B C	runon north of borrow area runon north of borrow area	69 79	76
M	1.00	100%	C	runon north of borrow area	79	79
N	7.82	100%	N/A	direct runon to pond	98	98
O	1.32	100%	C	runon north of borrow area	79	79
P	5.24	45% 55%	B C	runon north of borrow area runon north of borrow area	69 79	75
Q	7.70	70% 30%	B C	runon north of borrow area runon north of borrow area	69 79	72
R	2.61	55% 45%	B C	runon north of borrow area runon north of borrow area	69 79	74
S	0.40	10% 90%	B C	runon north of borrow area runon north of borrow area	69 79	78
TR	0.04	100%	C	grass area	74	74
U	4.15	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	72
V	0.27	100%	N/A	direct runon to pond	98	98
W	10.59	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	72
X	11.85	80% 20%	B C	runon east of OSDF runon east of OSDF	69 79	71
Y	6.52	60% 40%	B C	runon east of OSDF runon east of OSDF	69 79	73
Z	1.61	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	72
AA	2.71	55% 45%	B C	runon east of OSDF runon east of OSDF	69 79	74
BB	0.76	100%	C	runon east of OSDF	79	79
CC	0.12	100%	C	runon east of OSDF	79	79
DDR	0.86	100%	B/C	vegetated final cover	74	74
EE	0.93	20% 80%	B C	runon north of borrow area runon north of borrow area	69 79	77
FFR	2.41	100%	B/C	vegetated final cover	74	74
GGR	2.35	55% 45%	B C	grass area grass area	61 74	67
HH	0.55	100%	C	runon north of borrow area	79	79
II	1.67	50% 50%	B C	runon area to borrow area runon area to borrow area	61 74	68
JJ	0.91	93% 7%	B C	runon area to borrow area runon area to borrow area	61 74	62
KK	5.89	80% 20%	B C	runon area to borrow area runon area to borrow area	61 74	64
LL	7.05	100%	B	borrow area runoff	61	61
MM	1.94	100%	B	borrow area runoff	61	61
NN	1.27	60% 40%	B C	borrow area runoff borrow area runoff	61 74	66
OO	0.40	65% 35%	B C	runon area to borrow area runon area to borrow area	61 74	66
PP	40.96	80% 20%	B C	vegetated borrow area vegetated borrow area	61 74	64

N/A - Not Applicable

RESULTS FOR THE CALCULATION OF WEIGHTED CN
West OSDF Construction Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	83	83
B	5.34	100%	B/C	vegetated final cover	83	83
C	5.40	100%	B/C	vegetated final cover	83	83
D	5.53	100%	B/C	vegetated final cover	83	83
ER	5.32	100%	B/C	unvegetated final cover	89	89
F1R	0.92	100%	B/C	unvegetated final cover	89	89
F2R	1.55	100%	B/C	unvegetated final cover	89	89
FR	1.85	100%	B/C	unvegetated final cover	89	89
GR	0.37	72% 28%	B/C C	unvegetated final cover runon north of borrow area	89 79	86
HR	0.09	100%	B/C	runon north of borrow area	79	79
J1R	0.31	100%	C	construction laydown	82	82
J2R	0.85	100%	C	construction laydown	82	82
KR	2.37	38% 62%	C B/C	runon north of borrow area unvegetated final cover	79 89	85
LR	2.29	100%	C	construction laydown	82	82
MR	0.68	100%	C	runon north of borrow area	79	79
N	1.04	100%	C	construction laydown	82	82
O	2.25	100%	N/A	direct runon to pond	98	98
P1R	0.67	100%	C	construction laydown	82	82
P2R	0.21	100%	C	construction laydown	82	82
QN	0.13	100%	C	runon north of borrow area	79	79

RESULTS FOR THE CALCULATION OF WEIGHTED CN
West OSDF Post Development Design Scenario

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	74	74
B	5.34	100%	B/C	vegetated final cover	74	74
C	5.40	100%	B/C	vegetated final cover	74	74
D	5.53	100%	B/C	vegetated final cover	74	74
ER	5.32	100%	B/C	vegetated final cover	74	74
F1R	0.92	100%	B/C	vegetated final cover	74	74
F2R	1.55	100%	B/C	vegetated final cover	74	74
FR	1.85	100%	B/C	vegetated final cover	74	74
GR	0.37	72% 28%	B/C C	vegetated final cover runon north of borrow area	74 79	75
HR	0.09	100%	B/C	runon north of borrow area	79	79
J1R	0.31	100%	C	grass area	74	74
J2R	0.85	100%	C	grass area	74	74
KR	2.37	38% 62%	C B/C	runon north of borrow area vegetated final cover	79 74	76
LR	2.29	100%	C	grass area	74	74
MR	0.68	100%	C	runon north of borrow area	79	79
N	1.04	100%	C	grass area	74	74
O	2.25	100%	N/A	direct runon to pond	98	98
P1R	0.67	100%	C	grass area	74	74
P2R	0.21	100%	C	grass area	74	74
QN	0.13	100%	C	runon north of borrow area	79	79

N/A - Not Applicable

RESULTS FOR THE CALCULATION OF WEIGHTED CN
Design Case "A"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	1.93	100%	B/C	liner runout	89	89
B	0.88	100%	C	construction laydown	82	82
C	0.71	100%	C	construction laydown	82	82
D	0.65	100%	C	construction laydown	82	82
E	1.29	100%	C	construction laydown	82	82
F	0.34	100%	C	construction laydown	82	82
G	1.86	100%	C	construction laydown	82	82
H	0.65	60% 40%	C C	pavement construction laydown	98 82	92

RESULTS FOR THE CALCULATION OF WEIGHTED CN
Design Case "B"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	5.13	100%	B/C	non vegetated final cover	89	89
B	5.09	100%	B/C	non vegetated final cover	89	89
C	1.19	100%	B/C	subgrade	87	87
D	1.19	100%	B/C	subgrade	87	87
E	1.76	100%	B/C	subgrade	87	87
F1	0.24	100%	C	construction support	82	82
F2	0.51	100%	C	construction support	82	82
G	2.19	100%	B/C	subgrade	87	87
H	0.50	50% 50%	C B/C	construction support subgrade	82 87	85
I	1.45	100%	C	construction support	82	82
J	0.74	100%	C	construction support	82	82
K	1.96	100%	B/C	vegetated final cover	83	83
L	1.68	100%	B/C	vegetated final cover	83	83
M	1.18	100%	B/C	vegetated final cover	83	83

N/A - Not Applicable

RESULTS FOR THE CALCULATION OF WEIGHTED CN
Design Case "C"

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN	Weighted CN
A	2.73	100%	B/C	vegetated final cover	83	83
B	5.34	100%	B/C	vegetated final cover	83	83
C	5.40	100%	B/C	vegetated final cover	83	83
D	5.53	100%	B/C	non vegetated final cover	89	89

N/A - Not Applicable

Written by: Dana Mehlman (DBM) DBM Date: 1/29/2002 Reviewed by: DKP Date: 30 JAN 02

Client: Fluor Fernald, Inc. Project: OSDF PHASE V Project/Proposal No.:GQ1342 Task No.:17

EXAMPLE CALCULATION FOR WEIGHTED CURVE NUMBER OF SUBCATCHMENT J OF THE EAST OSDF CONSTRUCTION-PHASE DESIGN SCENARIO

PURPOSE

The computation below illustrates the method for calculating a composite curve number (CN) for a subcatchment area comprising more than one CN. This CN value is used as one of the input parameters in the computer program "HydroCAD" for computing runoff.

CALCULATION PROCEDURE

The composite CN for a subcatchment area comprising more than one CN is calculated by summing the products of each CN multiplied by its percentage of the total area.

DATA VERIFICATION

The table below lists the CN's for subcatchment area J of the East OSDF Construction-Phase Design Scenario grouped according to Hydrological Soil Group (HSG), the contributing percentage of the total area for subcatchment area J, and land use.

HSG	Percent of Area %	Land Use Description	CN
B	10	Disturbed Area-Construction Support Zone	74
C	90	Disturbed Area-Construction Support Zone	82

CALCULATIONS

Weighted CN = (74)(0.10)+(82)(0.90)

= **81**

ATTACHMENT C-3

TABULATED ANALYSIS RESULTS FOR CHANNELS

OSDF CONSTRUCTION/FILLING PERIOD CONDITIONS
SUMMARY OF CHANNEL ANALYSIS RESULTS

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node	HydroCAD Q[4] (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth[5] Y (ft)	Estimated Q[5] (cfs)	Channel Freeboard[7] (ft)	Peak Flow Velocity (fps)	Lining Type[6]
7R	new	E OSDF	vee	6.0	1.00%	0.030	0	6	3	8R	75.90	16.07	17.47	0.92	1.89	75.51	4.1	4.70	grass
8R	new	E OSDF	vee	5.5	0.50%	0.030	0	6	2	9R	75.75	20.25	18.72	1.08	2.25	74.95	3.2	3.70	grass
9R	new	E OSDF	trapezoidal	3.8	0.50%	0.030	4.35	6	3	10AR	75.94	20.99	20.34	1.03	1.73	75.29	2.1	3.59	grass
10AR	new	E OSDF	trapezoidal	3.9	0.50%	0.030	10.12	6	3	28R	77.19	22.31	22.79	0.98	1.37	77.26	2.5	3.46	grass
10BR	new/existing	E OSDF	trapezoidal	2.6	0.29%	0.030	10.21	3	4.6	11	79.26	26.74	23.04	1.16	1.63	78.99	1.0	2.95	grass
12R	existing	E OSDF	trapezoidal	2.5	0.63%	0.030	14	3	4.3	12R + HH	81.07	21.38	22.87	0.93	1.17	80.57	1.3	3.77	grass
13R	existing	E OSDF	trapezoidal	2.1	0.67%	0.030	23.11	2.3	4	13R	144.60	33.81	31.40	1.08	1.25	144.40	0.8	4.43	grass
18	new	E OSDF	vee	3.0	1.00%	0.030	0	3	3	19	38.43	8.77	10.81	0.81	1.71	37.89	1.3	4.32	grass
19	new	E OSDF	vee	3.0	0.90%	0.030	0	3	3	20	43.35	10.05	11.57	0.87	1.83	43.07	1.2	4.29	grass
20	new	E OSDF	vee	3.0	0.83%	0.030	0	3	3	1P - U - V	40.72	9.94	11.51	0.86	1.82	40.77	1.2	4.10	grass
30	new	E OSDF	vee	2.5	1.00%	0.030	0	3	3	30	45.98	10.05	11.57	0.87	1.83	45.40	0.7	4.52	grass
21	new	E OSDF	vee	3.0	1.00%	0.030	0	3	3	22	46.33	10.27	11.70	0.88	1.85	46.74	1.2	4.55	grass
22	new	E OSDF	vee	4.0	1.00%	0.030	0	3	3	29	47.10	10.27	11.70	0.88	1.85	46.74	2.2	4.55	grass
29	new	E OSDF	vee	3.5	1.00%	0.030	0	3	3	23	48.76	10.49	11.83	0.89	1.87	48.10	1.6	4.58	grass
24	new	E OSDF	trapezoidal	2.0	0.75%	0.030	8.5	3	3	24	57.15	14.21	15.96	0.89	1.18	56.54	0.8	3.98	grass
26	new	E OSDF	vee	2.5	0.75%	0.030	0	3	3	27	65.00	14.52	13.91	1.04	2.20	64.26	0.3	4.43	grass
7BR	new	W OSDF	vee	3.77	0.23%	0.030	0	6	2	7BR	57.98	22.47	19.72	1.14	2.37	58.39	1.4	2.60	grass
7DR	existing	W OSDF	trapezoidal	4.7	0.42%	0.030	2.56	4.3	3.9	7DR	58.26	18.07	17.84	1.01	1.81	58.64	2.9	3.25	grass
8AR	existing	W OSDF	trapezoidal	3.0	0.48%	0.030	13.28	4.2	2.6	8AR	83.95	23.68	22.73	1.04	1.33	83.73	1.7	3.54	grass
8CR	existing	W OSDF	trapezoidal	5.0	1.59%	0.030	1.17	2.4	2.3	8CR	81.93	12.49	11.74	1.06	2.07	81.52	2.9	6.53	rip rap
9AR	new	W OSDF	vee	3.0	2.50%	0.030	0	3	3	9AR	13.68	2.94	6.26	0.47	0.99	13.95	2.0	4.74	grass
9R	new	W OSDF	vee	6.0	2.49%	0.030	0	3	3	9R	13.16	2.82	6.13	0.46	0.97	13.18	5.0	4.67	grass
10AR	new	W OSDF	trapezoidal	1.8	6.50%	0.030	5	3	3	10AR	9.78	1.84	6.96	0.26	0.31	9.58	1.4	5.21	rip rap
10R	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	3	3	10R	21.20	8.12	12.38	0.66	0.85	21.52	1.7	2.65	grass
11AR	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	2.8	3	11AR	20.52	7.83	12.13	0.65	0.83	20.51	1.7	2.62	grass
16N	existing	W OSDF	vee	2.9	0.69%	0.030	0	2.2	1.4	16N	3.58	1.56	3.85	0.41	0.93	3.51	2.0	2.26	grass
2	existing	DC A	vee	3.0	1.50%	0.030	0	4	6	1 + G	8.82	2.81	7.65	0.37	0.75	8.77	2.3	3.12	grass
5	new	DC A	vee	2.5	0.34%	0.030	0	3	3	5	12.05	5.63	8.66	0.65	1.37	12.16	1.1	2.16	grass
6	new	DC A	vee	2.5	0.23%	0.030	0	3	3	6 + D	12.43	6.66	9.42	0.71	1.49	12.53	1.0	1.88	grass
7	existing	DC A	vee	2.0	2.00%	0.030	0	4	6	7 + E	21.87	5.10	10.36	0.49	1.01	22.41	1.0	4.39	grass
1	existing	DC B	vee	6.5	0.45%	0.030	0	5	3	1	45.68	14.44	15.70	0.92	1.90	45.51	4.6	3.15	grass
2	new	DC B	vee	7.4	0.50%	0.030	0	3	4	2	66.65	17.88	16.46	1.09	2.26	66.32	5.1	3.71	grass
3	new	DC B	vee	6.5	0.50%	0.030	0	3	4	3	64.14	17.56	16.32	1.08	2.24	64.77	4.3	3.69	grass
4	new	DC B	vee	3	0.50%	0.030	0	3	6	4	62.72	18.00	18.49	0.97	2.00	62.09	1.0	3.45	grass
5	new	DC B	vee	3	0.50%	0.030	0	3	6	5	62.18	18.00	18.49	0.97	2.00	62.09	1.0	3.45	grass
6A	new	DC B	trapezoidal	2.75	0.50%	0.030	5.73	3.2	6	6A	64.11	18.95	19.88	0.95	1.50	64.42	1.3	3.40	grass
6B	new	DC B	trapezoidal	2	0.50%	0.030	7.1	3.2	3.5	6B	65.36	18.19	17.59	1.03	1.50	65.32	0.5	3.59	grass
8	new	DC B	trapezoidal	1.28	1.00%	0.030	2	3	5	8	13.70	4.33	8.77	0.49	0.82	13.42	0.5	3.10	grass
9	new	DC B	vee	2.5	1.50%	0.030	0	3	3	9	13.96	3.50	6.83	0.51	1.08	13.62	1.4	3.89	grass
11	existing	DC B	vee	5	0.45%	0.030	0	6	4	11	20.89	8.45	13.27	0.64	1.30	20.84	3.7	2.47	grass
1	new	DC C	vee	4	0.75%	0.030	0	2	6	2	25.75	7.73	11.56	0.67	1.39	25.41	2.6	3.29	grass
2	new	DC C	vee	4	0.75%	0.030	0	2	6	3	41.23	11.16	13.89	0.80	1.67	41.45	2.3	3.72	grass
3	new	DC C	vee	4	0.75%	0.030	0	2	6	4	46.28	12.25	14.56	0.84	1.75	46.96	2.3	3.83	grass
4	new	DC C	vee	4	0.76%	0.030	0	2	6	5	45.14	11.70	14.23	0.82	1.71	44.45	2.3	3.80	grass

E OSDF = East OSDF Construction-Phase Design Scenario
W OSDF = West OSDF Construction-Phase Design Scenario
DC A = Design Case "A"
DC B = Design Case "B"

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from the Drawings.
4. Peak inflow rates calculated by HydroCAD for each reach. See attachment C-1.
5. Calculated flow rates using an iterative procedure and compared with flow from HydroCAD.
6. Maximum permissible velocity for grass lined channels is 5 fps.
7. Calculated as the difference between minimum available flow depth and peak flow depth.

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OSDF POST DEVELOPMENT PERIOD CONDITIONS
SUMMARY OF CHANNEL ANALYSIS RESULTS

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations								
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node [3]	HydroCAD Q[4] (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth[5] Y (ft)	Estimated Q[5] (cfs)	Channel Freeboard[7] (ft)	Peak Flow Velocity (fps)	Sufficient to Minimize Sedimentation?	Lining Type[6]
1	existing	E OSDF PD	vee	5	0.45%	0.030	0	6	4	2	19.04	7.81	12.76	0.61	1.25	18.77	3.75	2.40	Is adressed in a separate calculation package presented for Phase V.	grass
2	existing	E OSDF PD	vee	6.5	0.45%	0.030	0	3	5	3	29.26	10.37	13.30	0.78	1.61	29.62	4.89	2.82		grass
3	new	E OSDF PD	vee	7.4	0.50%	0.030	0	3	4	4	37.70	11.72	13.33	0.88	1.83	37.78	5.57	3.22		grass
4	new	E OSDF PD	vee	6.5	0.50%	0.030	0	3	4	5	44.86	13.31	14.21	0.94	1.95	44.75	4.55	3.36		grass
5	new	E OSDF PD	vee	3	0.50%	0.030	0	3	6	6	51.10	15.40	17.10	0.90	1.85	50.44	1.15	3.27		grass
6	new	E OSDF PD	vee	3	1.00%	0.030	0	3	6	7R	55.14	12.55	15.44	0.81	1.67	54.29	1.33	4.33		grass
7R	new	E OSDF PD	vee	6.0	1.00%	0.030	0	6	3	8R	56.86	13.01	15.72	0.83	1.70	56.93	4.29	4.38		grass
8R	new	E OSDF PD	vee	5.5	0.50%	0.030	0	6	2	9R	56.94	16.32	16.80	0.97	2.03	56.22	3.44	3.44		grass
9R	new	E OSDF PD	trapezoidal	3.8	0.50%	0.030	4.35	6	3	10AR	57.17	17.01	18.40	0.92	1.52	56.68	2.28	3.33		grass
10AR	new	E OSDF PD	trapezoidal	3.9	0.50%	0.030	10.12	6	3	28R	59.26	18.62	21.21	0.88	1.20	59.97	2.65	3.22		grass
10BR	new/existing	E OSDF PD	trapezoidal	2.6	0.29%	0.030	10.21	3	4.6	11	60.72	22.16	21.39	1.04	1.42	60.70	1.20	2.74		grass
12R	existing	E OSDF PD	trapezoidal	2.5	0.63%	0.030	14	3	4.3	12R + HH	62.55	18.08	21.73	0.83	1.02	63.04	1.43	3.49		grass
13R	existing	E OSDF PD	trapezoidal	2.1	0.67%	0.030	23.11	2.3	4	13R	126.44	31.05	30.80	1.01	1.16	126.88	0.90	4.09		grass
14	existing	E OSDF PD	vee	1.5	0.40%	0.030	0	3	5	15	3.20	2.02	5.87	0.34	0.71	3.11	0.79	1.54		grass
15	existing	E OSDF PD	vee	2.0	0.63%	0.030	0	3	5	16	9.76	4.08	8.34	0.49	1.01	9.98	0.99	2.45		grass
16	existing	E OSDF PD	vee	3.4	0.74%	0.030	0	2.5	5	17	12.43	4.46	8.49	0.52	1.09	12.38	2.31	2.78		grass
17	existing	E OSDF PD	vee	3.5	1.25%	0.030	0	4	5	18	21.43	5.75	10.42	0.55	1.13	21.45	2.37	3.73		grass
18	new	E OSDF PD	vee	3.0	1.00%	0.030	0	3	3	19	38.43	8.77	10.81	0.81	1.71	37.89	1.29	4.32		grass
19	new	E OSDF PD	vee	3.0	0.90%	0.030	0	3	3	20	43.35	10.05	11.57	0.87	1.83	43.07	1.17	4.29		grass
20	new	E OSDF PD	vee	3.0	0.83%	0.030	0	3	3	1P - U - V	40.72	9.94	11.51	0.86	1.82	40.77	1.18	4.10		grass
30	new	E OSDF PD	vee	2.5	1.00%	0.030	0	3	3	30	45.98	10.05	11.57	0.87	1.83	45.40	0.67	4.52		grass
21	new	E OSDF PD	vee	3.0	1.00%	0.030	0	3	3	22	46.39	10.27	11.70	0.88	1.85	46.74	1.15	4.55		grass
22	new	E OSDF PD	vee	4.0	1.00%	0.030	0	3	3	29	47.16	10.27	11.70	0.88	1.85	46.74	2.15	4.55		grass
29	new	E OSDF PD	vee	3.5	1.00%	0.030	0	3	3	23	48.82	10.72	11.95	0.90	1.89	49.48	1.61	4.62		grass
24	new	E OSDF PD	trapezoidal	2.0	0.75%	0.030	8.5	3	3	24	57.21	14.21	15.96	0.89	1.18	56.54	0.82	3.98		grass
26	new	E OSDF PD	vee	2.5	0.75%	0.030	0	3	3	27	65.08	14.79	14.04	1.05	2.22	65.83	0.28	4.45		grass
1	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	2	18.66	6.37	11.00	0.58	1.19	19.04	2.81	2.99	Intentionally left blank.	grass
2	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	3	29.58	8.95	13.04	0.69	1.41	29.94	2.59	3.35		grass
3	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	4	39.78	11.09	14.51	0.76	1.57	39.88	2.43	3.59		grass
4	new	W OSDF PD	vee	4	0.76%	0.030	0	2	6	5	39.58	11.09	14.51	0.76	1.57	40.14	2.43	3.62		grass
6	new	W OSDF PD	vee	4	0.75%	0.030	0	2	6	7AR	47.24	12.70	15.53	0.82	1.68	47.77	2.32	3.76		grass
7BR	new	W OSDF	vee	3.77	0.23%	0.030	0	6	2	7BR	47.27	19.01	18.14	1.05	2.18	46.72	1.59	2.46		grass
7DR	existing	W OSDF	trapezoidal	4.7	0.42%	0.030	2.56	4.3	3.9	7DR	48.38	15.55	16.57	0.94	1.66	47.96	3.05	3.08		grass
8AR	existing	W OSDF	trapezoidal	3.0	0.48%	0.030	13.28	4.2	2.6	8AR	57.22	18.31	20.95	0.87	1.08	57.58	1.92	3.15		grass
8CR	existing	W OSDF	trapezoidal	5.0	1.59%	0.030	1.17	2.4	2.3	8CR	56.92	9.53	10.26	0.93	1.78	56.79	3.22	5.96		riprap
9AR	new	W OSDF	vee	3.0	2.50%	0.030	0	3	3	9AR	7.76	1.92	5.06	0.38	0.80	7.90	2.20	4.11		grass
9R	new	W OSDF	vee	6.0	2.49%	0.030	0	3	3	9R	7.76	1.92	5.06	0.38	0.80	7.88	5.20	4.11		grass
10AR	new	W OSDF	trapezoidal	1.8	6.50%	0.030	5	3	3	10AR	3.93	1.00	6.14	0.16	0.18	3.76	1.57	3.77		
10R	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	3	3	10R	8.94	4.45	10.29	0.43	0.52	8.94	1.98	2.01		grass
11AR	new	W OSDF	trapezoidal	2.5	0.50%	0.030	7	2.8	3	11AR	8.96	4.43	10.21	0.43	0.52	8.91	1.98	2.01		grass
16N	existing	W OSDF	vee	2.9	0.69%	0.030	0	2.2	1.4	16N	3.58	1.56	3.85	0.41	0.93	3.51	1.95	2.26		grass

E OSDF PD= East OSDF Post Development Design Scenario
W OSDF PD= West OSDF Post Development Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from the Drawings.
3. N/A indicates that there is not specific HydroCAD node associated with the particular channel.
4. Peak flow rates calculated by HydroCAD for each reach. See attachment C-1.
5. Calculated flow rates using an iterative procedure and compared with flow from HydroCAD.
6. Maximum permissible velocity for grass lined channels is 5 fps.
7. Calculated as the difference between minimum available flow depth and peak flow depth.

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ATTACHMENT C-4A

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

EAST OSDF DESIGN SCENARIO

Culvert Designer/Analyzer Report
east node 11

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	586.62	ft	Discharge	79.26	cfs
Headwater Depth/Height	1.31		Tailwater Elevation	584.74	ft
Inlet Control HW Elev.	586.62	ft	Control Type	Inlet Control	
Outlet Control HW Elev.	586.62	ft			

Grades					
Upstream Invert	583.67	ft	Downstream Invert	583.58	ft
Length	40.00	ft	Constructed Slope	0.002355	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.79	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.79	ft
Velocity Downstream	7.77	ft/s	Critical Slope	0.004539	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.010	
Section Material	Corrugated HDPE (Smooth Interior)		Span	2.25	ft
Section Size	27 inch		Rise	2.25	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	586.62	ft	Upstream Velocity Head	0.75	ft
Ke	0.20		Entrance Loss	0.15	ft

Inlet Control Properties					
Inlet Control HW Elev.	586.62	ft	Flow Control	Submerged	
Inlet Type	Groove end projecting		Area Full	11.9	ft²
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

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Culvert Designer/Analyzer Report
east node 23

sign:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	590.00	ft	Storm Event	Design	
Computed Headwater Elev	589.02	ft	Discharge	48.76	cfs
Headwater Depth/Height	0.90		Tailwater Elevation	587.01	ft
Inlet Control HW Elev.	588.83	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	589.02	ft			

Grades					
Upstream Invert	586.32	ft	Downstream Invert	585.78	ft
Length	92.00	ft	Constructed Slope	0.005870	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.59	ft
Slope Type	Mild		Normal Depth	1.78	ft
Flow Regime	Subcritical		Critical Depth	1.59	ft
Velocity Downstream	6.40	ft/s	Critical Slope	0.008394	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.018	
Section Material	CMP		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	589.02	ft	Upstream Velocity Head	0.48	ft
Ke	0.90		Entrance Loss	0.44	ft

Inlet Control Properties					
Inlet Control HW Elev.	588.83	ft	Flow Control	N/A	
Inlet Type	Projecting		Area Full	14.1	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

000496

310/344

5316

Culvert Designer/Analyzer Report
east node 25

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	588.50	ft	Storm Event	Design	
Computed Headwater Eleva	587.71	ft	Discharge	64.24	cfs
Headwater Depth/Height	1.18		Tailwater Elevation	586.73	ft
Inlet Control HW Elev.	587.53	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	587.71	ft			

Grades					
Upstream Invert	584.85	ft	Downstream Invert	584.53	ft
Length	53.00	ft	Constructed Slope	0.006038	ft/ft

Hydraulic Profile					
Profile	M1		Depth, Downstream	2.20	ft
Slope Type	Mild		Normal Depth	1.78	ft
Flow Regime	Subcritical		Critical Depth	1.48	ft
Velocity Downstream	4.93	ft/s	Critical Slope	0.009284	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.018	
Section Material	Steel and Aluminum Var CR		Span	3.50	ft
Section Size	42 x 29 inch		Rise	2.42	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	587.71	ft	Upstream Velocity Head	0.40	ft
Ke	0.90		Entrance Loss	0.36	ft

Inlet Control Properties					
Inlet Control HW Elev.	587.53	ft	Flow Control	Unsubmerged	
Inlet Type	Thin wall projecting		Area Full	13.0	ft^2
K	0.03400		HDS 5 Chart	34	
M	1.50000		HDS 5 Scale	3	
C	0.04960		Equation Form	1	
Y	0.57000				

000497

Culvert Designer/Analyzer Report
east node 27

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	587.00	ft	Storm Event	Design	
Computed Headwater Eleva	585.63	ft	Discharge	65.00	cfs
Headwater Depth/Height	1.17		Tailwater Elevation	583.88	ft
Inlet Control HW Elev.	585.50	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	585.63	ft			

Grades					
Upstream Invert	582.80	ft	Downstream Invert	582.36	ft
Length	106.00	ft	Constructed Slope	0.004151	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.52	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.49	ft
Velocity Downstream	6.78	ft/s	Critical Slope	0.009343	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.018	
Section Material	Steel and Aluminum Var CR		Span	3.50	ft
Section Size	42 x 29 inch		Rise	2.42	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	585.63	ft	Upstream Velocity Head	0.45	ft
Ke	0.90		Entrance Loss	0.40	ft

Inlet Control Properties					
Inlet Control HW Elev.	585.50	ft	Flow Control	Unsubmerged	
Inlet Type	Thin wall projecting		Area Full	13.0	ft^2
K	0.03400		HDS 5 Chart	34	
M	1.50000		HDS 5 Scale	3	
C	0.04960		Equation Form	1	
Y	0.57000				

000498

Culvert Designer/Analyzer Report
east node 28R

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	588.57	ft	Discharge	77.19	cfs
Headwater Depth/Height	1.02		Tailwater Elevation	585.57	ft
Inlet Control HW Elev.	588.41	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	588.57	ft			

Grades					
Upstream Invert	585.75	ft	Downstream Invert	585.00	ft
Length	140.00	ft	Constructed Slope	0.005357	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.53	ft
Slope Type	Mild		Normal Depth	1.90	ft
Flow Regime	Subcritical		Critical Depth	1.53	ft
Velocity Downstream	6.89	ft/s	Critical Slope	0.009110	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.019	
Section Material	Steel and Aluminum Var CR		Span	4.08	ft
Section Size	49 x 33 inch		Rise	2.75	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	588.57	ft	Upstream Velocity Head	0.50	ft
Ke	0.90		Entrance Loss	0.45	ft

Inlet Control Properties					
Inlet Control HW Elev.	588.41	ft	Flow Control	Unsubmerged	
Inlet Type	Thin wall projecting		Area Full	17.8	ft^2
K	0.03400		HDS 5 Chart	34	
M	1.50000		HDS 5 Scale	3	
C	0.04960		Equation Form	1	
Y	0.57000				

000499

313/344

5316

Culvert Designer/Analyzer Report
east node 31

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	588.50	ft	Storm Event	Design	
Computed Headwater Elev	585.49	ft	Discharge	6.54	cfs
Headwater Depth/Height	0.66		Tailwater Elevation	584.51	ft
Inlet Control HW Elev.	585.20	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	585.49	ft			

Grades					
Upstream Invert	584.00	ft	Downstream Invert	583.00	ft
Length	80.00	ft	Constructed Slope	0.012500	ft/ft

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	1.51	ft
Slope Type	Steep		Normal Depth	0.64	ft
Flow Regime	N/A		Critical Depth	0.87	ft
Velocity Downstream	2.31	ft/s	Critical Slope	0.003722	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	2.25	ft
Section Size	27 inch		Rise	2.25	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	585.49	ft	Upstream Velocity Head	0.33	ft
Ke	0.90		Entrance Loss	0.29	ft

Inlet Control Properties					
Inlet Control HW Elev.	585.20	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.0	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000500

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

WEST OSDF SCENARIO

Culvert Designer/Analyzer Report
west node 5 design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	584.89	ft	Discharge	55.45	cfs
Headwater Depth/Height	1.20		Tailwater Elevation	582.50	ft
Inlet Control HW Elev.	584.67	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	584.89	ft			

Grades					
Upstream Invert	580.68	ft	Downstream Invert	579.98	ft
Length	95.00	ft	Constructed Slope	0.007368	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	2.52	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	2.33	ft
Velocity Downstream	7.48	ft/s	Critical Slope	0.016887	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	3.50	ft
Section Size	42 inch		Rise	3.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	584.89	ft	Upstream Velocity Head	0.59	ft
Ke	0.90		Entrance Loss	0.53	ft

Inlet Control Properties					
Inlet Control HW Elev.	584.67	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	9.6	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

000502

316/344
5316

Culvert Designer/Analyzer Report
west node 7AR design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	582.10	ft	Discharge	57.96	cfs
Headwater Depth/Height	1.27		Tailwater Elevation	579.58	ft
Inlet Control HW Elev.	581.80	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	582.10	ft			

Grades					
Upstream Invert	577.67	ft	Downstream Invert	577.23	ft
Length	81.46	ft	Constructed Slope	0.005292	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	2.39	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	2.39	ft
Velocity Downstream	8.30	ft/s	Critical Slope	0.017334	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	3.50	ft
Section Size	42 inch		Rise	3.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	582.10	ft	Upstream Velocity Head	0.59	ft
Ke	0.90		Entrance Loss	0.53	ft

Inlet Control Properties					
Inlet Control HW Elev.	581.80	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	9.6	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

000503

317/344
5316

Culvert Designer/Analyzer Report
west node 7CR design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	578.01	ft	Discharge	58.08	cfs
Headwater Depth/Height	1.08		Tailwater Elevation	575.39	ft
Inlet Control HW Elev.	577.92	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	578.01	ft			

Grades					
Upstream Invert	574.96	ft	Downstream Invert	573.50	ft
Length	296.00	ft	Constructed Slope	0.004932	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.79	ft
Slope Type	Steep		Normal Depth	1.79	ft
Flow Regime	Supercritical		Critical Depth	1.95	ft
Velocity Downstream	8.40	ft/s	Critical Slope	0.003931	ft/ft

Section					
Section Shape	Horizontal Ellipse		Mannings Coefficient	0.013	
Section Material	Concrete		Span	4.44	ft
Section Size	34x53 inch		Rise	2.83	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	578.01	ft	Upstream Velocity Head	0.92	ft
Ke	0.20		Entrance Loss	0.18	ft

Inlet Control Properties					
Inlet Control HW Elev.	577.92	ft	Flow Control	Unsubmerged	
Inlet Type	Groove end with headwall (horizontal ellipse)		Area Full	10.2	ft^2
K	0.00180		HDS 5 Chart	29	
M	2.50000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

000504

Culvert Designer/Analyzer Report
west node 8BR

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	577.00	ft	Storm Event	Design	
Computed Headwater Eleva	575.32	ft	Discharge	81.21	cfs
Headwater Depth/Height	1.07		Tailwater Elevation	573.29	ft
Inlet Control HW Elev.	575.19	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	575.32	ft			

Grades					
Upstream Invert	572.12	ft	Downstream Invert	572.00	ft
Length	30.00	ft	Constructed Slope	0.004000	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	2.08	ft
Slope Type	Mild		Normal Depth	2.36	ft
Flow Regime	Subcritical		Critical Depth	2.08	ft
Velocity Downstream	7.78	ft/s	Critical Slope	0.005456	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	575.32	ft	Upstream Velocity Head	0.80	ft
Ke	0.20		Entrance Loss	0.16	ft

Inlet Control Properties					
Inlet Control HW Elev.	575.19	ft	Flow Control	Unsubmerged	
Inlet Type	Groove end w/headwall		Area Full	14.1	ft^2
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

000505

319/344

5316

Culvert Designer/Analyzer Report
west node 9BR design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	581.91	ft	Discharge	13.09	cfs
Headwater Depth/Height	2.55		Tailwater Elevation	576.97	ft
Inlet Control HW Elev.	581.91	ft	Control Type	Inlet Control	
Outlet Control HW Elev.	581.62	ft			

Grades					
Upstream Invert	578.08	ft	Downstream Invert	576.00	ft
Length	87.63	ft	Constructed Slope	0.023736	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.35	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.35	ft
Velocity Downstream	7.80	ft/s	Critical Slope	0.026149	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.018	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	581.62	ft	Upstream Velocity Head	0.85	ft
Ke	0.90		Entrance Loss	0.77	ft

Inlet Control Properties					
Inlet Control HW Elev.	581.91	ft	Flow Control	Submerged	
Inlet Type	Projecting		Area Full	1.8	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

000506

320/344

5316

Culvert Designer/Analyzer Report
west node 10BR

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	581.12	ft	Discharge	9.65	cfs
Headwater Depth/Height	1.16		Tailwater Elevation	580.06	ft
Inlet Control HW Elev.	581.04	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	581.12	ft			

Grades					
Upstream Invert	579.67	ft	Downstream Invert	579.52	ft
Length	44.12	ft	Constructed Slope	0.003400	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.89	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	0.89	ft
Velocity Downstream	5.16	ft/s	Critical Slope	0.007602	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.25	ft
Section Size	15 inch		Rise	1.25	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	581.12	ft	Upstream Velocity Head	0.27	ft
Ke	0.20		Entrance Loss	0.05	ft

Inlet Control Properties					
Inlet Control HW Elev.	581.04	ft	Flow Control	Transition	
Inlet Type	Groove end projecting		Area Full	2.5	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000507

Culvert Designer/Analyzer Report
west node 11R design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	580.64	ft	Discharge	19.28	cfs
Headwater Depth/Height	1.32		Tailwater Elevation	578.64	ft
Inlet Control HW Elev.	580.58	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	580.64	ft			

Grades					
Upstream Invert	578.01	ft	Downstream Invert	577.81	ft
Length	48.60	ft	Constructed Slope	0.004115	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.58	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.58	ft
Velocity Downstream	7.25	ft/s	Critical Slope	0.007804	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	580.64	ft	Upstream Velocity Head	0.61	ft
Ke	0.20		Entrance Loss	0.12	ft

Inlet Control Properties					
Inlet Control HW Elev.	580.58	ft	Flow Control	Submerged	
Inlet Type	Groove end projecting		Area Full	3.1	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000508

Culvert Designer/Analyzer Report
west node 12 design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	581.90	ft	Storm Event	Design	
Computed Headwater Eleva	579.42	ft	Discharge	32.49	cfs
Headwater Depth/Height	1.37		Tailwater Elevation	575.11	ft
Inlet Control HW Elev.	579.11	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	579.42	ft			

Grades					
Upstream Invert	576.00	ft	Downstream Invert	575.75	ft
Length	104.80	ft	Constructed Slope	0.002385	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.94	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.94	ft
Velocity Downstream	7.95	ft/s	Critical Slope	0.006986	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	579.42	ft	Upstream Velocity Head	0.68	ft
Ke	0.20		Entrance Loss	0.14	ft

Inlet Control Properties					
Inlet Control HW Elev.	579.11	ft	Flow Control	Submerged	
Inlet Type	Groove end projecting		Area Full	4.9	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000509

323/344

5316

Culvert Designer/Analyzer Report
west node 13

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	581.50	ft	Storm Event	Design	
Computed Headwater Eleva	580.39	ft	Discharge	5.73	cfs
Headwater Depth/Height	0.93		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	580.36	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	580.39	ft			

Grades					
Upstream Invert	579.00	ft	Downstream Invert	578.00	ft
Length	120.00	ft	Constructed Slope	0.008300	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.84	ft
Slope Type	Steep		Normal Depth	0.84	ft
Flow Regime	Supercritical		Critical Depth	0.92	ft
Velocity Downstream	5.66	ft/s	Critical Slope	0.006095	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	580.39	ft	Upstream Velocity Head	0.39	ft
Ke	0.20		Entrance Loss	0.08	ft

Inlet Control Properties					
Inlet Control HW Elev.	580.36	ft	Flow Control	Unsubmerged	
Inlet Type	Groove end projecting		Area Full	1.8	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000510

Culvert Designer/Analyzer Report
west node 14 design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	581.90	ft	Storm Event	Design	
Computed Headwater Eleva	579.26	ft	Discharge	3.20	cfs
Headwater Depth/Height	0.26		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	579.10	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	579.26	ft			

Grades					
Upstream Invert	578.60	ft	Downstream Invert	575.00	ft
Length	112.00	ft	Constructed Slope	0.032143	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.32	ft
Slope Type	Steep		Normal Depth	0.32	ft
Flow Regime	Supercritical		Critical Depth	0.39	ft
Velocity Downstream	4.04	ft/s	Critical Slope	0.013400	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.024	
Section Material	2x1 Corrugations Historic		Span	4.17	ft
Section Size	50 x 31 inch		Rise	2.58	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	579.26	ft	Upstream Velocity Head	0.14	ft
Ke	0.90		Entrance Loss	0.13	ft

Inlet Control Properties					
Inlet Control HW Elev.	579.10	ft	Flow Control	Unsubmerged	
Inlet Type	CR structural plate, projecting		Area Full	8.4	ft²
K	0.03000		HDS 5 Chart	35	
M	1.50000		HDS 5 Scale	1	
C	0.04960		Equation Form	1	
Y	0.57000				

000511

Culvert Designer/Analyzer Report
west node 15N design

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	584.26	ft	Discharge	0.46	cfs
Headwater Depth/Height	0.24		Tailwater Elevation	582.99	ft
Inlet Control HW Elev.	584.23	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	584.26	ft			

Grades					
Upstream Invert	583.90	ft	Downstream Invert	583.60	ft
Length	55.00	ft	Constructed Slope	0.005455	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.22	ft
Slope Type	Steep		Normal Depth	0.22	ft
Flow Regime	Supercritical		Critical Depth	0.25	ft
Velocity Downstream	2.89	ft/s	Critical Slope	0.003059	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.010	
Section Material	HDPE (Smooth Interior)		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	584.26	ft	Upstream Velocity Head	0.09	ft
Ke	0.20		Entrance Loss	0.02	ft

Inlet Control Properties					
Inlet Control HW Elev.	584.23	ft	Flow Control	Unsubmerged	
Inlet Type	Groove end projecting		Area Full	1.8	ft^2
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

000512

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

DESIGN CASE "A"

327/344

5316

Culvert Designer/Analyzer Report
reach 1

Peak Discharge Method: User-Specified			
Design Discharge	2.02 cfs	Check Discharge	0.00 cfs

Grades Model: Inverts			
Invert Upstream	587.35 ft	Invert Downstream	586.37 ft
Length	80.00 ft	Slope	0.012250 ft/ft
Drop	0.98 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	590.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	586.80 ft

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-18.0 x 11.0 inch Arch	2.02 cfs	588.03 ft	

000514

Culvert Designer/Analyzer Report
reach 1

sign:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	590.00	ft	Storm Event	Design	
Computed Headwater Elev	588.03	ft	Discharge	2.02	cfs
Headwater Depth/Height	0.75		Tailwater Elevation	586.80	ft
Inlet Control HW Elev.	587.97	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	588.03	ft			

Grades					
Upstream Invert	587.35	ft	Downstream Invert	586.37	ft
Length	80.00	ft	Constructed Slope	0.012250	ft/ft

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.43	ft
Slope Type	Steep		Normal Depth	0.35	ft
Flow Regime	N/A		Critical Depth	0.41	ft
Velocity Downstream	3.25	ft/s	Critical Slope	0.007284	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.018	
Section Material	Concrete		Span	1.50	ft
Section Size	18.0 x 11.0 inch		Rise	0.92	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	588.03	ft	Upstream Velocity Head	0.18	ft
Ke	0.50		Entrance Loss	0.09	ft

Inlet Control Properties					
Inlet Control HW Elev.	587.97	ft	Flow Control	N/A	
Inlet Typ	Square edge w/headwall (arch)		Area Full	1.1	ft^2
K	0.00980		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03980		Equation Form	1	
Y	0.67000				

000515

329/344

5316

Culvert Designer/Analyzer Report
reach 3

Peak Discharge Method: User-Specified			
Design Discharge	8.41 cfs	Check Discharge	0.00 cfs

Grades Model: Inverts			
Invert Upstream	581.60 ft	Invert Downstream	581.30 ft
Length	55.00 ft	Slope	0.005455 ft/ft
Drop	0.30 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	585.50 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	582.27 ft

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	2-18 inch Circular	8.41 cfs	582.76 ft	

000516

330/344
5316

Culvert Designer/Analyzer Report
reach 3

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	585.50	ft	Storm Event	Design	
Computed Headwater Elev.	582.76	ft	Discharge	8.41	cfs
Headwater Depth/Height	0.77		Tailwater Elevation	582.27	ft
Inlet Control HW Elev.	582.70	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	582.76	ft			

Grades					
Upstream Invert	581.60	ft	Downstream Invert	581.30	ft
Length	55.00	ft	Constructed Slope	0.005455	ft/ft

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.97	ft
Slope Type	Steep		Normal Depth	0.68	ft
Flow Regime	N/A		Critical Depth	0.79	ft
Velocity Downstream	3.48	ft/s	Critical Slope	0.003243	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.010	
Section Material	HDPE (Smooth Interior)		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	582.76	ft	Upstream Velocity Head	0.31	ft
Ke	0.20		Entrance Loss	0.06	ft

Inlet Control Properties					
Inlet Control HW Elev.	582.70	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	3.5	ft^2
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

000517

Culvert Designer/Analyzer Report
reach 4

Peak Discharge Method: User-Specified			
Design Discharge	1.90 cfs	Check Discharge	0.00 cfs

Grades Model: Inverts			
Invert Upstream	582.70 ft	Invert Downstream	581.50 ft
Length	60.00 ft	Slope	0.020000 ft/ft
Drop	1.20 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	587.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	582.94 ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-18 inch Circular	1.90 cfs	583.45 ft	

000518

Culvert Designer/Analyzer Report
reach 4

esign:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	587.00	ft	Storm Event	Design	
Computed Headwater Elev	583.45	ft	Discharge	1.90	cfs
Headwater Depth/Height	0.50		Tailwater Elevation	582.94	ft
Inlet Control HW Elev.	583.40	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	583.45	ft			

Grades					
Upstream Invert	582.70	ft	Downstream Invert	581.50	ft
Length	60.00	ft	Constructed Slope	0.020000	ft/ft

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	1.44	ft
Slope Type	Steep		Normal Depth	0.32	ft
Flow Regime	N/A		Critical Depth	0.52	ft
Velocity Downstream	1.09	ft/s	Critical Slope	0.002919	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.010	
Section Material	HDPE (Smooth Interior)		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	583.45	ft	Upstream Velocity Head	0.19	ft
Ke	0.20		Entrance Loss	0.04	ft

Inlet Control Properties					
Inlet Control HW Elev.	583.40	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	1.8	ft^2
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

000519

333/344

5316

Culvert Designer/Analyzer Report
reach 8

Peak Discharge Method: User-Specified			
Design Discharge	24.73 cfs	Check Discharge	0.00 cfs

Grades Model: Inverts			
Invert Upstream	579.33 ft	Invert Downstream	578.84 ft
Length	49.00 ft	Slope	0.010000 ft/ft
Drop	0.49 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	582.50 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	579.84 ft

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	2-30 inch Circular	24.73 cfs	581.38 ft	

