Appendix O

Water and Groundwater Resources

Appendix O1

Water Resources Information

HEI LLC-080208-040.020.020. BVTrms-04

August 15, 2008

BUENA VISTA WATER STORAGE DISTRICT
Summary of Proposed Water Transfer Terms

GENERAL

Buyer: Hydrogen Energy International LLC (the "Buyer")

Seller: Buena Vista Water Storage District (the "Seller")

Description: The Buyer seeks to purchase a firm quantity of water as described in this Summary of Proposed Water Transfer Terms ("Term Sheet") from the Seller on a long-term basis ("Sale Water") pursuant to a Purchase Agreement (as defined below).

Effective Date: January 1, 2015 of Purchase Agreement; Buyer shall have the right to terminate this Term Sheet at any time in its sole discretion and will thereafter have no further obligations under this Term Sheet.

Term and Termination: 25 years from the Effective Date.

WATER SUPPLY

Source of Water: Seller will supply Sale Water to Buyer from wells providing brackish groundwater supply available to Seller.

Quantity of Water: Annual firm supply of seven thousand five hundred (7,500) acre-feet of Sale Water.

Quality of Water: The Sale Water shall have a TDS averaging about 2,000 mg/L with an acceptable range of from about 1000 mg/L to 4000 mg/L

Availability: The Sale Water is available upon completion of environmental review and facilities for the marketing program contemplated by this agreement.

DELIVERY

Delivery Point: Seller will deliver the Sale Water to the Buyer's gasification and power plant ("Plant") located in Kern County within or reasonably near Section 16, T30S R24E.

Delivery Schedule: Seller shall deliver 100% of the Sale Water to the Plant. Buyer will supply annual delivery schedule in a quantity not to exceed 14% of the annual amount per month.

PAYMENT

Water Rate: Buyer shall pay an initial price of four hundred and fifty dollars ($450.00) per acre-foot (the "Water Rate") as of June 2008.

Facility Construction: Buyer shall construct all necessary recovery, monitoring, and conveyance facilities (the "facilities"), to the full reasonable satisfaction of the Seller, and transfer said facilities to Seller upon their completion. Alternatively, if Seller chooses to construct the facilities, Buyer shall reimburse Seller actual reasonable costs of such construction.

Facility O,M,P&R: Seller shall assume all O,M,P&R duties and be reimbursed by the Buyer.

Escalator: The Water Rate shall be adjusted each year, starting January 2009 using an average of the Consumer Price Index (All Urban Consumers - All Items - Southern California Area) and the SWP unit cost (i.e., initial annual obligation of the full Table A Amount divided by the most current Department of Water Resources long-term reliability factor).

Payment Options: Buyer will pay for a percentage of the Sale Water whether it is taken or not in accordance with the following table:

From	To	Percentage of Annual amount
Jan. 1, 2015	Dec 31, 2015	25%
Jan 1, 2016	Dec 31, 2016	40%
Jan 1, 2017	Dec 31, 2017	55%
Jan 1, 2018	Dec 31, 2018	70%
Jan 1, 2019	Dec 31, 2039	100%

Reservation Agreement: Seller will grant and Buyer will reserve the exclusive right to negotiate for the Sale Water by executing a Reservation Agreement January 1, 2009 whereby Buyer agrees to deposit with Seller a non-refundable annual reservation fee equal to 7,500 AF x Water Rate x 15%, payable in quarterly installments. At the point which the California Energy Commission has given the Plant a favorable preliminary staff assessment, but no later than January 1, 2010, the annual option payment will increase to 7,500 AF x Water Rate x 20% payable in quarterly installments (collectively, the "Option Fee"). This exclusive right will be available until 2015; provided, however, that Buyer's obligation to pay the Option Fee shall terminate upon Buyer's notice to Seller of Buyer's intent to terminate this Term Sheet or the Reservation Agreement.

General Expenses: Each party shall be responsible for its own fees and expenses arising out of the negotiation and execution of agreements related to this transaction, obtaining necessary approvals, and the like.

CEQA Compliance: Both parties shall cooperate with one another with respect to CEQA compliance for the proposed sale. Seller shall be the lead agency with respect to CEQA. Buyer shall be solely responsible for all fees and costs associated with CEQA compliance, whether incurred by Buyer or Seller, including litigation expenses if any.

Permit Costs: Buyer shall be responsible for any and all regulatory and permitting fees and costs associated with the water transfer and transportation of Sale Water.