000520

Culvert Designer/Analyzer Report
reach 8

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	582.50	ft	Storm Event	Design	
Computed Headwater Elev	581.38	ft	Discharge	24.73	cfs
Headwater Depth/Height	0.82		Tailwater Elevation	579.84	ft
Inlet Control HW Elev.	581.13	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	581.38	ft			

Grades					
Upstream Invert	579.33	ft	Downstream Invert	578.84	ft
Length	49.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.09	ft
Slope Type	Steep		Normal Depth	1.09	ft
Flow Regime	Supercritical		Critical Depth	1.18	ft
Velocity Downstream	6.01	ft/s	Critical Slope	0.007567	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.017	
Section Material	CMP		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	581.38	ft	Upstream Velocity Head	0.46	ft
Ke	0.90		Entrance Loss	0.41	ft

Inlet Control Properties					
Inlet Control HW Elev.	581.13	ft	Flow Control	N/A	
Inlet Type	Projecting		Area Full	9.8	ft^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GO3211 Task No.: 6/4

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

DESIGN CASE "B"

000522

Culvert Designer/Analyzer Report
DCB node 7

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	589.44	ft	Discharge	64.43	cfs
Headwater Depth/Height	0.91		Tailwater Elevation	587.98	ft
Inlet Control HW Elev.	589.27	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	589.44	ft			

Grades					
Upstream Invert	586.95	ft	Downstream Invert	586.53	ft
Length	92.00	ft	Constructed Slope	0.004565	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.45	ft
Slope Type	Mild		Normal Depth	1.74	ft
Flow Regime	Subcritical		Critical Depth	1.38	ft
Velocity Downstream	6.10	ft/s	Critical Slope	0.008520	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.019	
Section Material	Steel and Aluminum Var CR		Span	4.08	ft
Section Size	49 x 33 inch		Rise	2.75	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	589.44	ft	Upstream Velocity Head	0.42	ft
Ke	0.90		Entrance Loss	0.38	ft

Inlet Control Properties					
Inlet Control HW Elev.	589.27	ft	Flow Control	Unsubmerged	
Inlet Type	Thin wall projecting		Area Full	17.8	ft^2
K	0.03400		HDS 5 Chart	34	
M	1.50000		HDS 5 Scale	3	
C	0.04960		Equation Form	1	
Y	0.57000				

000523

Written by: Victoria Cheplak (VSC) Date 12/19/03 Reviewed by: _____ Date: _____

Client: Fluor Fernald, Inc. Project: OSDF Phase V Revision Project No.: GQ3211 Task No.: 6/4

CulvertMaster® OUTPUT REPORTS FOR CULVERTS

DESIGN CASE "C"

338/344

5316

Culvert Design Report
Design Case C node 5

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	N/A ft	Storm Event	Design
Computed Headwater Elevation	584.36 ft	Discharge	45.14 cfs
Headwater Depth/Height	1.05	Tailwater Elevation	581.71 ft
Inlet Control HW Elev.	584.11 ft	Control Type	Outlet Control
Outlet Control HW Elev.	584.36 ft		

Grades			
Upstream Invert	580.68 ft	Downstream Invert	579.98 ft
Length	95.00 ft	Constructed Slope	0.007368 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	2.10 ft
Slope Type	Mild	Normal Depth	2.21 ft
Flow Regime	Subcritical	Critical Depth	2.10 ft
Velocity Downstream	7.51 ft/s	Critical Slope	0.008606 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.018
Section Material	CMP	Span	3.50 ft
Section Size	42 inch	Rise	3.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	584.36 ft	Upstream Velocity Head	0.78 ft
Ke	0.90	Entrance Loss	0.70 ft

Inlet Control Properties			
Inlet Control HW Elev.	584.11 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	9.6 ft^2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

000525

ATTACHMENT C-4B

TABULATED ANALYSIS RESULTS FOR CULVERTS

OSDF CONSTRUCTION/FILLING PERIOD CONDITIONS
SUMMARY OF CULVERT ANALYSES RESULTS

CULVERT IDENTIFICATION			PHYSICAL CHARACTERISTICS OF CULVERT						CULVERT PROFILE				CULVERTMASTER® MODELING CHARACTERISTICS			HYDRAULIC CAPACITY					STRUCTURAL CAPACITY (6)				OUTLET PROTECTION (6)				
Culvert Name	Status (1)	Design Scenario	Material - Type	Entrance Loss Coefficient (Ke)	Manning's n	Entrance Configuration (2)	Number of Culverts - Diameter	Approximate Length (ft)	Inlet Invert Elevation (ft MSL)	Outlet Invert Elevation (ft MSL)	Slope ft/ft	Overtopping Elevation (ft MSL)	Entrance Configuration(2)	Entrance Loss Coefficient (Ke)	Number of Culverts - Diameter (3)	HydroCad Node / Peak Flow Rate (cfs)	Tailwater Elevation (ft MSL)	Calculated Headwater Depth - Inlet Control (4) (ft MSL)	Calculated Headwater Depth Outlet Control (4) (ft MSL)	Calculated Freeboard (ft)	Available Cover (ft)	Design Traffic Type	Minimum Required Cover (ft)	Structurally Stable	Outlet Velocity (ft/s)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	d_{50} (in)	Thickness (in)
11a	existing	E OSDF	HDPE	0.2	0.010	Projecting	2 - 27 inch	40	583.67	583.58	0.0023	587.20	Groove - Projecting	0.2	3 - 27 inch	11R / 79.26	584.74	586.62	586.62	0.6	-	-	-	-	7.8	-	-	-	-
11b	existing	E OSDF	RCP	0.2	0.013	Projecting	1 - 30 inch	40																					
23	new	E OSDF	Helical CMP	0.9	0.018	Projecting	2 - 36 inch	92	586.32	585.78	0.0059	590.00	Projecting	0.9	2 - 36 inch	23 / 48.76	587.01	588.83	589.02	1.0	2.04	On-Highway	2	yes	6.4	6	12	6	12
25	new	E OSDF	Helical CMP - Arch	0.9	0.018	Projecting	2 - 42 x 29 inch	53	584.85	584.53	0.0060	588.50	Thin Wall Projecting	0.9	2 - 42 x 29 inch	25 / 64.24	586.73	578.53	587.71	0.8	3.23	On-Highway	2	yes	4.9	0	0	0	0
27	new	E OSDF	Helical CMP - Arch	0.9	0.018	Projecting	2 - 42 x 29 inch	106	582.80	582.36	0.0042	587.00	Thin Wall Projecting	0.9	2 - 42 x 29 inch	27 / 65.00	583.88	585.50	585.63	1.4	3.78	Off-Highway	3	yes	6.8	7	14	6	12
28R	new - temporary	E OSDF	Helical CMP - Arch	0.9	0.019	Projecting	2 - 49 x 33 inch	140	585.75	585.00	0.0054	592.39	Thin Wall Projecting	0.9	2 - 49 x 33 inch	28R / 77.19	585.57	588.41	588.57	3.8	3.89	Off-Highway	3	yes	6.9	8	16	6	12
31	existing	E OSDF	HDPE	0.9	0.012	Projecting	1 - 27 inch	80	584.00	583.00	0.0125	588.50	Groove - Projecting	0.9	1 - 27 inch	31 / 6.54	584.51	585.20	585.49	3.0	-	-	-	-	2.3	-	-	-	-
5	new - temporary	W OSDF	Helical CMP	0.9	0.024	Projecting	1 - 42 inch	95	560.68	579.98	0.0737	585.34	Projecting	0.9	1 - 42 inch	5 / 55.45	582.50	584.67	584.89	0.5	27.64	Off-Highway	3	yes	7.48	7	14	6	12
7AR	new	W OSDF	CMP	0.9	0.024	Projecting	1 - 42 inch	82	577.67	577.23	0.0053	582.57	Projecting	0.9	1 - 42 inch	7AR / 57.96	579.58	581.8	582.10	0.5	4.83	Off-Highway	3	yes	8.30	6	12	6	12
7CR	existing	W OSDF	RCP - Horizontal Ellipse	0.2	0.013	Concrete Headwall	1 - 34 x 53 inch	296	574.96	573.50	0.00493	580.00	Groove - Headwall	0.2	1 - 34 x 53 inch	7CR / 58.08	575.39	577.92	578.01	2.0	-	-	-	-	8.40	-	-	-	-
8BR	existing	W OSDF	RCP	0.2	0.013	Concrete Headwall	2 - 36 inch	30	572.12	572.00	0.00400	577.00	Groove - Headwall	0.2	2 - 36 inch	8BR / 81.21	573.29	575.19	575.32	1.7	-	-	-	-	7.78	-	-	-	-
9BR	new	W OSDF	Helical CMP	0.9	0.018	Projecting	1 - 18 inch	88	578.08	576.00	0.02361	585.00	Projecting	0.9	1 - 18 inch	9BR / 13.09	576.97	581.91	581.62	3.1	5.42	Off-Highway	3	yes	7.80	3	6	6	12
10BR	new	W OSDF	RCP	0.2	0.013	Projecting	2 - 15 inch	44	579.67	579.52	0.00341	581.92	Groove - Projecting	0.2	2 - 15 inch	10BR / 9.65	580.06	581.04	581.12	0.8	1.00	N/A	N/A	N/A	5.16	2.5	5	6	12
11R	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 24 inch	49	578.01	577.81	0.00412	583.66	Groove -Projecting	0.2	1 - 24 inch	11R / 19.28	578.64	580.58	580.64	3.0	4.65	On-Highway	2	yes	7.25	4	8	6	12
12	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 30 inch	105	576.00	575.75	0.0024	582.40	Groove -Projecting	0.2	1 - 30 inch	12 / 32.49	575.11	579.11	579.42	3.0	3.90	On-Highway	2	yes	7.95	5	10	6	12
13	new	W OSDF	RCP	0.2	0.013	Projecting	1 - 18 inch	120	579.00	578.00	0.0083	582.33	Groove - Projecting	0.2	1 - 18 inch	13 / 5.73	N/A	580.36	580.39	1.9	2.33	On-Highway	2	yes	5.66	3	6	6	12
14	existing	W OSDF	CMP	0.9	0.024	Projecting	1 - 50 x 31 inch	112	578.60	575.00	0.0321	581.90	Projecting	0.9	1 - 50 x 31 inch	14 / 3.20	N/A	579.1	579.26	2.6	-	-	-	-	4.04	-	-	-	-
15N	existing	W OSDF	HDPE	0.2	0.010	Projecting	1 - 18 inch	55	583.90	583.60	0.0055	585.05	Groove - Projecting	0.2	1 - 18 inch	15N / 0.46	582.99	584.23	584.26	0.8	-	-	-	-	2.89	-	-	-	-
1	existing - temporary	DC A	CMPA - Arch	0.5	0.018	Flared End Section	1 - 13 x 17 inch	80	587.35	586.37	0.0123	590.00	Headwall	0.5	1 - 11 x 18 inch	1 / 2.02	586.80	587.97	588.03	2.0	-	-	-	-	3.3	-	-	-	-
3	existing - temporary	DC A	PVC	0.2	0.010	Concrete Headwall	2 - 18 inch	55	581.60	581.30	0.0055	585.50	Groove Headwall	0.2	2 - 18 inch	3 / 8.41	582.27	582.70	582.76	2.7	-	-	-	-	3.5	-	-	-	-
4	existing - temporary	DC A	PVC	0.2	0.010	Concrete Headwall	2 - 18 inch	60	582.70	581.50	0.0200	587.00	Groove Headwall	0.2	2 - 18 inch	4 / 1.90	582.94	583.4	583.45	3.5	-	-	-	-	1.1	-	-	-	-
8	new - temporary	DC A	Helical CMP	0.9	0.017	Projecting	2 - 30 inch	49	579.33	578.84	0.0100	582.50	Projecting	0.9	2 - 30 inch	8 / 24.73	579.84	581.13	581.38	1.1	2.32	On-Highway	2	yes	6.0	5	10	6	12
7	new - temporary	DC B	Helical CMP - Arch	0.9	0.019	Projecting	2 - 49 x 33 inch	92	586.95	586.53	0.0046	593.5	Thin Wall Projecting	0.9	2 - 49 x 33 inch	7 / 64.43	587.98	589.27	589.44	4.1	3.8	Off-Highway	3	yes	6.1	8	16	6	12
5	new - temporary	DC C	Helical CMP	0.9	0.018	Projecting	1 - 42 inch	95	580.68	579.98	0.0074	591.82	Projecting	0.9	1 - 42 inch	5 / 45.14	581.71	584.11	584.36	7.5	7.64	Off-Highway	3	yes	7.51	7	14	6	12

- E OSDF = East OSDF Construction-Phase Design Scenario
- W OSDF = West OSDF Construction-Phase Design Scenario
- DC A = Design Case "A"
- N/A = Not Applicable
- d_{50} = Average particle diameter

Notes
(1) New indicates a new culvert to be installed.
(2) Entrance configuration assumed.
(3) Dimensions and entrance configurations used in the Culvertmaster software package were selected to match existing culvert characteristics as closely as possible.
(4) Headwater depths calculated using Culvertmaster software package. Summary output presented for each culvert in Attachment C-4A.
(5) Grading is provided in the Construction Drawings
(6) Neither structural capacity nor outlet protection are evaluated for existing culverts.

OSDF CONSTRUCTION/FILLING PERIOD CONDITIONS
SUMMARY OF CULVERT RIP RAP ANALYSES RESULTS

CULVERT IDENTIFICATION			PHYSICAL CHARACTERISTICS OF CULVERT				OUTLET PROTECTION									
									Temporary Protection		Permanent Protection		DCP Minimum Apron Length			
Culvert Name	Status [1]	Design Scenario	Material - Type	Manning's n	Number of Culverts - Diameter	Approximate Length (ft)	HydroCad Node / Peak Flow Rate (cfs)	Outlet Velocity (ft/s)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	Riprap Length at Inlet (ft)	Riprap Length at Outlet (ft)	d_{50} (in)	Thickness (in)
11a	existing	E OSDF	HDPE	0.010	2 - 27 inch	40	11R / 79.26	7.7	-	-	-	-	-	-	-	-
11b	existing	E OSDF	RCP	0.013	1 - 30 inch	40			-	-	-	-	-	-	-	-
23	new	E OSDF	Helical CMP	0.018	2 - 36 inch	92	23 / 48.76	6.4	-	-	6	8	6	12	6	12
25	new	E OSDF	Helical CMP - Arch	0.018	2 - 42 x 29 inch	53	25 / 64.24	4.9	-	-	none recommended		7	14	6	12
27	new	E OSDF	Helical CMP - Arch	0.018	2 - 42 x 29 inch	106	27 / 65.00	6.8	-	-	7	8	7	14	6	12
28R	new - temporary	E OSDF	Helical CMP - Arch	0.019	2 - 49 x 33 inch	140	28R / 77.19	6.9	none recommended		-	-	8	16	6	12
31	existing	E OSDF	HDPE	0.012	1 - 27 inch	80	31 / 6.54	2.3	-	-	-	-	-	-	-	-
5	new - temporary	W OSDF	Helical CMP	0.024	1 - 42 inch	95	5 / 55.45	7.48	7	12	-	-	7	14	6	12
7AR	new	W OSDF	CMP	0.024	1 - 42 inch	82	7AR / 57.96	8.27	-	-	6	9	6	12	6	12
7CR	existing	W OSDF	RCP - Horizontal Ellipse	0.013	1 - 34 x 53 inch	296	7CR / 58.08	8.36	-	-	-	-	-	-	-	-
8BR	existing	W OSDF	RCP	0.013	2 - 36 inch	30	8BR / 81.21	7.63	-	-	-	-	-	-	-	-
9BR	new	W OSDF	Helical CMP	0.018	1 - 18 inch	88	9BR / 13.09	7.81	-	-	3	5	3	6	6	12
10BR	new	W OSDF	RCP	0.013	2 - 15 inch	44	10BR / 9.65	5.16			2.5	5	2.5	5	6	12
11R	new	W OSDF	RCP	0.013	1 - 24 inch	49	11R / 19.28	7.3	-	-	4	6	4	8	6	12
12	new	W OSDF	RCP	0.013	1 - 30 inch	105	12 / 32.49	7.81	-	-	5	7	5	10	6	12
13	new	W OSDF	RCP	0.013	1 - 18 inch	120	13 / 5.73	5.66	-	-	3	5	3	6	6	12
14	existing	W OSDF	CMP	0.024	1 - 50 x 31 inch	112	14 / 3.20	4.04	-	-	-	-	-	-	-	-
15N	existing	W OSDF	HDPE	0.010	1 - 18 inch	55	15N / 0.46	2.89	-	-	-	-	-	-	-	-
1	existing - temporary	DC A	CMPA - Arch	0.018	1 - 13 x 17 inch	80	1 / 2.02	3.3	-	-	-	-	-	-	-	-
3	existing - temporary	DC A	PVC	0.010	2 - 18 inch	55	3 / 8.41	3.5	-	-	-	-	-	-	-	-
4	existing - temporary	DC A	PVC	0.010	2 - 18 inch	60	4 / 1.90	1.1	-	-	-	-	-	-	-	-
8	new - temporary	DC A	Helical CMP	0.017	2 - 30 inch	49	8 / 24.73	6.0	4	8	-	-	5	10	6	12
7	new - temporary	DC B	Helical CMP - Arch	0.7	0.019	65	7 / 64.43	6.1	8	10	-	-	8	16	6	12
5	new - temporary	DC C	Helical CMP	0.9	1 - 42 inch	95	5 / 45.14	7.5	7	12			7	14	6	12

- E OSDF = East OSDF Construction-Phase Design Scenario
- W OSDF = West OSDF Construction-Phase Design Scenario
- DC A = Design Case "A"
- N/A = Not Applicable
- d_{50} = Average particle diameter

ATTACHMENT C-5

TABULATED ANALYSIS RESULTS FOR BASIN OUTLET STRUCTURES

ITEM		BORROW AREA BASIN		
		DESCRIPTION	PARAMETER VALUE IN UNITS SHOWN	
PRINCIPAL SPILLWAY	Riser Pipe	Existing Twin 48" CMP	ELEVATION (ft MSL)	575.3
	Outlet Pipe	Existing Twin 48" CMP		569.8
EMERGENCY SPILLWAY		20' long rectangular		578.0
EMBANKMENT		Cut to existing ground		579.0
AVAILABLE STORAGE VOLUME (TO RISER INLET)		To primary spillway riser pipe inlet	VOLUME (acre-ft)	35.8
SUBCATCHMENT		Total Upstream Drainage Area	AREA (acres)	160.89

Notes

1. Minimum Sedimentation Basin volume of 35.8 acre-ft exceeds disturbed area-based volume of 6.7 acre-ft.
2. A freeboard greater than 1 ft of maintained for the 25-year, 24-hour storm event.
3. Calculation for volume based on drainage area.
   (1800 cf) x (160.89 acres of upstream drainage area) x (1 year/cleanout) = 289,602 cf/cleanout

BORROW AREA BASIN ROUTING RESULTS

DESIGN PARAMETER	Value
25-YEAR 24-HOUR PEAK WATER ELEVATION (ft MSL)	574.16
REQUIRED STORAGE VOLUME BASED ON DRAINAGE AREA (acre-ft)	6.6

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ITEM		OSDF SEDIMENTATION BASIN 2		
		DESCRIPTION	PARAMETER VALUE IN UNITS SHOWN	
PRINCIPAL SPILLWAY	Riser Pipe	48"	ELEVATION (ft MSL)	575.5
	Outlet Pipe	New 36" CMP pipe/72" x 44" CMP pipe arch bulkhead eccentric reducer coupled to existing 72" x 44" CMP pipe arch		570.8
EMERGENCY SPILLWAY		20 ' long rectangular		576.0
EMBANKMENT		Cut to existing ground surface		577.0
AVAILABLE STORAGE VOLUME (TO RISER INLET)		To primary spillway riser pipe inlet	VOLUME (acre-ft)	8.6
SUBCATCHMENT		Total Upstream Drainage Area	AREA (acres)	39.90

OSDF SEDIMENTATION BASIN 2 ROUTING RESULTS

DESIGN PARAMETER	Value
10-YEAR 24-HOUR RUNOFF VOLUME (acre-ft)	8.51
25-YEAR 24-HOUR PEAK WATER ELEVATION (ft MSL)	575.67
100-YEAR 24-HOUR PEAK WATER ELEVATION (ft MSL)	575.85
REQUIRED STORAGE VOLUME BASED ON DRAINAGE AREA (acre ft)	4.988

Notes

1. Minimum Sedimentation Basin volume of 8.6 acre-ft exceeds disturbed area-based volume of 4.901 acre-ft.
   Minimum Sedimentation Basin volume of 8.6 acre-ft exceeds the 10-year, 24-hour runoff volume of 8.33 acre-ft
2. Flow does not enter emergency spillway for the 25-year, 24-hour storm event.
3. A freeboard of 1 ft is maintained for the 100-yr, 24-hour storm event.
4. Calculation for volume based on drainage area.
   (0.125 acre-ft/acre-year) x (39.21 acres of upstream drainage area) x (1 year/cleanout) = 4.99 acre-ft/cleanout

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13.3 OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

COMPUTATION COVER SHEET

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SUBJECT OF COMPUTATIONS OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

Computations By:
(Cognizant Engineer)

Signature: Victoria Cheplak — Date: 1-21-04

Printed Name and Title: Victoria Cheplak, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: [signature] — Date: 1-21-04

Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Computations Checked by:

Signature: Hollie Kinnecom — Date: 1-21-04

Printed Name and Title: Holly Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: Victoria Cheplak — Date: 1-21-04

Printed Name and Title: Victoria Cheplak, Senior Staff Engineer

Approved by:
(PDP)

Signature: [signature] — Date: 1-21-04

Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 1/22/04

Printed Name and Title: R. Bonaparte, Engineer of Record

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval
0	Submittal to FF/DOE/EPA	30 Jan 02	DGP for DBM	DGP	JFB
1	CFC Revision 1 Submittal to FF/DOE/EPA	23 Jan 04	VSC VSC	GG	RB
1					

ADDENDUM TO SECTION 13.1

(ADDED TO REVISION 1 PACKAGE)

The 2000-year drainage channel aligned along the east perimeter of the OSDF was originally designed to convey runoff from the east slope of the OSDF final cover system and runon from east of the OSDF. This channel was designed to include a 1% overbank between the 25-year channel and the Emergency Access Road (formerly the Rerouted North Entrance Road), to accommodate these flows. Further analyses (presented in this addendum) show that a portion of the runon from the 2000-year storm event is diverted by the road embankment and thus does not enter the channel. Additionally, the geometry of a segment of the channel differs from the original design by not including a 1% overbank.

This addendum is prepared to evaluate the adequacy of the East 2000-year channel considering the diversion of runon by the Emergency Access Road and the existing and as-designed geometry of the channel. For Cells 1 to 3, the channel geometry used in the evaluation is consistent with a recent aerial topographic plan, which does not reflect a 1% overbank. For Cell 4, the channel geometry used in the evaluation is consistent with OSDF Phase IV construction drawings, which does not include a 1% overbank. For Cells 5 to 8, the channel geometry used in the evaluation is consistent with OSDF Phase V construction drawings, which shows the originally designed 1% overbank along a portion of the cells. Calculation procedures and input data are similar to that used in Section 13.1. This addendum is presented as Section 13.3 of the OSDF Final Design Calculation Package and is entitled "OSDF Phase V, East 2000-Year Drainage Channel Evaluation". Section 13.3 is presented in Volume VII of the OSDF Final Design Calculation Package.

OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

EXECUTIVE SUMMARY

PURPOSE OF ANALYSES

The 2000-year drainage channel aligned along the east perimeter of the OSDF (2000-year channel) was originally designed to convey runoff from the east slope of the OSDF final cover system and runon from east of the OSDF, for the 2000-year 24-hour storm event. This channel was previously evaluated as part of Calculation Section 13.1.

For the evaluation presented in Calculation Section 13.1, the channel geometry was consistent with the OSDF Final Design Package, which included a 1% overbank between the East 25-year runoff channel (25-year channel) and the Emergency Access Road (formerly the Rerouted North Entrance Road). The final channel geometry East of Cells 1 to 4 will differ from the OSDF Final Design Package by not incorporating a 1% overbank. Furthermore, analyses presented herein indicate that runon south of Cell 4 is expected to be diverted by the Emergency Access Road (road) embankment and thus not enter the 2000-year channel. Runon along and north of Cell 4 is considered to enter the 2000-year channel due to the presence of a culvert and berm crossing the runon channel at the southeast corner of Cell 4.

The purpose of this calculation is to revaluate the adequacy of the 2000-year channel using a channel geometry that exists along Cells 1 to 3 and is expected to exist (with the completion of Phases IV and V construction) along Cells 4 to 8, to convey runoff from the 2000-year 24-hour storm event with a minimum 0.5 ft freeboard.

METHOD OF ANALYSES

Analysis methods and input data, not specific to channel geometry, are consistent with that used in the OSDF Final Design calculation package "Stormwater Runon/Runoff and Drainage Control Structures" (i.e., Calculation Section 13.1).

Cross-sectional geometry for the 2000-year channel along Cells 1 to 3 was obtained from a topographic map prepared after construction of this segment of the channel. This channel segment exists and was constructed without the 1% overbank. Cross-sectional geometry for the 2000-year channel along Cell 4 was obtained from OSDF Phase IV Final Certified-For-Construction drawings (Phase IV drawings). The channel segment along Cell 4 is yet to be constructed; Phase IV drawings show this segment to be constructed without a 1% overbank. Cross-sectional geometry for the 2000-year channel along Cells 5, 6, 7, and 8 was obtained from OSDF Phase V Certified-For-Construction drawings (Phase V drawings).

RESULTS AND CONCLUSIONS

The results of the analyses performed indicate that freeboard for the 2000-year channel will equal or exceed 0.5 ft (measured vertically from the subgrade of the Monitoring Access which is located at the approximate terminal end of the final cover system) for peak flows from the 2000-year 24-hour storm event. Based on the above, the 2000-year channel as constructed for Cells 1 to 3 and to be constructed for Cells 4 to 8 is expected to convey the 2000-year 24-hour event without adversely impacting the On-Site Disposal Facility (OSDF) final cover system.

OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

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OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

PROCEDURES

INTRODUCTION AND PURPOSE

The 2000-year drainage channel aligned along the east perimeter of the OSDF (2000-year channel) was originally designed to convey runoff from the east slope of the OSDF final cover system and runon from east of the OSDF, for the 2000-year 24-hour storm event. This channel was previously evaluated as part of Calculation Section 13.1.

For the evaluation presented in Calculation Section 13.1, the OSDF Final Design Package which included a 1% overbank between the East 25-year runoff channel (25-year channel) and the Emergency Access Road (formerly the Rerouted North Entrance Road). The final channel geometry East of Cells 1 to 4 will differ from the OSDF Final Design Package by not incorporating a 1% overbank. Furthermore, analyses presented herein indicate that runon downstream of Cell 4 is expected to be diverted by the Emergency Access Road (road) embankment and thus not enter the 2000-year channel. Runon along and north of Cell 4 is considered to enter the 2000-year channel due to the presence of a culvert and berm crossing the runon channel at the southeast corner of Cell 4.

The purpose of this calculation is to revaluate the adequacy of the 2000-year channel using a channel geometry that exists along Cells 1 to 3 and is expected to exist (with the completion of Phases IV and V construction) along Cells 4 to 8, to convey runoff from the 2000-year 24-hour storm event with a minimum 0.5 ft freeboard.

DESIGN CRITERIA

The design criteria for this calculation are consistent with that used in Calculation Section 13.1.

DESIGN SCENARIOS

As in the OSDF Final Design Package [GeoSyntec, 1997], three independent scenarios were

analyzed for the 2000-year channel. These three scenarios model differing vegetative conditions to reflect different time periods after the closure of the facility. The scenarios are identified as follows: 2000-Year Storm Design Scenario-Light Vegetation, 2000-Year Storm Design Scenario-Moderate Vegetation, and 2000-Year Storm Design Scenario-Heavy Vegetation.

Layout for 2000-Year Design Scenarios

The layout of the East Perimeter of the OSDF for the 2000-year design scenarios is consistent with existing conditions and future modifications shown on Phase IV and Phase V drawings (Phases yet to be constructed). Runon along and north of Cell 4 is considered to enter the 2000-year channel due to the presence of a culvert and berm crossing the runon channel at the southeast corner of Cell 4. The capacity of the Emergency Access Road (road) embankment to divert runon downstream of Cell 4 for the 2000-year storm event (thus preventing the runon from entering the 2000-year channel) is evaluated. A schematic drawing showing the layout of the East Perimeter of the OSDF for the purpose of hydrologic calculations is included as Attachment A-1.

SOFTWARE

The software (i.e. HydroCad™) and analysis methods employed for this calculation is consistent with that used in Calculation Section 13.1.

HYDROLOGIC ANALYSES

Procedures used for hydrologic analyses are consistent with that used in Calculation Section 13.1, updated to reflect the expected long-term geometry of the 2000-year drainage channel and the configuration of the Emergency Access Road embankment.

HYDRAULIC ANALYSES

Procedures for hydraulic analyses are consistent with that used in Calculation Section 13.1, updated to include the 1% overbank (where expected to be present along the channel alignment), the geometry of the Emergency Access Road embankment, and the adjacent runon diversion area.

ATTACHMENT A-1

LAYOUT OF 2000-YEAR STORM DESIGN SCENARIOS

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LEGEND

SUBCATCHMENT LABEL AND BOUNDARY

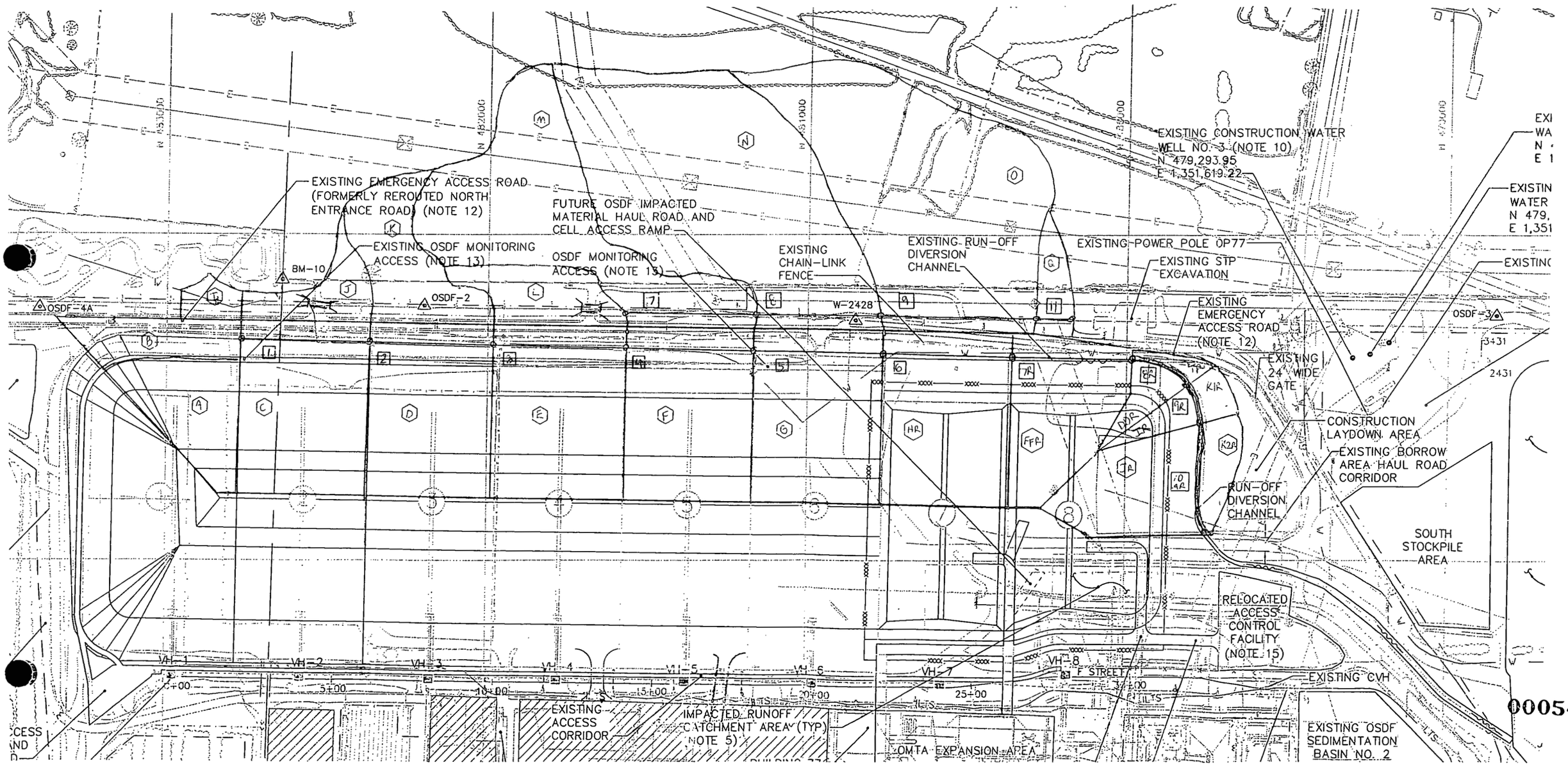
REACH ALIGNMENT AND LABEL

CULVERT

PHASE V
2000 YEAR STORM DESIGN SCENARIO
SCALE 1" = 300'

N

0 300'



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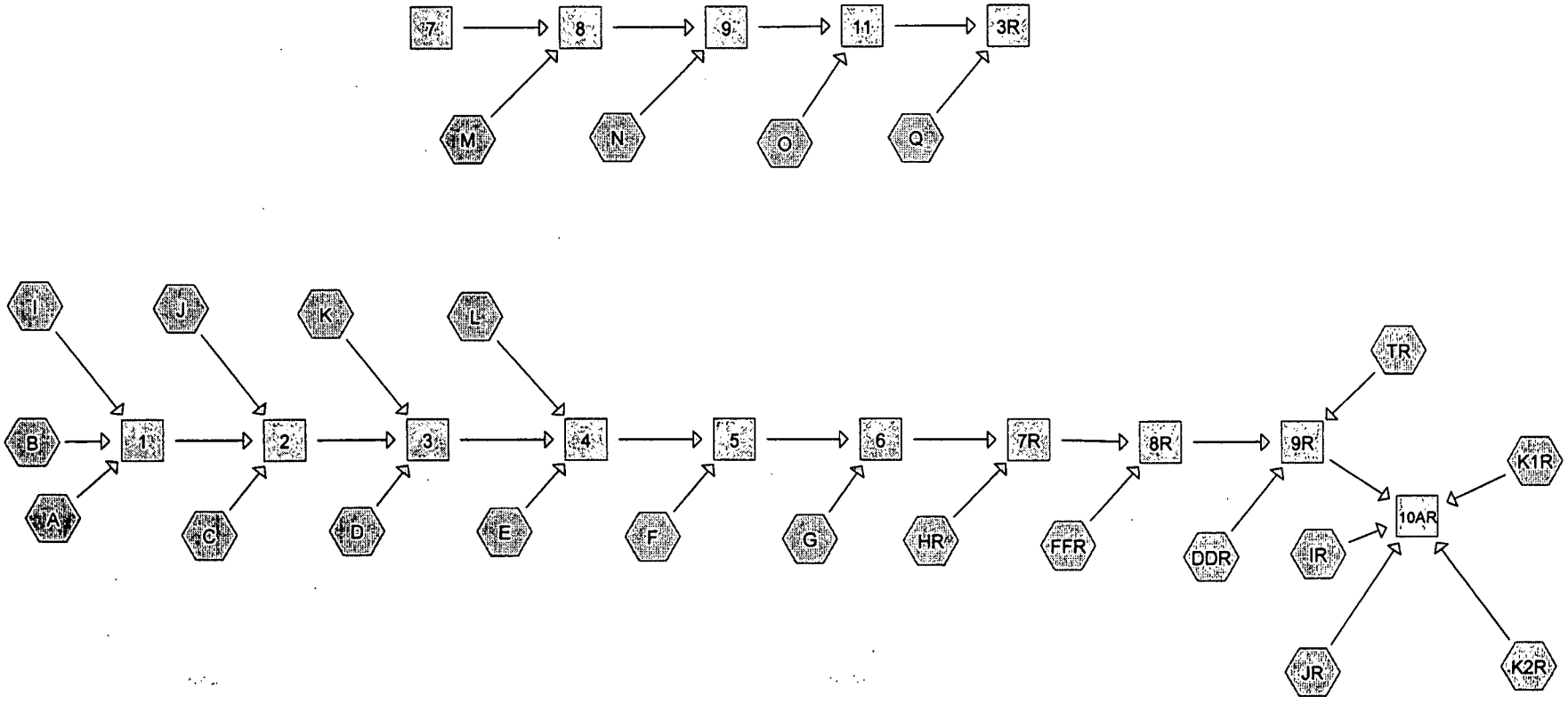
ATTACHMENT A-2

NODAL NETWORK DIAGRAM



Subcat Reach Pond Link

Drainage Diagram for 2000 year storm-light
Prepared by GeoSyntec Consultants 1/15/2004
HydroCAD® 6.00 s/n 000929 © 1986-2001 Applied Microcomputer Systems

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OSDF PHASE V, EAST-2000 YEAR DRAINAGE CHANNEL

DATA VERIFICATION

INTRODUCTION

As described in the Procedures Section, the purpose of this calculation is to re-evaluate the adequacy of the 2000-year channel, using the channel geometry that exists along Cells 1 to 3 and is expected to exist (with the completion of Phases IV and V construction) along Cells 4 to 8, to convey runoff from the 2000-year 24-hour storm event with a minimum 0.5 ft freeboard. This section (Data Verification) presents the selection of parameters used to perform analyses in the Calculations Section of this calculation package.

HYDROLOGIC ANALYSES

For the three 2000 Year Storm Design Scenarios, the relationships of subcatchments and reaches are shown by the nodal network diagram presented in Attachment A-2.

Rainfall Distribution

The rainfall distribution used for this calculation is consistent with Calculation Section 13.1 (i.e., an SCS Type II Rainfall Distribution used for the Fernald site location).

Rainfall Depth

The rainfall depths used for this calculation is consistent with Calculation Section 13.1 (i.e., a rainfall depth of 13.0 inches is used for the 2000-year storm event).

Runoff curve numbers

The runoff curve numbers used for this calculation are consistent with Calculation Section 12.5, "OSDF Phase V, Surface-Water Management System Design and Post-Closure Hydrology", adjusted to an antecedent moisture condition (AMC) of III. Subcatchment

characteristics including total area and data for calculation of weighted CN are tabulated in Attachment B-1. Data includes the percentage of subcatchment area for combinations of HSG, CN, and a land use description for each subcatchment. Land use description is selected to be consistent with conditions expected for the post-closure period.

Subcatchment Time of Concentration

Subcatchment characteristics for calculation of time of concentration are tabulated in Attachment B-2. Parameters include those for sheet, shallow concentrated, and channel flow. As in Calculation Section 13.1, three different scenarios are analyzed. Different combinations of Manning's number, for both sheet and channel flow, are selected for each design scenario. These parameters are presented below and are consistent with those used in Calculation Section 13.1:

2000-Year Storm Design Scenario	Manning's n for Sheet Flow	Manning's n for Channel Flow
Light Vegetation	0.150	0.030
Moderate Vegetation	0.240	0.030
Heavy Vegetation	0.240	0.070

HYDRAULIC ANALYSES

Geometric characteristics (i.e., sideslopes, width, and longitudinal slope) for the channel segment along Cells 1 – 3 were established from site topography from the January 2000 flyover (existing topography). Geometric characteristics for the channel along Cell 4 were established from the Phase IV Certified-For-Construction drawings. Geometric characteristics for the channel along Cells 5 – 8 were established from the Phase V Certified-For-Construction drawings. As described above, the Manning's n value will vary between scenarios. For the Light Vegetation, Moderate Vegetation and Heavy Vegetation 2000 Year Storm Design Scenarios, the Manning's n values are 0.030, 0.030, and 0.070, respectively. Data for channel segments are presented in Attachment B-3.

ATTACHMENT B-1

SUBCATCHMENT AREA AND WEIGHTED CURVE NUMBER DATA

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN
2000 YEAR STORM DESIGN SCENARIOS

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN AMC = 2	Weighted CN AMC = 2	Weighted CN AMC = 3
A	2.60	100%	B/C	vegetated final cover	74	Intentionally left blank. Is adressed in the calculation section	Intentionally left blank. Is adressed in the calculation section.
B	1.64	100%	B/C	vegetated final cover	74		
C	4.96	100%	B/C	vegetated final cover	74		
D	4.75	100%	B/C	vegetated final cover	74		
DDR	0.86	100%	B/C	vegetated final cover	74		
E	4.95	100%	B/C	vegetated final cover	74		
F	4.81	100%	B/C	vegetated final cover	74		
FFR	2.41	100%	B/C	vegetated final cover	74		
G	4.95	100%	B/C	vegetated final cover	74		
HR	4.59	100%	B/C	vegetated final cover	74		
I	0.53	100%	C	runon east of OSDF	79		
IR	0.60	100%	B/C	vegetated final cover	74		
J	1.24	100%	C	runon east of OSDF	79		
JR	2.52	100%	B/C	vegetated final cover	74		
K	2.62	65% 35%	B C	runon east of OSDF runon east of OSDF	69 79		
K1R	0.38	100%	C	construction support	82		
K2R	0.53	65% 35%	B C	construction support construction support	74 82		
L	1.78	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79		
M	7.23	60% 40%	B C	runon east of OSDF runon east of OSDF	69 79		
N	11.66	75% 25%	B C	runon east of OSDF runon east of OSDF	69 79		
O	10.94	65% 35%	B C	runon east of OSDF runon east of OSDF	69 79		
Q	1.52	50% 50%	B C	runon east of OSDF runon east of OSDF	69 79		
TR	0.04	100%	C	construction support	82		

N/A - Not Applicable

ATTACHMENT B-2

DATA FOR CALCULATION OF TIME OF CONCENTRATION

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
2000 YEAR STORM DESIGN SCENARIO - LIGHT VEGETATION

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	vegetated final cover	90	grass: short	0.150	0.0750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130	0	2.03	6.0, 6.0	0.030	0.0250	320	0	2.03	4.0, 6.0	0.030	0.0075
C	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	190	unpaved	0.1700	-	-	-	370	0	2.33	6.0, 4.0	0.030	0.0035	-	-	-	-	-	-
D	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	180	unpaved	0.1700	-	-	-	200	0	2.86	6.0, 5.0	0.030	0.0083	150	0	2.86	6.0, 4.0	0.030	0.0045
DDR	vegetated final cover	150	grass: short	0.150	0.1500	-	-	-	-	-	-	-	-	330	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	170	unpaved	0.1700	-	-	-	50	0	3.32	6.0, 4.0	0.030	0.0045	320	0	3.32	6.0, 3.0	0.030	0.0105
F	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	175	unpaved	0.1700	-	-	-	360	0	3.68	4.0, 6.0	0.030	0.0050	-	-	-	-	-	-
FFR	vegetated final cover	85	grass: short	0.150	0.0500	50	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	160	unpaved	0.1700	-	-	-	365	0	5.49	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
G	vegetated final cover	90	grass: short	0.150	0.0500	60	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	175	unpaved	0.1700	-	-	-	370	0	3.86	3.0, 6.0	0.030	0.0050	-	-	-	-	-	-
HR	vegetated final cover	90	grass: short	0.150	0.0500	50	grass: short	0.150	0.1000	150	grass: short	0.150	0.1700	160	unpaved	0.1700	-	-	-	400	0	5.70	3.0, 6.0	0.030	0.0100	-	-	-	-	-	-
I	runoe east of OSDF	210	grass: short	0.150	0.0050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55	0	2.03	4.0, 6.0	0.030	0.0075	-	-	-	-	-	-
IR	vegetated final cover	150	grass: short	0.150	0.1500	-	-	-	-	-	-	-	-	220	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J	runoe east of OSDF	300	grass: short	0.150	0.0158	-	-	-	-	-	-	-	-	100	unpaved	0.0158	-	-	-	150	0	2.33	6.0, 4.0	0.030	0.0035	-	-	-	-	-	-
JR	vegetated final cover	80	grass: short	0.150	0.0176	60	grass: short	0.150	0.0830	150	grass: short	0.150	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	runoe east of OSDF	300	grass: short	0.150	0.0070	-	-	-	-	-	-	-	-	290	unpaved	0.0200	-	-	-	250	0	2.86	6.0, 4.0	0.030	0.0045	-	-	-	-	-	-
K1R	construction support	33	grass: short	0.150	0.0160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2R	construction support	300	grass: short	0.150	0.0110	-	-	-	-	-	-	-	-	23	unpaved	0.0110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	runoe east of OSDF	300	grass: short	0.150	0.0250	-	-	-	-	-	-	-	-	140	unpaved	0.0250	170	unpaved	0.0375	90	0	3.32	6.0, 3.0	0.030	0.0105	-	-	-	-	-	-
M	runoe east of OSDF	300	grass: short	0.150	0.0100	-	-	-	-	-	-	-	-	350	unpaved	0.0139	180	unpaved	0.0167	360	0	0.82	4.0, 3.0	0.030	0.0125	-	-	-	-	-	-
N	runoe east of OSDF	300	grass: short	0.150	0.0198	-	-	-	-	-	-	-	-	770	unpaved	0.0198	-	-	-	395	0	1.17	58.0, 3.0	0.030	0.0100	-	-	-	-	-	-
O	runoe east of OSDF	300	grass: short	0.150	0.0200	-	-	-	-	-	-	-	-	420	unpaved	0.0200	-	-	-	250	0	1.17	60.0, 3.0	0.030	0.0100	-	-	-	-	-	-
Q	runoe east of OSDF	300	grass: short	0.150	0.0200	-	-	-	-	-	-	-	-	250	unpaved	0.0200	-	-	-	170	0	4.08	5.7, 13.5	0.030	0.0100	-	-	-	-	-	-
TR	construction support	40	grass: short	0.150	0.0460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
2000 YEAR STORM DESIGN SCENARIO - MODERATE VEGETATION

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	vegetated final cover	90	grass: dense	0.240	0.0750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130	0	2.03	6.0, 6.0	0.030	0.0250	320	0	2.03	4.0, 6.0	0.030	0.0075
C	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	370	0	2.33	6.0, 4.0	0.030	0.0035	-	-	-	-	-	-
D	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	180	unpaved	0.1700	-	-	-	200	0	2.86	6.0, 5.0	0.030	0.0083	150	0	2.86	6.0, 4.0	0.030	0.0045
DDR	vegetated final cover	150	grass: dense	0.240	0.1500	-	-	-	-	-	-	-	-	330	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	170	unpaved	0.1700	-	-	-	50	0	3.32	6.0, 4.0	0.030	0.0045	320	0	3.32	6.0, 3.0	0.030	0.0105
F	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	175	unpaved	0.1700	-	-	-	360	0	3.68	4.0, 6.0	0.030	0.0050	-	-	-	-	-	-
FFR	vegetated final cover	85	grass: dense	0.240	0.0500	50	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	160	unpaved	0.1700	-	-	-	365	0	5.49	6.0, 3.0	0.030	0.0050	-	-	-	-	-	-
G	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	175	unpaved	0.1700	-	-	-	370	0	3.86	3.0, 6.0	0.030	0.0050	-	-	-	-	-	-
HR	vegetated final cover	90	grass: dense	0.240	0.0500	50	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	160	unpaved	0.1700	-	-	-	400	0	5.70	3.0, 6.0	0.030	0.0100	-	-	-	-	-	-
I	runoe east of OSDF	210	grass: dense	0.240	0.0050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55	0	2.03	4.0, 6.0	0.030	0.0075	-	-	-	-	-	-
IR	vegetated final cover	150	grass: dense	0.240	0.1500	-	-	-	-	-	-	-	-	220	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J	runoe east of OSDF	300	grass: dense	0.240	0.0158	-	-	-	-	-	-	-	-	100	unpaved	0.0158	-	-	-	150	0	2.33	6.0, 4.0	0.030	0.0035	-	-	-	-	-	-
JR	vegetated final cover	80	grass: dense	0.240	0.0176	60	grass: dense	0.240	0.0830	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	runoe east of OSDF	300	grass: dense	0.240	0.0070	-	-	-	-	-	-	-	-	290	unpaved	0.0200	-	-	-	250	0	2.86	6.0, 4.0	0.030	0.0045	-	-	-	-	-	-
K1R	construction support	33	grass: dense	0.240	0.0160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2R	construction support	300	grass: dense	0.240	0.0110	-	-	-	-	-	-	-	-	23	unpaved	0.0110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	runoe east of OSDF	300	grass: dense	0.240	0.0250	-	-	-	-	-	-	-	-	140	unpaved	0.0250	170	unpaved	0.0375	90	0	3.32	6.0, 3.0	0.030	0.0105	-	-	-	-	-	-
M	runoe east of OSDF	300	grass: dense	0.240	0.0100	-	-	-	-	-	-	-	-	350	unpaved	0.0139	180	unpaved	0.0167	360	0	0.82	4.0, 3.0	0.030	0.0125	-	-	-	-	-	-
N	runoe east of OSDF	300	grass: dense	0.240	0.0198	-	-	-	-	-	-	-	-	770	unpaved	0.0198	-	-	-	395	0	1.17	58.0, 3.0	0.030	0.0100	-	-	-	-	-	-
O	runoe east of OSDF	300	grass: dense	0.240	0.0200	-	-	-	-	-	-	-	-	420	unpaved	0.0200	-	-	-	250	0	1.17	60.0, 3.0	0.030	0.0100	-	-	-	-	-	-
Q	runoe east of OSDF	300	grass: dense	0.240	0.0200	-	-	-	-	-	-	-	-	250	unpaved	0.0200	-	-	-	170	0	4.08	5.7, 13.5	0.030	0.0100	-	-	-	-	-	-
TR	construction support	40	grass: dense	0.240	0.0460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF TIME OF CONCENTRATION
2000 YEAR STORM DESIGN SCENARIO - HEAVY VEGETATION

2-year, 24-hr Design Rainfall Depth, $P_{2,24}$ = 2.60 inches

SUBCATCHMENT LABEL AND DESCRIPTION		SHEET FLOW 1				SHEET FLOW 2				SHEET FLOW 3				SHALLOW CONCENTRATED FLOW			SHALLOW CONCENTRATED FLOW			CHANNEL FLOW 1						CHANNEL FLOW 2					
No.	Description	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Manning's n	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Surface Description	Land Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)	Flow Length (ft)	Bottom Width (ft)	Flow Depth (ft)	Sideslopes (ft/ft)	Manning's n	Longitudinal Slope (ft/ft)
A	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	vegetated final cover	90	grass: dense	0.240	0.0750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130	0	2.03	6.0, 6.0	0.070	0.0250	320	0	2.03	4.0, 6.0	0.070	0.0075
C	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	370	0	2.33	6.0, 4.0	0.070	0.0035	-	-	-	-	-	-
D	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	180	unpaved	0.1700	-	-	-	200	0	2.86	6.0, 5.0	0.070	0.0083	150	0	2.86	6.0, 4.0	0.070	0.0045
DDR	vegetated final cover	150	grass: dense	0.240	0.1500	-	-	-	-	-	-	-	-	330	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	170	unpaved	0.1700	-	-	-	50	0	3.32	6.0, 4.0	0.070	0.0045	320	0	3.32	6.0, 3.0	0.070	0.0105
F	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	175	unpaved	0.1700	-	-	-	360	0	3.68	4.0, 6.0	0.070	0.0050	-	-	-	-	-	-
FFR	vegetated final cover	85	grass: dense	0.240	0.0500	50	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	160	unpaved	0.1700	-	-	-	365	0	5.49	6.0, 3.0	0.070	0.0050	-	-	-	-	-	-
G	vegetated final cover	90	grass: dense	0.240	0.0500	60	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	175	unpaved	0.1700	-	-	-	370	0	3.86	3.0, 6.0	0.070	0.0050	-	-	-	-	-	-
HR	vegetated final cover	90	grass: dense	0.240	0.0500	50	grass: dense	0.240	0.1000	150	grass: dense	0.240	0.1700	160	unpaved	0.1700	-	-	-	400	0	5.70	3.0, 6.0	0.070	0.0100	-	-	-	-	-	-
I	runon east of OSDF	210	grass: dense	0.240	0.0050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55	0	2.03	4.0, 6.0	0.070	0.0075	-	-	-	-	-	-
IR	vegetated final cover	150	grass: dense	0.240	0.1500	-	-	-	-	-	-	-	-	220	unpaved	0.1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J	runon east of OSDF	300	grass: dense	0.240	0.0158	-	-	-	-	-	-	-	-	100	unpaved	0.0158	-	-	-	150	0	2.33	6.0, 4.0	0.070	0.0035	-	-	-	-	-	-
JR	vegetated final cover	80	grass: dense	0.240	0.0176	60	grass: dense	0.240	0.0830	150	grass: dense	0.240	0.1700	190	unpaved	0.1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	runon east of OSDF	300	grass: dense	0.240	0.0070	-	-	-	-	-	-	-	-	290	unpaved	0.0200	-	-	-	250	0	2.86	6.0, 4.0	0.070	0.0045	-	-	-	-	-	-
K1R	construction support	33	grass: dense	0.240	0.0160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2R	construction support	300	grass: dense	0.240	0.0110	-	-	-	-	-	-	-	-	23	unpaved	0.0110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	runon east of OSDF	300	grass: dense	0.240	0.0250	-	-	-	-	-	-	-	-	140	unpaved	0.0250	170	unpaved	0.0375	90	0	3.32	6.0, 3.0	0.070	0.0105	-	-	-	-	-	-
M	runon east of OSDF	300	grass: dense	0.240	0.0100	-	-	-	-	-	-	-	-	350	unpaved	0.0139	180	unpaved	0.0167	360	0	0.82	4.0, 3.0	0.070	0.0125	-	-	-	-	-	-
N	runon east of OSDF	300	grass: dense	0.240	0.0198	-	-	-	-	-	-	-	-	770	unpaved	0.0198	-	-	-	395	0	1.17	58.0, 3.0	0.070	0.0100	-	-	-	-	-	-
O	runon east of OSDF	300	grass: dense	0.240	0.0200	-	-	-	-	-	-	-	-	420	unpaved	0.0200	-	-	-	250	0	1.17	60.0, 3.0	0.070	0.0100	-	-	-	-	-	-
Q	runon east of OSDF	300	grass: dense	0.240	0.0200	-	-	-	-	-	-	-	-	250	unpaved	0.0200	-	-	-	170	0	4.08	5.7, 13.5	0.070	0.0100	-	-	-	-	-	-
TR	construction support	40	grass: dense	0.240	0.0460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ATTACHMENT B-3

CHANNEL ANALYSIS INPUT DATA

2000 YEAR STORM DESIGN SCENARIO - LIGHT VEGETATION
SUMMARY OF CHANNEL INPUT DATA

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	Downstream HydroCAD Node [3]	HydroCAD Q (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth Y (ft)	Estimated Q (cfs)	Channel Freeboard (ft)	Peak Flow Velocity (fps)	Lining Type
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.030	0	6	4	1	Intentionally left blank. Is addressed in the calculation section.								
reach 1	existing	2000 DS	vee	8.29	0.35%	0.030	0	6	4	2									
reach 2	existing	2000 DS	vee	6.57	0.64%	0.030	0	6	5	3									
reach 3	new [4]	2000 DS	vee	6.26	0.75%	0.030	0	6	3	4									
reach 4	new	2000 DS	vee	6.14	0.50%	0.030	0	6	4	5									
reach 5	new	2000 DS	vee	5.32	0.50%	0.030	0	6	3	6									
reach 6	new	2000 DS	vee	6.20	0.50%	0.030	0	6	3	7R									
reach 7	new	2000 DS	vee	3.10	1.25%	0.030	0	4	3	8									
reach 7R	new	2000 DS	vee	5.99	1.00%	0.030	0	6	3	8R									
reach 8	new	2000 DS	vee	3.01	1.00%	0.030	0	58	3	9									
reach 8R	new	2000 DS	vee	5.47	0.50%	0.030	0	6	2	9R									
reach 9	new	2000 DS	vee	6.31	1.00%	0.030	0	60	3	11									
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.030	4.35	6	3	9R+K1R+IR									
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.030	10.12	6	3	10AR									
reach 11	new	2000 DS	vee	4.08	1.00%	0.030	0	5.7	13.5	3R									

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and construction drawings.
3. N/A indicates that there is no specific HydroCAD node downstream of the particular channel.
4. This channel will be constructed as part of Phase IV project.

2000 YEAR STORM DESIGN SCENARIO -MODERATE VEGETATION
SUMMARY OF CHANNEL INPUT DATA

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	Downstream HydroCAD Node [3]	HydroCAD Q (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth Y (ft)	Estimated Q (cfs)	Channel Freeboard (ft)	Peak Flow Velocity (fps)	Lining Type
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.030	0	6	4	1									
reach 1	existing	2000 DS	vee	8.29	0.35%	0.030	0	6	4	2									
reach 2	existing	2000 DS	vee	6.57	0.64%	0.030	0	6	5	3									
reach 3	new [4]	2000 DS	vee	6.26	0.75%	0.030	0	6	3	4									
reach 4	new	2000 DS	vee	6.14	0.50%	0.030	0	6	4	5									
reach 5	new	2000 DS	vee	5.32	0.50%	0.030	0	6	3	6									
reach 6	new	2000 DS	vee	6.20	0.50%	0.030	0	6	3	7R									
reach 7	new	2000 DS	vee	3.10	1.25%	0.030	0	4	3	8		Intentionally left blank. Is addressed in the calculation section.							
reach 7R	new	2000 DS	vee	5.99	1.00%	0.030	0	6	3	8R									
reach 8	new	2000 DS	vee	3.01	1.00%	0.030	0	58	3	9									
reach 8R	new	2000 DS	vee	5.47	0.50%	0.030	0	6	2	9R									
reach 9	new	2000 DS	vee	6.31	1.00%	0.030	0	60	3	11									
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.030	4.35	6	3	9R+K1R+IR									
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.030	10.12	6	3	10AR									
reach 11	new	2000 DS	vee	4.08	1.00%	0.030	0	5.7	13.5	3R									

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and construction drawings.
3. N/A indicates that there is no specific HydroCAD node downstream of the particular channel.
4. This channel will be constructed as part of Phase IV project.

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2000 YEAR STORM DESIGN SCENARIO - HEAVY VEGETATION
SUMMARY OF CHANNEL INPUT DATA

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	Downstream HydroCAD Node [3]	HydroCAD Q (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth Y (ft)	Estimated Q (cfs)	Channel Freeboard (ft)	Peak Flow Velocity (fps)	Lining Type
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.070	0	6	4	1	Intentionally left blank. Is addressed in the calculation section.								
reach 1	existing	2000 DS	vee	8.29	0.35%	0.070	0	6	4	2									
reach 2	existing	2000 DS	vee	6.57	0.64%	0.070	0	6	5	3									
reach 3	new [4]	2000 DS	vee	6.26	0.75%	0.070	0	6	3	4									
reach 4	new	2000 DS	vee	6.14	0.50%	0.070	0	6	4	5									
reach 5	new	2000 DS	vee	5.32	0.50%	0.070	0	6	3	6									
reach 6	new	2000 DS	vee	6.20	0.50%	0.070	0	6	3	7R									
reach 7	new	2000 DS	vee	3.10	1.25%	0.070	0	4	3	8									
reach 7R	new	2000 DS	vee	5.99	1.00%	0.070	0	6	3	8R									
reach 8	new	2000 DS	vee	3.01	1.00%	0.070	0	58	3	9									
reach 8R	new	2000 DS	vee	5.47	0.50%	0.070	0	6	2	9R									
reach 9	new	2000 DS	vee	6.31	1.00%	0.070	0	60	3	11									
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.070	4.35	6	3	9R+K1R+IR									
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.070	10.12	6	3	10AR									
reach 11	new	2000 DS	vee	4.08	1.00%	0.070	0	5.7	13.5	3R									

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and construction drawings.
3. N/A indicates that there is no specific HydroCAD node downstream of the particular channel.
4. This channel will be constructed as part of Phase IV project.

OSDF PHASE V, EAST 2000-YEAR DRAINAGE CHANNEL EVALUATION

CALCULATIONS

INTRODUCTION

As described in the Procedures Section, the purpose of this calculation is to revaluate the adequacy of the 2000-year channel, using the channel geometry that exists along Cells 1 to 3 and is expected to exist (with the completion of Phases IV and V construction) along Cells 4 to 8, to convey runoff from the 2000-year 24-hour storm event with a minimum 0.5 ft freeboard. This section (Calculations) presents calculations based on procedures and data presented in the Procedures and Data Verification Sections of this calculation package.

HYDROLOGIC ANALYSES

Hydrologic analyses are completed for the three 2000-Year Storm Design Scenarios, nodal networks are prepared, and HydroCAD™ runs are performed for the 2000-year, 24-hour storm event. HydroCAD™ output reports for these runs are presented in Attachment C-1A, C-1B, and C-1C for the Light Vegetation, Moderate Vegetation, and Heavy Vegetation 2000-Year Design Scenarios, respectively. The primary calculation parameter obtained from the HydroCAD™ output reports for use in this evaluation is 2000-year, 24-hour peak flow rate.

Weighted runoff curve numbers are calculated using a spreadsheet. Results are presented in Attachment C-2. The calculated weighted runoff curve numbers are directly input into HydroCAD™.

HYDRAULIC ANALYSES

A cross-section was selected for each channel for evaluation of freeboard using the peak flow rate from each of the three design scenarios. Freeboard is measured vertically between the level of the Monitoring Access subgrade or the Emergency Access Road, whichever is lower, and the water level calculated using Manning's equation for 2000-year, 24-hour peak flow rates. Calculations for freeboard were performed using a computer spreadsheet. Spreadsheets for each design scenario are presented in Attachment C-3.

For incorporation into Manning's equation, the geometry of the 2000-year channel was modeled to be V-shaped or trapezoidal. Since the configurations of the channels are non-uniform, calculation results (for the design scenario with the greatest flow depths, the heavy vegetation scenario for all cells) are presented on cross-sections for each cell in Attachment C-4.

RESULTS AND CONCLUSIONS

Results of the analyses performed indicate that freeboard for the 2000-year channel will equal or exceed 0.5 ft for peak 2000-year 24-hour storm event. Based on the above, the 2000-year channel as constructed for Cells 1 to 3 and to be constructed for Cells 4 to 8 is expected to convey the 2000-year 24-hour event without adversely impacting the On-Site Disposal Facility (OSDF) final cover system.

ATTACHMENT C-1

HydroCAD™ OUTPUT REPORTS

ATTACHMENT C-1A

2000-YEAR STORM DESIGN SCENARIO – LIGHT VEGETATION
2000-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=13.00"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=17.6 min CN=99 Area=2.601 ac Runoff= 33.78 cfs 2.784 af

Subcatchment B: vegetated final cover
Tc=7.4 min CN=99 Area=1.637 ac Runoff= 28.68 cfs 1.755 af

Subcatchment C: vegetated final cover
Tc=19.5 min CN=99 Area=4.960 ac Runoff= 61.28 cfs 5.307 af

Subcatchment D: vegetated final cover
Tc=18.8 min CN=99 Area=4.746 ac Runoff= 59.75 cfs 5.079 af

Subcatchment DDR: (new node)
Tc=7.6 min CN=99 Area=0.860 ac Runoff= 14.99 cfs 0.922 af

Subcatchment E: vegetated final cover
Tc=18.5 min CN=99 Area=4.946 ac Runoff= 62.74 cfs 5.293 af

Subcatchment F: vegetated final cover
Tc=18.7 min CN=99 Area=4.814 ac Runoff= 60.75 cfs 5.152 af

Subcatchment FFR: vegetated final cover
Tc=17.6 min CN=99 Area=2.410 ac Runoff= 31.30 cfs 2.580 af

Subcatchment G: vegetated final cover
Tc=18.7 min CN=99 Area=4.946 ac Runoff= 62.42 cfs 5.293 af

Subcatchment HR: vegetated final cover
Tc=17.7 min CN=99 Area=4.590 ac Runoff= 59.48 cfs 4.913 af

Subcatchment I: runon east of OSDF
Tc=13.8 min CN=90 Area=0.530 ac Runoff= 7.50 cfs 0.518 af

Subcatchment IR: (new node)
Tc=7.3 min CN=99 Area=0.600 ac Runoff= 10.54 cfs 0.643 af

Subcatchment J: runon east of OSDF
Tc=30.4 min CN=90 Area=1.242 ac Runoff= 11.61 cfs 1.210 af

Subcatchment JR: (new node)
Tc=20.6 min CN=99 Area=2.520 ac Runoff= 30.26 cfs 2.696 af

Subcatchment K: runon east of OSDF
Tc=42.9 min CN=86 Area=2.623 ac Runoff= 19.08 cfs 2.435 af

Subcatchment K1R: (new node)
Tc=4.9 min CN=91 Area=0.382 ac Runoff= 7.09 cfs 0.378 af

Subcatchment K2R: (new node)
Tc=33.4 min CN=88 Area=0.530 ac Runoff= 4.62 cfs 0.505 af

Subcatchment L: runon east of OSDF
Tc=25.9 min CN=88 Area=1.779 ac Runoff= 17.88 cfs 1.657 af

Subcatchment M: runon east of OSDF
Tc=41.0 min CN=86 Area=7.234 ac Runoff= 54.37 cfs 6.718 af

Subcatchment N: runon east of OSDF
Tc=33.9 min CN=85 Area=11.664 ac Runoff= 98.78 cfs 10.718 af

Subcatchment O: runon east of OSDF
Tc=30.5 min CN=86 Area=10.935 ac Runoff= 99.64 cfs 10.177 af

Subcatchment Q: runon east of OSDF
Tc=28.4 min CN=87 Area=1.520 ac Runoff= 14.59 cfs 1.432 af

Subcatchment TR: (new node)
Tc=3.7 min CN=91 Area=0.040 ac Runoff= 0.77 cfs 0.040 af

Reach 1: runoff channel — Inflow= 63.03 cfs 5.057 af
Length= 405.0' Max Vel= 2.9 fps Capacity= 2,565.53 cfs Outflow= 60.41 cfs 5.048 af

Reach 2: runoff channel — Inflow= 130.73 cfs 11.565 af
Length= 385.0' Max Vel= 4.3 fps Capacity= 2,054.66 cfs Outflow= 127.85 cfs 11.552 af

Reach 3: runoff channel — Inflow= 197.61 cfs 19.066 af
Length= 405.0' Max Vel= 5.3 fps Capacity= 1,590.57 cfs Outflow= 194.12 cfs 19.048 af

Reach 3R: (new node) — Inflow= 242.40 cfs 28.988 af
Outflow= 242.40 cfs 28.988 af

Reach 4: runoff channel — Inflow= 268.53 cfs 25.998 af
Length= 395.0' Max Vel= 4.8 fps Capacity= 1,377.52 cfs Outflow= 264.05 cfs 25.971 af

Reach 5: runoff channel — Inflow= 314.55 cfs 31.123 af
Length= 405.0' Max Vel= 5.2 fps Capacity= 840.15 cfs Outflow= 310.32 cfs 31.092 af

Reach 6: runoff channel — Inflow= 358.43 cfs 36.385 af
Length= 490.0' Max Vel= 5.3 fps Capacity= 1,011.11 cfs Outflow= 353.15 cfs 36.342 af

Reach 7: east runon ditch
Length= 395.0' Max Vel= 0.0 fps Capacity= 242.98 cfs Outflow= 0.00 cfs 0.000 af

Reach 7R: (new node) — Inflow= 390.04 cfs 41.255 af
Length= 400.0' Max Vel= 7.1 fps Capacity= 1,293.72 cfs Outflow= 387.02 cfs 41.226 af

Reach 8: east runon ditch — Inflow= 54.37 cfs 6.718 af
Length= 405.0' Max Vel= 2.7 fps Capacity= 1,794.23 cfs Outflow= 53.84 cfs 6.705 af

Reach 8R: (new node) — Inflow= 404.97 cfs 43.805 af
Length= 220.0' Max Vel= 5.6 fps Capacity= 618.57 cfs Outflow= 402.80 cfs 43.784 af

Reach 9: east runon ditch — Inflow= 145.85 cfs 17.423 af
Length= 475.0' Max Vel= 3.4 fps Capacity= 13,339.82 cfs Outflow= 144.46 cfs 17.391 af

Reach 9R: (new node) — Inflow= 404.93 cfs 44.746 af
Length= 120.0' Max Vel= 5.5 fps Capacity= 2,047.79 cfs Outflow= 403.60 cfs 44.733 af

Reach 10AR: (new node) — Inflow= 431.08 cfs 48.955 af
Length= 365.0' Max Vel= 5.5 fps Capacity= 1,992.86 cfs Outflow= 427.54 cfs 48.909 af

Reach 11: (new node) — Inflow= 231.03 cfs 27.568 af
Length= 170.0' Max Vel= 5.2 fps Capacity= 1,267.78 cfs Outflow= 230.19 cfs 27.556 af

Runoff Area = 78.109 ac Volume = 78.204 af Average Depth = 12.01"

Subcatchment A: vegetated final cover

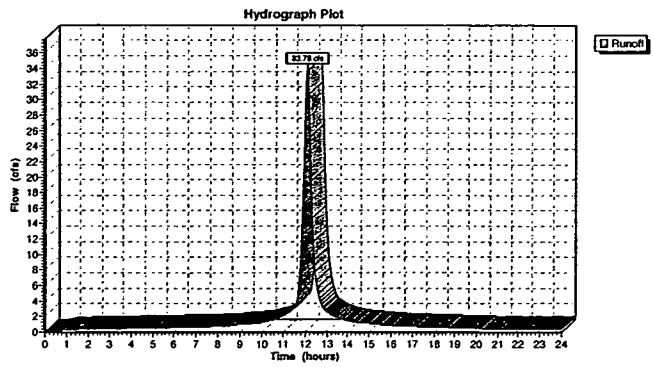
Runoff = 33.78 cfs @ 12.09 hrs, Volume= 2.784 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.601	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
17.6	490	Total			

Subcatchment A: vegetated final cover



Subcatchment B: vegetated final cover

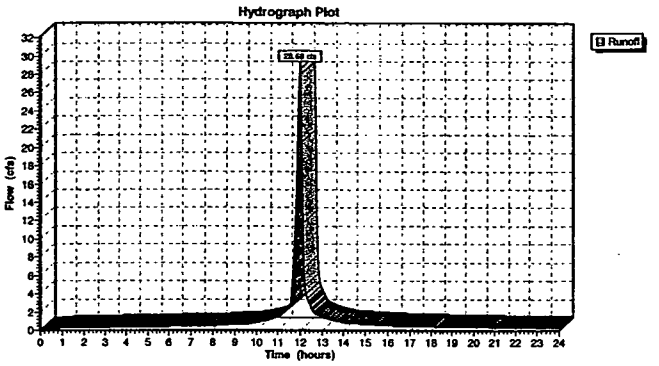
Runoff = 28.68 cfs @ 11.98 hrs, Volume= 1.755 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.637	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.9	90	0.0750	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.3	130	0.0250	7.8	193.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 6.0 '/' n= 0.030
1.2	320	0.0075	4.3	88.06	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.030
7.4	540	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

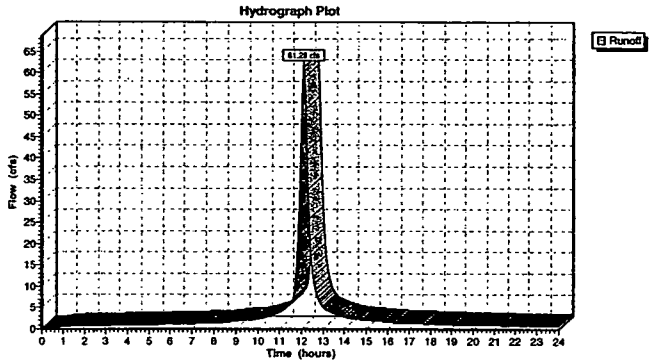
Runoff = 61.28 cfs @ 12.11 hrs, Volume= 5.307 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.960	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.9	370	0.0035	3.2	86.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.030
19.5	860	Total			

Subcatchment C: vegetated final cover



Subcatchment D: vegetated final cover

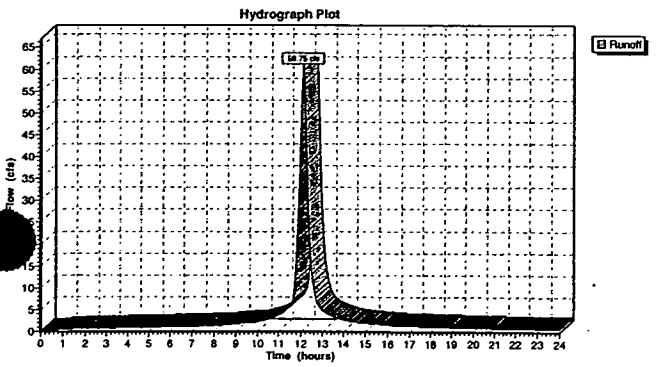
Runoff = 59.75 cfs @ 12.10 hrs, Volume= 5.079 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.746	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.6	200	0.0083	5.7	254.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 5.0 '/' n= 0.030
0.6	150	0.0045	4.2	170.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.030
18.8	830	Total			

Subcatchment D: vegetated final cover



Subcatchment DDR: (new node)

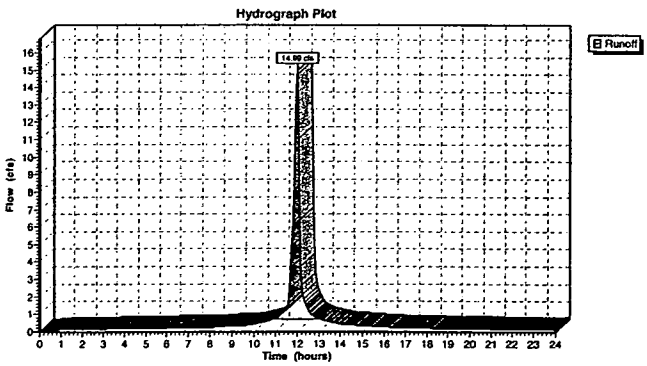
Runoff = 14.99 cfs @ 11.98 hrs, Volume= 0.922 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.860	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.6	480	Total			

Subcatchment DDR: (new node)



Subcatchment E: vegetated final cover

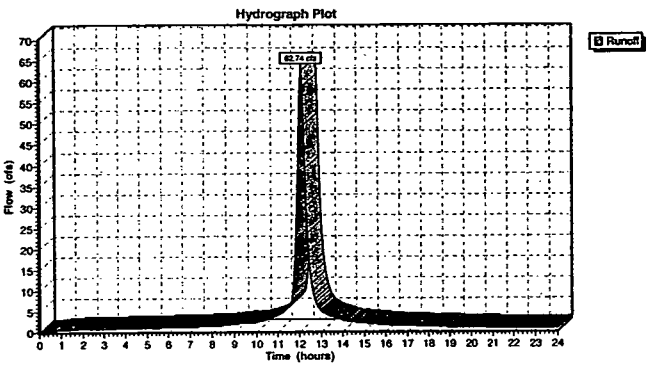
Runoff = 62.74 cfs @ 12.10 hrs, Volume= 5.293 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	50	0.0045	4.6	253.27	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 4.0 '/' n= 0.030
0.8	320	0.0105	7.0	346.69	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.030
18.5	840	Total			

Subcatchment E: vegetated final cover



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Subcatchment F: vegetated final cover

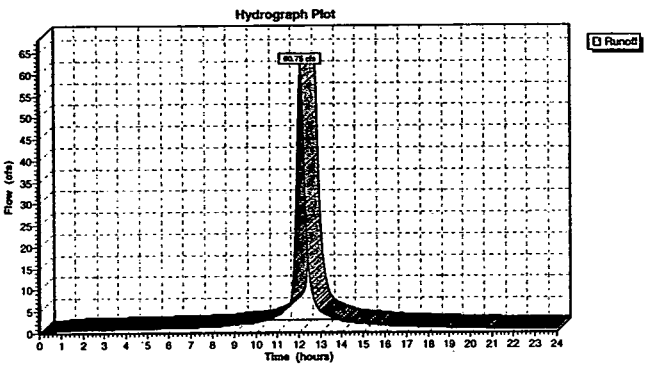
Runoff = 60.75 cfs @ 12.10 hrs, Volume= 5.152 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.814	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	360	0.0050	5.2	351.31	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.68' Z= 4.0 & 6.0 '/' n= 0.030
18.7	835	Total			

Subcatchment F: vegetated final cover



Subcatchment FFR: vegetated final cover

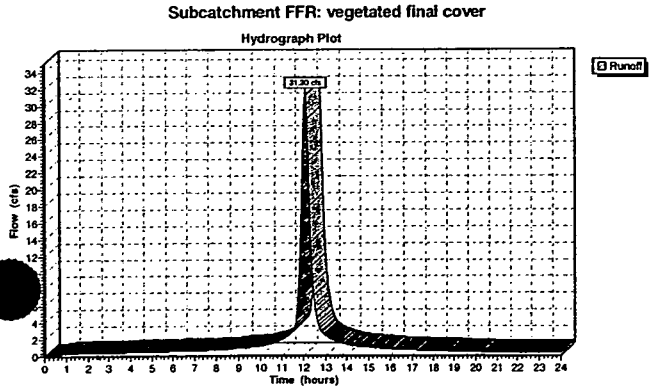
Runoff = 31.30 cfs @ 12.09 hrs, Volume= 2.580 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.410	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	85	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	365	0.0050	6.7	914.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.030
17.6	810	Total			

Subcatchment FFR: vegetated final cover



Subcatchment G: vegetated final cover

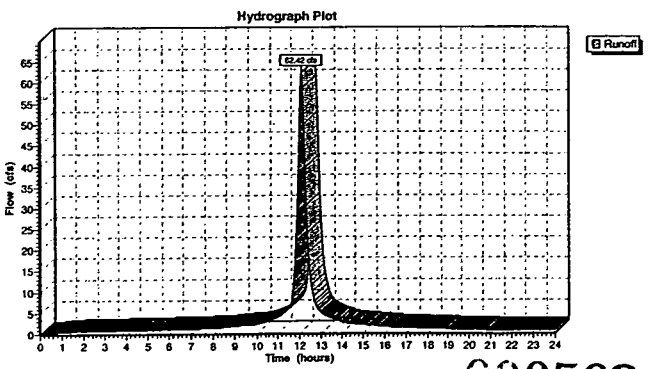
Runoff = 62.42 cfs @ 12.10 hrs, Volume= 5.293 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.8	60	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	370	0.0050	5.3	357.57	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.86' Z= 3.0 & 6.0 '/' n= 0.030
18.7	845	Total			

Subcatchment G: vegetated final cover



Subcatchment HR: vegetated final cover

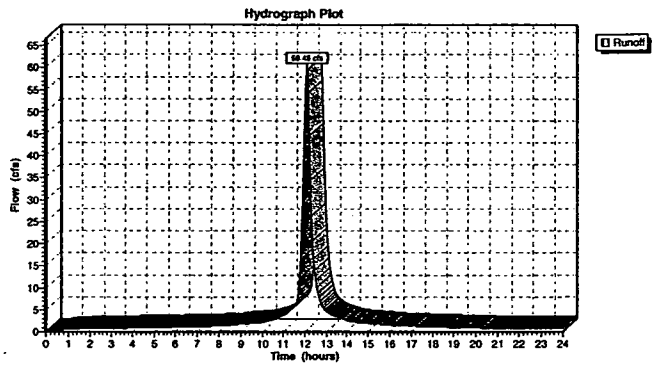
Runoff = 59.48 cfs @ 12.09 hrs, Volume= 4.913 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.590	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	90	0.0500	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.3	50	0.1000	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.7	400	0.0100	9.8	1,429.92	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.70' Z= 3.0 & 6.0 '/' n= 0.030
17.7	850	Total			

Subcatchment HR: vegetated final cover



5316

Subcatchment I: runon east of OSDF

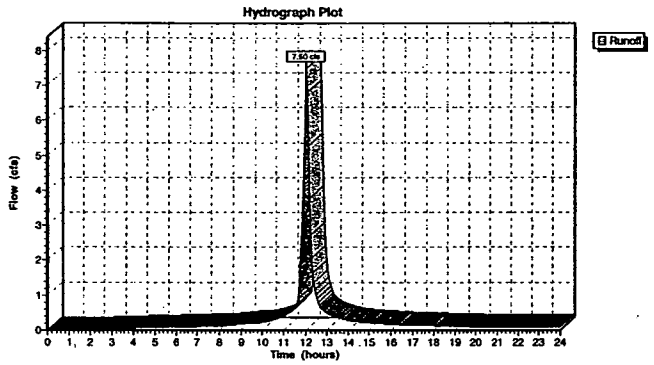
Runoff = 7.50 cfs @ 12.05 hrs, Volume= 0.518 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.6	210	0.0500	0.3		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.2	55	0.0075	4.3	88.06	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.030
13.8	265	Total			

Subcatchment I: runon east of OSDF



Subcatchment IR: (new node)

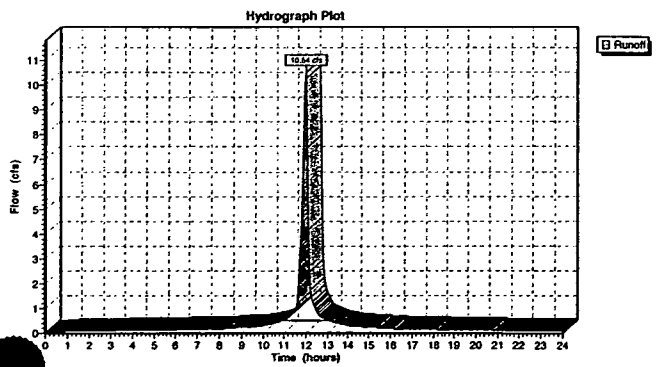
Runoff = 10.54 cfs @ 11.98 hrs, Volume= 0.643 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.600	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	150	0.1500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.6	220	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.3	370	Total			

Subcatchment IR: (new node)



Subcatchment J: runon east of OSDF

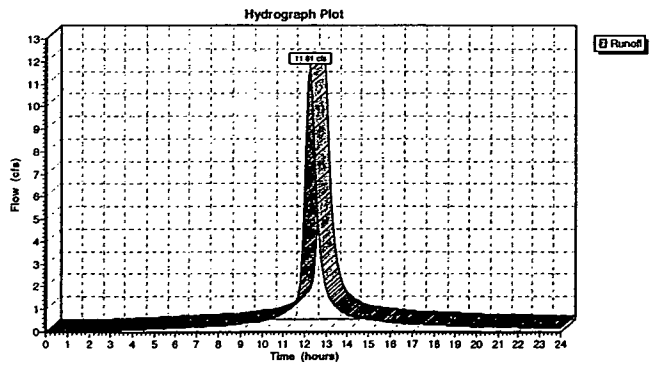
Runoff = 11.61 cfs @ 12.23 hrs, Volume= 1.210 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.242	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.8	300	0.0158	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.8	100	0.0158	2.0		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	150	0.0035	3.2	86.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.030
30.4	550	Total			

Subcatchment J: runon east of OSDF



Subcatchment JR: (new node)

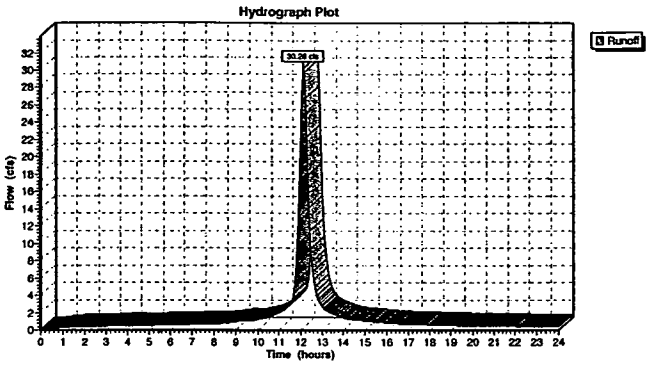
Runoff = 30.26 cfs @ 12.12 hrs, Volume= 2.696 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.520	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	80	0.0176	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
4.1	60	0.0830	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
6.4	150	0.1700	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
20.6	480	Total			

Subcatchment JR: (new node)



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Subcatchment K: runon east of OSDF

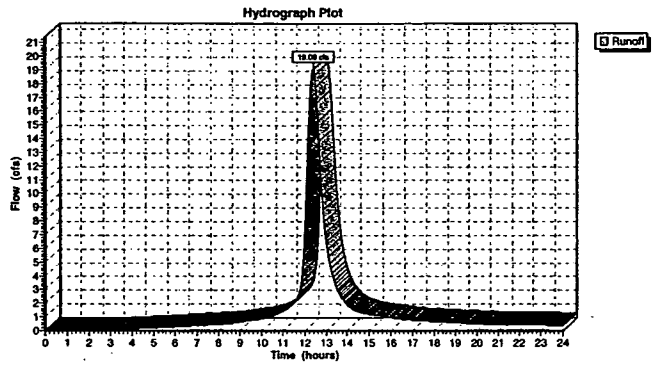
Runoff = 19.08 cfs @ 12.38 hrs, Volume= 2.435 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.623	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
39.8	300	0.0070	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.0	250	0.0045	4.2	170.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.030
42.9	840	Total			

Subcatchment K: runon east of OSDF



Subcatchment K1R: (new node)

[49] Hint: Tc<2dt may require smaller dt

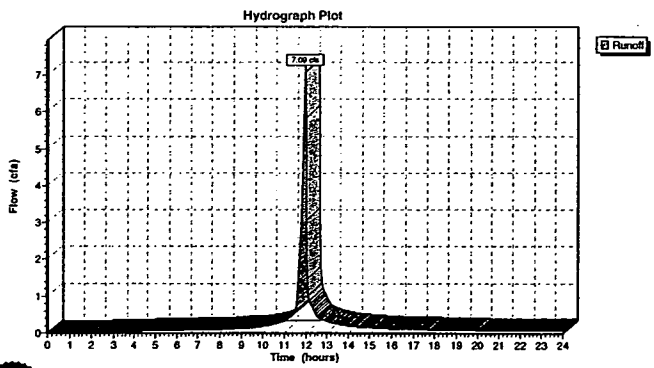
Runoff = 7.09 cfs @ 11.95 hrs, Volume= 0.378 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.382	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	33	0.0160	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment K1R: (new node)



Subcatchment K2R: (new node)

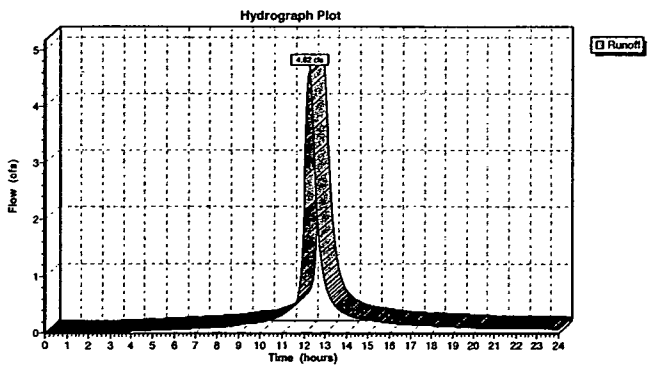
Runoff = 4.62 cfs @ 12.27 hrs, Volume= 0.505 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	88	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.2	300	0.0110	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.2	23	0.0110	1.7		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
33.4	323	Total			

Subcatchment K2R: (new node)



Subcatchment L: runon east of OSDF

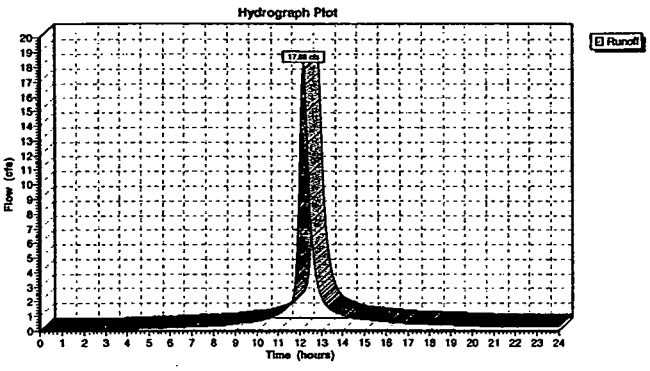
Runoff = 17.88 cfs @ 12.18 hrs, Volume= 1.657 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.779	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.9	300	0.0250	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
0.9	140	0.0250	2.5		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	170	0.0375	3.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	90	0.0105	7.0	346.69	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.030
25.9	700	Total			

Subcatchment L: runon east of OSDF



Subcatchment M: runon east of OSDF

5316

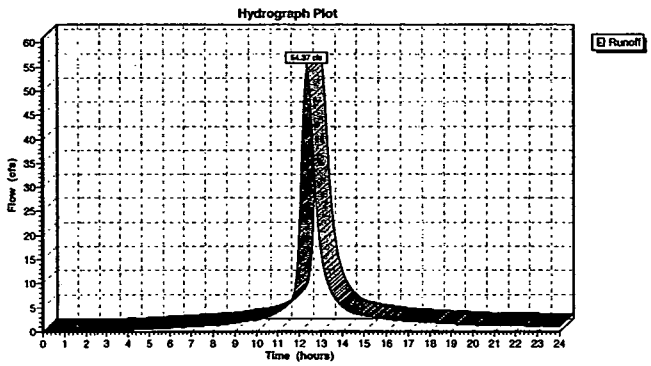
Runoff = 54.37 cfs @ 12.36 hrs, Volume= 6.718 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
7.234	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.5	300	0.0100	0.1		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.1	350	0.0139	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.4	180	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.0	360	0.0125	3.0	7.00	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.82' Z= 4.0 & 3.0 '/' n= 0.030
41.0	1,190	Total			

Subcatchment M: runon east of OSDF



Subcatchment N: runon east of OSDF

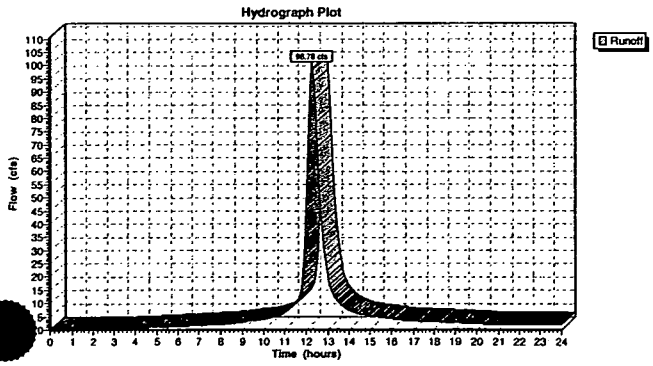
Runoff = 98.78 cfs @ 12.27 hrs, Volume= 10.718 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
11.664	85	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.3	300	0.0198	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
5.7	770	0.0198	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.9	395	0.0100	3.5	144.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.17' Z= 58.0 & 3.0 '/' n= 0.030
33.9	1,465	Total			

Subcatchment N: runon east of OSDF



Subcatchment O: runon east of OSDF

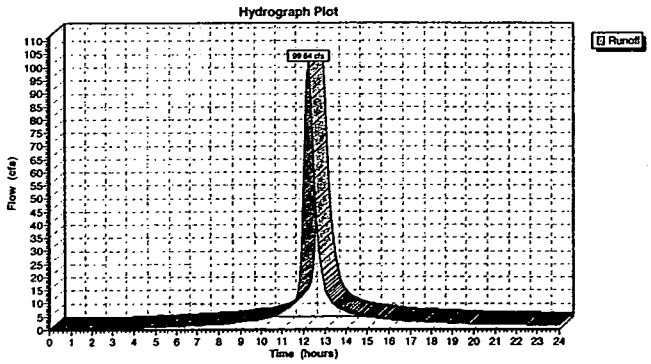
Runoff = 99.64 cfs @ 12.24 hrs, Volume= 10.177 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
10.935	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.2	300	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
3.1	420	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	250	0.0100	3.5	149.13	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.17' Z= 60.0 & 3.0 '/' n= 0.030
30.5	970	Total			

Subcatchment O: runon east of OSDF



Subcatchment Q: runon east of OSDF

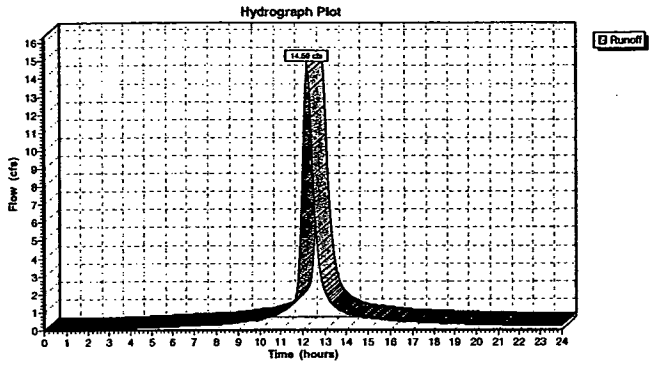
Runoff = 14.59 cfs @ 12.21 hrs, Volume= 1.432 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
24-hr Rainfall=13.00"