MISCELLANEOUS

Non-Binding Effect: This Term Sheet is intended to be a non-binding statement of the terms of the proposed transaction. It is subject to the negotiation, execution and delivery of the Reservation and Purchase Agreements by Buyer and Seller not inconsistent with the basic terms and conditions set forth herein ("Purchase Agreement"). Full execution of this Term Sheet does not create a binding agreement between Buyer and Seller; that will occur only upon the execution and delivery of the Reservation and Purchase Agreements.

Representations and Warranties

Seller will provide usual and customary representations and warranties including: 1) Seller's title to the Sale Water; 2) the adequacy and firmness of the Sale Water; 3) authority of Seller to transfer the Sale Water pursuant to the Purchase Agreement.

SELLER: Don W. Bell 8-15-08
(signature) (date)

BUYER: JMBriggs 8-26-08
(signature) (date)
JONATHAN BRIGGS

Appendix O2

Groundwater Model Documentation

APPENDIX O2
GROUNDWATER MODEL DOCUMENTATION

HECA Project Site

Buena Vista Water Storage District

Kern County, California

Prepared for

Hydrogen Energy International LLC
One World Trade Center
Suite 1600
Long Beach, CA 90831

April 30, 2009

URS

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Hydrogen Energy International LLC (HEI or Applicant) is jointly owned by BP Alternative Energy North America Inc. and Rio Tinto Hydrogen Energy LLC. HEI is proposing to build an Integrated Gasification Combined-Cycle power generating facility called Hydrogen Energy California (HECA or the Project) in Kern County, California. The Project will produce low-carbon baseload electricity by capturing carbon dioxide (CO_2) and transporting it for CO_2 enhanced oil recovery (EOR) and sequestration (storage)[1].

The Project will use impaired-quality groundwater provided by the Buena Vista Water Storage District (BVWSD) as the source of process water. A three-dimensional groundwater flow model was constructed to evaluate the effects of pumping groundwater for the proposed Project from a proposed well field within the BVWSD Buttonwillow Service Area in Kern County, California (Figure 1). The groundwater flow model was developed to evaluate the potential net impacts of project-specific pumping on the underlying and adjacent aquifer system. This aquifer system has been locally termed as the Buttonwillow Subbasin (KCWA 1991), which is located within the regional Kern County Subbasin. This model is a "superposition model," in which all non–project-specific hydrologic features were excluded, based on the application of the "principle of superposition" (Reilly, et al. 1987). MODFLOW, a groundwater modeling program developed by the U.S. Geological Survey (USGS), was used for model development and simulations.

The primary objective of this superposition model is to evaluate the net effects of project-specific pumping by:

1. Simulating net changes of groundwater flow conditions and aquifer response to project-specific pumping;

2. Providing sufficiently fine grid spacing to simulate groundwater pumping via extraction wells; and

3. Evaluating the sensitivity of groundwater flow in the aquifer to aquifer property assumptions.

[1] This carbon dioxide will be compressed and transported via pipeline to the custody transfer point at the adjacent Elk Hills Field, where it will be injected. The CO_2 EOR process involves the injection and reinjection of carbon dioxide to reduce the viscosity and enhance other properties of the trapped oil, thus allowing it to flow through the reservoir and improve extraction. During the process, the injected carbon dioxide becomes sequestered in a secure geologic formation. This process is referred to herein as CO_2 EOR and Sequestration.

This section discusses the Project's process water supply and the hydrologic setting of the proposed well field.

2.1 PROPOSED WATER SUPPLY

BVWSD will supply the proposed project with impaired-quality groundwater (average total dissolved solids [TDS] approximately equal to 2,000 milligrams per liter [mg/L]) for hydrogen generation, power-plant cooling, gasification, and other industrial processes. The groundwater will be supplied by a proposed well field to be constructed and operated by BVWSD. The proposed well field will intercept groundwater (i.e., first water [30 feet below ground surface (bgs)] to 300+ feet bgs) on the western side of the BVWSD.

As shown on Figure 1, the proposed Project well field is a northwest-oriented rectangular area located on the western side of the BVWSD Buttonwillow Service Area near Seventh Standard Road and the California Aqueduct. It includes portions of Sections 34 and 35 of Township 28S, Range 22E, and portions of Sections 1, 2, and 12 of Township 29S, Range 22E. The water pumped from the well field will be piped approximately 15 miles southeast to the project site.