(ac)	CN	Description
1.520	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.2	300	0.0200	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"
1.8	250	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	170	0.0100	7.9	1,267.78	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.08' Z= 5.7 & 13.5 '/' n= 0.030
28.4	720	Total			

Subcatchment Q: runon east of OSDF



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Subcatchment TR: (new node)

[49] Hint: Tc<2dt may require smaller dt

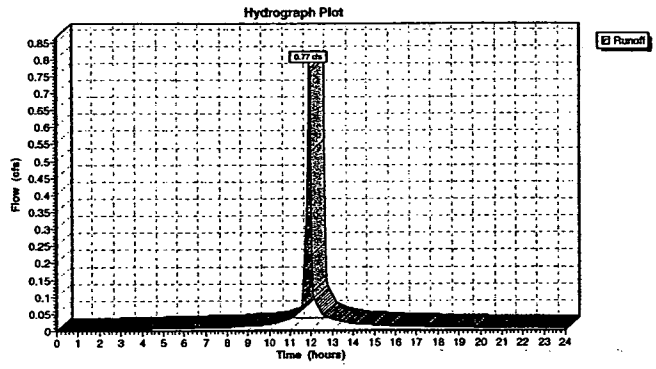
Runoff = 0.77 cfs @ 11.94 hrs, Volume= 0.040 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.040	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	40	0.0460	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 2.60"

Subcatchment TR: (new node)



Reach 1: runoff channel

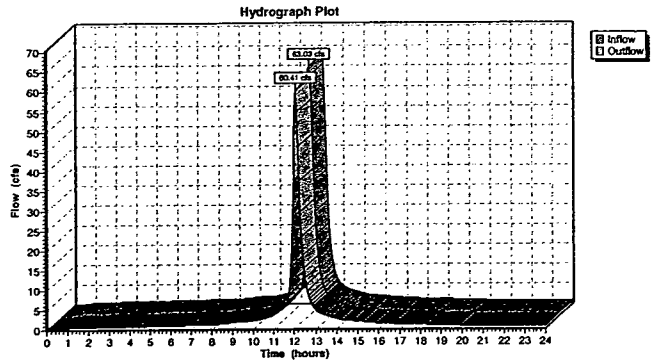
[65] Warning: Inlet elevation not specified

Inflow = 63.03 cfs @ 12.02 hrs, Volume= 5.057 af
Outflow = 60.41 cfs @ 12.09 hrs, Volume= 5.048 af, Atten= 4%, Lag= 4.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.9 min

Peak Depth= 2.04'
Capacity at bank full= 2,565.53 cfs
0.00' x 8.29' deep channel, n= 0.030 Length= 405.0' Slope= 0.0035 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: runoff channel



Reach 2: runoff channel

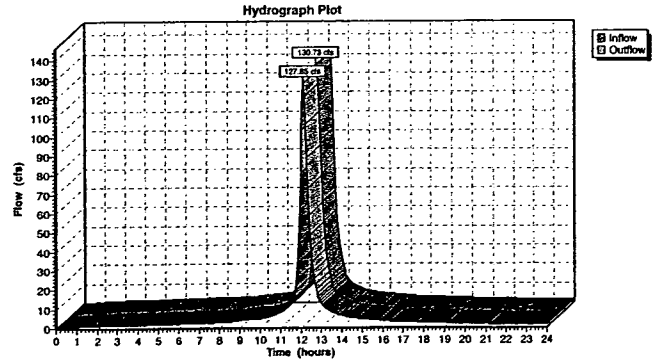
[65] Warning: Inlet elevation not specified

Inflow = 130.73 cfs @ 12.10 hrs, Volume= 11.565 af
Outflow = 127.85 cfs @ 12.15 hrs, Volume= 11.552 af, Atten= 2%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 3.7 min

Peak Depth= 2.33'
Capacity at bank full= 2,054.66 cfs
0.00' x 6.57' deep channel, n= 0.030 Length= 385.0' Slope= 0.0064 '/'
Side Slope Z-value= 6.0 5.0 '/'

Reach 2: runoff channel



Reach 3: runoff channel

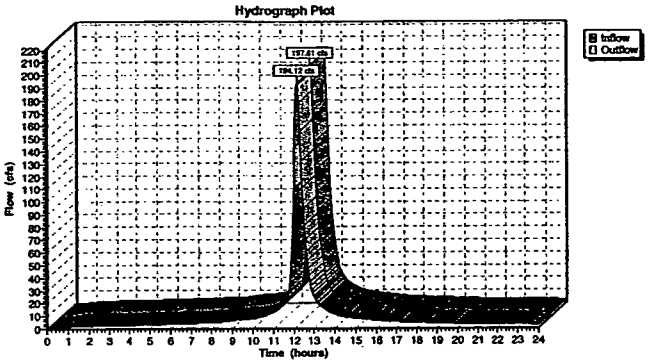
[65] Warning: Inlet elevation not specified

Inflow = 197.61 cfs @ 12.14 hrs, Volume= 19.066 af
Outflow = 194.12 cfs @ 12.18 hrs, Volume= 19.048 af, Atten= 2%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 3.1 min

Peak Depth= 2.86'
Capacity at bank full= 1,590.57 cfs
0.00' x 6.26' deep channel, n= 0.030 Length= 405.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 3: runoff channel



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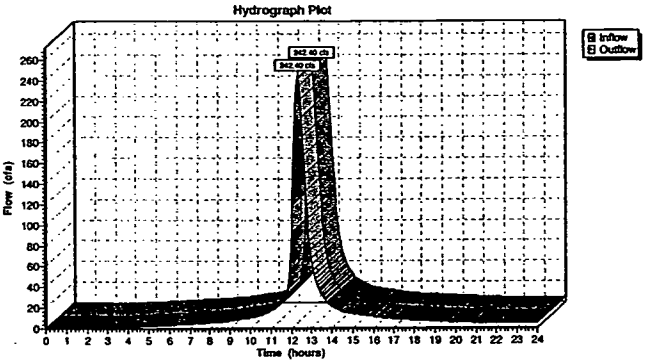
Reach 3R: (new node)

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 242.40 cfs @ 12.33 hrs, Volume= 28.988 af
Outflow = 242.40 cfs @ 12.33 hrs, Volume= 28.988 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Reach 3R: (new node)



Reach 4: runoff channel

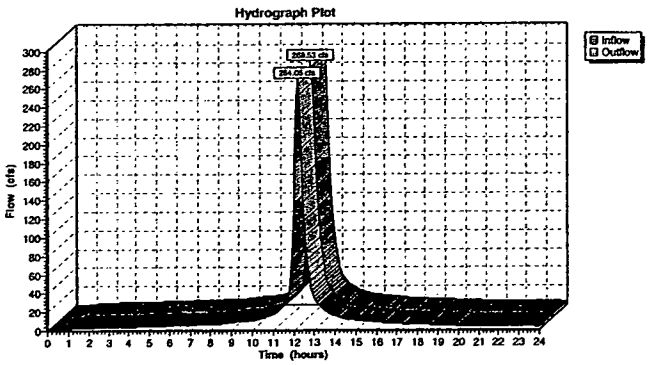
[65] Warning: Inlet elevation not specified

Inflow = 268.53 cfs @ 12.16 hrs, Volume= 25.998 af
Outflow = 264.05 cfs @ 12.20 hrs, Volume= 25.971 af, Atten= 2%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.8 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 3.3 min

Peak Depth= 3.32'
Capacity at bank full= 1,377.52 cfs
0.00' x 6.14' deep channel, n= 0.030 Length= 395.0' Slope= 0.0050 '/'
Side Slope Z-value= 4.0 6.0 '/'

Reach 4: runoff channel



Reach 5: runoff channel

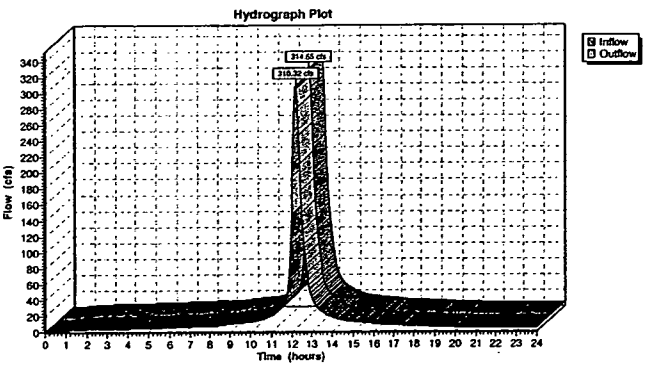
[65] Warning: Inlet elevation not specified

Inflow = 314.55 cfs @ 12.18 hrs, Volume= 31.123 af
Outflow = 310.32 cfs @ 12.22 hrs, Volume= 31.092 af, Atten= 1%, Lag= 2.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.2 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 3.2 min

Peak Depth= 3.68'
Capacity at bank full= 840.15 cfs
0.00' x 5.32' deep channel, n= 0.030 Length= 405.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 5: runoff channel



Reach 6: runoff channel

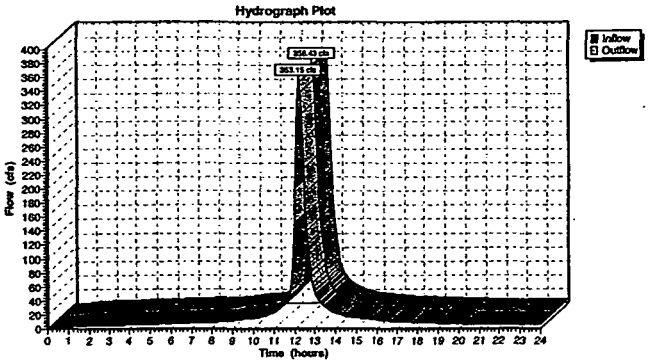
[65] Warning: Inlet elevation not specified

Inflow = 358.43 cfs @ 12.20 hrs, Volume= 36.385 af
Outflow = 353.15 cfs @ 12.25 hrs, Volume= 36.342 af, Atten= 1%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 3.7 min

Peak Depth= 3.86'
Capacity at bank full= 1,011.11 cfs
0.00' x 5.70' deep channel, n= 0.030 Length= 490.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 6: runoff channel



5316

Reach 7: east runon ditch

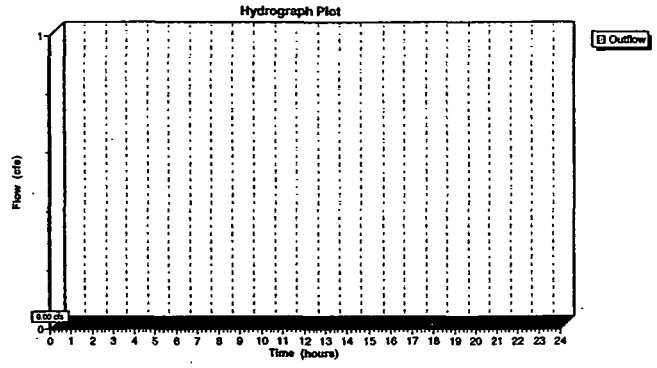
[43] Hint: Has no inflow (Outflow=Zero)

Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.0 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.0 fps, Avg. Travel Time= 0.0 min

Peak Depth= 0.00'
Capacity at bank full= 242.98 cfs
0.00' x 3.10' deep channel, n= 0.030 Length= 395.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 3.0 '/'

Reach 7: east runon ditch



Reach 7R: (new node)

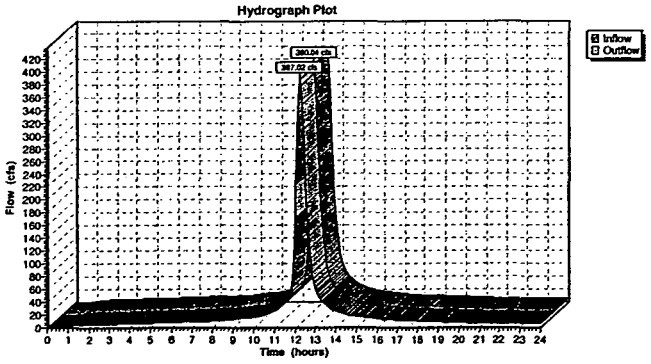
[65] Warning: Inlet elevation not specified

Inflow = 390.04 cfs @ 12.23 hrs, Volume= 41.255 af
Outflow = 387.02 cfs @ 12.26 hrs, Volume= 41.226 af, Atten= 1%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.1 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 2.3 min

Peak Depth= 3.50'
Capacity at bank full= 1,293.72 cfs
0.00' x 5.49' deep channel, n= 0.030 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 7R: (new node)



Reach 8: east runon ditch

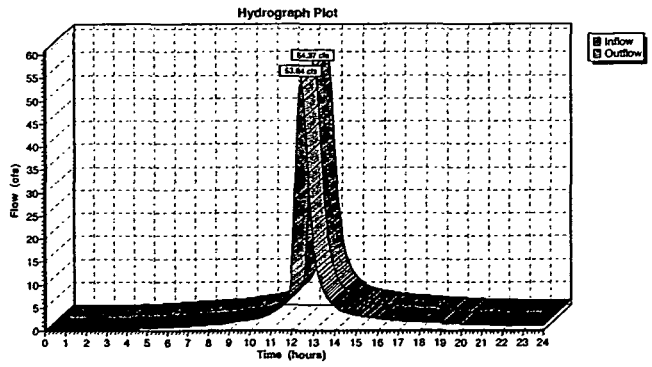
[65] Warning: Inlet elevation not specified

Inflow = 54.37 cfs @ 12.36 hrs, Volume= 6.718 af
Outflow = 53.84 cfs @ 12.44 hrs, Volume= 6.705 af, Atten= 1%, Lag= 4.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.8 min

Peak Depth= 0.81'
Capacity at bank full= 1,794.23 cfs
0.00' x 3.01' deep channel, n= 0.030 Length= 405.0' Slope= 0.0100 '/'
Side Slope Z-value= 58.0 3.0 '/'

Reach 8: east runon ditch



Reach 8R: (new node)

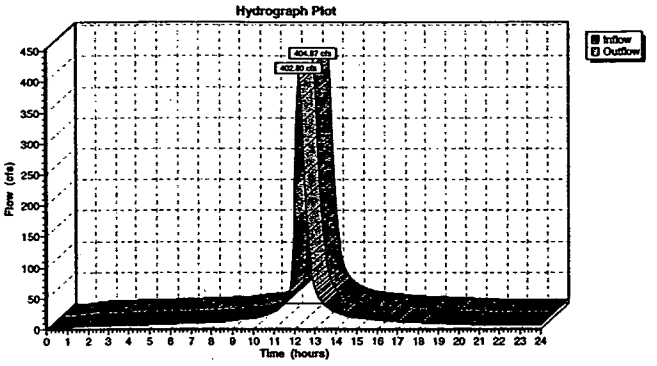
[65] Warning: Inlet elevation not specified

Inflow = 404.97 cfs @ 12.24 hrs, Volume= 43.805 af
Outflow = 402.80 cfs @ 12.26 hrs, Volume= 43.784 af, Atten= 1%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.6 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 1.6 min

Peak Depth= 4.24'
Capacity at bank full= 618.57 cfs
0.00' x 4.97' deep channel, n= 0.030 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: (new node)



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Reach 9: east runon ditch

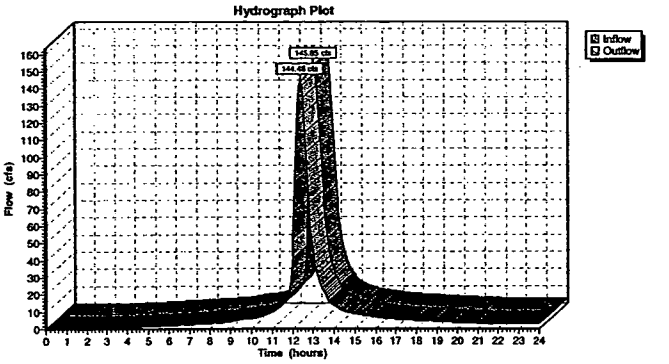
[65] Warning: Inlet elevation not specified

Inflow = 145.85 cfs @ 12.32 hrs, Volume= 17.423 af
Outflow = 144.46 cfs @ 12.40 hrs, Volume= 17.391 af, Atten= 1%, Lag= 4.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 5.4 min

Peak Depth= 1.16'
Capacity at bank full= 13,339.82 cfs
0.00' x 6.31' deep channel, n= 0.030 Length= 475.0' Slope= 0.0100 '/'
Side Slope Z-value= 60.0 3.0 '/'

Reach 9: east runon ditch



Reach 9R: (new node)

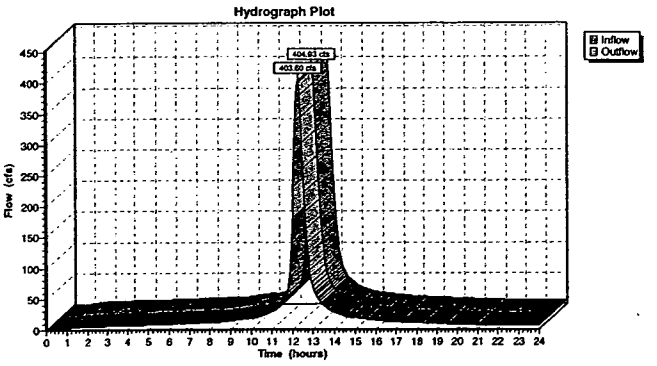
[65] Warning: Inlet elevation not specified

Inflow = 404.93 cfs @ 12.26 hrs, Volume= 44.746 af
Outflow = 403.60 cfs @ 12.27 hrs, Volume= 44.733 af, Atten= 0%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.5 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 0.9 min

Peak Depth= 3.59'
Capacity at bank full= 2,047.79 cfs
4.35' x 6.96' deep channel, n= 0.030 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: (new node)



Reach 10AR: (new node)

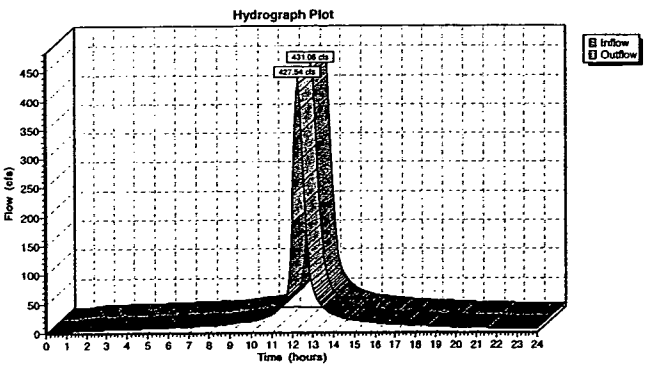
[65] Warning: Inlet elevation not specified

Inflow = 431.08 cfs @ 12.26 hrs, Volume= 48.955 af
Outflow = 427.54 cfs @ 12.30 hrs, Volume= 48.909 af, Atten= 1%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.5 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 3.0 min

Peak Depth= 3.19'
Capacity at bank full= 1,992.86 cfs
10.12' x 6.33' deep channel, n= 0.030 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 10AR: (new node)



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Reach 11: (new node)

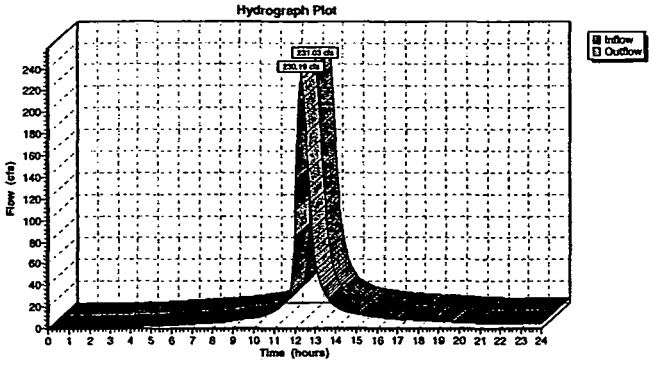
[65] Warning: Inlet elevation not specified

Inflow = 231.03 cfs @ 12.32 hrs, Volume= 27.568 af
= 230.19 cfs @ 12.34 hrs, Volume= 27.556 af, Atten= 0%, Lag= 1.1 min

by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.2 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 1.3 min

Peak Depth= 2.15'
Capacity at bank full= 1,267.78 cfs
0.00' x 4.08' deep channel, n= 0.030 Length= 170.0' Slope= 0.0100 '/'
Side Slope Z-value= 5.7 13.5 '/'

Reach 11: (new node)



ATTACHMENT C-1B

2000-YEAR STORM DESIGN SCENARIO – MODERATE VEGETATION
2000-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=13.00"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=25.4 min CN=99 Area=2.601 ac Runoff= 27.84 cfs 2.780 af

Subcatchment B: vegetated final cover
Tc=10.1 min CN=99 Area=1.637 ac Runoff= 26.40 cfs 1.754 af

Subcatchment C: vegetated final cover
Tc=27.3 min CN=99 Area=4.960 ac Runoff= 50.82 cfs 5.300 af

Subcatchment D: vegetated final cover
Tc=26.6 min CN=99 Area=4.746 ac Runoff= 49.42 cfs 5.072 af

Subcatchment DDR: (new node)
Tc=10.7 min CN=99 Area=0.860 ac Runoff= 13.59 cfs 0.922 af

Subcatchment E: vegetated final cover
Tc=26.3 min CN=99 Area=4.946 ac Runoff= 51.86 cfs 5.286 af

Subcatchment F: vegetated final cover
Tc=26.5 min CN=99 Area=4.814 ac Runoff= 50.19 cfs 5.145 af

Subcatchment FFR: vegetated final cover
Tc=25.0 min CN=99 Area=2.410 ac Runoff= 26.02 cfs 2.576 af

Subcatchment G: vegetated final cover
Tc=26.5 min CN=99 Area=4.946 ac Runoff= 51.56 cfs 5.286 af

Subcatchment HR: vegetated final cover
Tc=25.3 min CN=99 Area=4.590 ac Runoff= 49.25 cfs 4.906 af

Subcatchment I: runon east of OSDF
Tc=20.1 min CN=90 Area=0.530 ac Runoff= 6.29 cfs 0.517 af

Subcatchment IR: (new node)
Tc=10.4 min CN=99 Area=0.600 ac Runoff= 9.58 cfs 0.643 af

Subcatchment J: runon east of OSDF
Tc=43.5 min CN=90 Area=1.242 ac Runoff= 9.20 cfs 1.207 af

Subcatchment JR: (new node)
Tc=29.7 min CN=99 Area=2.520 ac Runoff= 24.56 cfs 2.692 af

Subcatchment K: runon east of OSDF
Tc=61.1 min CN=86 Area=2.623 ac Runoff= 14.89 cfs 2.426 af

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Subcatchment K1R: (new node)
Tc=7.1 min CN=91 Area=0.382 ac Runoff= 6.63 cfs 0.378 af

Subcatchment K2R: (new node)
Tc=48.6 min CN=88 Area=0.530 ac Runoff= 3.60 cfs 0.503 af

Subcatchment L: runon east of OSDF
Tc=36.9 min CN=86 Area=1.779 ac Runoff= 14.33 cfs 1.654 af

Subcatchment M: runon east of OSDF
Tc=56.8 min CN=86 Area=7.234 ac Runoff= 43.39 cfs 6.697 af

Subcatchment N: runon east of OSDF
Tc=45.9 min CN=85 Area=11.664 ac Runoff= 80.52 cfs 10.692 af

Subcatchment O: runon east of OSDF
Tc=42.4 min CN=86 Area=10.935 ac Runoff= 80.34 cfs 10.152 af

Subcatchment Q: runon east of OSDF
Tc=40.3 min CN=87 Area=1.520 ac Runoff= 11.63 cfs 1.429 af

Subcatchment TR: (new node)
Tc=5.5 min CN=91 Area=0.040 ac Runoff= 0.73 cfs 0.040 af

Reach 1: runoff channel — Inflow= 51.77 cfs 5.052 af
Length= 405.0' Max Vel= 2.8 fps Capacity= 2,565.53 cfs Outflow= 50.12 cfs 5.043 af

Reach 2: runoff channel — Inflow= 105.85 cfs 11.550 af
Length= 385.0' Max Vel= 4.1 fps Capacity= 2,054.66 cfs Outflow= 104.63 cfs 11.536 af

Reach 3: runoff channel — Inflow= 161.73 cfs 19.034 af
Length= 405.0' Max Vel= 5.1 fps Capacity= 1,590.57 cfs Outflow= 160.07 cfs 19.016 af

Reach 3R: (new node) — Inflow= 200.13 cfs 28.911 af
Outflow= 200.13 cfs 28.911 af

Reach 4: runoff channel — Inflow= 222.92 cfs 25.955 af
Length= 395.0' Max Vel= 4.6 fps Capacity= 1,377.52 cfs Outflow= 220.51 cfs 25.927 af

Reach 5: runoff channel — Inflow= 266.10 cfs 31.072 af
Length= 405.0' Max Vel= 4.9 fps Capacity= 840.15 cfs Outflow= 263.40 cfs 31.041 af

Reach 6: runoff channel — Inflow= 307.27 cfs 36.326 af
Length= 490.0' Max Vel= 5.1 fps Capacity= 1,011.11 cfs Outflow= 303.96 cfs 36.283 af

Reach 7: east runon ditch
Length= 395.0' Max Vel= 0.0 fps Capacity= 242.98 cfs Outflow= 0.00 cfs 0.000 af

Reach 7R: (new node) — Inflow= 340.29 cfs 41.190 af
Length= 400.0' Max Vel= 6.8 fps Capacity= 1,293.72 cfs Outflow= 337.91 cfs 41.160 af

Reach 8: east runon ditch — Inflow= 43.39 cfs 6.697 af
Length= 405.0' Max Vel= 2.6 fps Capacity= 1,794.23 cfs Outflow= 43.13 cfs 6.683 af

Reach 8R: (new node) — Inflow= 355.64 cfs 43.736 af
Length= 220.0' Max Vel= 5.5 fps Capacity= 618.57 cfs Outflow= 354.11 cfs 43.715 af

Reach 9: east runon ditch — Inflow= 118.35 cfs 17.375 af
Length= 475.0' Max Vel= 3.3 fps Capacity= 13,339.82 cfs Outflow= 117.63 cfs 17.342 af

Reach 9R: (new node) — Inflow= 356.17 cfs 44.676 af
Length= 120.0' Max Vel= 5.3 fps Capacity= 2,047.79 cfs Outflow= 355.22 cfs 44.663 af

Reach 10AR: (new node) — Inflow= 380.81 cfs 48.878 af
Length= 365.0' Max Vel= 5.3 fps Capacity= 1,992.86 cfs Outflow= 378.18 cfs 48.832 af

Reach 11: (new node) — Inflow= 190.17 cfs 27.495 af
Length= 170.0' Max Vel= 4.9 fps Capacity= 1,267.78 cfs Outflow= 189.81 cfs 27.482 af

Runoff Area = 78.109 ac Volume = 78.055 af Average Depth = 11.99"

Subcatchment A: vegetated final cover

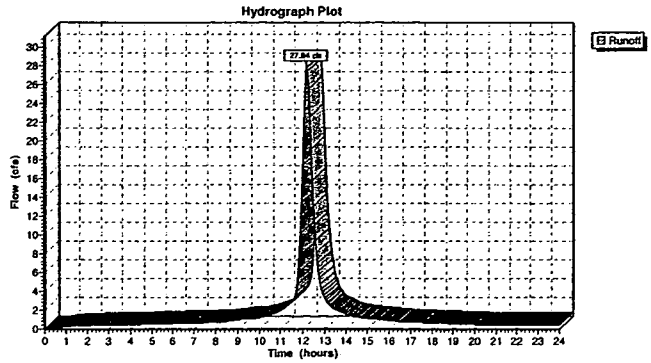
Runoff = 27.84 cfs @ 12.17 hrs, Volume= 2.780 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.601	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
25.4	490	Total			

Subcatchment A: vegetated final cover



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Subcatchment B: vegetated final cover

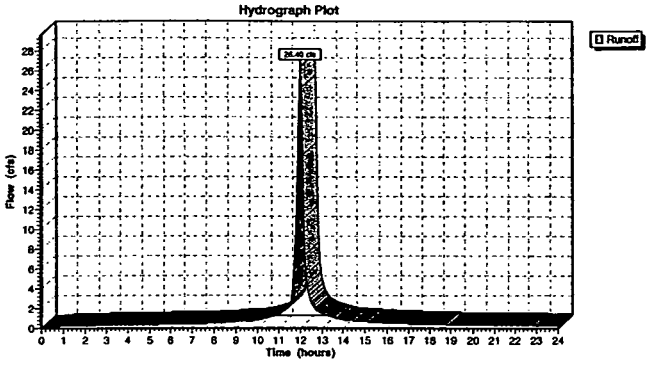
Runoff = 26.40 cfs @ 12.01 hrs, Volume= 1.754 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.637	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.6	90	0.0750	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.3	130	0.0250	7.8	193.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 6.0 '/' n= 0.030
1.2	320	0.0075	4.3	88.06	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.030
10.1	540	Total			

Subcatchment B: vegetated final cover



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Subcatchment C: vegetated final cover

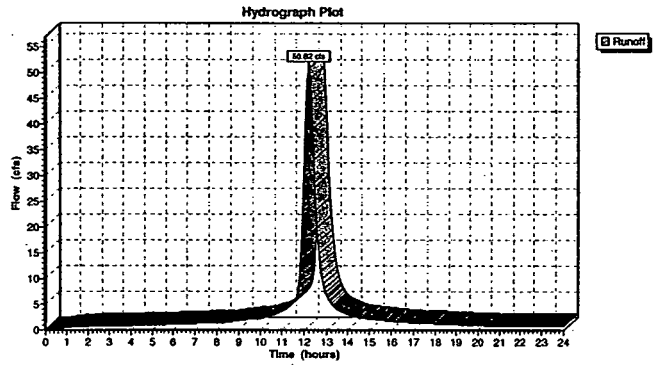
Runoff = 50.82 cfs @ 12.20 hrs, Volume= 5.300 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.960	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.9	370	0.0035	3.2	86.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.030
27.3	860	Total			

Subcatchment C: vegetated final cover



Subcatchment D: vegetated final cover

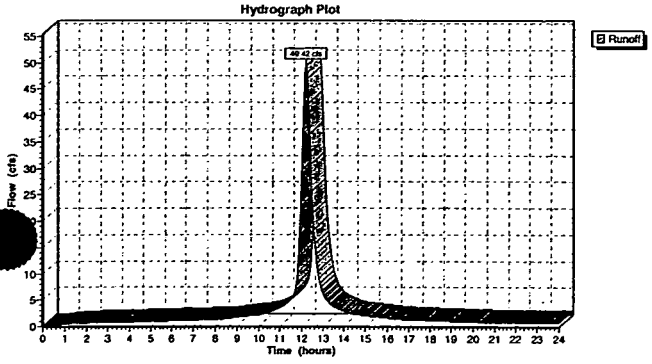
Runoff = 49.42 cfs @ 12.19 hrs, Volume= 5.072 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.746	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.6	200	0.0083	5.7	254.88	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 5.0 '/' n= 0.030
0.6	150	0.0045	4.2	170.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.030
26.6	830	Total			

Subcatchment D: vegetated final cover



Subcatchment DDR: (new node)

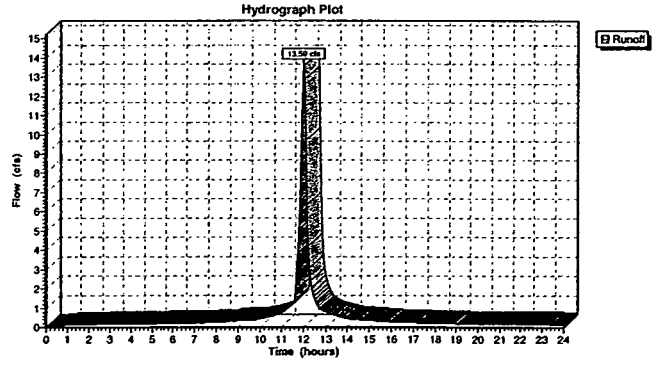
Runoff = 13.59 cfs @ 12.01 hrs, Volume= 0.922 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.860	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	150	0.1500	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
10.7	480	Total			

Subcatchment DDR: (new node)



Subcatchment E: vegetated final cover

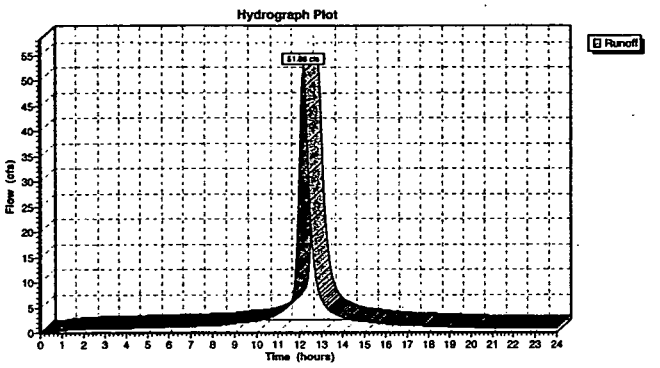
Runoff = 51.86 cfs @ 12.18 hrs, Volume= 5.286 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	50	0.0045	4.6	253.27	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 4.0 '/' n= 0.030
0.8	320	0.0105	7.0	346.69	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.030
26.3	840	Total			

Subcatchment E: vegetated final cover



Subcatchment F: vegetated final cover

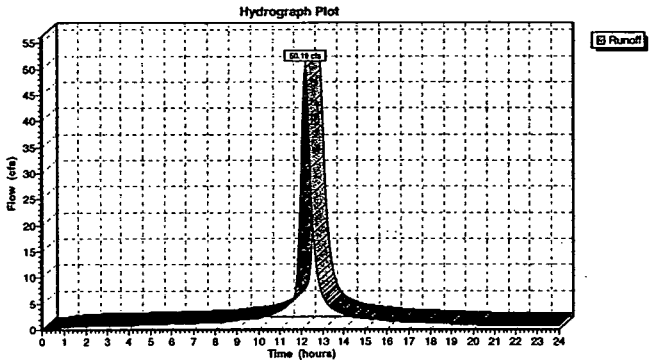
Runoff = 50.19 cfs @ 12.19 hrs, Volume= 5.145 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.814	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	360	0.0050	5.2	351.31	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.68' Z= 4.0 & 6.0 '/' n= 0.030
26.5	835	Total			

Subcatchment F: vegetated final cover



Subcatchment FFR: vegetated final cover

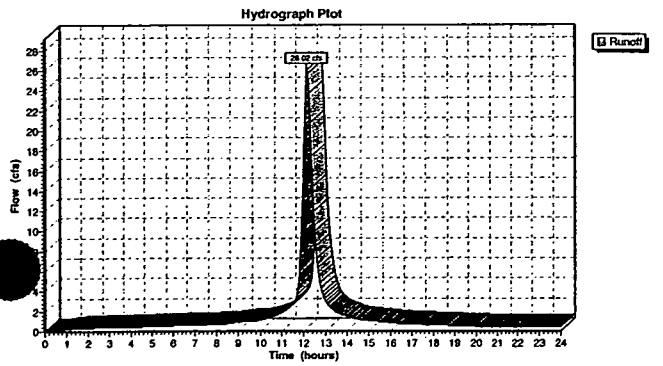
Runoff = 26.02 cfs @ 12.17 hrs, Volume= 2.576 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.410	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	85	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
4.8	50	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	365	0.0050	6.7	914.80	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.030
25.0	810	Total			

Subcatchment FFR: vegetated final cover



Subcatchment G: vegetated final cover

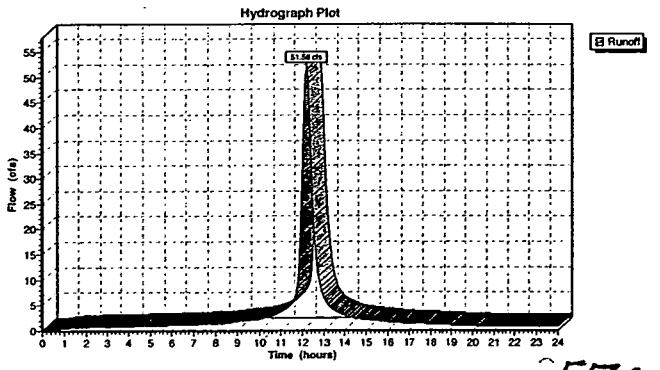
Runoff = 51.56 cfs @ 12.19 hrs, Volume= 5.286 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	370	0.0050	5.3	357.57	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.86' Z= 3.0 & 6.0 '/' n= 0.030
26.5	845	Total			

Subcatchment G: vegetated final cover



Subcatchment HR: vegetated final cover

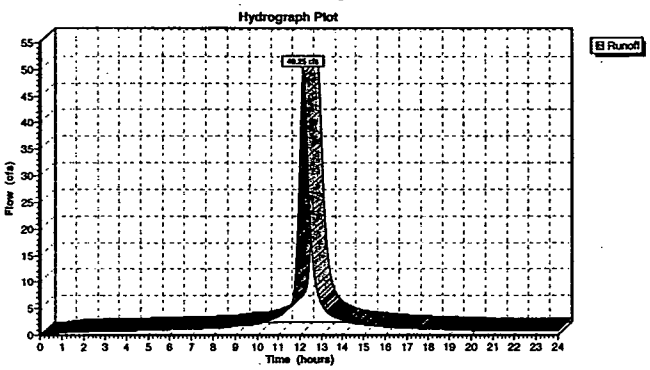
Runoff = 49.25 cfs @ 12.17 hrs, Volume= 4.906 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.590	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
4.8	50	0.1000	0.2		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
0.4	160	0.1700	6.6		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.7	400	0.0100	9.8	1,429.92	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=5.70' Z= 3.0 & 6.0 '/' n= 0.030
25.3	850	Total			

Subcatchment HR: vegetated final cover



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Subcatchment I: runon east of OSDF

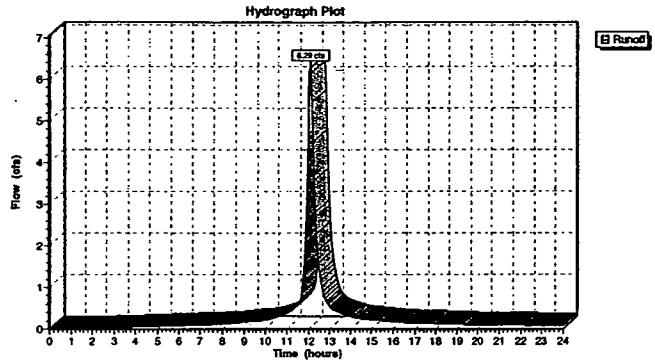
Runoff = 6.29 cfs @ 12.12 hrs, Volume= 0.517 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.9	210	0.0500	0.2		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
0.2	55	0.0075	4.3	88.06	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.030
20.1	265	Total			

Subcatchment I: runon east of OSDF



Subcatchment IR: (new node)

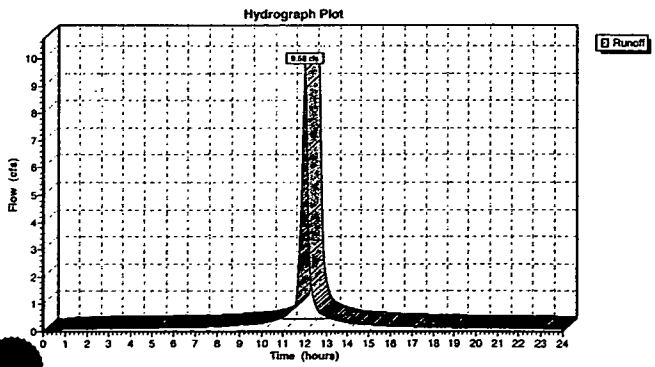
Runoff = 9.58 cfs @ 12.01 hrs, Volume= 0.643 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.600	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	150	0.1500	0.3		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
0.6	220	0.1500	6.2		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
10.4	370	Total			

Subcatchment IR: (new node)



Subcatchment J: runon east of OSDF

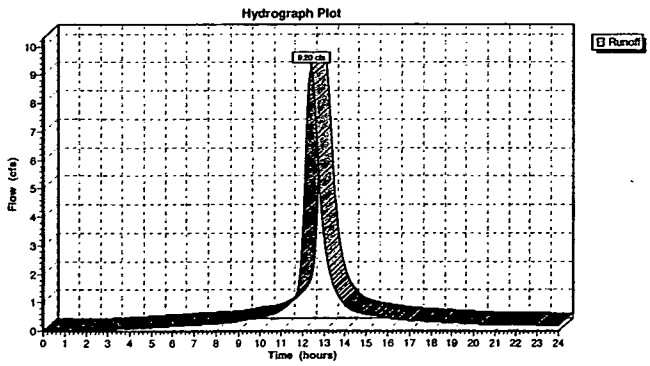
Runoff = 9.20 cfs @ 12.39 hrs, Volume= 1.207 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.242	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
41.9	300	0.0158	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
0.8	100	0.0158	2.0		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.8	150	0.0035	3.2	86.88	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.030
43.5	550	Total			

Subcatchment J: runon east of OSDF



Subcatchment JR: (new node)

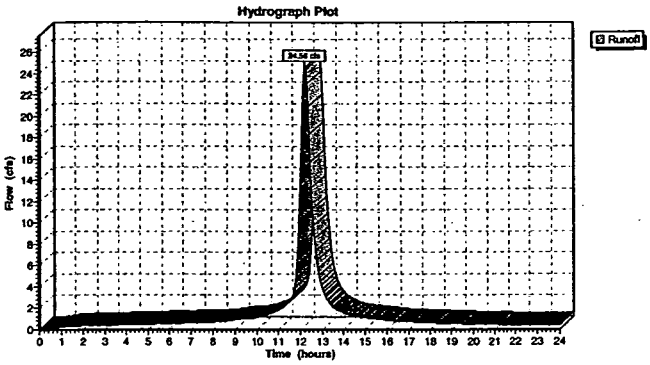
Runoff = 24.56 cfs @ 12.22 hrs, Volume= 2.692 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.520	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9	80	0.0176	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
6.0	60	0.0830	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
29.7	480	Total			

Subcatchment JR: (new node)



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Subcatchment K: runon east of OSDF

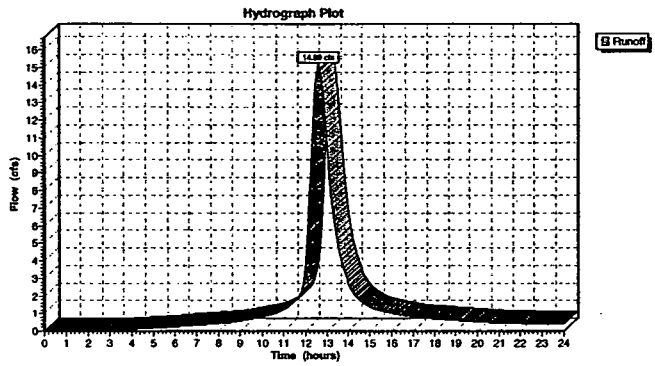
Runoff = 14.89 cfs @ 12.60 hrs, Volume= 2.426 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.623	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
58.0	300	0.0070	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.0	250	0.0045	4.2	170.16	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.030
61.1	840	Total			

Subcatchment K: runon east of OSDF



Subcatchment K1R: (new node)

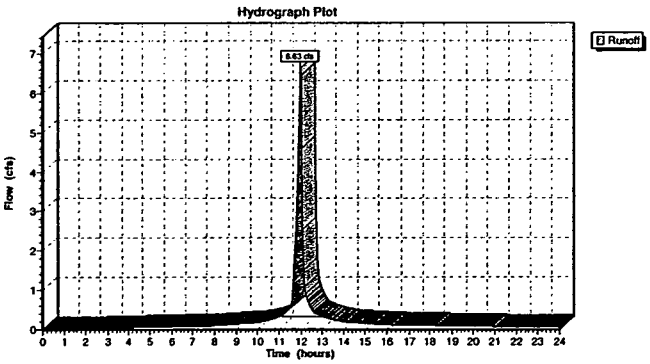
Runoff = 6.63 cfs @ 11.98 hrs, Volume= 0.378 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.382	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1	33	0.0160	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"

Subcatchment K1R: (new node)



Subcatchment K2R: (new node)

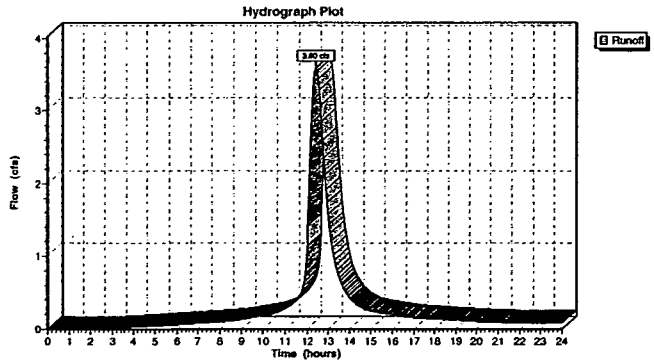
Runoff = 3.60 cfs @ 12.45 hrs, Volume= 0.503 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	88	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
48.4	300	0.0110	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.2	23	0.0110	1.7		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
48.6	323	Total			

Subcatchment K2R: (new node)



Subcatchment L: runon east of OSDF

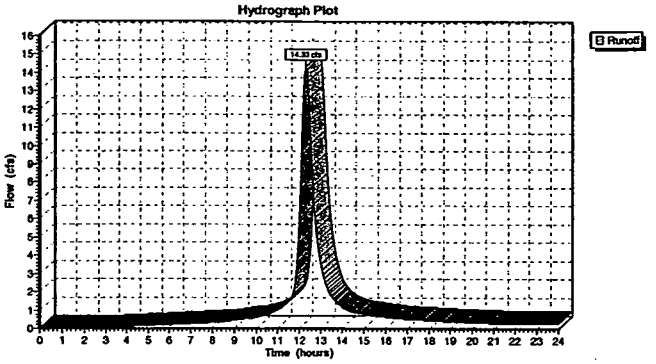
Runoff = 14.33 cfs @ 12.31 hrs, Volume= 1.654 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.779	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.9	300	0.0250	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.9	140	0.0250	2.5		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	170	0.0375	3.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	90	0.0105	7.0	346.69	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.030
36.9	700	Total			

Subcatchment L: runon east of OSDF



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Subcatchment M: runon east of OSDF

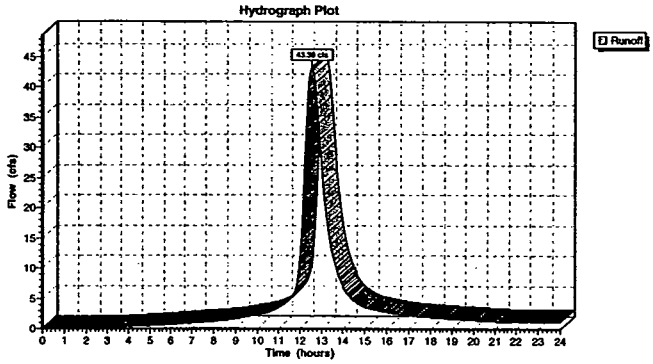
Runoff = 43.39 cfs @ 12.55 hrs, Volume= 6.697 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
7.234	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.3	300	0.0100	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
3.1	350	0.0139	1.9		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.4	180	0.0167	2.1		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.0	360	0.0125	3.0	7.00	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.82' Z= 4.0 & 3.0 '/' n= 0.030
56.8	1,190	Total			

Subcatchment M: runon east of OSDF



Subcatchment N: runon east of OSDF

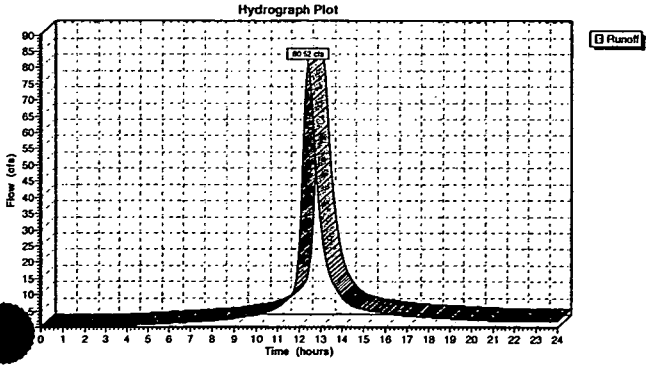
Runoff = 80.52 cfs @ 12.42 hrs, Volume= 10.692 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
11.664	85	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.3	300	0.0198	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.7	770	0.0198	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.9	395	0.0100	3.5	144.39	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.17' Z= 58.0 & 3.0 '/' n= 0.030
45.9	1,465	Total			

Subcatchment N: runon east of OSDF



Subcatchment O: runon east of OSDF

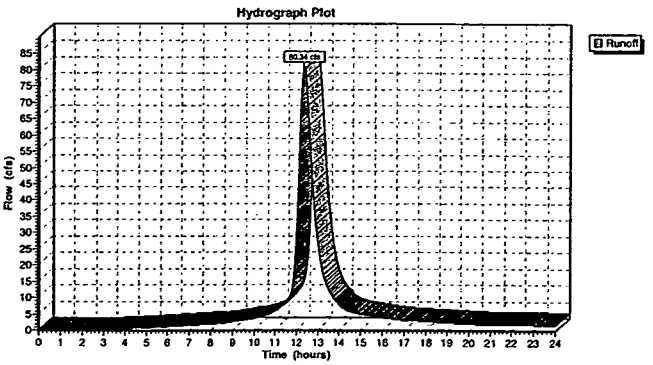
Runoff = 80.34 cfs @ 12.38 hrs, Volume= 10.152 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
10.935	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.1	300	0.0200	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
3.1	420	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.2	250	0.0100	3.5	149.13	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.17' Z= 60.0 & 3.0 '/' n= 0.030
42.4	970	Total			

Subcatchment O: runon east of OSDF



Subcatchment Q: runon east of OSDF

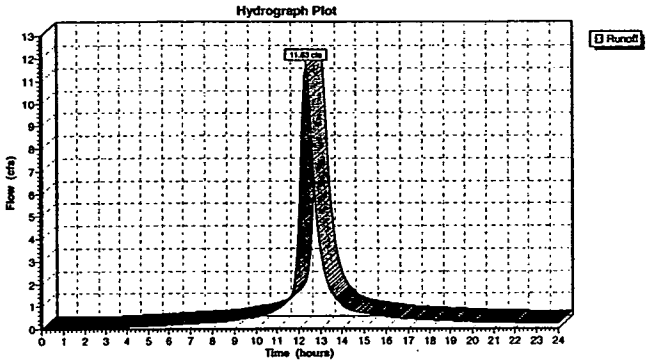
Runoff = 11.63 cfs @ 12.35 hrs, Volume= 1.429 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.520	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.1	300	0.0200	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
1.8	250	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	170	0.0100	7.9	1,267.78	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.08' Z= 5.7 & 13.5 '/' n= 0.030
40.3	720	Total			

Subcatchment Q: runon east of OSDF



Subcatchment TR: (new node)

[49] Hint: Tc<2dt may require smaller dt

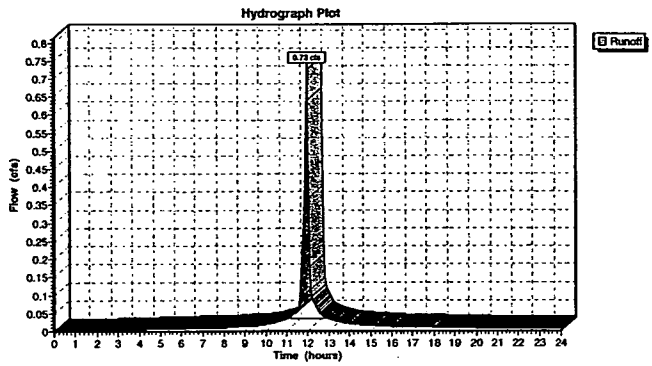
Runoff = 0.73 cfs @ 11.96 hrs, Volume= 0.040 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.040	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	40	0.0460	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"

Subcatchment TR: (new node)



Reach 1: runoff channel

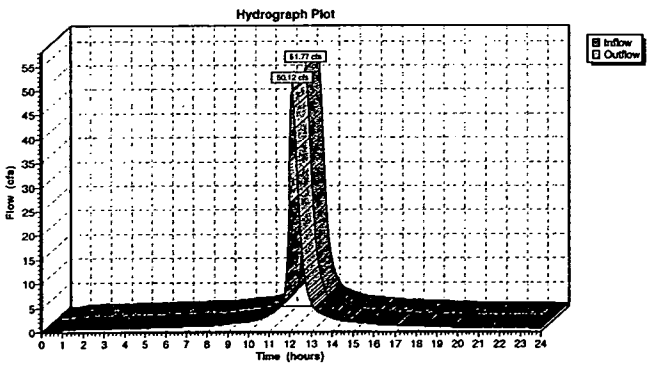
[65] Warning: Inlet elevation not specified

Inflow = 51.77 cfs @ 12.05 hrs, Volume= 5.052 af
Outflow = 50.12 cfs @ 12.13 hrs, Volume= 5.043 af, Atten= 3%, Lag= 4.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.8 min

Peak Depth= 1.90'
Capacity at bank full= 2,565.53 cfs
0.00' x 8.29' deep channel, n= 0.030 Length= 405.0' Slope= 0.0035 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: runoff channel



Reach 2: runoff channel

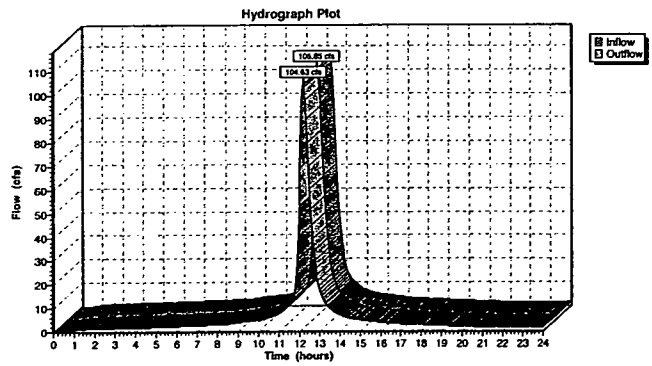
[65] Warning: Inlet elevation not specified

Inflow = 105.85 cfs @ 12.17 hrs, Volume= 11.550 af
Outflow = 104.63 cfs @ 12.22 hrs, Volume= 11.536 af, Atten= 1%, Lag= 3.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 3.7 min

Peak Depth= 2.16'
Capacity at bank full= 2,054.66 cfs
0.00' x 6.57' deep channel, n= 0.030 Length= 385.0' Slope= 0.0064 '/'
Side Slope Z-value= 6.0 5.0 '/'

Reach 2: runoff channel



Reach 3: runoff channel

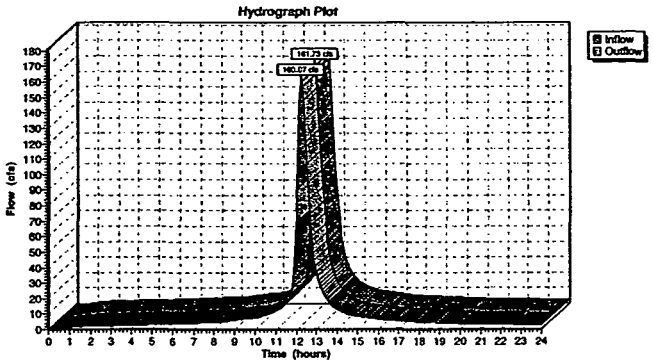
[65] Warning: Inlet elevation not specified

Inflow = 161.73 cfs @ 12.22 hrs, Volume= 19.034 af
Outflow = 160.07 cfs @ 12.26 hrs, Volume= 19.016 af, Atten= 1%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.1 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 3.1 min

Peak Depth= 2.65'
Capacity at bank full= 1,590.57 cfs
0.00' x 6.26' deep channel, n= 0.030 Length= 405.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 3: runoff channel



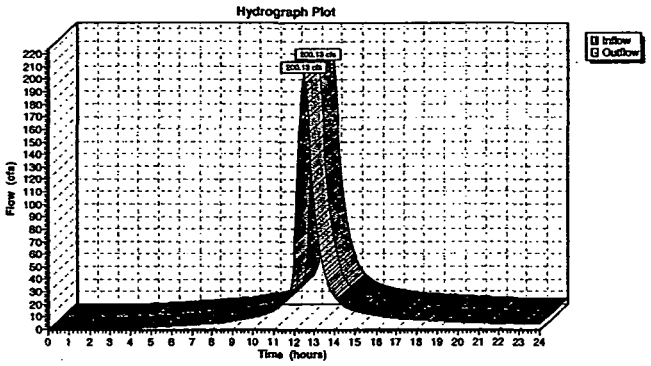
Reach 3R: (new node)

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 200.13 cfs @ 12.49 hrs, Volume= 28.911 af
Outflow = 200.13 cfs @ 12.49 hrs, Volume= 28.911 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Reach 3R: (new node)



Reach 4: runoff channel

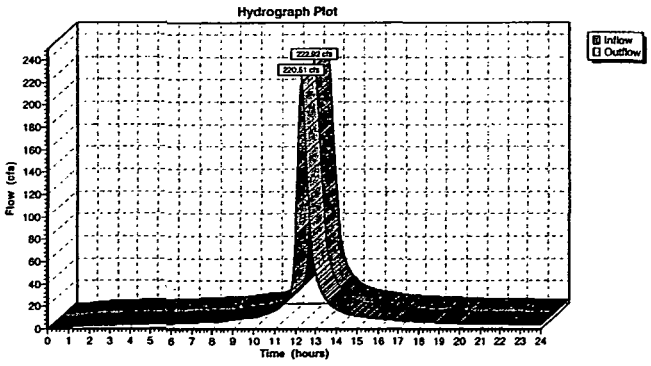
[65] Warning: Inlet elevation not specified

Inflow = 222.92 cfs @ 12.24 hrs, Volume= 25.955 af
Outflow = 220.51 cfs @ 12.29 hrs, Volume= 25.927 af, Atten= 1%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 3.3 min

Peak Depth= 3.10'
Capacity at bank full= 1,377.52 cfs
0.00' x 6.14' deep channel, n= 0.030 Length= 395.0' Slope= 0.0050 '/'
Side Slope Z-value= 4.0 6.0 '/'

Reach 4: runoff channel



Reach 5: runoff channel

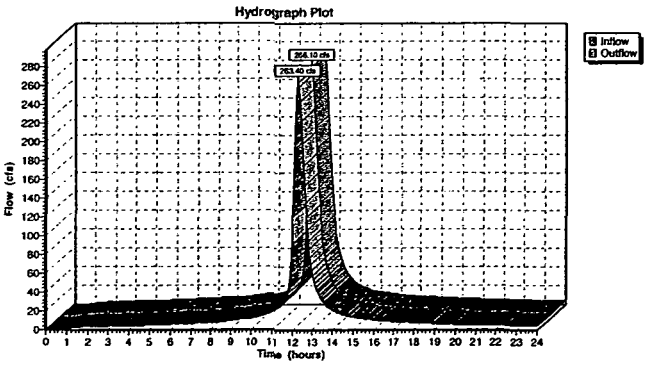
[65] Warning: Inlet elevation not specified

Inflow = 266.10 cfs @ 12.27 hrs, Volume= 31.072 af
Outflow = 263.40 cfs @ 12.31 hrs, Volume= 31.041 af, Atten= 1%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 3.2 min

Peak Depth= 3.45'
Capacity at bank full= 840.15 cfs
0.00' x 5.32' deep channel, n= 0.030 Length= 405.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 5: runoff channel



Reach 6: runoff channel

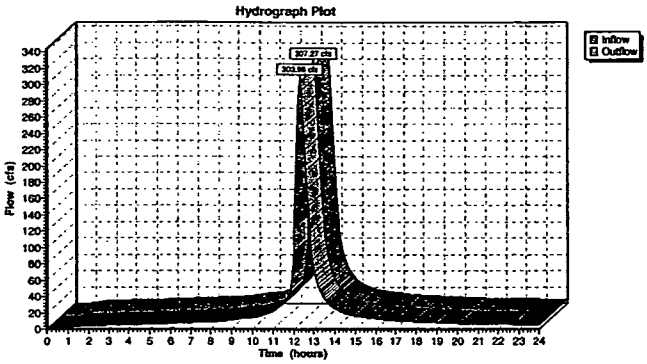
[65] Warning: Inlet elevation not specified

Inflow = 307.27 cfs @ 12.29 hrs, Volume= 36.326 af
Outflow = 303.96 cfs @ 12.34 hrs, Volume= 36.283 af, Atten= 1%, Lag= 2.9 min

[illegible] by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
[illegible]elocity= 5.1 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 3.7 min

Peak Depth= 3.64'
Capacity at bank full= 1,011.11 cfs
0.00' x 5.70' deep channel, n= 0.030 Length= 490.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 6: runoff channel



Reach 7: east runon ditch

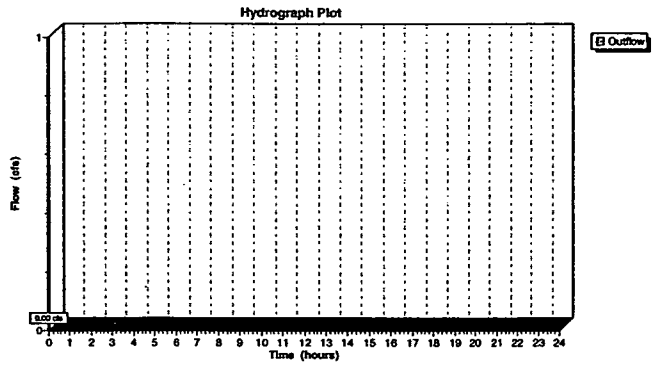
[43] Hint: Has no inflow (Outflow=Zero)

Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.0 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.0 fps, Avg. Travel Time= 0.0 min

Peak Depth= 0.00'
Capacity at bank full= 242.98 cfs
0.00' x 3.10' deep channel, n= 0.030 Length= 395.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 3.0 '/'

Reach 7: east runon ditch



Reach 7R: (new node)

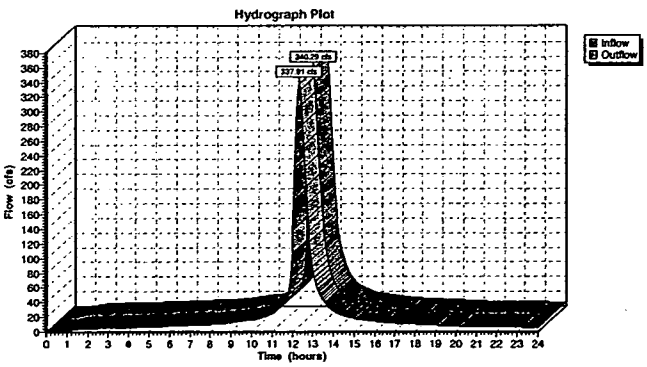
[65] Warning: Inlet elevation not specified

Inflow = 340.29 cfs @ 12.32 hrs, Volume= 41.190 af
Outflow = 337.91 cfs @ 12.35 hrs, Volume= 41.160 af, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.8 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 2.3 min

Peak Depth= 3.32'
Capacity at bank full= 1,293.72 cfs
0.00' x 5.49' deep channel, n= 0.030 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 7R: (new node)



Reach 8: east runon ditch

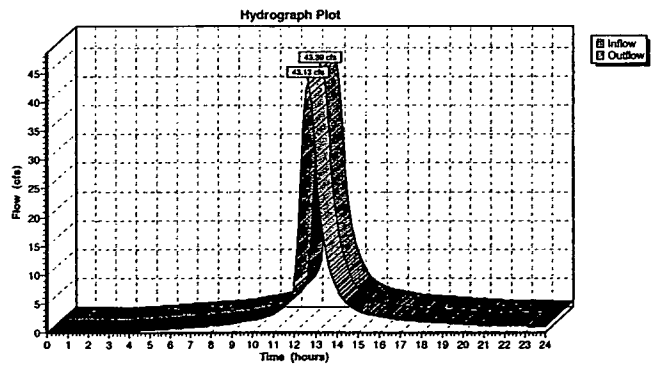
[65] Warning: Inlet elevation not specified

Inflow = 43.39 cfs @ 12.55 hrs, Volume= 6.697 af
Outflow = 43.13 cfs @ 12.63 hrs, Volume= 6.683 af, Atten= 1%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 2.6 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.8 min

Peak Depth= 0.74'
Capacity at bank full= 1,794.23 cfs
0.00' x 3.01' deep channel, n= 0.030 Length= 405.0' Slope= 0.0100 '/'
Side Slope Z-value= 58.0 3.0 '/'

Reach 8: east runon ditch



Reach 8R: (new node)

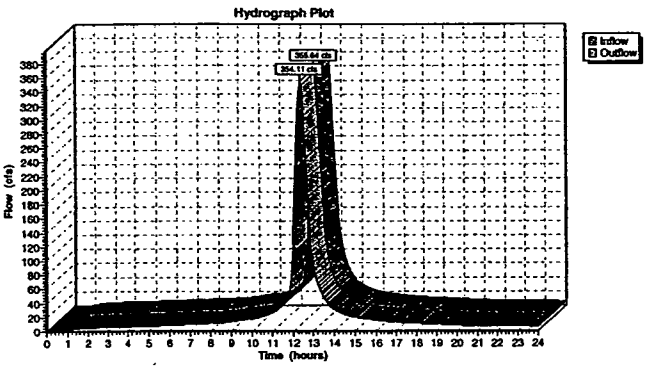
[65] Warning: Inlet elevation not specified

Inflow = 355.64 cfs @ 12.34 hrs, Volume= 43.736 af
Outflow = 354.11 cfs @ 12.36 hrs, Volume= 43.715 af, Atten= 0%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.5 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 1.6 min

Peak Depth= 4.04'
Capacity at bank full= 618.57 cfs
0.00' x 4.97' deep channel, n= 0.030 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: (new node)



Reach 9: east runon ditch

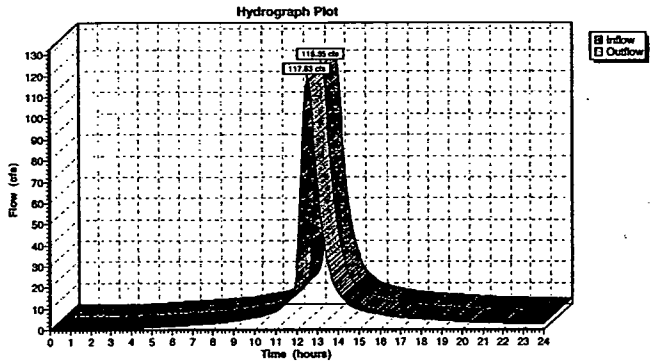
[65] Warning: Inlet elevation not specified

Inflow = 118.35 cfs @ 12.49 hrs, Volume= 17.375 af
Outflow = 117.63 cfs @ 12.56 hrs, Volume= 17.342 af, Atten= 1%, Lag= 4.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 5.3 min

Peak Depth= 1.07'
Capacity at bank full= 13,339.82 cfs
0.00' x 6.31' deep channel, n= 0.030 Length= 475.0' Slope= 0.0100 '/'
Side Slope Z-value= 60.0 3.0 '/'

Reach 9: east runon ditch



Reach 9R: (new node)

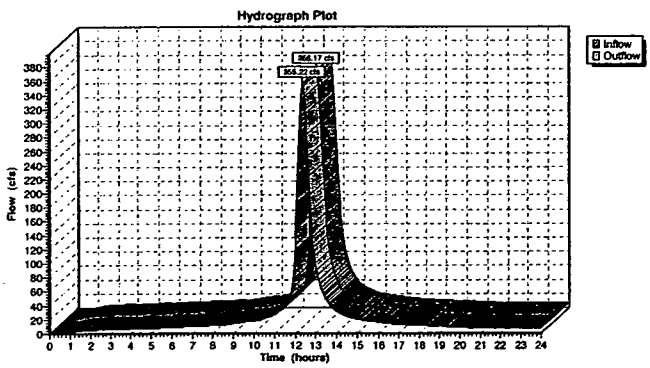
[65] Warning: Inlet elevation not specified

Inflow = 356.17 cfs @ 12.36 hrs, Volume= 44.676 af
Outflow = 355.22 cfs @ 12.37 hrs, Volume= 44.663 af, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 0.9 min

Peak Depth= 3.41'
Capacity at bank full= 2,047.79 cfs
4.35' x 6.96' deep channel, n= 0.030 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: (new node)



Reach 10AR: (new node)

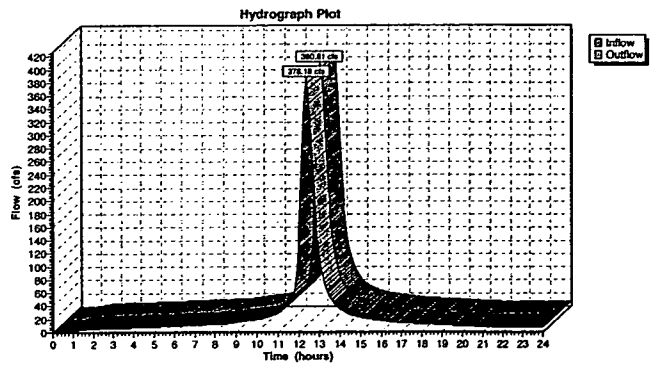
[65] Warning: Inlet elevation not specified

Inflow = 380.81 cfs @ 12.36 hrs, Volume= 48.878 af
Outflow = 378.18 cfs @ 12.40 hrs, Volume= 48.832 af, Atten= 1%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 3.0 min

Peak Depth= 3.01'
Capacity at bank full= 1,992.86 cfs
10.12' x 6.33' deep channel, n= 0.030 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 10AR: (new node)



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Reach 11: (new node)

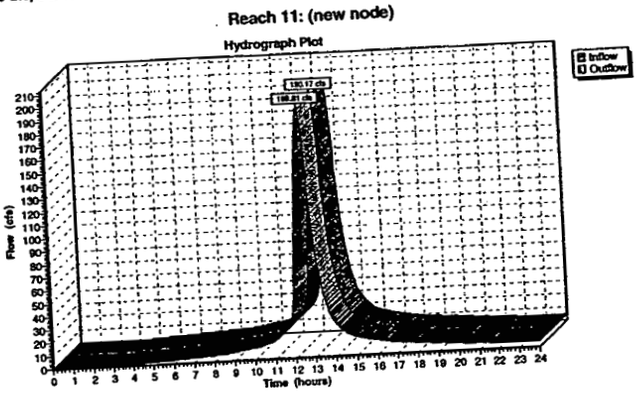
[65] Warning: Inlet elevation not specified

Inflow = 190.17 cfs @ 12.48 hrs, Volume= 27.495 af
Outflow = 189.81 cfs @ 12.50 hrs, Volume= 27.482 af, Atten= 0%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 1.3 min

Peak Depth= 2.00'
Capacity at bank full= 1,267.78 cfs
0.00' x 4.08' deep channel, n= 0.030 Length= 170.0' Slope= 0.0100 '/'
Side Slope Z-value= 5.7 13.5 '/'

Reach 11: (new node)



ATTACHMENT C-1C

2000-YEAR STORM DESIGN SCENARIO – HEAVY VEGETATION
2000-YEAR, 24-HOUR STORM EVENT

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Type II 24-hr Rainfall=13.00"
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: vegetated final cover
Tc=25.4 min CN=99 Area=2.601 ac Runoff= 27.84 cfs 2.780 af

Subcatchment B: vegetated final cover
Tc=12.1 min CN=99 Area=1.637 ac Runoff= 24.87 cfs 1.754 af

Subcatchment C: vegetated final cover
Tc=29.9 min CN=99 Area=4.960 ac Runoff= 48.10 cfs 5.297 af

Subcatchment D: vegetated final cover
Tc=28.2 min CN=99 Area=4.746 ac Runoff= 47.77 cfs 5.070 af

Subcatchment DDR: (new node)
Tc=10.7 min CN=99 Area=0.860 ac Runoff= 13.59 cfs 0.922 af

Subcatchment E: vegetated final cover
Tc=27.5 min CN=99 Area=4.946 ac Runoff= 50.54 cfs 5.285 af

Subcatchment F: vegetated final cover
Tc=28.0 min CN=99 Area=4.814 ac Runoff= 48.59 cfs 5.143 af

Subcatchment FFR: vegetated final cover
Tc=26.2 min CN=99 Area=2.410 ac Runoff= 25.32 cfs 2.576 af

Subcatchment G: vegetated final cover
Tc=28.0 min CN=99 Area=4.946 ac Runoff= 49.93 cfs 5.284 af

Subcatchment HR: vegetated final cover
Tc=26.2 min CN=99 Area=4.590 ac Runoff= 48.22 cfs 4.905 af

Subcatchment I: runon east of OSDF
Tc=20.4 min CN=90 Area=0.530 ac Runoff= 6.24 cfs 0.517 af

Subcatchment IR: (new node)
Tc=10.4 min CN=99 Area=0.600 ac Runoff= 9.58 cfs 0.643 af

Subcatchment J: runon east of OSDF
Tc=44.5 min CN=90 Area=1.242 ac Runoff= 9.07 cfs 1.207 af

Subcatchment JR: (new node)
Tc=29.7 min CN=99 Area=2.520 ac Runoff= 24.56 cfs 2.692 af

Subcatchment K: runon east of OSDF
Tc=62.4 min CN=86 Area=2.623 ac Runoff= 14.65 cfs 2.425 af

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Subcatchment K1R: (new node)
Tc=7.1 min CN=91 Area=0.382 ac Runoff= 6.63 cfs 0.378 af

Subcatchment K2R: (new node)
Tc=48.6 min CN=88 Area=0.530 ac Runoff= 3.60 cfs 0.503 af

Subcatchment L: runon east of OSDF
Tc=37.2 min CN=86 Area=1.779 ac Runoff= 14.28 cfs 1.653 af

Subcatchment M: runon east of OSDF
Tc=59.5 min CN=86 Area=7.234 ac Runoff= 41.83 cfs 6.693 af

Subcatchment N: runon east of OSDF
Tc=48.4 min CN=85 Area=11.664 ac Runoff= 77.52 cfs 10.687 af

Subcatchment O: runon east of OSDF
Tc=44.0 min CN=86 Area=10.935 ac Runoff= 78.19 cfs 10.149 af

Subcatchment Q: runon east of OSDF
Tc=40.7 min CN=87 Area=1.520 ac Runoff= 11.56 cfs 1.428 af

Subcatchment TR: (new node)
Tc=5.5 min CN=91 Area=0.040 ac Runoff= 0.73 cfs 0.040 af

Reach 1: runoff channel — Inflow= 52.44 cfs 5.051 af
Length= 405.0' Max Vel= 1.5 fps Capacity= 1,099.51 cfs Outflow= 49.07 cfs 5.034 af

Reach 2: runoff channel — Inflow= 104.36 cfs 11.538 af
Length= 385.0' Max Vel= 2.2 fps Capacity= 880.57 cfs Outflow= 102.73 cfs 11.513 af

Reach 3: runoff channel — Inflow= 155.41 cfs 19.009 af
Length= 405.0' Max Vel= 2.7 fps Capacity= 681.67 cfs Outflow= 153.39 cfs 18.973 af

Reach 3R: (new node) — Inflow= 180.08 cfs 28.844 af
Outflow= 180.08 cfs 28.844 af

Reach 4: runoff channel — Inflow= 206.22 cfs 25.911 af
Length= 395.0' Max Vel= 2.4 fps Capacity= 590.36 cfs Outflow= 203.76 cfs 25.859 af

Reach 5: runoff channel — Inflow= 238.60 cfs 31.002 af
Length= 405.0' Max Vel= 2.5 fps Capacity= 360.07 cfs Outflow= 234.19 cfs 30.942 af

Reach 6: runoff channel — Inflow= 262.61 cfs 36.226 af
Length= 490.0' Max Vel= 2.6 fps Capacity= 433.33 cfs Outflow= 259.87 cfs 36.144 af

Reach 7: east runon ditch
Length= 395.0' Max Vel= 0.0 fps Capacity= 104.13 cfs Outflow= 0.00 cfs 0.000 af

Reach 7R: (new node) — Inflow= 279.05 cfs 41.049 af
Length= 400.0' Max Vel= 3.4 fps Capacity= 554.45 cfs Outflow= 277.35 cfs 40.992 af

Reach 8: east runon ditch — Inflow= 41.83 cfs 6.693 af
Length= 405.0' Max Vel= 1.3 fps Capacity= 768.96 cfs Outflow= 41.21 cfs 6.667 af

Reach 8R: (new node) — Inflow= 286.18 cfs 43.567 af
Length= 220.0' Max Vel= 2.7 fps Capacity= 265.10 cfs Outflow= 284.95 cfs 43.526 af

Reach 9: east runon ditch — Inflow= 110.42 cfs 17.353 af
Length= 475.0' Max Vel= 1.7 fps Capacity= 5,717.07 cfs Outflow= 108.78 cfs 17.290 af

Reach 9R: (new node) — Inflow= 286.17 cfs 44.487 af
Length= 120.0' Max Vel= 2.7 fps Capacity= 877.62 cfs Outflow= 285.41 cfs 44.462 af

Reach 10AR: (new node) — Inflow= 299.48 cfs 48.678 af
Length= 365.0' Max Vel= 2.7 fps Capacity= 854.08 cfs Outflow= 297.94 cfs 48.592 af

Reach 11: (new node) — Inflow= 171.73 cfs 27.440 af
Length= 170.0' Max Vel= 2.5 fps Capacity= 543.34 cfs Outflow= 171.26 cfs 27.416 af

Runoff Area = 78.109 ac Volume = 78.032 af Average Depth = 11.99"

Subcatchment A: vegetated final cover

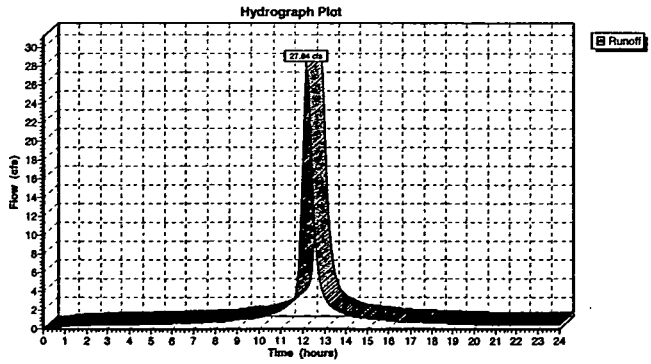
Runoff = 27.84 cfs @ 12.17 hrs, Volume= 2.780 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.601	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
25.4	490	Total			

Subcatchment A: vegetated final cover



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Subcatchment B: vegetated final cover

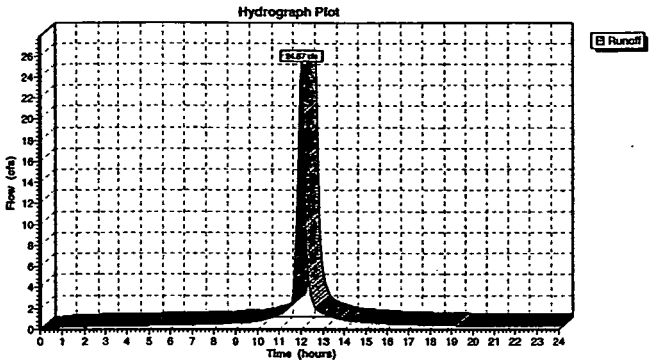
Runoff = 24.87 cfs @ 12.03 hrs, Volume= 1.754 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.637	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.6	90	0.0750	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.6	130	0.0250	3.4	83.06	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 6.0 '/' n= 0.070
2.9	320	0.0075	1.8	37.74	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.070
12.1	540	Total			

Subcatchment B: vegetated final cover



Subcatchment C: vegetated final cover

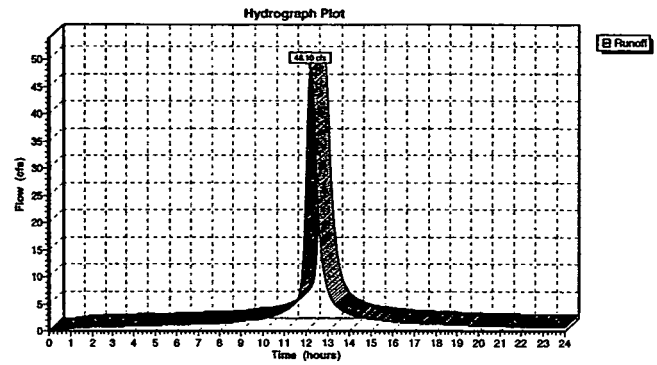
Runoff = 48.10 cfs @ 12.23 hrs, Volume= 5.297 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.960	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
4.5	370	0.0035	1.4	37.24	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.070
29.9	860	Total			

Subcatchment C: vegetated final cover



Subcatchment D: vegetated final cover

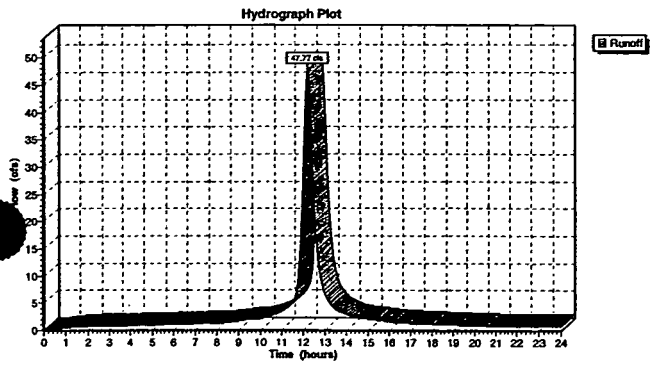
Runoff = 47.77 cfs @ 12.21 hrs, Volume= 5.070 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.746	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	180	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.4	200	0.0083	2.4	109.24	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 5.0 '/' n= 0.070
1.4	150	0.0045	1.8	72.93	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.070
28.2	830	Total			

Subcatchment D: vegetated final cover



Subcatchment DDR: (new node)

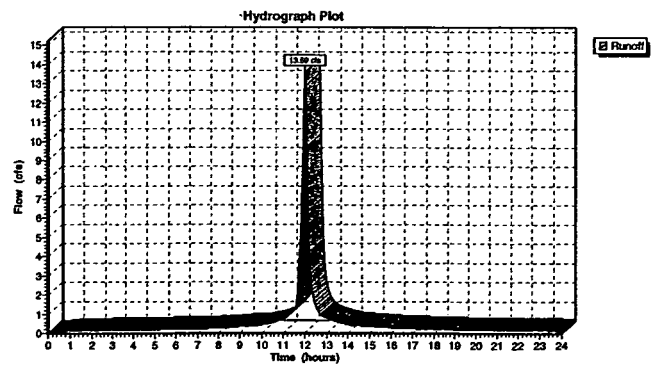
Runoff = 13.59 cfs @ 12.01 hrs, Volume= 0.922 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.860	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	150	0.1500	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.9	330	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
10.7	480	Total			

Subcatchment DDR: (new node)



Subcatchment E: vegetated final cover

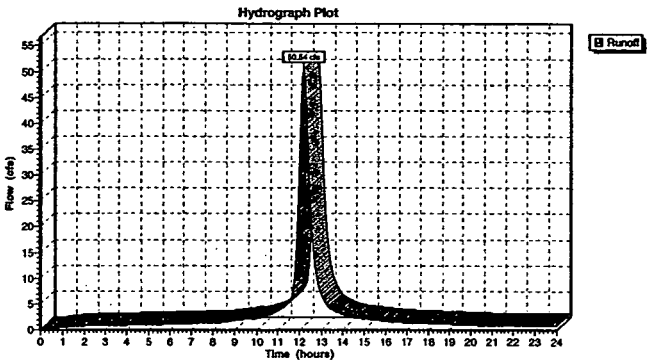
Runoff = 50.54 cfs @ 12.20 hrs, Volume= 5.285 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	170	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	50	0.0045	2.0	108.55	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 4.0 '/' n= 0.070
1.8	320	0.0105	3.0	148.58	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.070
27.5	840	Total			

Subcatchment E: vegetated final cover



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Subcatchment F: vegetated final cover

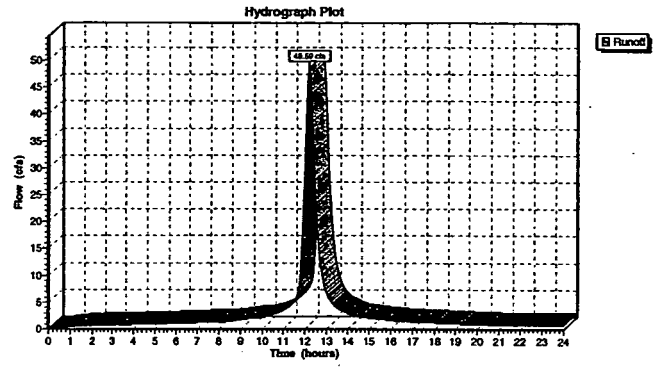
Runoff = 48.59 cfs @ 12.20 hrs, Volume= 5.143 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.814	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.7	360	0.0050	2.2	150.56	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.68' Z= 4.0 & 6.0 '/' n= 0.070
28.0	835	Total			

Subcatchment F: vegetated final cover



Subcatchment FFR: vegetated final cover

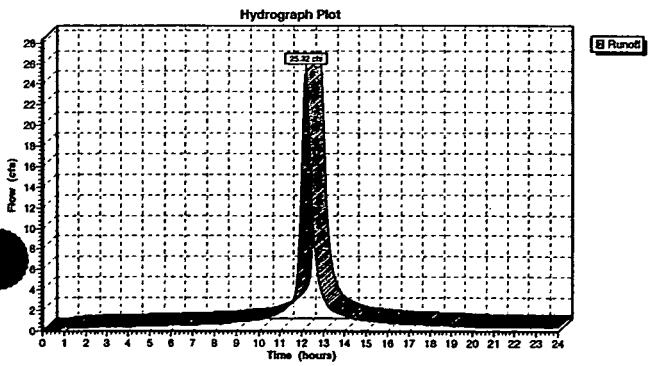
Runoff = 25.32 cfs @ 12.18 hrs, Volume= 2.576 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.410	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	85	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
4.8	50	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.1	365	0.0050	2.9	392.06	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.49' Z= 6.0 & 3.0 '/' n= 0.070
26.2	810	Total			

Subcatchment FFR: vegetated final cover



Subcatchment G: vegetated final cover

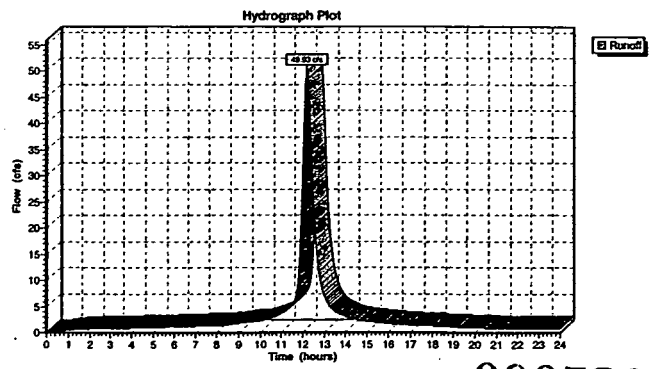
Runoff = 49.93 cfs @ 12.20 hrs, Volume= 5.284 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.946	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
5.5	60	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	175	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.7	370	0.0050	2.3	153.25	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=3.86' Z= 3.0 & 6.0 '/' n= 0.070
28.0	845	Total			

Subcatchment G: vegetated final cover



Subcatchment HR: vegetated final cover

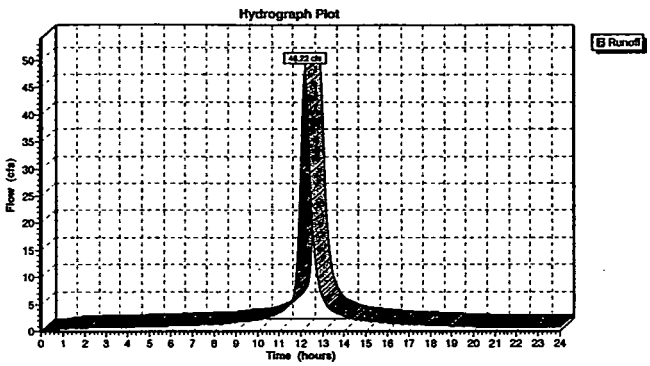
Runoff = 48.22 cfs @ 12.18 hrs, Volume= 4.905 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
4.590	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	90	0.0500	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
4.8	50	0.1000	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.4	160	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.6	400	0.0100	4.2	612.82	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=5.70' Z= 3.0 & 6.0 '/' n= 0.070
26.2	850	Total			

Subcatchment HR: vegetated final cover



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Subcatchment I: runon east of OSDF

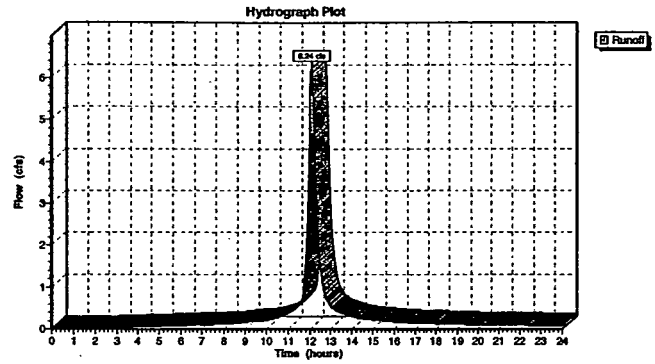
Runoff = 6.24 cfs @ 12.12 hrs, Volume= 0.517 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.9	210	0.0500	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	55	0.0075	1.8	37.74	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.03' Z= 4.0 & 6.0 '/' n= 0.070
20.4	265	Total			

Subcatchment I: runon east of OSDF



Subcatchment IR: (new node)

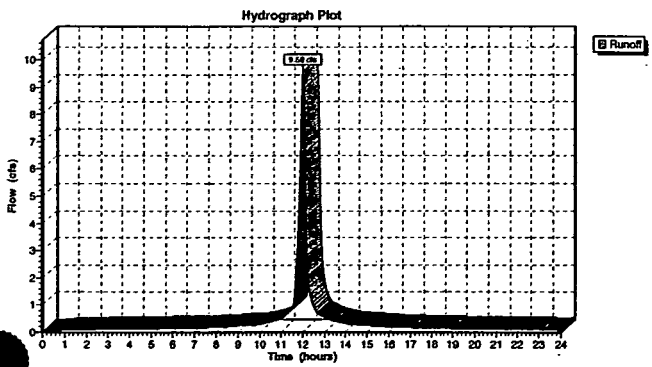
Runoff = 9.58 cfs @ 12.01 hrs, Volume= 0.643 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.600	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	150	0.1500	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.6	220	0.1500	6.2		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
10.4	370	Total			

Subcatchment IR: (new node)



Subcatchment J: runon east of OSDF

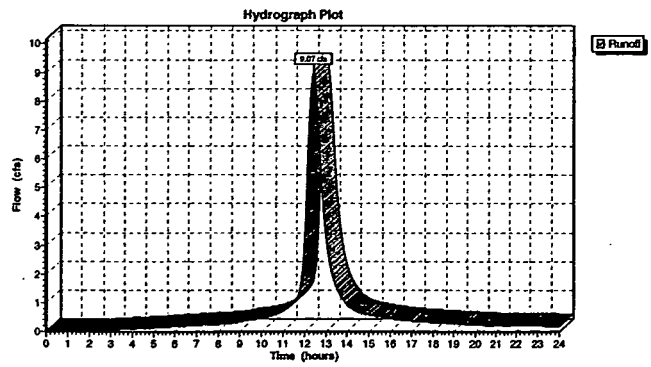
Runoff = 9.07 cfs @ 12.40 hrs, Volume= 1.207 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.242	90	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
41.9	300	0.0158	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.8	100	0.0158	2.0		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.8	150	0.0035	1.4	37.24	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.33' Z= 6.0 & 4.0 '/' n= 0.070
44.5	550	Total			

Subcatchment J: runon east of OSDF



Subcatchment JR: (new node)

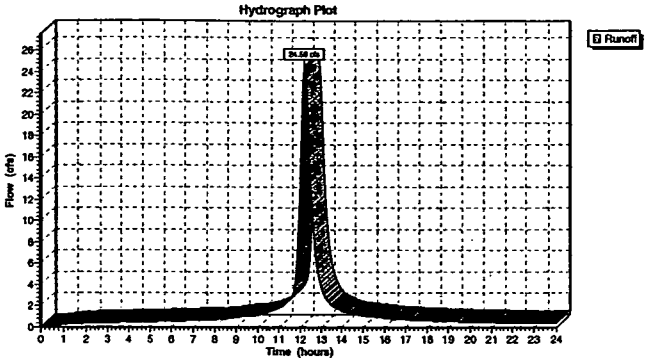
Runoff = 24.56 cfs @ 12.22 hrs, Volume= 2.692 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.520	99	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9	80	0.0176	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
6.0	60	0.0830	0.2		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
9.3	150	0.1700	0.3		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.5	190	0.1700	6.6		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
29.7	480	Total			