BVWSD will provide the Project with up to approximately 7,500 acre-feet of groundwater each year. Although the water supply system is anticipated to provide environmental benefits and will not include use of fresh water, the California Energy Commission (CEC) requires evaluation of the potential environmental impacts associated with development of this water supply. Therefore, this groundwater flow model was constructed to evaluate the net effects of project groundwater pumping, and to support the analysis presented in the Project's Revised Application for Certification (AFC).

2.2 HYDROGEOLOGIC SETTING

The proposed well field is located in the Kern County Subbasin (DWR subbasin no. 5-22.14) of the San Joaquin Valley groundwater basin. The southern San Joaquin Valley, of which the Kern County Subbasin is a part, has been further divided into additional hydrogeologic subbasins that are bounded by distinct structural highs due to folding or faulting (KCWA 1991). These subbasins may contain isolated or partially isolated hydrogeologic systems. BVWSD's Buttonwillow Service Area is located in what is locally known as the Buttonwillow Subbasin, which is separated from the Jerry Slough Subbasin to the west, the Tulare Subbasin to the north, and by structural highs to the west.

Although there are many agricultural pumping wells within the region, not much geologic or hydrogeologic data have been collected in the vicinity of the proposed well field. As such, regional and local geologic and hydrogeologic reports from other studies in Kern County, as well as information provided by the BVWSD and their hydrogeologic consultant, Sierra Scientific Services, were used as a basis to develop this groundwater flow model. The region is underlain by unconsolidated sediments originating from an alluvial depositional setting with discontinuous lacustrine clay lenses. Alluvial deposits, by nature, are heterogeneous assemblages of both coarse- and fine-grained material. Based on available geophysical logs, the stratigraphy is

dominated by interbedded sands and gravels with minor vertically and laterally discontinuous silt and clay layers.

The aquifer system is both unconfined, and most likely, semi-confined in places. Based on a 2008 depth to water map provided by BVWSD, depth to groundwater in the vicinity of the proposed well field is approximately 30 feet bgs.

This section briefly describes model computer codes used to build the model.

3.1 GROUNDWATER MODELING SYSTEM INTERFACE

The computer software program chosen as the graphical interface for the modeling effort was the U.S. Department of Defense Groundwater Modeling System (GMS), version 6.0. GMS is a comprehensive graphical user interface (GUI) for performing groundwater simulations. GMS provides a graphical preprocessor and postprocessor interface to several groundwater modeling codes: MODFLOW, MODPATH, MT3DMS, RT3D, FEMWATER, SEEP2D, NUFT, and UTCHEM. The GMS interface was developed by the Environmental Modeling Research Laboratory of Brigham Young University in partnership with the U.S. Army Engineering Waterways Experiment Station. GMS was used to develop a simplified site conceptual hydrogeological model, and to convert it into a groundwater flow model.

3.2 MODFLOW GROUNDWATER FLOW MODEL

The computer code selected to model groundwater conditions was MODFLOW. MODFLOW is a three-dimensional, cell-centered, finite difference, saturated flow model developed by the USGS (McDonald and Harbaugh 1988). GMS provides an interface to the updated version, MODFLOW 2000 (Hill et al. 2000). Based on the information available, the uncertainty associated with site information, and the modeling objectives of evaluating the potential net effects of project-specific pumping, MODFLOW was considered an appropriate groundwater flow code.

3.3 MODPATH PARTICLE TRACKING MODEL

Particle tracking simulations provide a convenient means of visualizing groundwater flow paths. This is particularly useful for evaluating capture zones around a pumping well. MODPATH was selected as the particle tracking program for this effort. MODPATH is a three-dimensional particle tracking program developed by the USGS (Pollock 1994) that enables reverse and forward tracking from sinks (wells) and sources, respectively. GMS has updated the interface for MODPATH to a seamless module that couples with MODFLOW 2000. MODFLOW results are used as input for MODPATH runs.

The data used to develop the groundwater flow model was primarily provided by BVWSD, on behalf of Sierra Scientific Services, during meetings and in the form of e-mails, published reports (Sierra Scientific Services 2003; Sierra Scientific Services 2004; Sierra Scientific Services 2007a; and Sierra Scientific Services 2007b), and reports in preparation (Sierra Scientific Services 2009a and Sierra Scientific Services 2009b).

4.1 MODEL DOMAIN AND GRID

To eliminate the boundary effects on the simulated groundwater conditions, a model domain of 100 by 100 miles was specified, with the well field at the center of the model domain. This exaggerated domain size was created to ensure that drawdown simulated by well-field pumping was only affected by aquifer properties (e.g., hydraulic conductivity and storativity) and not by water flowing into or out of the boundary.