Subcatchment JR: (new node)



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Subcatchment K: runon east of OSDF

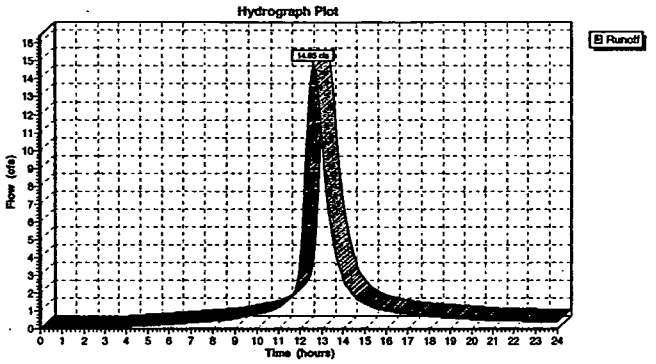
Runoff = 14.65 cfs @ 12.63 hrs, Volume= 2.425 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
2.623	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
58.0	300	0.0070	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
2.1	290	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	250	0.0045	1.8	72.93	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=2.86' Z= 6.0 & 4.0 '/' n= 0.070
62.4	840	Total			

Subcatchment K: runon east of OSDF



Subcatchment K1R: (new node)

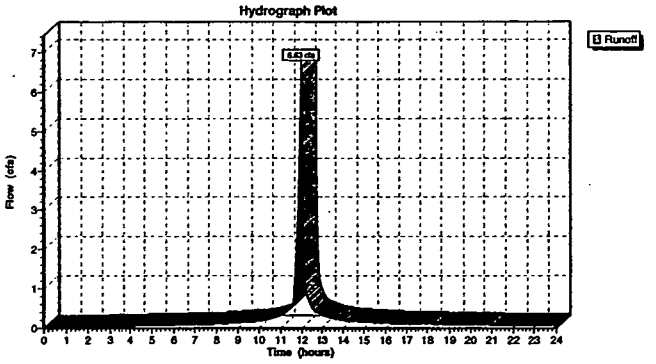
Runoff = 6.63 cfs @ 11.98 hrs, Volume= 0.378 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.382	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1	33	0.0160	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"

Subcatchment K1R: (new node)



Subcatchment K2R: (new node)

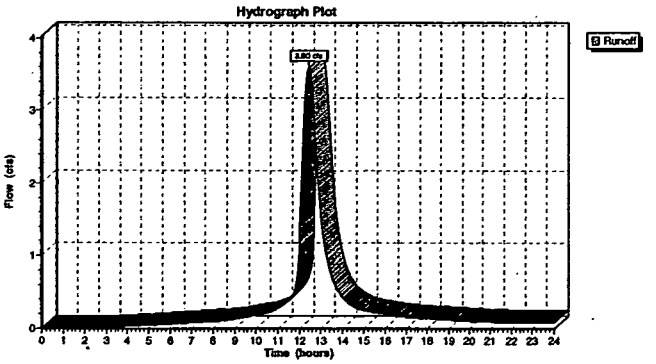
Runoff = 3.60 cfs @ 12.45 hrs, Volume= 0.503 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.530	88	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
48.4	300	0.0110	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
0.2	23	0.0110	1.7		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
48.6	323	Total			

Subcatchment K2R: (new node)



Subcatchment L: runon east of OSDF

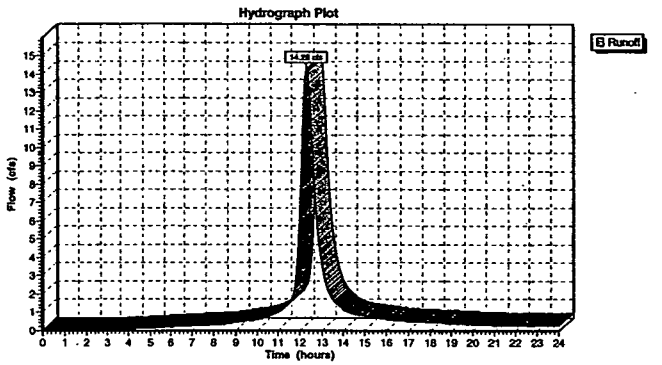
Runoff = 14.28 cfs @ 12.31 hrs, Volume= 1.653 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.779	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.9	300	0.0250	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
0.9	140	0.0250	2.5		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.9	170	0.0375	3.1		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.5	90	0.0105	3.0	148.58	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=3.32' Z= 6.0 & 3.0 '/' n= 0.070
37.2	700	Total			

Subcatchment L: runon east of OSDF



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Subcatchment M: runon east of OSDF

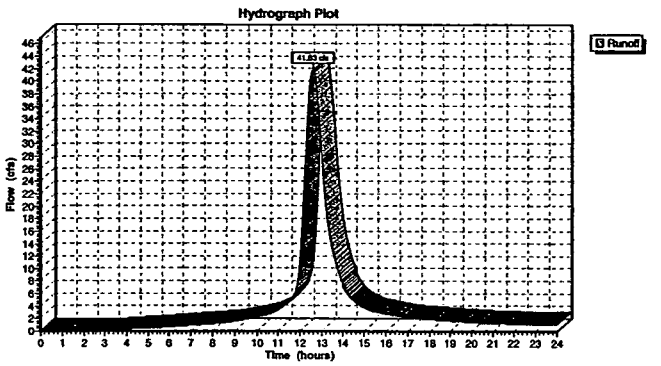
Runoff = 41.83 cfs @ 12.59 hrs, Volume= 6.693 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
7.234	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.3	300	0.0100	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
3.1	350	0.0139	1.9		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
1.4	180	0.0167	2.1		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
4.7	360	0.0125	1.3	3.00	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=0.82' Z= 4.0 & 3.0 '/' n= 0.070
59.5	1,190	Total			

Subcatchment M: runon east of OSDF



Subcatchment N: runon east of OSDF

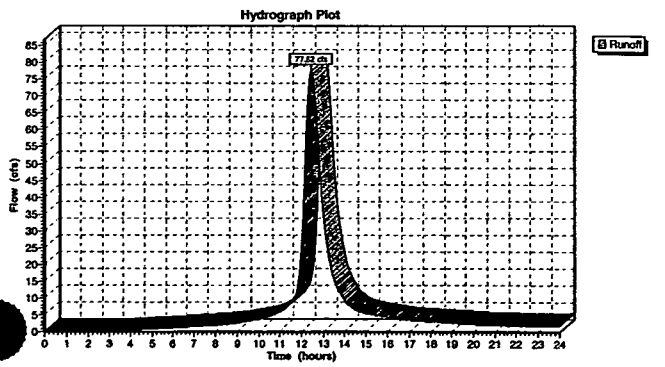
Runoff = 77.52 cfs @ 12.45 hrs, Volume= 10.687 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
11.664	85	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.3	300	0.0198	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
5.7	770	0.0198	2.3		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
4.4	395	0.0100	1.5	61.88	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.17' Z= 58.0 & 3.0 '/' n= 0.070
48.4	1,465	Total			

Subcatchment N: runon east of OSDF



Subcatchment O: runon east of OSDF

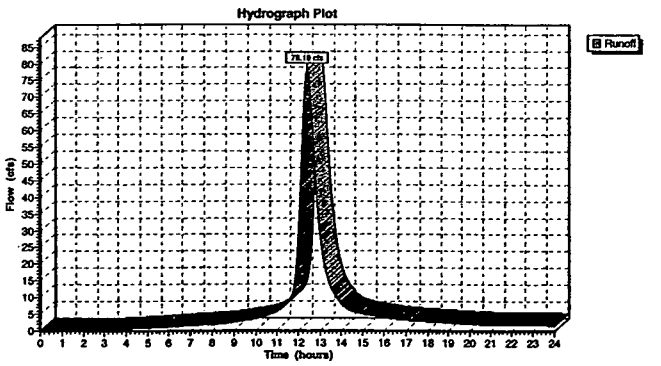
Runoff = 78.19 cfs @ 12.40 hrs, Volume= 10.149 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
10.935	86	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.1	300	0.0200	0.1		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.60"
3.1	420	0.0200	2.3		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
2.8	250	0.0100	1.5	63.91	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.17' Z= 60.0 & 3.0 '/' n= 0.070
44.0	970	Total			

Subcatchment O: runon east of OSDF



Subcatchment Q: runon east of OSDF

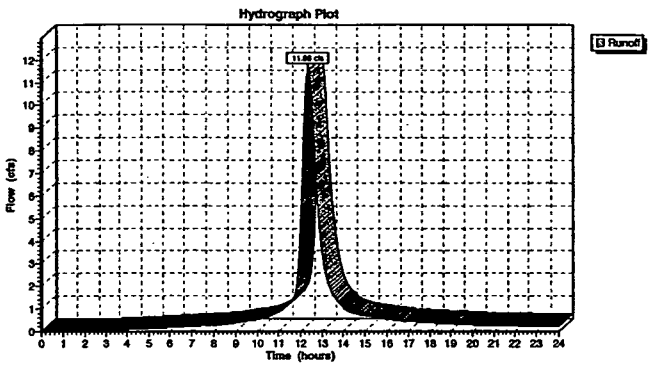
Runoff = 11.56 cfs @ 12.36 hrs, Volume= 1.428 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
1.520	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.1	300	0.0200	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"
1.8	250	0.0200	2.3		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.8	170	0.0100	3.4	543.34	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=4.08' Z= 5.7 & 13.5 '/' n= 0.070
40.7	720	Total			

Subcatchment Q: runon east of OSDF



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Subcatchment TR: (new node)

[49] Hint: Tc<2dt may require smaller dt

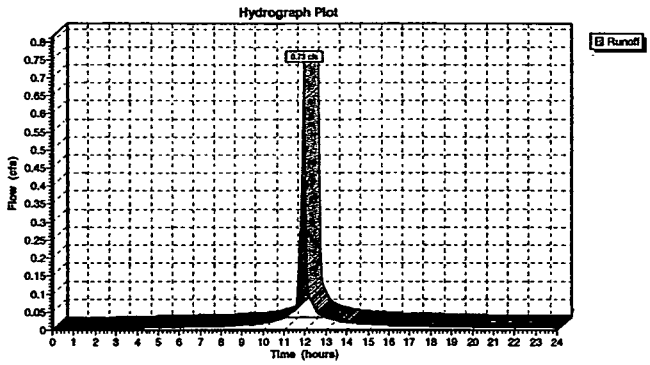
Runoff = 0.73 cfs @ 11.96 hrs, Volume= 0.040 af

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=13.00"

Area (ac)	CN	Description
0.040	91	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	40	0.0460	0.1		Sheet Flow, Grass: Dense n= 0.240 P2= 2.60"

Subcatchment TR: (new node)



Reach 1: runoff channel

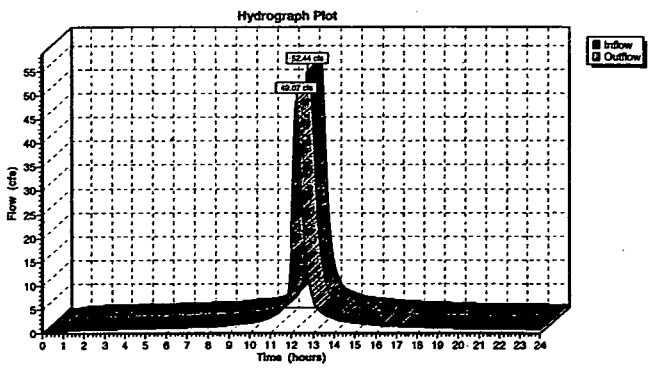
[65] Warning: Inlet elevation not specified

Inflow = 52.44 cfs @ 12.08 hrs, Volume= 5.051 af
Outflow = 49.07 cfs @ 12.22 hrs, Volume= 5.034 af, Atten= 6%, Lag= 8.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.5 fps, Min. Travel Time= 4.6 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 11.1 min

Peak Depth= 2.59'
Capacity at bank full= 1,099.51 cfs
0.00' x 8.29' deep channel, n= 0.070 Length= 405.0' Slope= 0.0035 '/'
Side Slope Z-value= 6.0 4.0 '/'

Reach 1: runoff channel



Reach 2: runoff channel

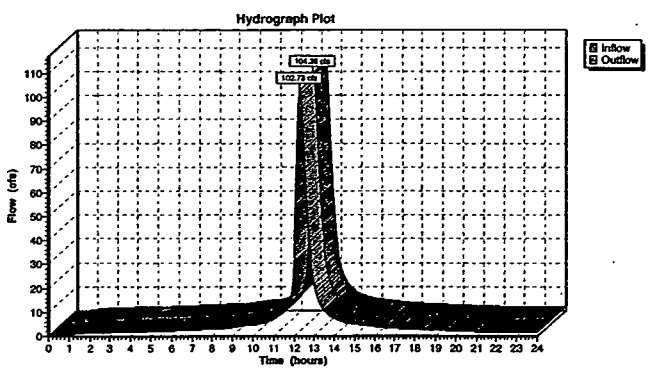
[65] Warning: Inlet elevation not specified

Inflow = 104.36 cfs @ 12.23 hrs, Volume= 11.538 af
Outflow = 102.73 cfs @ 12.32 hrs, Volume= 11.513 af, Atten= 2%, Lag= 5.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.2 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.9 fps, Avg. Travel Time= 7.0 min

Peak Depth= 2.94'
Capacity at bank full= 880.57 cfs
0.00' x 6.57' deep channel, n= 0.070 Length= 385.0' Slope= 0.0064 '/'
Side Slope Z-value= 6.0 5.0 '/'

Reach 2: runoff channel



Reach 3: runoff channel

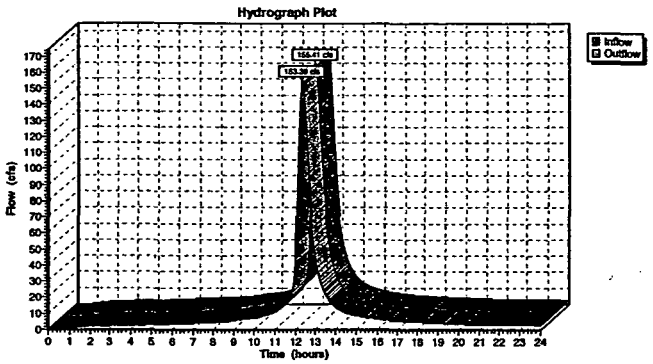
[65] Warning: Inlet elevation not specified

Inflow = 155.41 cfs @ 12.30 hrs, Volume= 19.009 af
Outflow = 153.39 cfs @ 12.37 hrs, Volume= 18.973 af, Atten= 1%, Lag= 4.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 5.9 min

Peak Depth= 3.58'
Capacity at bank full= 681.67 cfs
0.00' x 6.26' deep channel, n= 0.070 Length= 405.0' Slope= 0.0075 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 3: runoff channel



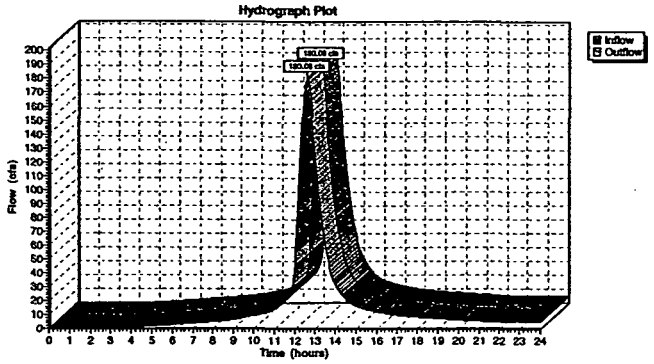
Reach 3R: (new node)

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 180.08 cfs @ 12.58 hrs, Volume= 28.844 af
Outflow = 180.08 cfs @ 12.58 hrs, Volume= 28.844 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Reach 3R: (new node)



Reach 4: runoff channel

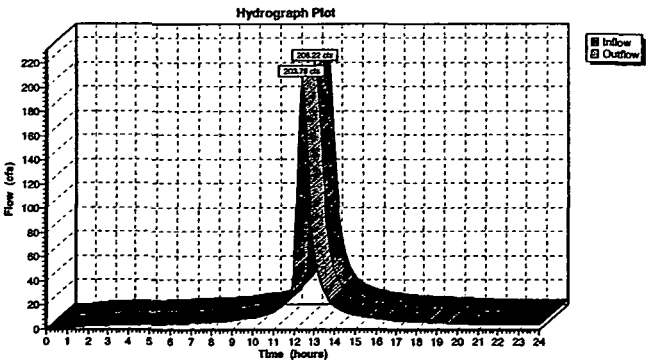
[65] Warning: Inlet elevation not specified

Inflow = 206.22 cfs @ 12.34 hrs, Volume= 25.911 af
Outflow = 203.76 cfs @ 12.42 hrs, Volume= 25.859 af, Atten= 1%, Lag= 4.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.3 min

Peak Depth= 4.12'
Capacity at bank full= 590.36 cfs
0.00' x 6.14' deep channel, n= 0.070 Length= 395.0' Slope= 0.0050 '/'
Side Slope Z-value= 4.0 6.0 '/'

Reach 4: runoff channel



Reach 5: runoff channel

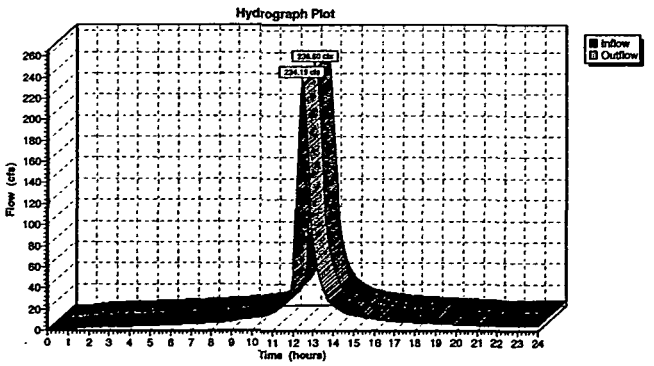
[65] Warning: Inlet elevation not specified

Inflow = 236.60 cfs @ 12.39 hrs, Volume= 31.002 af
Outflow = 234.19 cfs @ 12.47 hrs, Volume= 30.942 af, Atten= 1%, Lag= 4.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 6.1 min

Peak Depth= 4.53'
Capacity at bank full= 360.07 cfs
0.00' x 5.32' deep channel, n= 0.070 Length= 405.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 5: runoff channel



Reach 6: runoff channel

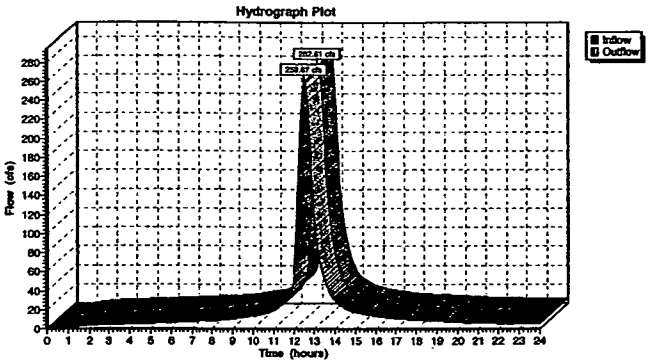
[65] Warning: Inlet elevation not specified

Inflow = 262.61 cfs @ 12.44 hrs, Volume= 36.226 af
Outflow = 259.87 cfs @ 12.53 hrs, Volume= 36.144 af, Atten= 1%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.6 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 7.1 min

Peak Depth= 4.71'
Capacity at bank full= 433.33 cfs
0.00' x 5.70' deep channel, n= 0.070 Length= 490.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 6: runoff channel



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Reach 7: east runon ditch

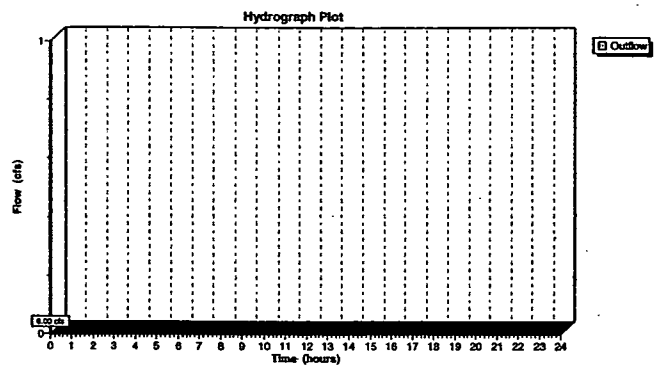
[43] Hint: Has no inflow (Outflow=Zero)

Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.0 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.0 fps, Avg. Travel Time= 0.0 min

Peak Depth= 0.00'
Capacity at bank full= 104.13 cfs
0.00' x 3.10' deep channel, n= 0.070 Length= 395.0' Slope= 0.0125 '/'
Side Slope Z-value= 4.0 3.0 '/'

Reach 7: east runon ditch



Reach 7R: (new node)

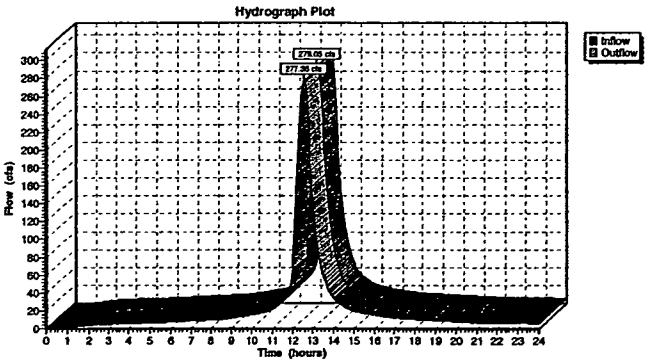
[65] Warning: Inlet elevation not specified

Inflow = 279.05 cfs @ 12.51 hrs, Volume= 41.049 af
Outflow = 277.35 cfs @ 12.56 hrs, Volume= 40.992 af, Atten= 1%, Lag= 3.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 4.3 min

Peak Depth= 4.24'
Capacity at bank full= 554.45 cfs
0.00' x 5.49' deep channel, n= 0.070 Length= 400.0' Slope= 0.0100 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 7R: (new node)



Reach 8: east runon ditch

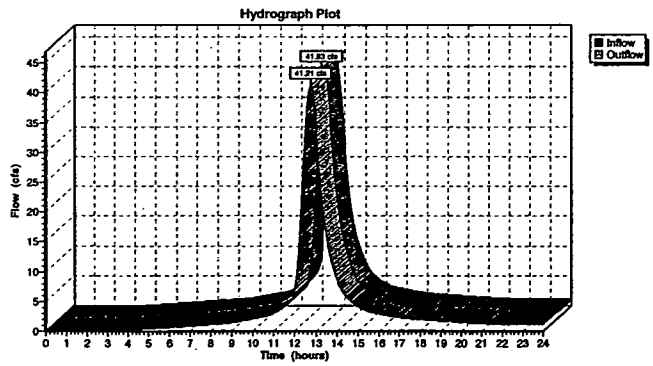
[65] Warning: Inlet elevation not specified

Inflow = 41.83 cfs @ 12.59 hrs, Volume= 6.693 af
Outflow = 41.21 cfs @ 12.74 hrs, Volume= 6.667 af, Atten= 1%, Lag= 8.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.3 fps, Min. Travel Time= 5.0 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 10.9 min

Peak Depth= 1.01'
Capacity at bank full= 768.96 cfs
0.00' x 3.01' deep channel, n= 0.070 Length= 405.0' Slope= 0.0100 '/'
Side Slope Z-value= 58.0 3.0 '/'

Reach 8: east runon ditch



Reach 8R: (new node)

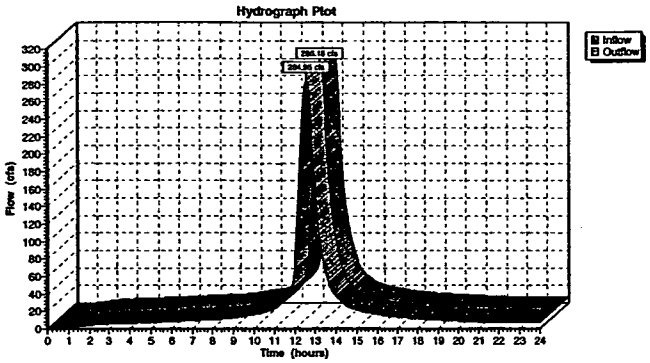
[65] Warning: Inlet elevation not specified
[91] Warning: Storage range exceeded by 0.15'
[55] Hint: Peak inflow is 108% of Manning's capacity

[illegible] = 286.18 cfs @ 12.55 hrs, Volume= 43.567 af
[illegible]ow = 284.95 cfs @ 12.59 hrs, Volume= 43.526 af, Atten= 0%, Lag= 2.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 3.0 min

Peak Depth= 5.12'
Capacity at bank full= 265.10 cfs
0.00' x 4.97' deep channel, n= 0.070 Length= 220.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 2.0 '/'

Reach 8R: (new node)



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Reach 9: east runon ditch

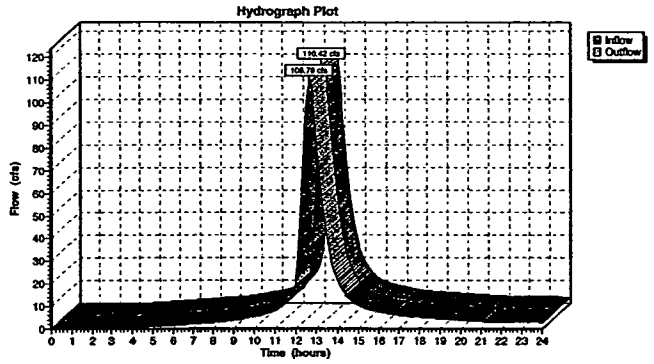
[65] Warning: Inlet elevation not specified

Inflow = 110.42 cfs @ 12.54 hrs, Volume= 17.353 af
Outflow = 108.78 cfs @ 12.68 hrs, Volume= 17.290 af, Atten= 1%, Lag= 8.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.7 fps, Min. Travel Time= 4.7 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 10.2 min

Peak Depth= 1.43'
Capacity at bank full= 5,717.07 cfs
0.00' x 6.31' deep channel, n= 0.070 Length= 475.0' Slope= 0.0100 '/'
Side Slope Z-value= 60.0 3.0 '/'

Reach 9: east runon ditch



Reach 9R: (new node)

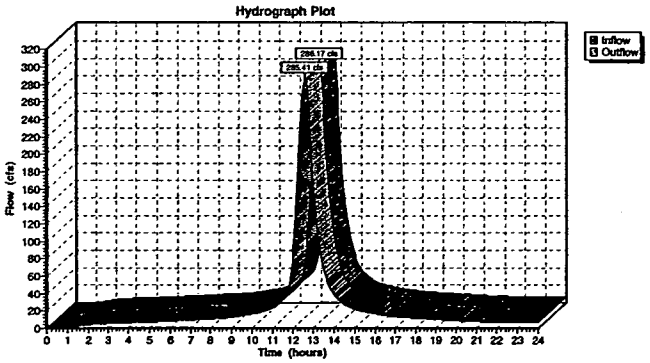
[65] Warning: Inlet elevation not specified

Inflow = 286.17 cfs @ 12.59 hrs, Volume= 44.487 af
Outflow = 285.41 cfs @ 12.61 hrs, Volume= 44.462 af, Atten= 0%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 1.7 min

Peak Depth= 4.42'
Capacity at bank full= 877.62 cfs
4.35' x 6.96' deep channel, n= 0.070 Length= 120.0' Slope= 0.0050 '/'
Side Slope Z-value= 6.0 3.0 '/'

Reach 9R: (new node)



Reach 10AR: (new node)

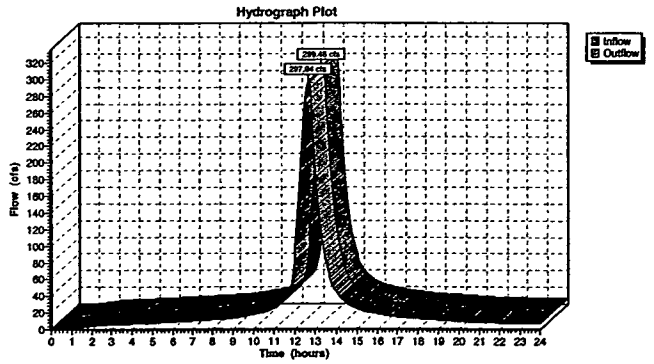
[65] Warning: Inlet elevation not specified

Inflow = 299.48 cfs @ 12.60 hrs, Volume= 48.678 af
Outflow = 297.94 cfs @ 12.67 hrs, Volume= 48.592 af, Atten= 1%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.7 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 5.4 min

Peak Depth= 3.98'
Capacity at bank full= 854.08 cfs
10.12' x 6.33' deep channel, n= 0.070 Length= 365.0' Slope= 0.0050 '/'
Side Slope Z-value= 3.0 6.0 '/'

Reach 10AR: (new node)



Reach 11: (new node)

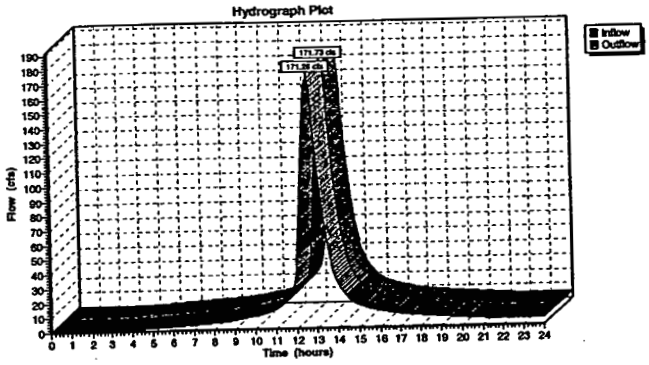
[65] Warning: Inlet elevation not specified

Inflow = 171.73 cfs @ 12.56 hrs, Volume= 27.440 af
Outflow = 171.26 cfs @ 12.59 hrs, Volume= 27.416 af, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.5 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 2.4 min

Peak Depth= 2.65'
Capacity at bank full= 543.34 cfs
0.00' x 4.08' deep channel, n= 0.070 Length= 170.0' Slope= 0.0100 '/'
Side Slope Z-value= 5.7 13.5 '/'

Reach 11: (new node)



ATTACHMENT C-2

WEIGHTED CURVE NUMBER CALCULATIONS

SUBCATCHMENT AREA AND HYDROCAD™ INPUT PARAMETERS FOR THE CALCULATION OF WEIGHTED CN
2000 YEAR STORM DESIGN SCENARIOS

Subcatchment Label	Area (acres)	Percent of Total Area %	HSG	Land Use Description	CN AMC = 2	Weighted CN AMC = 2	Weighted CN (2) AMC = 3
A	2.60	100%	B/C	vegetated final cover	74	(1) 98	99
B	1.64	100%	B/C	vegetated final cover	74	(1) 98	99
C	4.96	100%	B/C	vegetated final cover	74	(1) 98	99
D	4.75	100%	B/C	vegetated final cover	74	(1) 98	99
DDR	0.86	100%	B/C	vegetated final cover	74	(1) 98	99
E	4.95	100%	B/C	vegetated final cover	74	(1) 98	99
F	4.81	100%	B/C	vegetated final cover	74	(1) 98	99
FFR	2.41	100%	B/C	vegetated final cover	74	(1) 98	99
G	4.95	100%	B/C	vegetated final cover	74	(1) 98	99
HR	4.59	100%	B/C	vegetated final cover	74	(1) 98	99
I	0.53	100%	C	runon east of OSDF	79	79	90
IR	0.60	100%	B/C	vegetated final cover	74	(1) 98	99
J	1.24	100%	C	runon east of OSDF	79	79	90
JR	2.52	100%	B/C	vegetated final cover	74	(1) 98	99
K	2.62	65% 35%	B C	runon east of OSDF runon east of OSDF	69 79	73	86
K1R	0.38	100%	C	construction support	82	82	91
K2R	0.53	65% 35%	B C	construction support construction support	74 82	77	88
L	1.78	70% 30%	B C	runon east of OSDF runon east of OSDF	69 79	72	86
M	7.23	60% 40%	B C	runon east of OSDF runon east of OSDF	69 79	73	86
N	11.66	75% 25%	B C	runon east of OSDF runon east of OSDF	69 79	72	85
O	10.94	65% 35%	B C	runon east of OSDF runon east of OSDF	69 79	73	86
Q	1.52	50% 50%	B C	runon east of OSDF runon east of OSDF	69 79	74	87
TR	0.04	100%	C	construction support	82	82	91

Note (1): The weighted curve number of the final cover system is assumed to be 98, as consistent with the *OSDF Final Design Package*, prepared by GeoSyntec Consultants for the United States Department of Engergy, Fernald Environmental Management Project, in May 1997.
Note (2): The Antecedent Moisture Condition (III) was calculated using the equation CN(III) = 23CN(II) / 10 + 0.13CN(II).

N/A - Not Applicable

ATTACHMENT C-3

TABULATED CHANNEL ANALYSIS RESULTS

2000 YEAR STORM DESIGN SCENARIO - LIGHT VEGETATION
SUMMARY OF CHANNEL ANALYSIS RESULTS

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node	HydroCAD Q[3] (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth[5] Y (ft)	Estimated Q[5] (cfs)	Channel Freeboard[4] (ft)	Peak Flow Velocity (fps)	Lining Type[6]
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.030	0	6	4	1	63.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
reach 1	existing	2000 DS	vee	8.29	0.35%	0.030	0	6	4	2	130.7	36.72	27.66	1.33	2.71	130.35	5.58	3.55	riprap
reach 2	existing	2000 DS	vee	6.57	0.64%	0.030	0	6	5	3	197.6	40.99	30.53	1.34	2.73	198.26	3.84	4.84	riprap
reach 3	new[4]	2000 DS	vee	6.26	0.75%	0.030	0	6	3	4	268.5	46.37	29.68	1.56	3.21	268.59	3.05	5.79	riprap
reach 4	new	2000 DS	vee	6.14	0.50%	0.030	0	6	4	5	314.6	62.30	36.03	1.73	3.53	315.32	2.61	5.06	riprap
reach 5	new	2000 DS	vee	5.32	0.50%	0.030	0	6	3	6	358.4	66.70	35.59	1.87	3.85	356.14	1.47	5.34	riprap
reach 6	new	2000 DS	vee	6.20	0.50%	0.030	0	6	3	7R	390.0	71.64	36.89	1.94	3.99	391.73	2.21	5.47	riprap
reach 7	new	2000 DS	vee	3.10	1.25%	0.030	0	4	3	8	54.4	11.34	13.11	0.86	1.80	57.15	1.30	0.67	grass
reach 7R	new	2000 DS	vee	5.99	1.00%	0.030	0	6	3	8R	405.0	56.71	32.82	1.73	3.55	405.67	2.44	7.15	riprap
reach 8	new	2000 DS	vee	3.01	1.00%	0.030	0	58	3	9	145.9	41.75	71.57	0.58	1.17	144.75	1.84	3.47	grass
reach 8R	new	2000 DS	vee	5.47	0.50%	0.030	0	6	2	9R	404.9	71.57	35.19	2.03	4.23	403.60	1.24	5.64	riprap
reach 9	new	2000 DS	vee	6.31	1.00%	0.030	0	60	3	11	231.0	59.12	86.54	0.68	1.37	227.74	4.94	3.85	grass
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.030	4.35	6	3	9R+K1R+IR	422.6	75.83	38.09	1.99	3.65	421.50	3.31	5.56	riprap
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.030	10.12	6	3	10AR	431.1	78.08	39.61	1.97	3.19	431.14	3.14	5.52	riprap
reach 11	new	2000 DS	vee	4.08	1.00%	0.030	0	5.7	13.5	3R	242.4	47.11	43.94	1.07	1.75	245.12	2.33	5.20	riprap

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and Construction Drawings.
3. Peak flow rates calculated by HydroCAD for each reach. See attachment C-1.
4. Calculated as the difference between minimum channel depth and peak flow depth.
5. Calculated flow rates using Manning's equation.
6. Maximum permissible velocity for grass lined channels is 5 fps.
   Maximum permissible velocity for riprap lined channels is 12 fps.

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2000 YEAR STORM DESIGN SCENARIO - MODERATE VEGETATION
SUMMARY OF CHANNEL ANALYSIS RESULTS

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node	HydroCAD Q[3] (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth[5] Y (ft)	Estimated Q[5] (cfs)	Channel Freeboard[4] (ft)	Peak Flow Velocity (fps)	Lining Type[6]
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.030	0	6	4	1	51.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
reach 1	existing	2000 DS	vee	8.29	0.35%	0.030	0	6	4	2	105.9	31.50	25.62	1.23	2.51	106.25	5.78	3.37	riprap
reach 2	existing	2000 DS	vee	6.57	0.64%	0.030	0	6	5	3	161.7	35.20	28.29	1.24	2.53	161.85	4.04	4.60	riprap
reach 3	new[4]	2000 DS	vee	6.26	0.75%	0.030	0	6	3	4	222.9	40.23	27.64	1.46	2.99	222.26	3.27	5.52	riprap
reach 4	new	2000 DS	vee	6.14	0.50%	0.030	0	6	4	5	266.1	54.78	33.78	1.62	3.31	265.59	2.83	4.85	riprap
reach 5	new	2000 DS	vee	5.32	0.50%	0.030	0	6	3	6	307.3	59.95	33.74	1.78	3.65	308.91	1.67	5.15	riprap
reach 6	new	2000 DS	vee	6.20	0.50%	0.030	0	6	3	7R	340.3	64.64	35.04	1.84	3.79	341.53	2.41	5.28	riprap
reach 7	new	2000 DS	vee	3.10	1.25%	0.030	0	4	3	8	43.4	9.53	12.02	0.79	1.65	45.32	1.45	4.76	grass
reach 7R	new	2000 DS	vee	5.99	1.00%	0.030	0	6	3	8R	355.6	51.11	31.16	1.64	3.37	353.10	2.62	6.91	riprap
reach 8	new	2000 DS	vee	3.01	1.00%	0.030	0	58	3	9	118.4	36.24	66.68	0.54	1.09	119.24	1.92	3.31	grass
reach 8R	new	2000 DS	vee	5.47	0.50%	0.030	0	6	2	9R	356.2	64.96	33.52	1.94	4.03	354.69	1.44	5.46	riprap
reach 9	new	2000 DS	vee	6.31	1.00%	0.030	0	60	3	11	190.2	52.42	81.49	0.64	1.29	193.98	5.02	3.70	grass
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.030	4.35	6	3	9R+K1R+IR	372.4	69.28	36.43	1.90	3.47	373.54	3.49	5.39	riprap
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.030	10.12	6	3	10AR	380.8	71.23	37.95	1.88	3.01	380.75	3.32	5.35	riprap
reach 11	new	2000 DS	vee	4.08	1.00%	0.030	0	5.7	13.5	3R	200.1	78.98	217.05	0.36	0.37	199.86	3.71	2.53	grass

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and Construction Drawings.
3. Peak flow rates calculated by HydroCAD for each reach. See attachment C-1.
4. Calculated as the difference between minimum channel depth and peak flow depth.
5. Calculated flow rates using Manning's equation.
6. Maximum permissible velocity for grass lined channels is 5 fps.
   Maximum permissible velocity for riprap lined channels is 12 fps.

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2000 YEAR STORM DESIGN SCENARIO - HEAVY VEGETATION
SUMMARY OF CHANNEL ANALYSIS RESULTS

Channel Identification			Channel Characteristics							Hydrologic Calculations		Hydraulic Calculations							
Channel Name[1]	Status	Design Scenario	Section Shape	Minimum Channel Depth (ft)	Longitudinal Slope[2] (%)	Manning n	Bottom Width B (ft)	Side Slope M_1:1	Side Slope M_2:1	HydroCAD Node	HydroCAD Q[3] (cfs)	Area of Flow A (sq ft)	Perimeter P (ft)	Hydraulic Radius, R (ft)	Peak Flow Depth[5] Y (ft)	Estimated Q[5] (cfs)	Channel Freeboard[4] (ft)	Peak Flow Velocity (fps)	Lining Type[6]
subcatchment B	existing	2000 DS	vee	11.90	0.35%	0.070	0	6	4	1	52.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
reach 1	existing	2000 DS	vee	8.29	0.35%	0.070	0	6	4	2	104.4	58.8	35.01	1.68	3.43	104.72	4.86	1.78	riprap
reach 2	existing	2000 DS	vee	6.57	0.64%	0.070	0	6	5	3	155.4	64.71	38.35	1.69	3.43	156.18	3.14	2.41	riprap
reach 3	new[4]	2000 DS	vee	6.26	0.75%	0.070	0	6	3	4	206.2	71.64	36.89	1.94	3.99	205.62	2.27	2.87	riprap
reach 4	new	2000 DS	vee	6.14	0.50%	0.070	0	6	4	5	236.6	94.61	44.40	2.13	4.35	235.89	1.79	2.49	riprap
reach 5	new	2000 DS	vee	5.32	0.50%	0.070	0	6	3	6	262.6	99.83	43.54	2.29	4.71	261.31	0.61	2.62	riprap
reach 6	new	2000 DS	vee	6.20	0.50%	0.070	0	6	3	7R	279.1	104.98	44.65	2.35	4.83	279.45	1.37	2.66	riprap
reach 7	new	2000 DS	vee	3.10	1.25%	0.070	0	4	3	8	41.8	16.94	16.03	1.06	2.20	41.83	0.90	2.47	grass
reach 7R	new	2000 DS	vee	5.99	1.00%	0.070	0	6	3	8R	286.2	82.05	39.48	2.08	4.27	284.50	1.72	3.47	riprap
reach 8	new	2000 DS	vee	3.01	1.00%	0.070	0	58	3	9	110.4	64.13	88.70	0.72	1.45	109.94	1.56	1.71	grass
reach 8R	new	2000 DS	vee	5.47	0.50%	0.070	0	6	2	9R	286.2	104.45	42.51	2.46	4.86	286.34	0.61	2.75	riprap
reach 9	new	2000 DS	vee	6.31	1.00%	0.070	0	60	3	11	171.7	89.97	106.76	0.84	1.69	170.84	4.62	1.90	grass
reach 9R	new	2000 DS	trapezoidal	6.96	0.50%	0.070	4.35	6	3	9R+K1R+IR	302.4	111.15	46.05	2.41	4.51	301.13	2.45	2.71	riprap
reach 10AR	new	2000 DS	trapezoidal	6.33	0.50%	0.070	10.12	6	3	10AR	299.5	112.02	47.01	2.38	3.99	300.89	2.34	2.69	riprap
reach 11	new	2000 DS	vee	4.08	1.00%	0.070	0	5.7	13.5	3R	180.1	70.31	53.21	1.32	2.23	180.21	1.85	2.56	grass

2000 DS = 2000 Year Storm Design Scenario

Notes:
1. Channels are named after the corresponding subcatchment or reach.
2. Longitudinal slopes taken from existing topographic information and Construction Drawings.
3. Peak flow rates calculated by HydroCAD for each reach. See attachment C-1.
4. Calculated as the difference between minimum channel depth and peak flow depth.
5. Calculated flow rates using Manning's equation.
6. Maximum permissible velocity for grass lined channels is 5 fps.
   Maximum permissible velocity for riprap lined channels is 12 fps.

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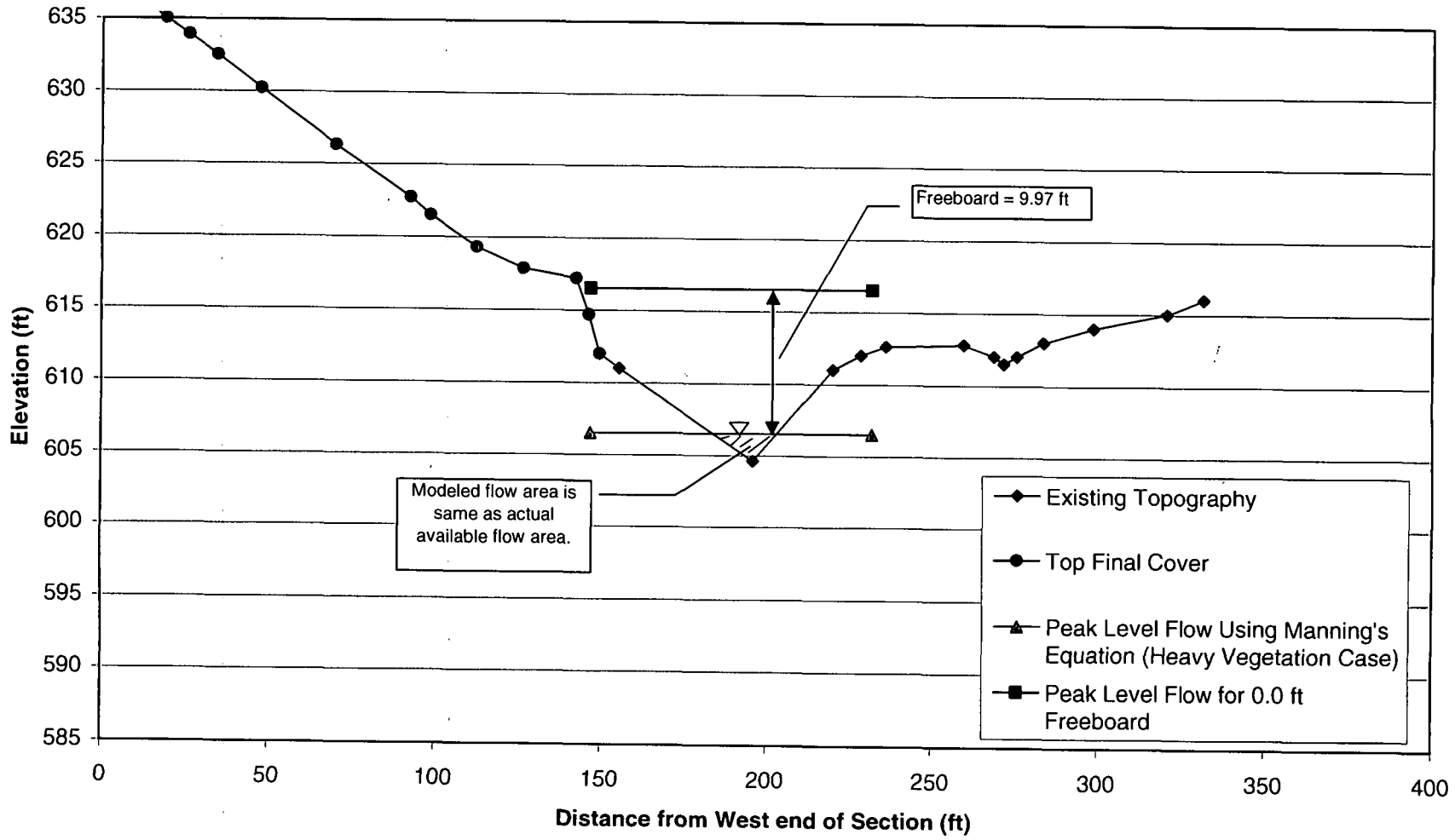
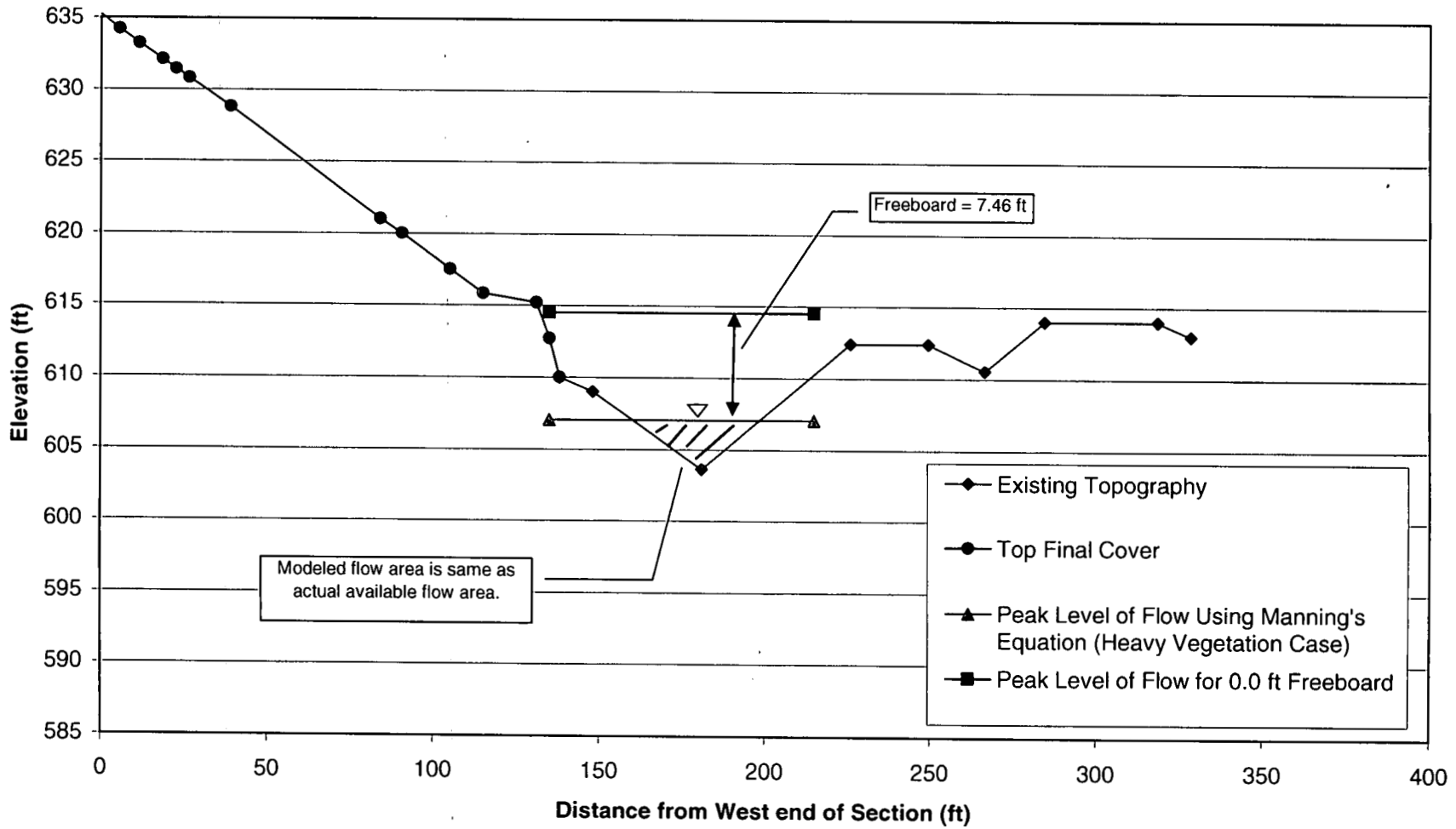
ATTACHMENT C-4

GRAPHICAL CHANNEL ANALYSIS RESULTS

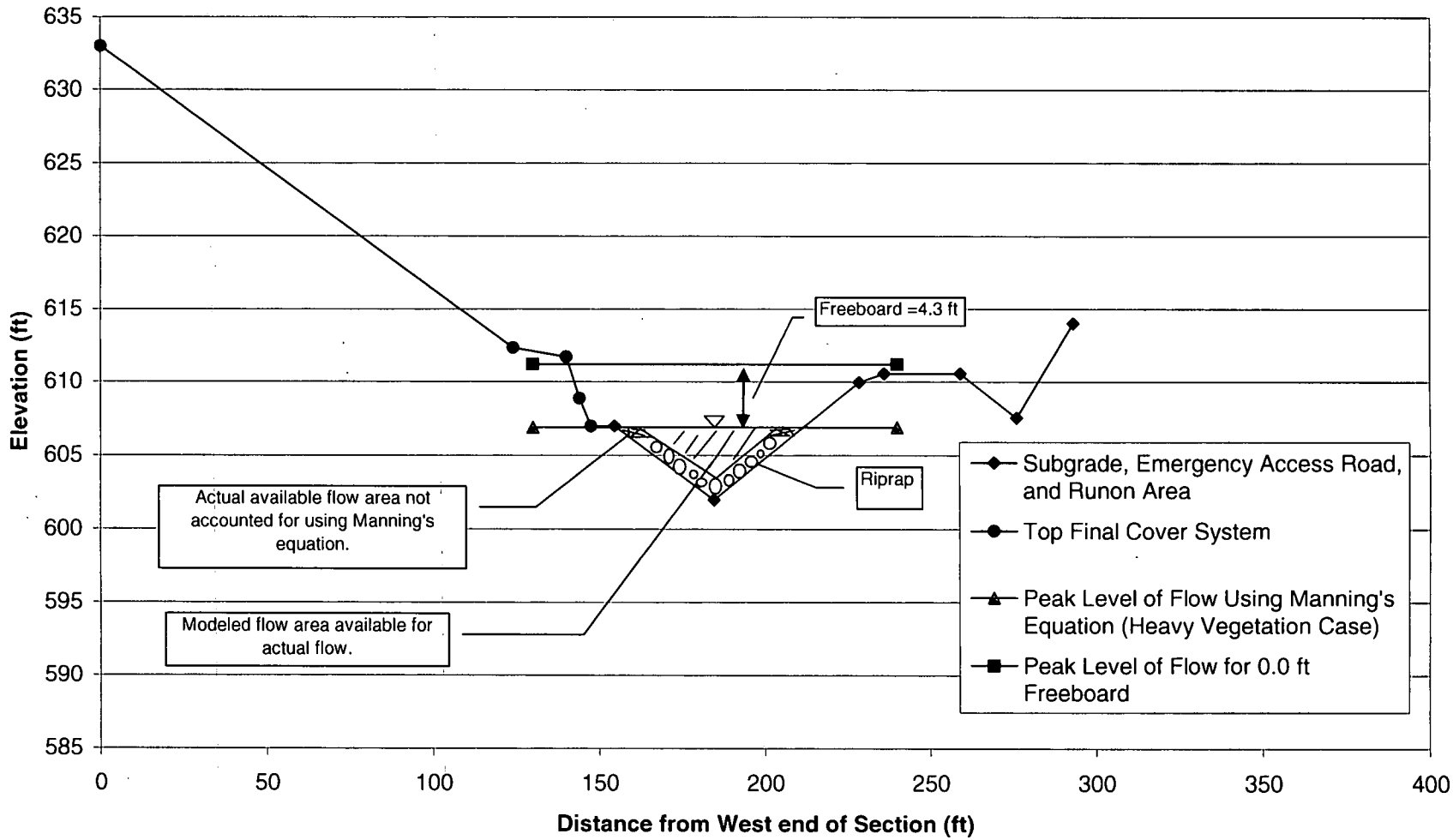
Analysis Cross-Section for Channel Segment Along Cell 1 (subcatchment B)
Coordinates for West End of Section: N 482904 E 1351478
Maximum Peak Flow Rate for Cell: Q = 52.4 cfs



Analysis Cross-Section for Channel Segment Along Cell 2 (corresponds with Reach 1)
Coordinates for West End of Section: N 482693 E 1351484
Maximum Peak Flow Rate for Cell: Q = 104.4 cfs



Analysis Cross-Section for Channel Segment Along Cell 3 (corresponds with Reach 2)
Coordinates for West End of Section: N 482231 E 1351470
Maximum Peak Flow Rate for Cell: Q = 155.4 cfs



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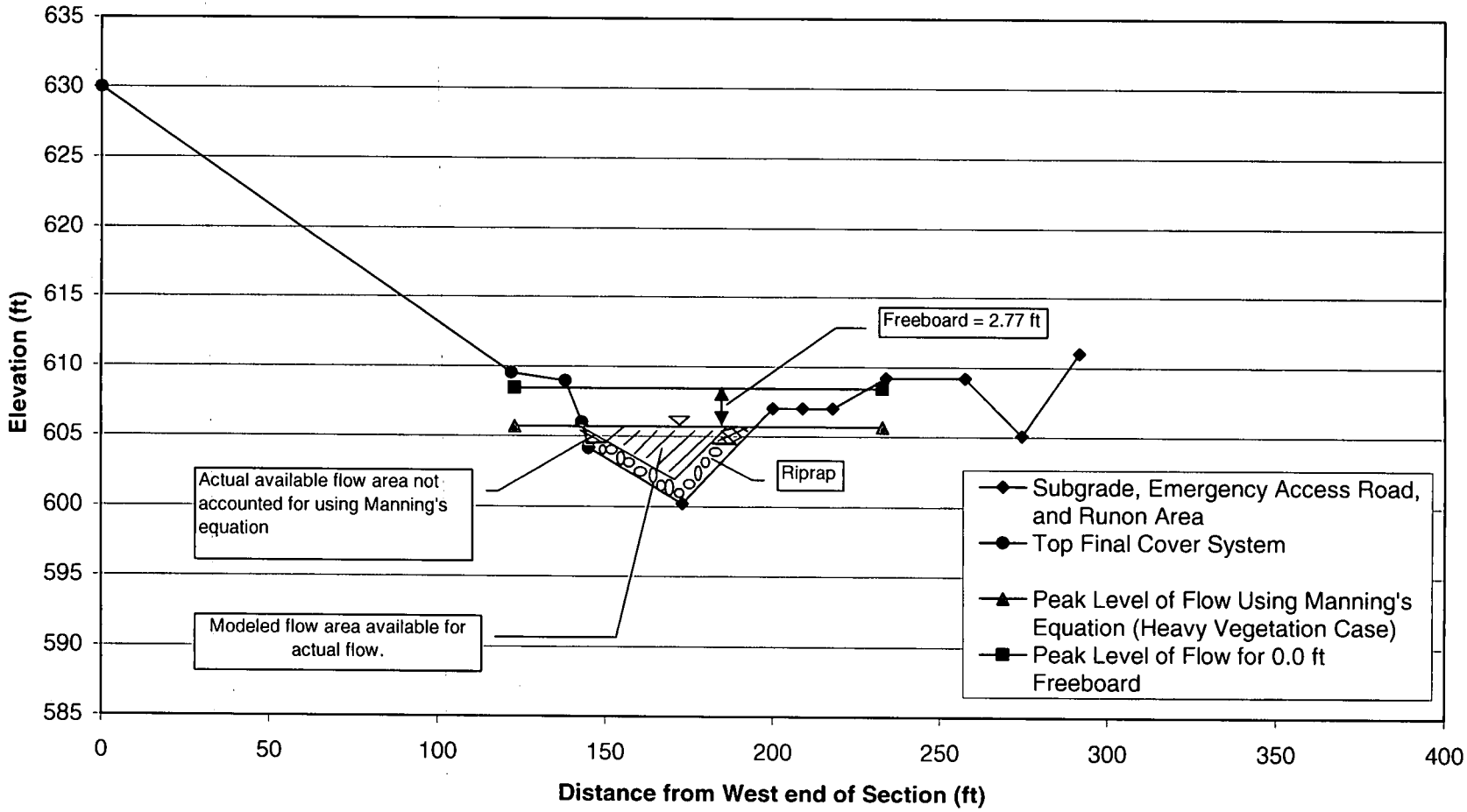
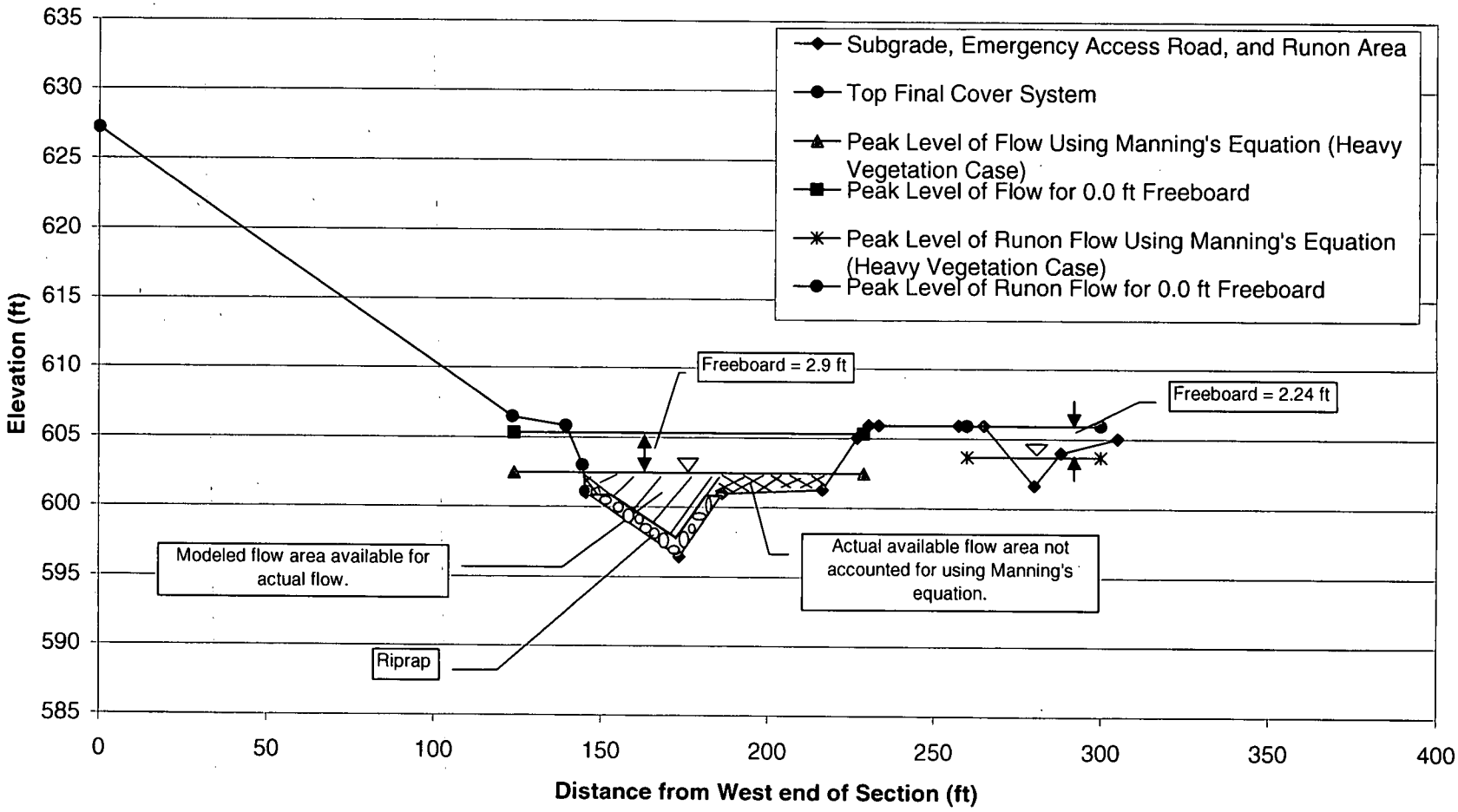
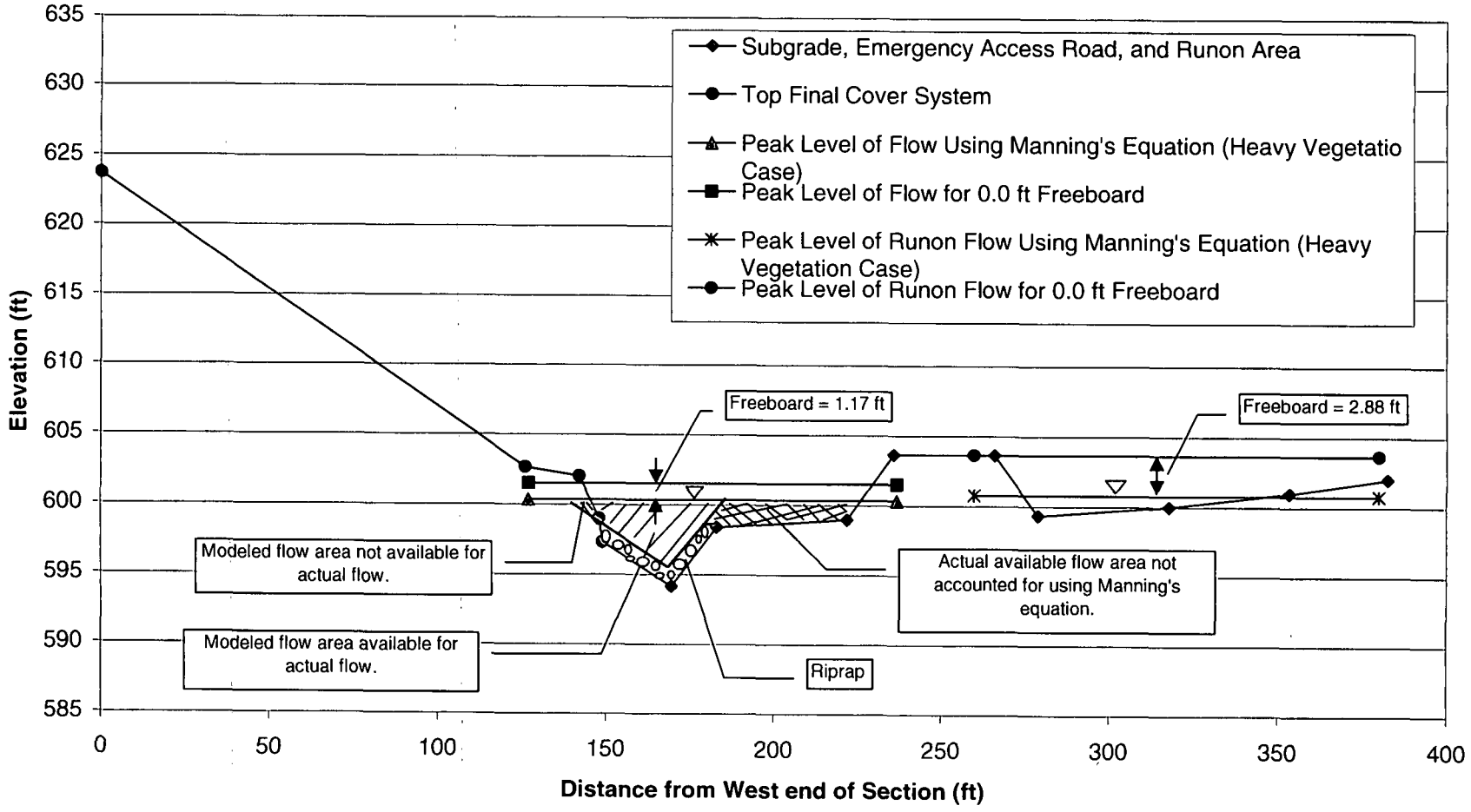
Analysis Cross-Section for Channel Segment Along Cell 4 (corresponds with Reach 3)
Coordinates for West End of Section: N 481859 E 1351467
Maximum Peak Flow Rate for Cell: Q = 206.2 cfs



Analysis Cross-Section for Channel Segment Along Cell 5 (corresponds with Reach 4)
Coordinates for West End of Section: N 481450 E 1351461
Maximum Peak Flow Rate for Cell: Q = 236.6 cfs



Analysis Cross-Section for Channel Segment Along Cell 6 (corresponds with Reach 5)
Coordinates for West End of Section: N 480941 E 1351453
Maximum Peak Flow Rate for Cell: Q = 262.6 cfs



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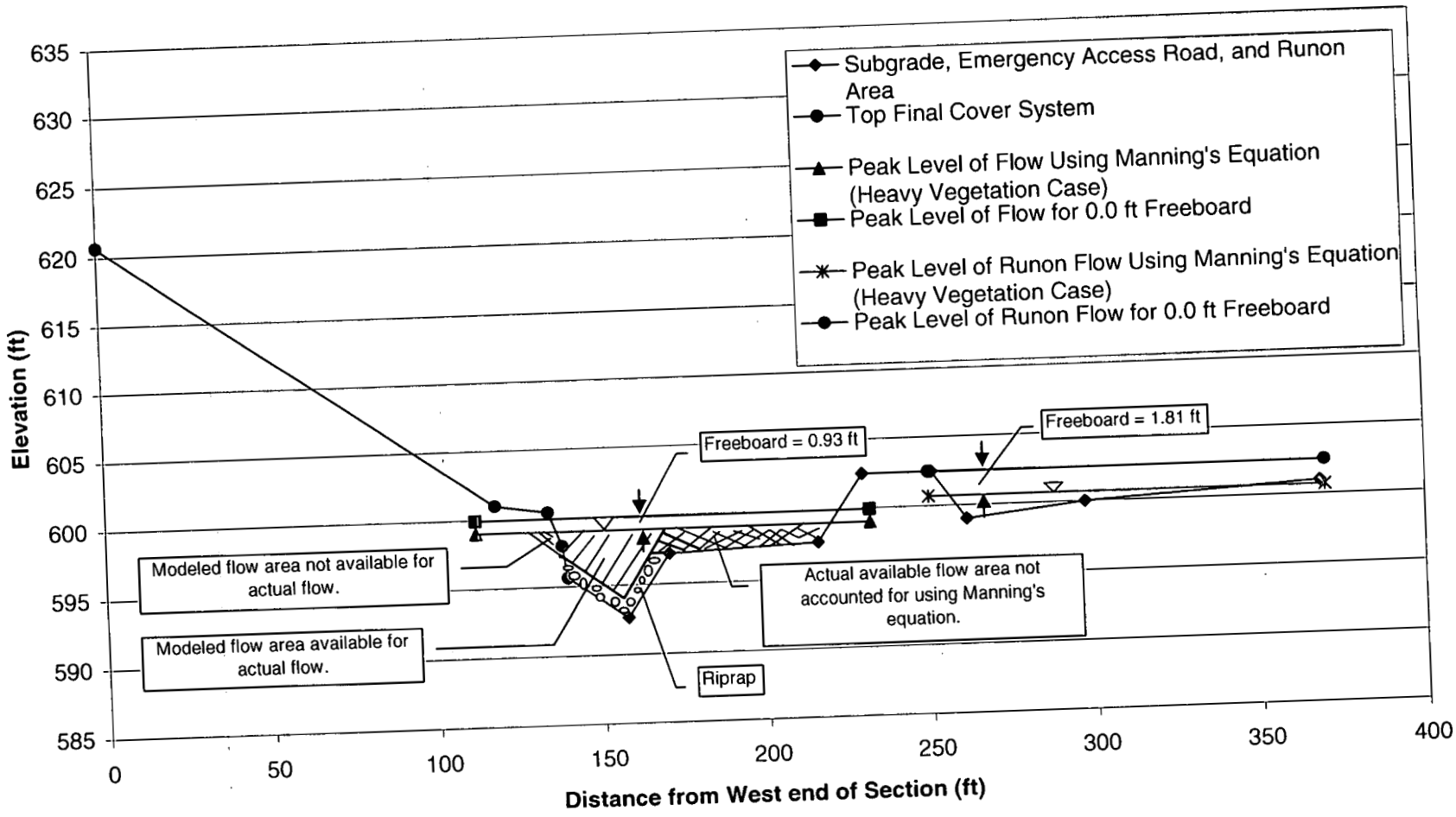
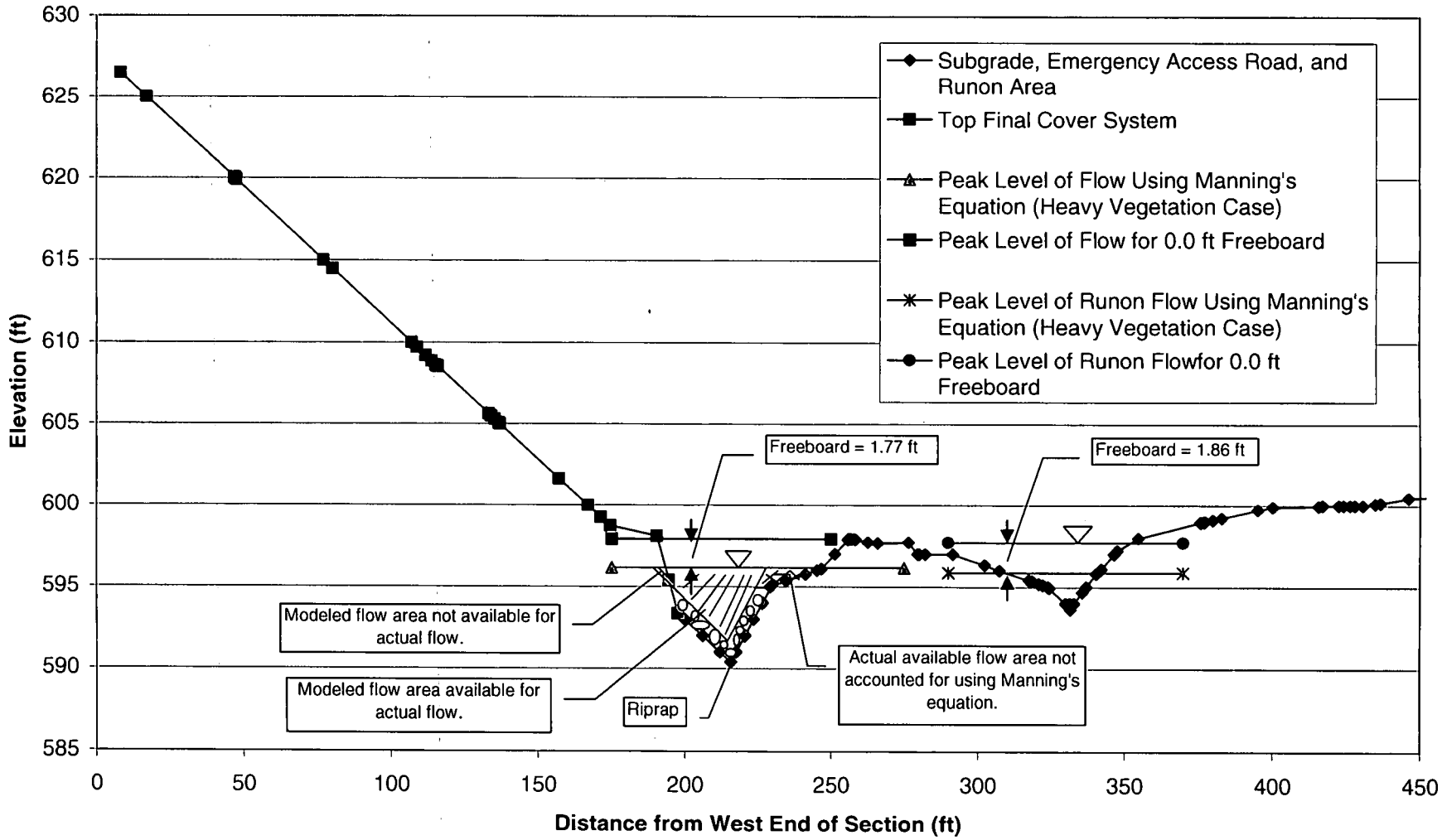
Analysis Cross-Section for Channel Segment Along Cell 7 (corresponds with Reach 6)
Coordinates for West End of Section: N 480696 E 1351458
Maximum Peak Flow Rate for Cell: Q = 279.1 cfs



Analysis Cross-Section for Channel Segment Along Cell 8 (corresponds with Reach 7R)
Coordinates for West End of Section: N 480250 E 1351396
Maximum Peak Flow Rate for Cell: Q = 286.2 cfs



13.4 SEDIMENTATION EVALUATION OF PERMANENT DRAINAGE CHANNELS FOR HIGH-FREQUENCY DESIGN STORMS

COMPUTATION COVER SHEET

SUBJECT OF COMPUTATIONS SEDIMENTATION EVALUATION OF PERMANENT DRAINAGE CHANNELS FOR HIGH-FREQUENCY DESIGN STORMS

Computations By:
(Cognizant Engineer)

Signature: Victoria S. Cheplak — Date: 1-22-04
Printed Name and Title: Victoria S. Cheplak, Senior Staff Engineer

Assumptions and Procedures Checked By:
(Checker)

Signature: [signature] — Date: 1-22-04
Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Computations Checked by:

Signature: Hollie Kinnecom — Date: 1-22-04
Printed Name and Title: Hollie Kinnecom, Staff Engineer

Computations Backchecked by:
(Cognizant Engineer)

Signature: Victoria S. Cheplak — Date: 1-22-04
Printed Name and Title: Victoria S. Cheplak, Senior Staff Engineer

Approved by:
(PDP)

Signature: [signature] — Date: 1-22-04
Printed Name and Title: Ganesh Gopalakrishnan, Senior Engineer

Approved by:
(DTL/TETL)

Signature: Rudolph Bonaparte — Date: 1/22/04
Printed Name and Title: R. Bonaparte, Engineer of Record

Record of Revision (Number and initial all revisions)

Rev. No.	Reason	Date	By	Checked	Approval
0	Submittal to FF/DOE/EPA	29 Jan 02	GG	DGP	DGP/JFB
1	CFC Revision 1 Submittal to FF/DOE/EPA	23 Jan 04	VSC VSC	GG	RB

Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

SEDIMENTATION EVALUATION OF PERMANENT DRAINAGE CHANNELS FOR HIGH-FREQUENCY STORM EVENTS

PURPOSE

The purpose of this package is to present an evaluation of the capacity of permanent channels associated with the Fernald On-Site Disposal Facility (OSDF) to resist accumulation of eroded sediments during high-frequency storm events (i.e., a low flow scenario). The 2-year 24-hour design storm event is considered for this evaluation. The hydrologic analysis results necessary to establish flows for the 2-year 24-hour design storm event were obtained from the calculation package titled "Phase V Surface-Water Management System Design and Post-Closure Hydrology".

APPROACH

The approach adopted in this package is to calculate a "maximum particle-size" corresponding to flow characteristics (i.e., velocity or tractive stress) in each drainage channel that will not be stable in the bed of the drainage channel. This implies that all sediment particle sizes smaller than the calculated maximum particle-size will be subject to movement (hereinafter referred to as "incipient motion") in the direction of flow for the conditions analyzed. The calculated maximum particle-size is compared to a site-specific envelope of laboratory particle-size distribution, which represents the range of particle sizes comprising surficial soils along permanent channel alignments and within the OSDF borrow area. For the purpose of this evaluation, permanent drainage channels are considered to be drainage channels within and south of the OSDF area expected to be in place at the end of Phase V construction.

METHODOLOGY

Three methods are used to evaluate the maximum particle-size expected to be subject to incipient motion under flow conditions considered for each drainage channel. Two methods correlate the flow velocity in the channel to a maximum particle-size (that is subject to incipient motion), and one method correlates the tractive stress in the channel to a maximum particle-size.

- **Method 1: Shield's Method [Vanoni, 1977].** The Shield's method provides a correlation between the shear stress in the channel and a maximum particle diameter subject to incipient motion. The Shield's Diagram used with this method is provided in Figure 1. As shown in Figure 1, the shear stress is expressed in terms of a dimensionless shear stress; and the particle diameter is expressed in terms of the Reynolds Number for flow at the boundary of the particle. For computational purposes, Shield's Diagram may be represented using the equation [USACE, 1995] provided in Figure 2. Figure 2 also provides a graph for this equation relating particle diameter directly to the dimensionless shear (also called the Shield's Parameter). For calculations performed herein, the equation provided in Figure 2 is solved to obtain a maximum particle diameter, which will be subject to incipient motion due to the calculated tractive stress in the drainage channel.

- **Method 2: Hjulstrom's Curve [Hjulstrom, 1935].** This method relates the mean velocity in the channel and the particle diameter to one of three phases: erosion; sedimentation; and transportation. Figure 3 provides Hjulstrom's Curve. A straight line boundary is provided between transportation and sedimentation phases. For calculations performed herein, an equation for this straight line is used to obtain a maximum particle diameter which will be subject to transportation (considered for the purposes of this calculation to correspond to incipient motion) due to the calculated velocity in the drainage channel.

- **Method 3: Mavis & Laushey Relationship [Vanoni, 1977].** Similar to Method 2 described above, this method provides a straight line boundary between transportation and sedimentation phases by relating the mean velocity in the channel and the particle diameter. Figure 4 provides this relationship. Similarly to Method 2, an equation for this straight line is used to obtain a maximum particle diameter which will be subject to incipient motion due to the calculated velocity in the drainage channel.

CALCULATIONS

- **Critical Particle Diameter.** Table 1 presents calculations for critical (i.e., maximum) particle diameter based on Methods 1, 2, and 3 described above.

- **Particle Size Distribution Curve.** An envelope of particle-size distribution for surficial soil samples collected and tested as part of the 1996 Test Pad Program is presented in Figure 5. This envelope presents the range of particles that are expected to be present along permanent drainage channels. The envelope was developed from particle-size distribution curves presented in the report "On-Site Disposal Facility Test Pad Program Final Report" [GeoSyntec, 1997]. These particle-size distribution curves are presented as Figure 6. Test samples are identified in the report as upper horizon brown till which comprises the surficial soil layer for the OSDF and borrow areas. A statistical comparison of particle-size diameters from the testing of 42 upper horizon brown till samples (obtained from locations distributed across the OSDF and borrow areas) and the Figure 5 envelope shows a consistency between the two sets of data.

RESULTS AND CONCLUSIONS

Calculation results presented on Table 1 show maximum particle sizes from the three methods to range from 3.6 mm to greater than 60 mm. The minimum of the calculated maximum particle sizes for each method ranges from 3.6 mm to 4.32 mm. This range is shown plotted against the site-specific envelope of laboratory particle-size distribution on Figure 5. The minimum of this range (i.e., 3.6 mm) corresponds to 91% finer by weight on the minimum curve (See Figure 5). Based on this comparison, approximately 90% of the soil particles that form the bed of permanent drainage channels are expected to be resistant to significant sedimentation from the high-frequency storm event considered.

Based on the results presented above, permanent drainage channels are expected to exhibit a low potential for sedimentation after closure of the OSDF.

REFERENCES

GeoSyntec Consultants, "*On-Site Disposal Facility Test Pad Program Final Report*", Volumes I to III, Fernald Environmental Management Project. DOE Fernald Area Office, Fernald, Ohio, 1997.

Hjulstrom, F., *The Morphological Activity of Rivers as Illustrated by River Fyris,* Bulletin of the Geological Institute, Uppasala, Vol. 25, Chapter 3., 1995.

USACE, *Sedimentation Investigation of Rivers and Reservoirs, Chapter 7: Sediment Transport Mechanics,* U.S. Army Corps of Engineers, Engineering Manual EM1110-2-4000, Washington D.C., 1975.

Vanoni, V.A., *Sedimentation Engineering*, ASCE Task Committee for the preparation of the Manual on Sedimentation of the Sedimentation Committee of the Hydraulics Division, 1975 (Reprinted 1977).

Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

FIGURE 1

SHIELD'S DIAGRAM

Written by: GG Date: 01/12/18 (YY/MM/DD) Reviewed by: DCP Date: 02/01/25 (YY/MM/DD)

Client: FERNALD Project: OSDF PHASE V Project/Proposal No.: GQ1342 Task No.: 17.4

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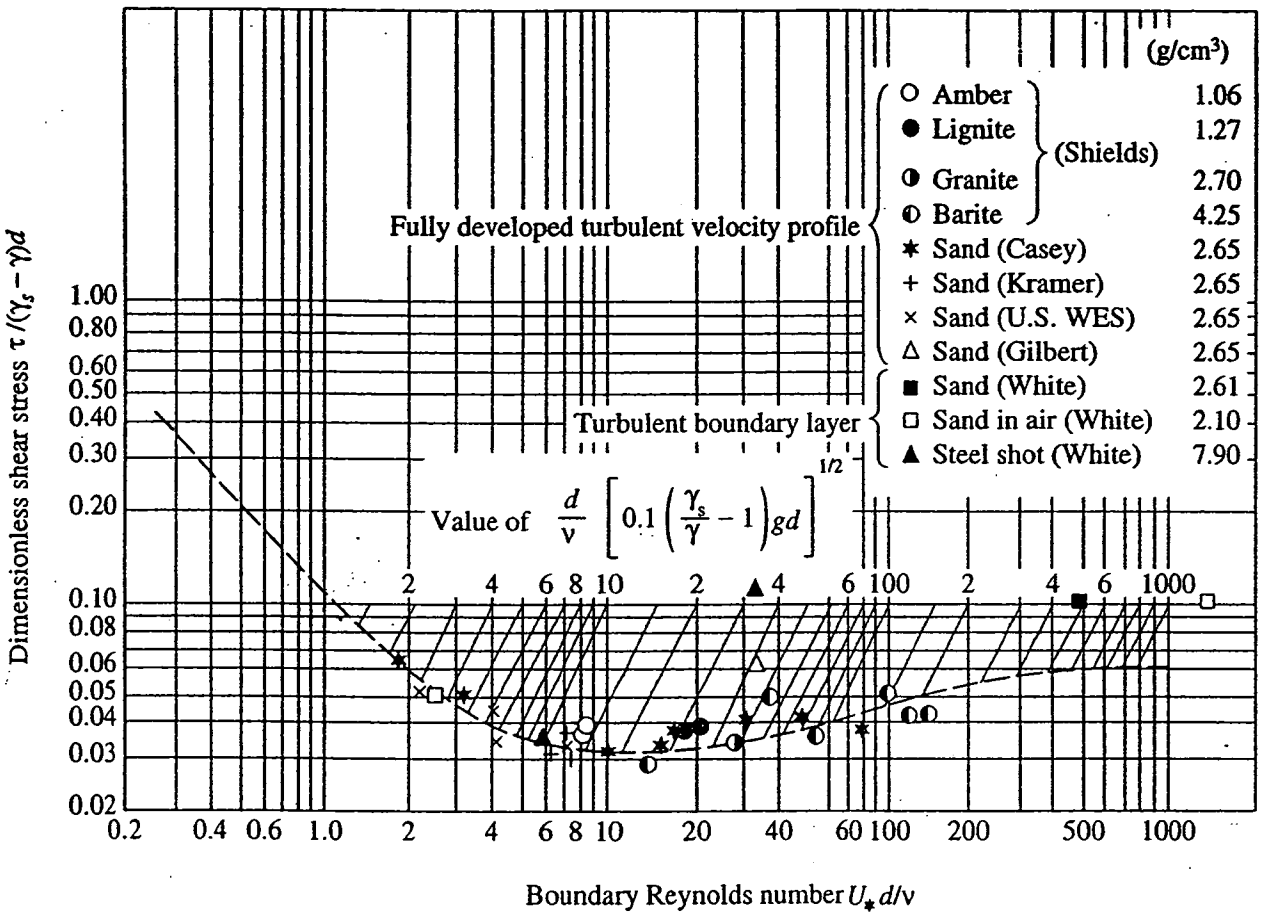


SHIELD'S DIAGRAM

Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

FIGURE 2

SHIELD'S DIAGRAM – COMPUTATIONAL METHOD

$$\tau* = 0.22\,\beta + 0.06 \times 10^{-7.7\beta}$$

$$\beta = \left(\frac{1}{\nu} \sqrt{\left(\frac{\gamma_s - \gamma}{\gamma} \right) g d^3} \right)^{0.6}$$

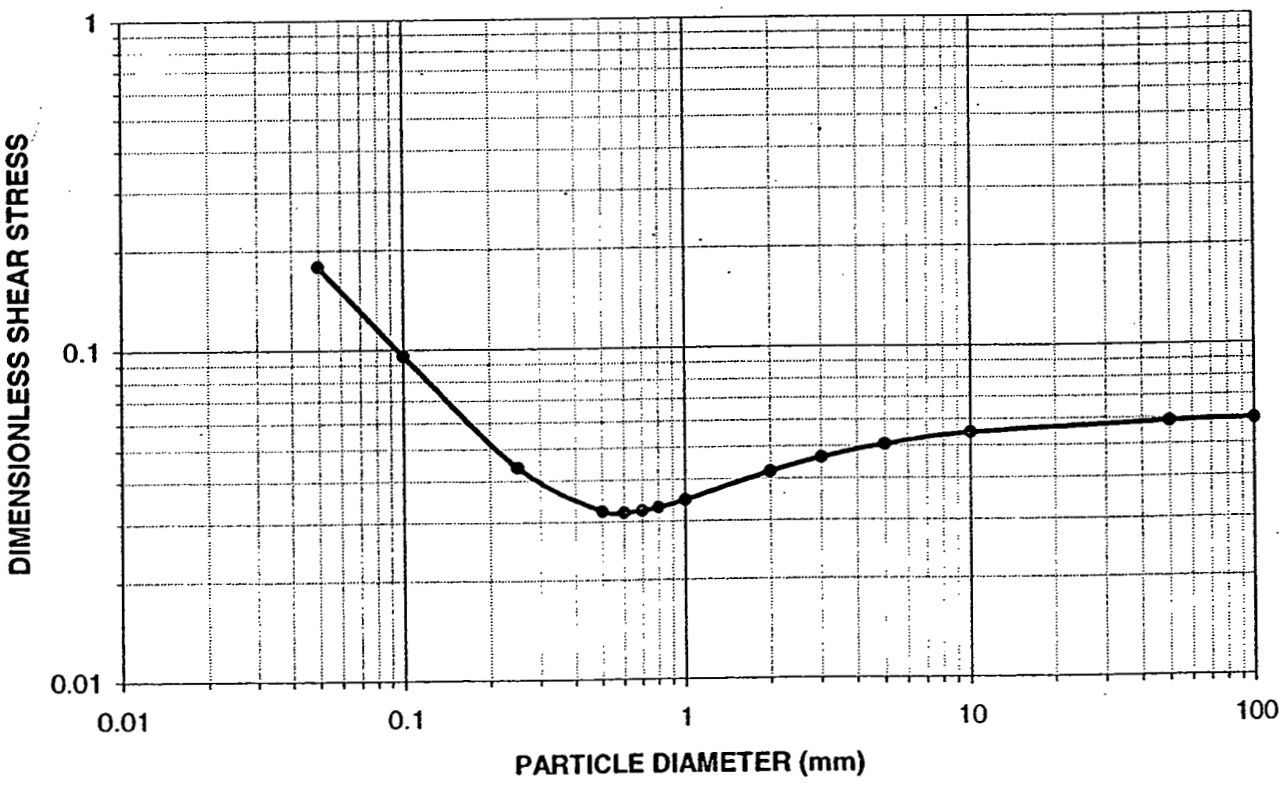
γ_s = particle specific weight

γ = fluid specific weight

ν = kinematic viscosity of the fluid

g = acceleration of gravity

d = particle diameter



Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

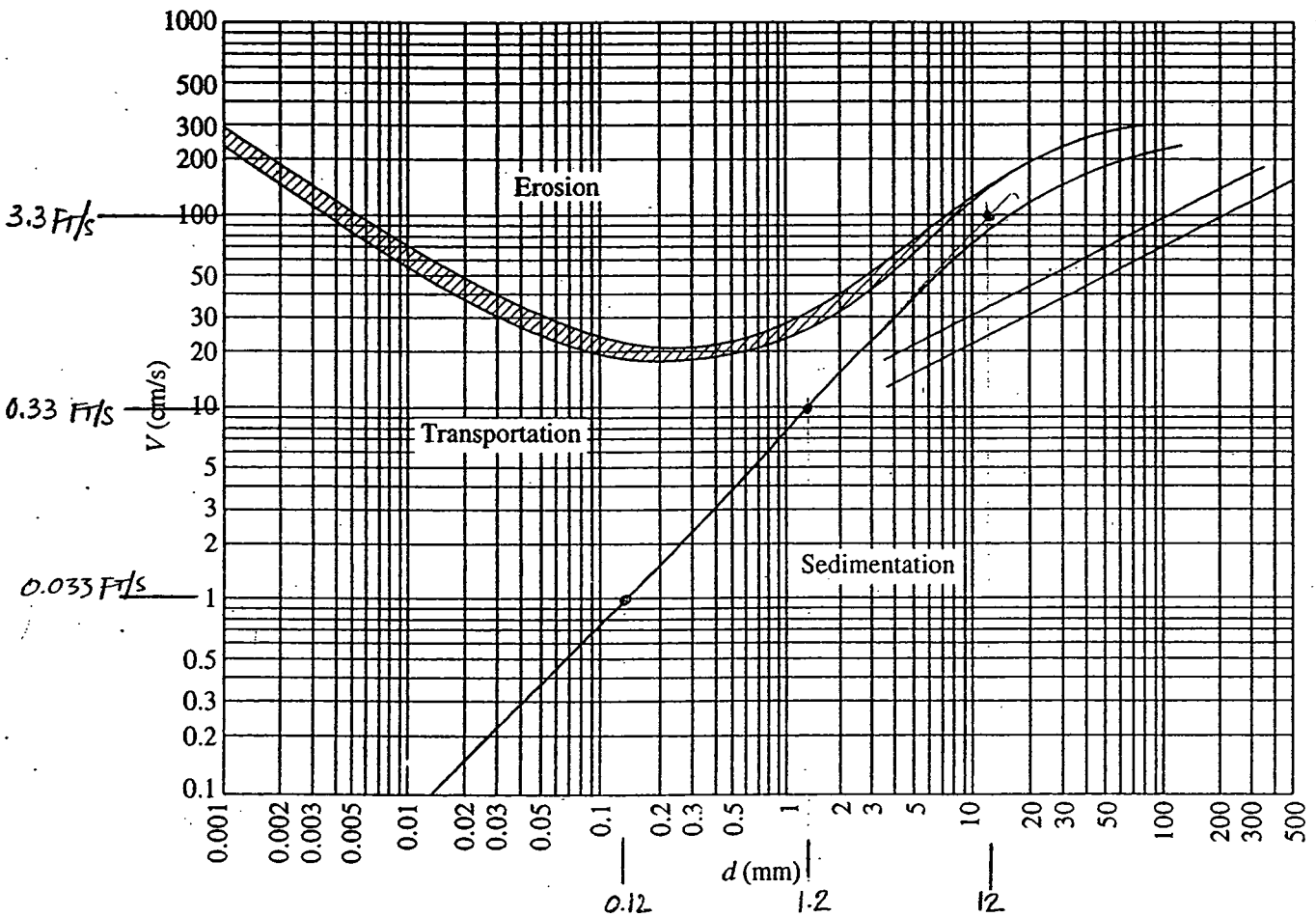
FIGURE 3

HJULSTROM'S CURVE

Written by: GG Date: 01/12/18 (YY/MM/DD) Reviewed by: DCP Date: 02/01/25 (YY/MM/DD)