Because the proposed wells are arranged linearly in a northwest-trending direction, the model domain is rotated 49 degrees from north to west so that the rows and columns of the discretized grid are perpendicular and parallel to the arranged well line. This oriented model domain allows the proposed wells to be in the same column so that the simulation results are more easily processed.

The model domain has three layers extending from ground surface to 2,000 feet bgs. The model layers extend from 0 (ground surface) to 300 feet bgs (shallow zone), 300 to 600 feet bgs (deep zone), and 600 to 2,000 feet bgs (deeper zone).

The model grid contains 243,789 cells, spatially discretized into 247 columns and 329 rows in the plan view, as shown in Figure 2. The model grid is refined in the vicinity of the pumping wells. Lateral cell size of 20 by 20 feet was specified in the vicinity of the pumping wells, and the grid size increases towards the model domain boundaries. The maximum cell size, at the model boundary, is 2,500 by 2,500 feet.

4.2 HYDRAULIC CONDUCTIVITY

The lithology underlying the proposed well field area is characterized by heterogeneous unconsolidated deposits characteristic of an alluvial depositional system. Geophysical logs within and in the vicinity of the well field area indicate that the aquifer system is dominated by coarse-grained sediments with discontinuous interbedded fine-grained sediments. The 3-layer computer model is a simplification of the many-layered aquifer system in the well field area. As such, aquifer properties of the three model layers are assigned so that they will correctly simulate the behavior of the multi-layered aquifer system. Our basis for model parameterization is to make the Transmissivity (T) and storativity (S) values of the three model layers equivalent to the aggregate average T and S values of the same respective thicknesses of the actual aquifer system.

As demonstrated by Sierra Scientific Services, 2004 (p. 53), if the sand fraction (Fsd) in a total thickness interval (H) of the aquifer is at least 20 percent, and if the sand intervals are at least 100 times more permeable than the interbedded silty or clayey strata, then the T of the aquifer

equals T = Ksd*H*Fsd, where K is hydraulic conductivity and Ksd is the K of the sand units, without knowing the K values of the interbedded silts or clays. This condition may be implemented in the computer model by substituting a value of effective conductivity (K*) which is applicable to the entire interval thickness, H, where K* = Ksd*Fsd. This implementation will then yield the correct value of T for aquifer modeling. The same mathematical equivalence is applied to derive a value of equivalent storativity, (S*).

Based on a review of geophysical logs, the range of sand in the aquifer is approximately 60 to 90 percent. It is assumed that the horizontal K value of the sand is 57 feet per day (ft/day); horizontal K assumed to be uniform throughout the model domain. In the baseline simulation it was assumed that 75 percent of the aquifer thickness contained sand at a horizontal K value of 57 ft/day.

In alluvial aquifer systems of this type, vertical hydraulic conductivity is less than the horizontal hydraulic conductivity. The vertical anisotropic ratio, defined as the ratio of horizontal hydraulic conductivity to the vertical hydraulic conductivity, ranges from approximately 10 to 50 ft/day. With the assumption that horizontal conductivity is 57 ft/day, vertical conductivity is estimated to range from 1.1 ft/day to 5.7 ft/day. A mid-range anisotropic ratio value of 30 is used for the baseline simulation, which corresponds to a vertical conductivity value of 1.9 ft/day. The anisotropic ratio is assumed to be uniform throughout the model domain.

4.3 SPECIFIC YIELD AND SPECIFIC STORAGE

Local information provided by the BVWSD and their hydrogeologic consultant, Sierra Scientific Services, was reviewed to develop estimates for specific storage and specific yield. The specific yield of the local aquifer system was estimated to range from approximately 0.15 to 0.20. A mid-range value of 0.18 is used in the model for the baseline simulation.

The specific storage of the local aquifer system was estimated to range from approximately 0.00004 to 0.00007 (1/ft). A mid-range value of 0.0000551/ft is used in model for the baseline simulation.

4.4 PUMPING

The model simulates project-specific pumping from a proposed well field. The well field is assumed to include five wells arranged linearly in a northwest-trending direction and spaced approximately 0.25 mile apart (Figure 3). The model simulates a well field pumping rate of 7,500 acre-feet per year (afy), or 4,650 gallons per minute (gpm), which represents the upper-limit water demand for the proposed Project. Three of the five wells would be pumping at once, while the other two wells would be redundant. Therefore, the total pumping rate is divided evenly among the three pumping wells, resulting in a pumping rate of 1,550 gpm per pumping well. To be conservative, the model assumes that the three pumping wells are adjacent to one another in the center of the well field. The wells are placed in the uppermost model layer to simulate shallow pumping. The pumping rate is steady and continuous throughout the 25-year model simulation.

To evaluate the net effect of project-specific pumping, all other existing pumping wells are excluded from the model.

4.5 RECHARGE

From 1962 to 2000, the BVWSD's operations in its 50,000-acre Buttonwillow Service Area have resulted in a positive groundwater balance of approximately 46,000 afy. BVWSD projects that a positive groundwater balance of approximately 25,000 afy will be maintained in the future (BVWSD – personal communications January through May 2009). Therefore, even though the southern San Joaquin Valley has been classified by the DWR as an overdrafted groundwater basin, the BVWSD has historically been able to achieve a positive groundwater balance. Water levels in the BVWSD Buttonwillow Service Area have and are expected to continue to rise in response to BVWSD's recharge/replenishment operations.

Recharge within BVWSD is primarily attributable to infiltration from over-irrigation, as well as seepage loss from the BVWSD irrigation ditch and canal system. The model simulates recharge of 7,500 afy from BVWSD positive water balance operations that can be attributed to offset Project-specific pumping. The infiltration rate in the vicinity of the well field is approximately 0.4 ft/year. Therefore, recharge is applied to the model within an area around the pumping wells that is approximately 29.3 square miles (i.e., 18,750 acres), in order to yield a total recharge volume of 7,500 afy. According to the BVWSD, seepage loss from the irrigation ditch and canal system occurs for about two-and-a-half months during the irrigations months. Therefore, recharge is simulated 75 days per year.

4.6 INITIAL AND BOUNDARY CONDITIONS

Because the primary model objective is to evaluate the aquifer response to Project-specific pumping, the initial head distribution was specified as a constant head distribution. Based on data collected in 2008 and provided by BVWSD, average depth to water in the vicinity of the proposed well field is approximately 30 feet bgs; therefore, initial heads were specified as 30 feet bgs throughout the model domain.

Because the model domain (100 by 100 miles) far exceeds the area of influence of project pumping, the model boundary will not have an effect on groundwater conditions. Consequently, boundary conditions do not have an effect on the model so long as they are consistent with the initial condition. Therefore, a general head boundary condition with a constant reference head of 30 feet bgs was specified along the edges of the model domain for all three model layers.

4.7 TIMING OF MODEL STRESSES

The model simulated transient flow conditions for 25 years. Stress periods were set to 75 days and 290 days to allow simulation of annual recharge events. Well pumping is constant throughout the simulation.

The model was used to simulate groundwater pumping and response in one base case and eight sensitivity runs. The total pumping volume, number of pumping wells, pumping well locations and depth, recharge rate and area, boundary conditions, initial head, model timing, and stress period setup remained the same for all simulation runs. Sensitivity runs were conducted to test the effect of sand percentage (equivalent horizontal K values), vertical anisotropic ratio, specific yield, and specific storage on resulting simulated drawdown. Model parameters are summarized in Table 1, and simulation results are summarized in Table 2.

5.1 BASE CASE

Mid-range aquifer parameters were simulated under the base case. Based on an assumed total sediment thickness of 75 percent sand, the horizontal hydraulic conductivity was estimated to be 43 ft/day. The anisotropic ratio was defined as 30, resulting in a vertical hydraulic conductivity value of 1.9 ft/day. Specific yield and specific storage were defined as 0.18 and 5.5×10^{-5} 1/ft, respectively. In addition to simulating the net changes of groundwater flow conditions and aquifer response to project-specific pumping, particle tracking using MODPATH (Pollock 1994), a particle-tracking post-processing model for MODFLOW, was conducted to estimate the groundwater movement towards the well field induced by project pumping. Simulation results are presented in a hydrograph for hypothetical observation points (i.e., wells) at various distances from the pumping wells (Figure 4); a hydrograph for hypothetical observation points 0.5 mile to the east, west, north, and south of the pumping wells (Figure 5); contour maps (Figures 6, 7, and 8); groundwater table profiles (Figures 9 and 10); and a groundwater pathline map (Figure 11).

Simulation results show a decline in water level on the order of about 30 feet near the pumping wells during the first 3 years of pumping. Approximately 90 percent of the drawdown occurs during the first 3 years of pumping. After 3 years of pumping, the water-level decline stabilizes until maximum drawdown is reached after approximately 9 years of pumping. The water level remains relatively stable throughout the remainder of the 25-year simulation. The water level response is cyclic in nature due to the application of recharge for 75 days out of every year. Water levels vary between approximately 1 and 2 feet on an annual basis throughout the duration of the simulation.