Client: FERNALD Project: OSDF PHASE V Project/Proposal No.: GQ1342 Task No.: 17.4

5316



HJULSTROM'S CURVE

Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

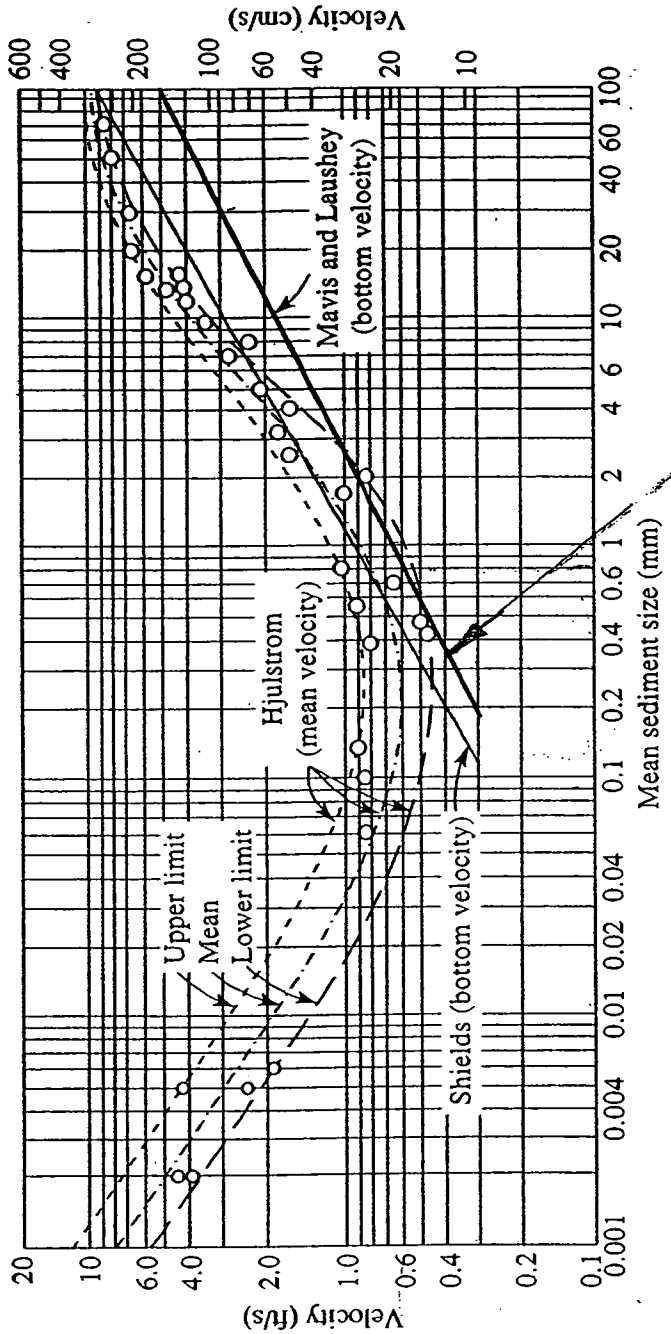
FIGURE 4

MAVIS & LAUSHEY RELATIONSHIP

Written by: GG Date: 01/12/18 (YY/MM/DD) Reviewed by: DCP Date: 02/01/25 (YY/MM/DD)

Client: FERNALD Project: DSDF PHASE V Project/Proposal No.: GC01342 Task No.: 17.X4

5316



MAVIS-LAUSHEY RELATIONSHIP

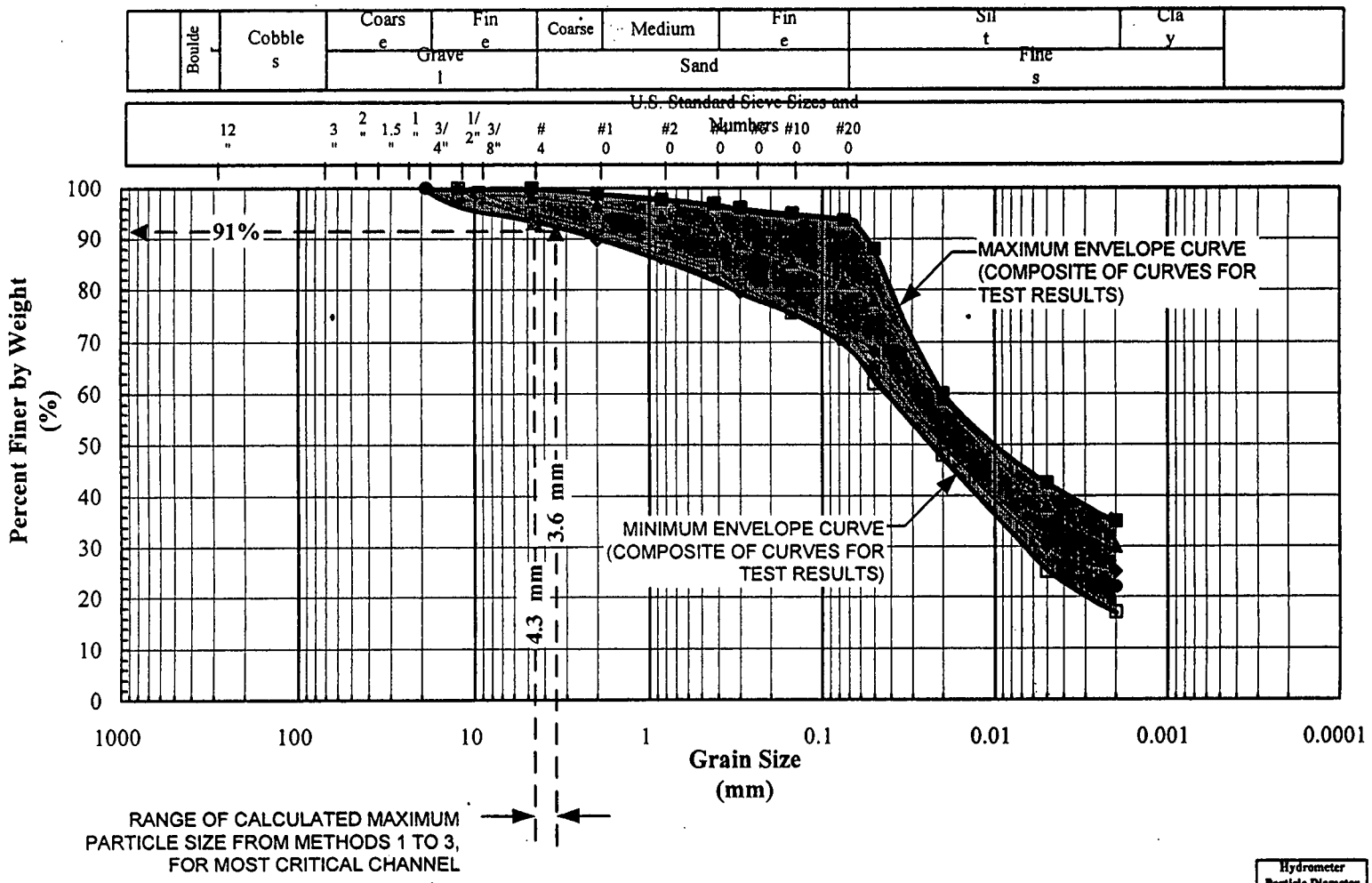
Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

FIGURE 5

SITE-SPECIFIC ENVELOPE OF PARTICLE-SIZE DISTRIBUTION

SITE-SPECIFIC ENVELOPE OF PARTICLE SIZE DISTRIBUTION



Hydrometer Particle Diameter (mm)
0.050
0.020
0.005
0.002
0.001

Sieve No.	Size (mm)
2"	50
1.5"	37.5
1"	25
3/4"	19
1/2"	12.5
3/8"	9.5
#4	4.75
#8	2.36
#10	2.00
#20	0.850
#40	0.425
#50	0.300
#60	0.250
#100	0.150
#200	0.075

NOTE: Grain Size Distribution Curves Obtained from "Test Pad Program Final Report" for 5 Upper Horizon Brown Till Samples.

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ATLANTA, GEORGIA

FIGURE NO. 5
PROJECT NO. GQ1342-17.2
DOCUMENT NO.
FILE NO.

000625

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Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

FIGURE 6

PARTICLE-SIZE DISTRIBUTION FOR UPPER HORIZON BROWN TILL

GEOSYNTEC CONSULTANTS

FERNALD ON-SITE DISPOSAL FACILITY

PARTICLE SIZE DISTRIBUTION AND SOIL CLASSIFICATION TEST RESULTS

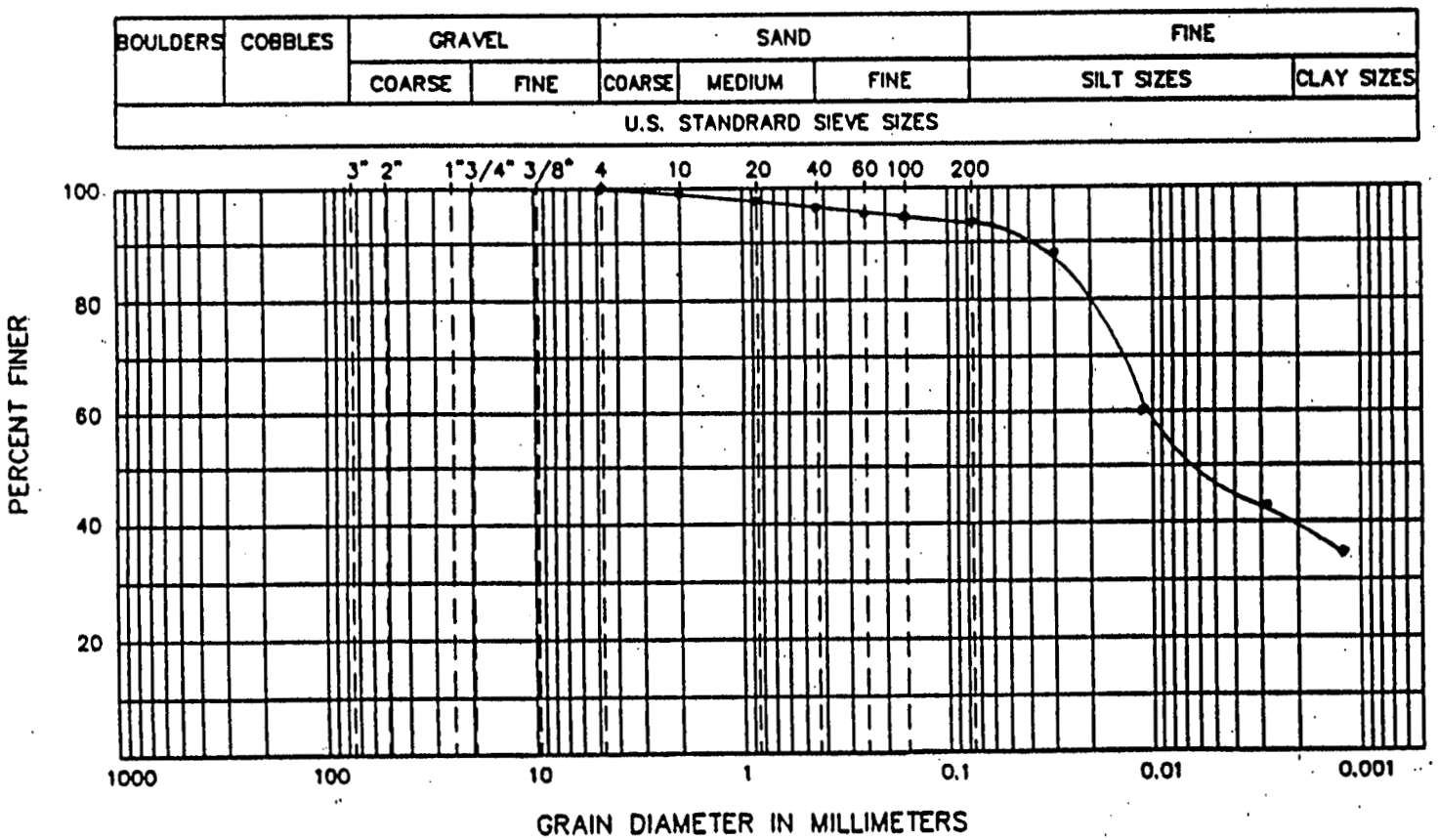
(ASTM D 422 & ASTM D 2487)

PROJECT: FERNALD ON-SITE DISPOSAL FACILITY

LOCATION: FERNALD, OHIO — PROJECT NO.: GE3900 TASK NO.: 5.3

DESCRIPTION: TEST PAD CONST. — DATE: 11 day JUNE month 1996 year

SOURCE: ON-SITE BORROW — MATERIAL TYPE: UPPER HOR. BR. TILL — SAMPLE NO.: UH-01 — QA ID: NM



CURVE COEFFICIENTS

(C_u) —

(C_c) —

ATTERBERG LIMITS

(LL) 55

(PL) 22

(PI) 33

SIEVE RESULTS

SIEVE SIZE	% FINER
3-in.	
2-in.	
1 1/2-in.	
1-in.	
3/4-in.	
1/2-in.	
3/8-in.	
NO. 4	100
NO. 10	98.9
NO. 20	97.7
NO. 40	96.9
NO. 60	96.1
NO. 100	95.0
NO. 200	93.6

SOIL CLASSIFICATION (ASTM D 2487): BROWN — FAT CLAY (CH)

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SHEET NO. 3 OF 3

000627

5316

16/22

GEOSYNTEC CONSULTANTS

FERMCO Restoration Management Corporation

FERNALD ON-SITE DISPOSAL FACILITY

PARTICLE SIZE DISTRIBUTION AND SOIL CLASSIFICATION TEST RESULTS

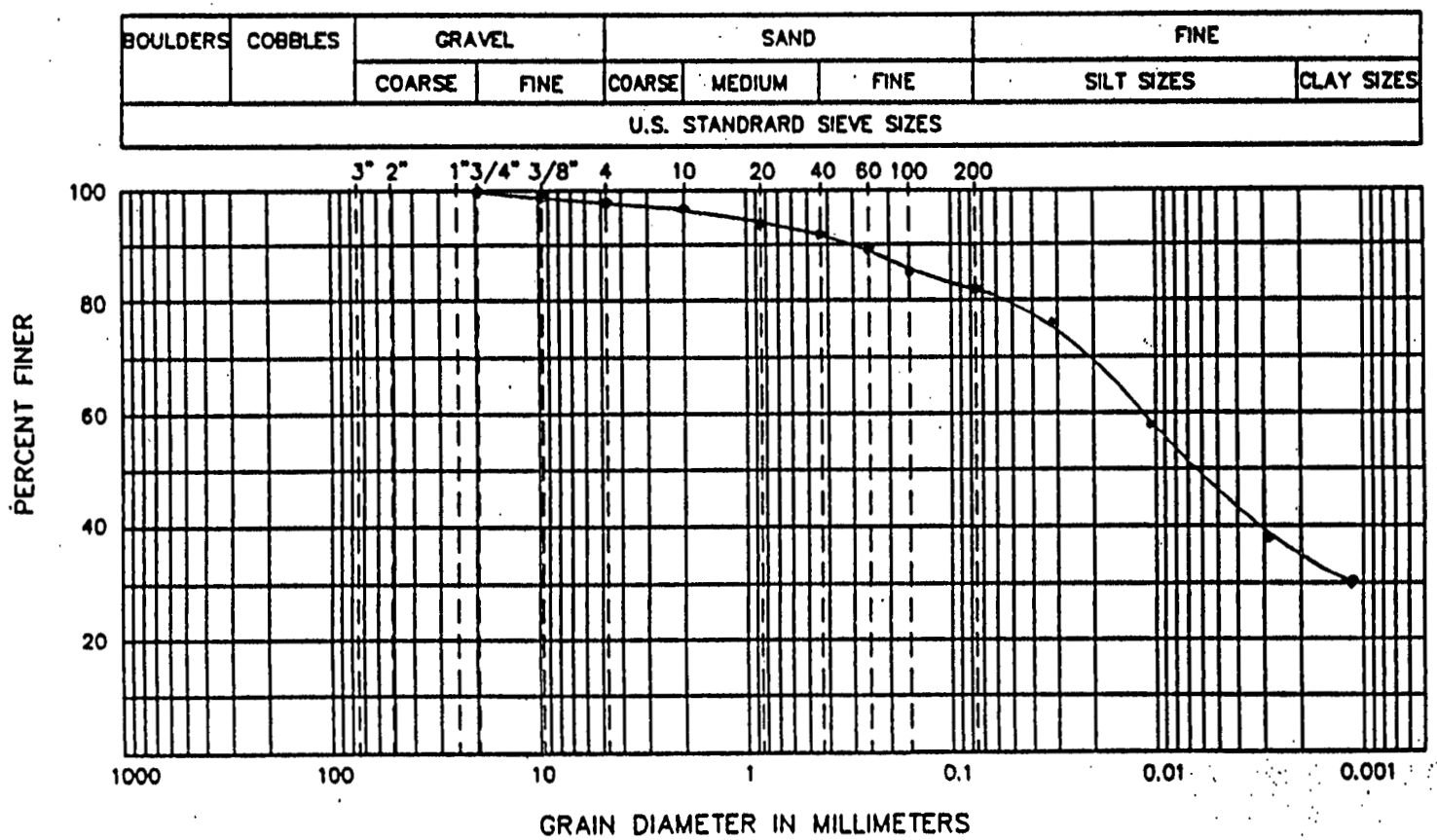
(ASTM D 422 & ASTM. D 2487)

PROJECT: FERNALD ON-SITE DISPOSAL FACILITY

LOCATION: FERNALD, OHIO — PROJECT NO.: GE 3900 TASK NO.: 5.3

DESCRIPTION: TEST PAD CONSTRUCTION — DATE: 19 day JUNE month 1996 year

SOURCE: ON-SITE BORROW 1'-2' MATERIAL TYPE: UPPER HORIZON BR. TILL — SAMPLE NO.: UH-04 QA ID: NM



CURVE COEFFICIENTS

(C_u) —

(C_c) —

ATTERBERG LIMITS

(LL) 49

(PL) 22

(PI) 27

SIEVE RESULTS

SIEVE SIZE	% FINER
3-in.	
2-in.	
1 1/2-in.	
1-in.	
3/4-in.	
1/2-in.	100
3/8-in.	98.7
NO. 4	98.2
NO. 10	96.6
NO. 20	94.3
NO. 40	91.8
NO. 60	89.1
NO. 100	85.4
NO. 200	81.5

SOIL CLASSIFICATION (ASTM D 2487): BROWN & GRAY - LEAN CLAY (CL) W/ SOME SAND & TR. of GVL

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SHEET NO. 3 OF 3

5316

000628

171 22

GEOSYNTEC CONSULTANTS

FERNALD ON-SITE DISPOSAL FACILITY

PARTICLE SIZE DISTRIBUTION AND SOIL CLASSIFICATION TEST RESULTS

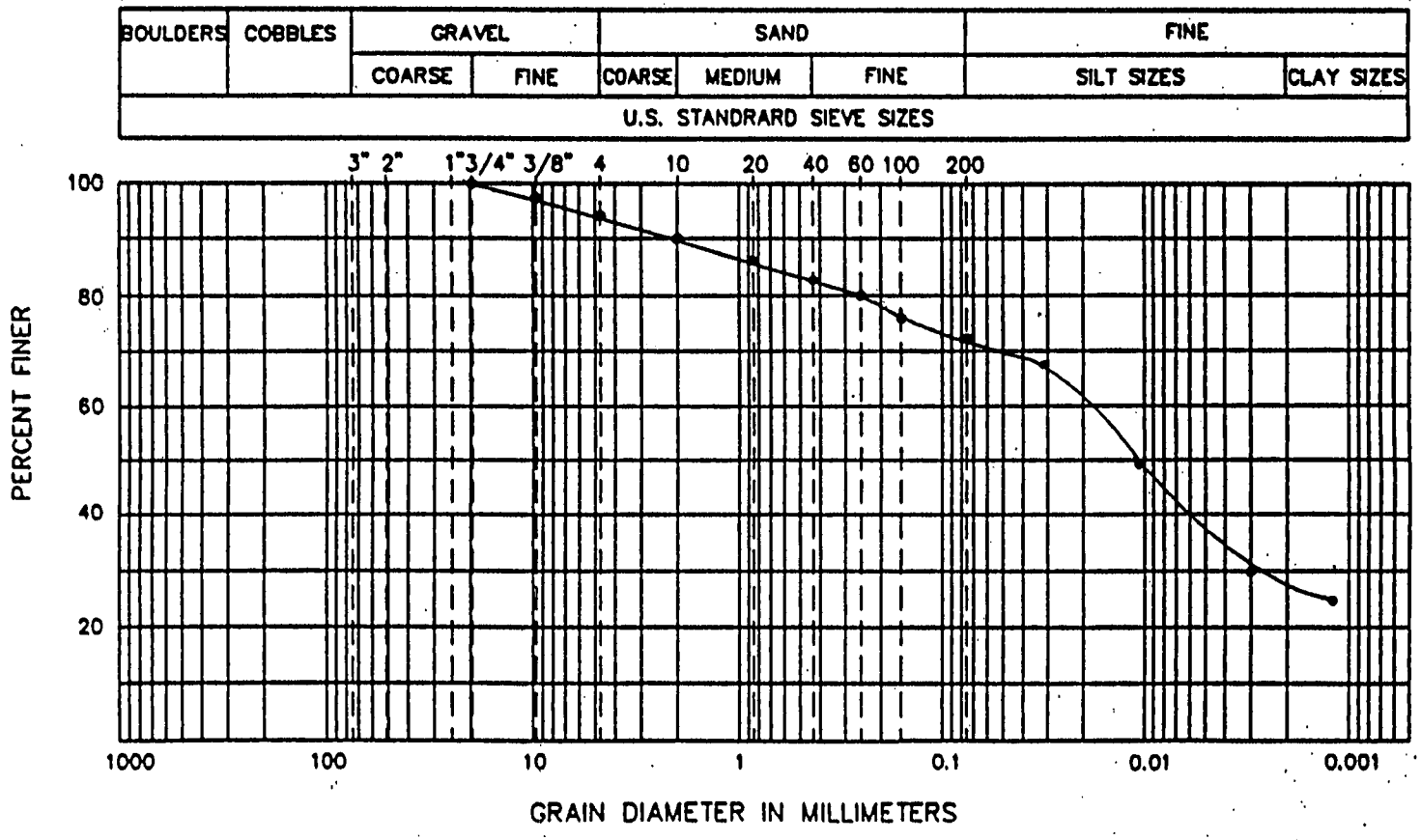
(ASTM D 422 & ASTM D 2487)

PROJECT: FERNALD ON-SITE DISPOSAL FACILITY

LOCATION: FERNALD, OHIO — PROJECT NO.: 6E3900 TASK NO.: 5.3

DESCRIPTION: TEST PAD CONSTRUCTION — DATE: 19 day JUNE month 1996 year

SOURCE: ON-SITE BORROW 2'-3' MATERIAL TYPE: UPPER HORIZON BR. TILL — SAMPLE NO.: UH-05 QA ID: NM



CURVE COEFFICIENTS

(C_u) —

(C_c) —

ATTERBERG LIMITS

(LL) 36

(PL) 19

(PI) 17

SIEVE RESULTS

SIEVE SIZE	% FINER
3-in.	
2-in.	
1 1/2-in.	
1-in.	
3/4-in.	
1/2-in.	100
3/8-in.	97.6
NO. 4	94.4
NO. 10	89.8
NO. 20	86.1
NO. 40	82.6
NO. 60	79.6
NO. 100	75.6
NO. 200	71.6

53116

SOIL CLASSIFICATION (ASTM D 2487): BROWN & GRAY — LEAN CLAY (CL) W/ SOME SAND & GVL.

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SHEET NO. 3 OF 3

000629

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22

GEOSYNTEC CONSULTANTS

FERNALD ON-SITE DISPOSAL FACILITY

PARTICLE SIZE DISTRIBUTION AND SOIL CLASSIFICATION TEST RESULTS

(ASTM D 422 & ASTM D 2487)

PROJECT: FERNALD ON-SITE DISPOSAL FACILITY

LOCATION: FERNALD, OHIO

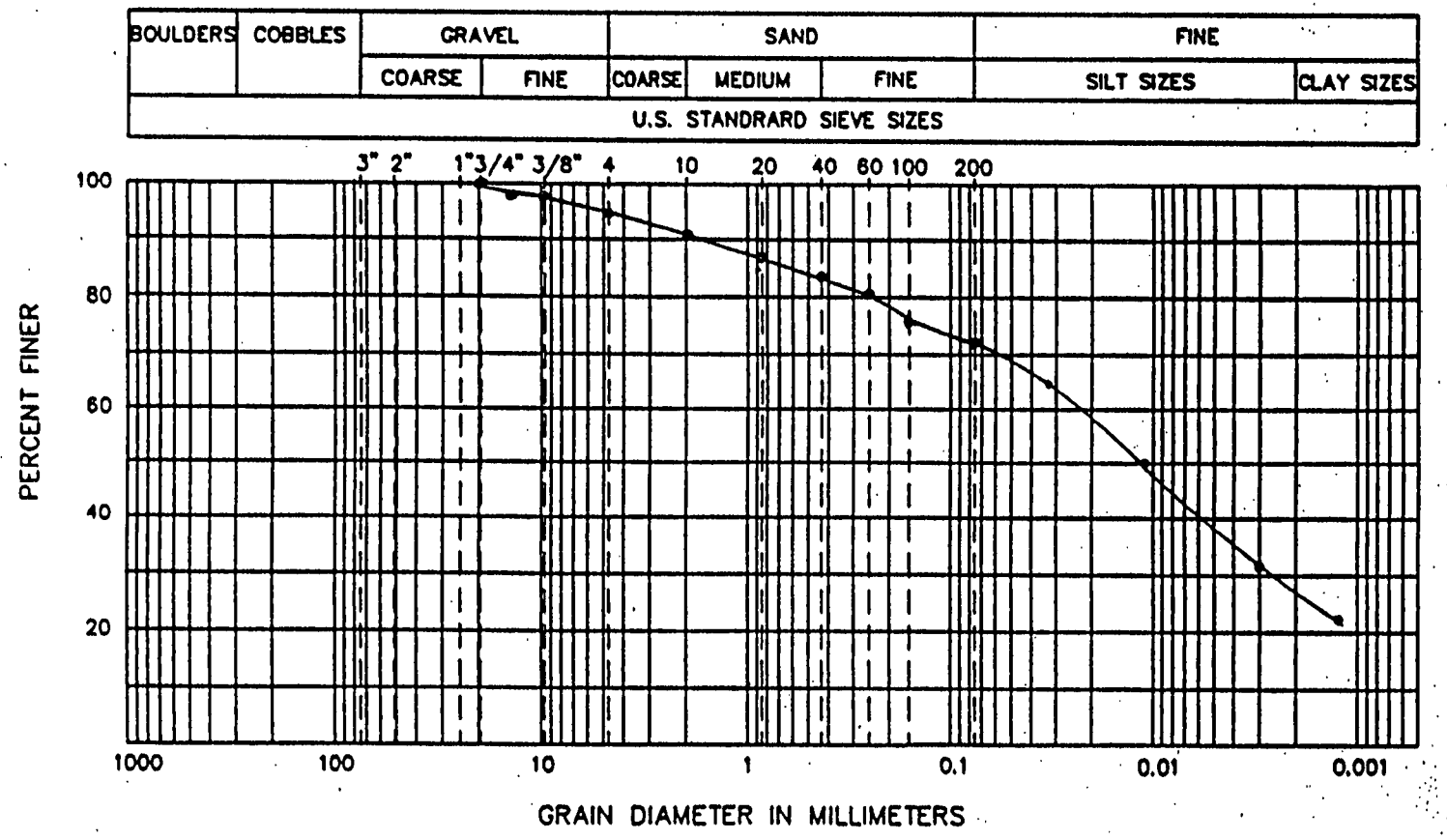
PROJECT NO.: GE3900 TASK NO.: 5.3

DESCRIPTION: TEST PAD CONSTRUCTION

DATE: 19 day JUNE month 1996 year

SOURCE: ON-SITE BORROW 3'-4' MATERIAL TYPE: UPPER HORIZON BR. TILL

SAMPLE NO.: UH-06 QA ID: NM



CURVE COEFFICIENTS

(C_u) —

(C_c) —

ATTERBERG LIMITS

(LL) 32

(PL) 18

(PI) 14

SIEVE RESULTS

SIEVE SIZE	% FINER
3-in.	
2-in.	
1 1/2-in.	
1-in.	
3/4-in.	100
1/2-in.	97.6
3/8-in.	97.6
NO. 4	95.0
NO. 10	90.6
NO. 20	86.9
NO. 40	83.5
NO. 60	80.5
NO. 100	76.4
NO. 200	72.4

5316

SOIL CLASSIFICATION (ASTM D 2487): BROWN & GRAY — SANDY LEAN CLAY (CL) w/ SOME GRAVEL

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NM

SHEET NO. 3 OF 3

000630

104/22

GEOSYNTEC CONSULTANTS

FERNALD ON-SITE DISPOSAL FACILITY

PARTICLE SIZE DISTRIBUTION AND SOIL CLASSIFICATION TEST RESULTS

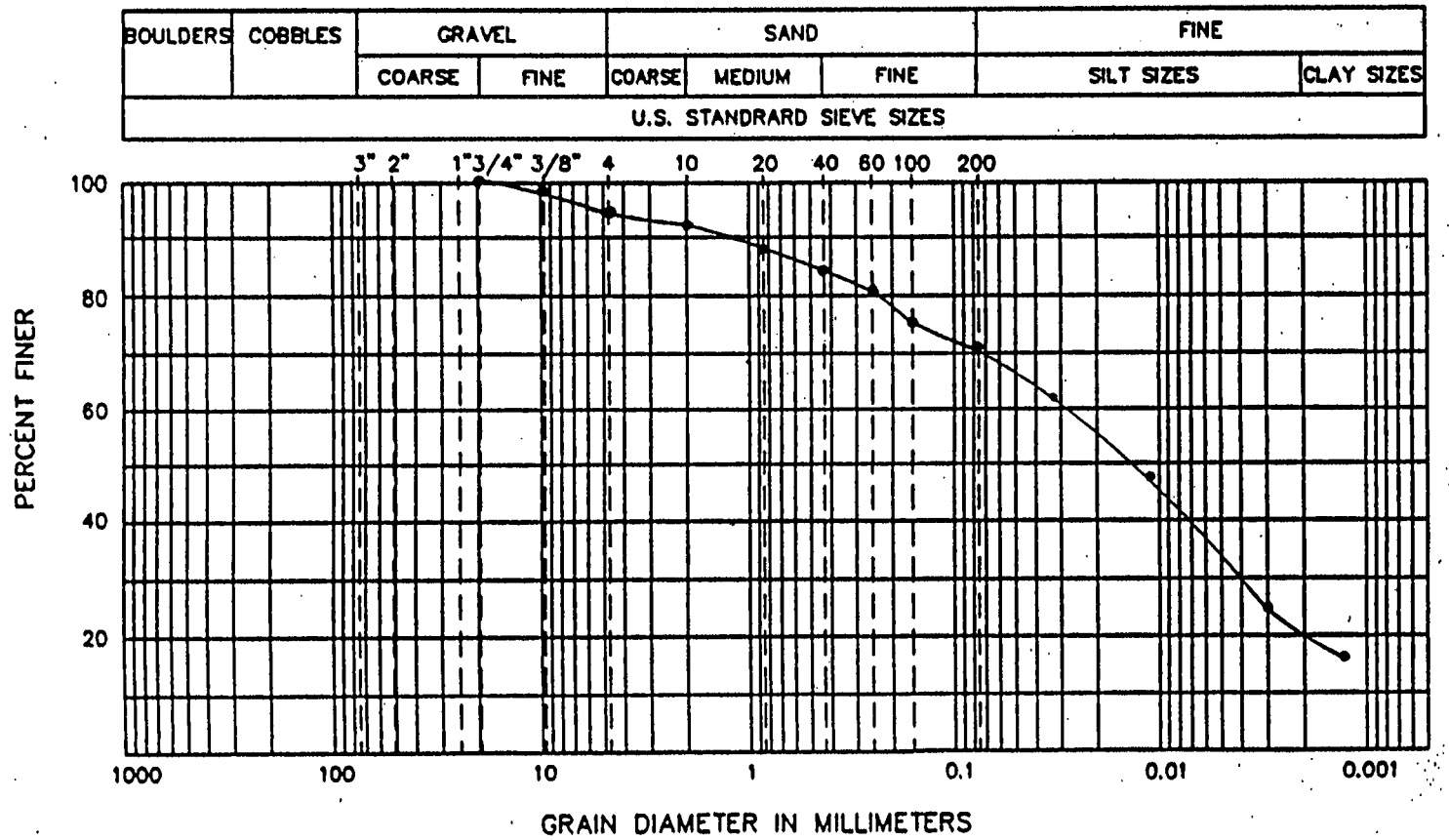
(ASTM D 422 & ASTM D 2487)

PROJECT: FERNALD ON-SITE DISPOSAL FACILITY

LOCATION: FERNALD, OHIO — PROJECT NO.: GE 390D TASK NO.: 5.3

DESCRIPTION: TEST PAD CONSTRUCTION — DATE: 19 day JUNE month 1996 year

SOURCE: ON-SITE BORROW 4'-5' MATERIAL TYPE: UPPER HORIZON BR TILL — SAMPLE NO.: UH-07 QA ID: NM



5316

CURVE COEFFICIENTS

(C_u) —

(C_c) —

ATTERBERG LIMITS

(LL) 28

(PL) 17

(PI) 11

SIEVE RESULTS

SIEVE SIZE	% FINER
3-in.	
2-in.	
1 1/2-in.	
1-in.	
3/4-in.	
1/2-in.	100
3/8-in.	99.1
NO. 4	95.2
NO. 10	91.9
NO. 20	88.1
NO. 40	84.4
NO. 60	80.8
NO. 100	75.6
NO. 200	70.6

SOIL CLASSIFICATION (ASTM D 2487): BROWN & GRAY - SANDY LEAN CLAY (CL) W/ SOME GRAVEL

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/NM

SHEET NO. 3 OF 3

000631

2/02

Written by: Ganesh Gopalakrishnan (GG) Date: 02/ 01/ 25 (YY MM DD) Reviewed by: Daniel G. Pass (DGP) Date: 02/ 1 /25 (YY MM DD)

Client: Fernald Project: Fernald OSDF Phase V Project/Proposal No.: GQ1342 Task No: 17.4

TABLE 1

SPREADSHEET COMPUTATIONS

TABLE 1

CALCULATIONS FOR SEDIMENTATION IN DRANAGE CHANNELS
FERNALD OSDF, PHASE V DESIGN

Input Parameters for Shield's Method

Water Temperature =	68	deg F
Kinematic Viscosity of Fluid =	1.08E-05	ft2/s
Particle Specific Weight =	165	psf
Unit Weight of Fluid =	62.4	psf

CHANNEL PROPERTIES									CALCULATED HYDRAULIC PROPERTIES								SHIELD'S METHOD					HJULSTROM's METHOD	MAVIS & LAUSHLEY
Location	Channel ID	Status	Peak 2-yr 24-hr Discharge	Bottom Width	Left Side Slope	Right Side Slope	Manning's Roughness	Channel Slope	Depth of Flow	Area of Flow	Wetted Perimeter	Hydraulic Radius	Slope	Average Velocity	Flow Rate (Check)	Average Tractive Stress	Critical Particle Diameter		Shield's Computational Parameter	Dimensionless Shield's Parameter	Dimensionless Shear Stress	Critical Particle Diameter	Critical Particle Diameter
			Q	B	Z1	Z2	n	So	Y	A	P	R=A/P		V	Q=AV	t_o	d	d	β			d	d
			cfs	ft	H:1V	H:1V		ft/ft	ft	ft^2	ft	ft	ft/ft	ft/s	ft^3/s	lb/ft^2	mm	ft			2.000	mm	mm
East	1	existing	5.0	0	6	4	0.030	0.0045	0.76	2.89	7.76	0.37	0.0045	1.72	5.0	0.105	5.99	1.97E-02	1.09E-02	5.18E-02	5.19E-02	6.27	9.055
East	2	existing	7.1	0	3	5	0.030	0.0045	0.94	3.53	7.77	0.46	0.0045	1.97	7.0	0.128	7.18	2.36E-02	9.27E-03	5.29E-02	5.29E-02	7.17	12.158
East	3	new	8.7	0	3	4	0.030	0.0050	1.06	3.93	7.72	0.51	0.0050	2.24	8.8	0.159	8.67	2.84E-02	7.82E-03	5.39E-02	5.44E-02	8.14	16.098
East	4	new	10.0	0	3	4	0.030	0.0050	1.12	4.39	8.16	0.54	0.0050	2.32	10.2	0.168	9.12	2.99E-02	7.48E-03	5.42E-02	5.47E-02	8.45	17.452
East	5	new	11.1	0	3	6	0.030	0.0050	1.04	4.87	9.61	0.51	0.0050	2.23	10.9	0.158	8.70	2.85E-02	7.80E-03	5.40E-02	5.39E-02	8.11	15.958
East	6	new	11.8	0	3	6	0.030	0.0100	0.94	3.98	8.69	0.46	0.0100	2.95	11.7	0.286	15.10	4.95E-02	4.75E-03	5.62E-02	5.62E-02	10.72	29.488
East	7R	new	12.1	0	6	3	0.030	0.0100	0.96	4.15	8.88	0.47	0.0100	2.99	12.4	0.292	15.24	5.00E-02	4.71E-03	5.62E-02	5.68E-02	10.87	30.413
East	8R	new	12.2	0	6	2	0.030	0.0050	1.14	5.20	9.48	0.55	0.0050	2.35	12.2	0.171	9.35	3.07E-02	7.31E-03	5.43E-02	5.43E-02	8.55	17.934
East	9R	new	12.2	4.35	6	3	0.030	0.0050	0.72	5.46	11.01	0.50	0.0050	2.20	12.0	0.155	8.63	2.83E-02	7.86E-03	5.39E-02	5.33E-02	8.01	15.511
East	10AR	new	12.6	10.12	6	3	0.030	0.0050	0.50	6.19	14.74	0.42	0.0050	1.97	12.2	0.131	7.44	2.44E-02	8.98E-03	5.31E-02	5.23E-02	7.15	12.114
East	10BR	new/existing	12.7	10.21	3	4.6	0.030	0.0029	0.60	7.49	14.93	0.50	0.0029	1.69	12.7	0.091	5.36	1.76E-02	1.21E-02	5.11E-02	5.03E-02	6.14	8.655
East	12R	existing	13.3	14	3	4.3	0.030	0.0063	0.42	6.52	17.18	0.38	0.0063	2.07	13.5	0.149	8.25	2.71E-02	8.18E-03	5.37E-02	5.37E-02	7.51	13.492
East	13R	existing	23.4	23.11	2.3	4	0.030	0.0067	0.42	10.26	25.90	0.40	0.0067	2.19	22.5	0.166	9.27	3.04E-02	7.37E-03	5.43E-02	5.31E-02	7.97	15.373
East	14	existing	1.0	0	3	5	0.030	0.0040	0.48	0.92	3.97	0.23	0.0040	1.19	1.1	0.058	3.59	1.18E-02	1.73E-02	4.80E-02	4.80E-02	4.32	3.984
East	15	existing	2.7	0	3	5	0.030	0.0063	0.62	1.54	5.12	0.30	0.0063	1.77	2.7	0.118	6.67	2.19E-02	9.91E-03	5.25E-02	5.26E-02	6.42	9.559
East	16	existing	3.2	0	2.5	5	0.030	0.0074	0.66	1.63	5.14	0.32	0.0074	1.99	3.2	0.147	8.12	2.66E-02	8.30E-03	5.36E-02	5.37E-02	7.23	12.396
East	17	existing	5.5	0	4	5	0.030	0.0125	0.68	2.08	6.27	0.33	0.0125	2.66	5.5	0.259	13.75	4.51E-02	5.17E-03	5.59E-02	5.59E-02	9.67	23.523
East	18	new	9.1	0	3	3	0.030	0.0100	1.00	3.00	6.32	0.47	0.0100	3.02	9.1	0.296	15.76	5.17E-02	4.57E-03	5.63E-02	5.58E-02	10.98	31.090
East	19	new	10.1	0	3	3	0.030	0.0090	1.06	3.37	6.70	0.50	0.0090	2.98	10.0	0.282	14.94	4.90E-02	4.79E-03	5.62E-02	5.61E-02	10.83	30.159
East	20	new	8.6	0	3	3	0.030	0.0083	1.02	3.12	6.45	0.48	0.0083	2.79	8.7	0.251	13.27	4.35E-02	5.33E-03	5.58E-02	5.63E-02	10.16	26.179
East	30	new	7.7	0	3	3	0.030	0.0100	0.94	2.65	5.95	0.45	0.0100	2.90	7.7	0.278	14.73	4.83E-02	4.86E-03	5.61E-02	5.61E-02	10.54	28.392
East	21	new	7.8	0	3	3	0.030	0.0100	0.94	2.65	5.95	0.45	0.0100	2.90	7.7	0.278	14.88	4.88E-02	4.81E-03	5.62E-02	5.55E-02	10.54	28.392
East	22	new	8.0	0	3	3	0.030	0.0100	0.96	2.76	6.07	0.46	0.0100	2.94	8.1	0.284	15.02	4.93E-02	4.77E-03	5.62E-02	5.62E-02	10.69	29.283
East	29	new	8.2	0	3	3	0.030	0.0100	0.96	2.76	6.07	0.46	0.0100	2.94	8.1	0.284	15.03	4.93E-02	4.77E-03	5.62E-02	5.62E-02	10.69	29.283
East	24	new	9.3	8.5	3	3	0.030	0.0075	0.42	4.10	11.16	0.37	0.0075	2.21	9.0	0.172	9.41	3.09E-02	7.27E-03	5.43E-02	5.43E-02	8.02	15.577
East	26	new	10.4	0	3	3	0.030	0.0075	1.12	3.76	7.08	0.53	0.0075	2.82	10.6	0.249	13.24	4.34E-02	5.35E-03	5.58E-02	5.58E-02	10.26	26.756
West	1	new	4.7	0	2	6	0.030	0.0075	0.74	2.19	6.16	0.36	0.0075	2.16	4.7	0.167	9.13	3.00E-02	7.47E-03	5.42E-02	5.42E-02	7.85	14.860
West	2	new	7.3	0	2	6	0.030	0.0075	0.88	3.10	7.32	0.42	0.0075	2.42	7.5	0.198	10.60	3.48E-02	6.53E-03	5.49E-02	5.55E-02	8.81	19.161
West	3	new	9.5	0	2	6	0.030	0.0075	0.96	3.69	7.99	0.46	0.0075	2.57	9.5	0.216	11.62	3.81E-02	6.01E-03	5.53E-02	5.52E-02	9.34	21.770
West	4	new	9.5	0	2	6	0.030	0.0076	0.96	3.69	7.99	0.46	0.0076	2.59	9.5	0.219	11.64	3.82E-02	6.00E-03	5.53E-02	5.59E-02	9.40	22.089
West	6	new	10.9	0	2	6	0.030	0.0075	1.02	4.16	8.49	0.49	0.0075	2.67	11.1	0.230	12.18	4.00E-02	5.76E-03	5.54E-02	5.60E-02	9.73	23.795
West	7BR	new	10.9	0	6	2	0.030	0.0023	1.26	6.35	10.48	0.61	0.0023	1.71	10.8	0.087	5.10	1.67E-02	1.26E-02	5.08E-02	5.06E-02	6.20	8.842
West	7DR	existing	11.2	2.56	4.3	3.9	0.030	0.0042	0.87	5.33	9.90	0.54	0.0042	2.13	11.4	0.141	7.77	2.55E-02	8.64E-03	5.34E-02	5.39E-02	7.74	14.414
West	8AR	existing	13.1	13.28	4.2	2.6	0.030	0.0048	0.46	6.83	16.55	0.41	0.0048	1.91	13.0	0.124	7.08	2.32E-02	9.39E-03	5.29E-02	5.19E-02	6.93	11.304
West	8CR	existing	13.0	1.17	2.4	2.3	0.030	0.0159	0.94	3.18	5.97	0.53	0.0159	4.11	13.1	0.528	21.71	7.12E-02	3.43E-03	5.72E-02	7.22E-02	14.95	61.251
West	9AR	new	2.3	0	3	3	0.030	0.025	0.50	0.75	3.16	0.24	0.0250	3.01	2.3	0.370	19.68	6.46E-02	3.74E-03	5.70E-02	5.58E-02	10.94	30.805
West	9R	new	2.3	0	3	3	0.030	0.0249	0.50	0.75	3.16	0.24	0.0249	3.00	2.3	0.369	19.60	6.43E-02	3.76E-03	5.70E-02	5.59E-02	10.91	30.670
West	10AR	new	1.1	5	3	3	0.030	0.065	0.08	0.42	5.51	0.08	0.0650	2.27	1.0	0.309	18.08	5.93E-02	4.04E-03	5.67E-02	5.07E-02	8.26	16.634
West	10R	new	2.4	7	3	3	0.030	0.005	0.24	1.85	8.52	0.22	0.0050	1.27	2.4	0.068	4.24	1.39E-02	1.49E-02	4.94E-02	4.75E-02	4.62	4.621
West	11AR	new	2.2	7	2.8	3	0.030	0.005	0.24	1.85	8.47	0.22	0.0050	1.27	2.3	0.068	3.98	1.31E-02	1.58E-02	4.88E-02	5.08E-02	4.62	4.636
West	16N	existing	1.2	0	2.2	1.4	0.030	0.0069	0.62	0.69	2.56	0.27	0.0069	1.72	1.2	0.116	6.68	2.19E-02	9.89E-03	5.25E-02	5.17E-02	6.26	9.031