Results show an asymmetric cone of depression due to the asymmetric application of recharge. The cone of depression extends further west of the pumping wells than it does to the east, north, or south, because the pumping wells are located near the western boundary of the recharge area, which is limited to BVWSD's Buttonwillow Service Area. After 25 years of pumping, the cone of depression extends approximately 1.4 miles from the pumping wells to the north, south, and east of the pumping wells, and approximately 2.5 miles to the west of the pumping wells. Slightly more drawdown is simulated perpendicular (to the east and west) than parallel (to the north and south) to the pumping wells due to the linear alignment of the three pumping wells.

Maximum simulated drawdown of approximately 37 feet occurs at the central pumping well. Drawdown decreases radially outward from the pumping wells such that maximum drawdown 200 feet east, 0.5 mile east, and 1 mile east of the pumping wells is 18.5, 5.2, and 2.0 feet,

respectively. Drawdown is slightly less to the north and south of the pumping wells at these same distances. Beyond 2 miles, drawdown is almost non-existent. Maximum drawdown 0.5 mile from the pumping wells was simulated to be at 5.2 feet to the east, 5.6 feet to the west, 3.9 feet to the north, and 3.9 feet to the south. Groundwater contour maps show that the cone of depression extends from the shallow zone (model layer 1), where the pumping wells are located, to the base of the model (model layer 3).

The hydrograph shows that a slight rise in water level occurs 2 miles north of the pumping wells due to the influence of recharge and lack of pumping well influence. Groundwater table profiles show that water level rises at a distance beyond the influence of the pumping wells to the north, south, and east of the pumping wells due to recharge.

Particle tracking results show that the maximum net movement of the groundwater induced by project pumping is approximately 0.8 mile towards the well field after 25 years of project pumping. Note that these derived groundwater pathlines exclude the effect of the natural groundwater gradient.

5.2 SENSITIVITY SIMULATIONS

Sensitivity simulations were conducted to test the sensitivity of the model results with respect to aquifer parameters for sand percentage, anisotropic ratio, specific yield, and storativity. Only one parameter was modified from the base case in each sensitivity run. Resulting hydrographs at an observation point located at the central pumping well, 200 feet east of the pumping wells, and 0.5 mile east of the pumping wells are presented on Figures 12, 13, and 14, respectively.

5.2.1 Sand Percentage

The model was used to simulate total sediment thickness at 60 and 90 percent sand, which corresponds to equivalent horizontal K values of 34 ft/day and 51 ft/day, respectively.

The drawdown response is similar to the base case in that the water level drop begins to flatten out after approximately 3 years of pumping. As in the base case, a cyclic water level response occurs due to the intermittent annual application of recharge. Maximum drawdown, which occurs at the central pumping well, is 47 feet with 60 percent sand, and 30.5 feet with 90 percent sand. This can be compared with the maximum base case drawdown of 37 feet, as summarized above.

As expected with a lower sand percentage (smaller equivalent horizontal K value), the cone of depression is deeper, yet aerially smaller, than with a higher sand percentage. The difference in drawdown between the lower-end and upper-end sand percentage simulations decreases with distance from the pumping wells. For example, at a distance of 1 mile from the pumping wells, drawdown is greater with a lower sand percentage (i.e., 2.4 feet of drawdown for 60 percent sand versus 1.7 feet of drawdown for 90 percent sand). At a distance of 0.5 mile from the pumping wells, drawdown would be 6.5 feet at 60 percent sand versus 4.4 feet of drawdown for 90 percent sand.

Overall, model results show that drawdown is sensitive to sand percentage.

5.2.2 Anisotropic Ratio

Anisotropic ratios of 10 and 50 were simulated, which correspond to vertical K values of 5.7 ft/day and 1.1 ft/day, respectively.

The behavior of the water level response is similar to the base case. Maximum drawdown at the central pumping well is approximately 32 feet with an anisotropic ratio of 10 and approximately 39 feet with an anisotropic ratio of 50. These results bracket the maximum drawdown in the base case (37 feet).

As the anisotropic ratio increases (the vertical hydraulic conductivity decreases), there is greater drawdown because less water flows from the deeper zones to the shallow zone of the model. For example, at a distance of one-half mile from the pumping wells, the model simulates maximum drawdown of 3.6 feet with an anisotropic ratio of 10, and 6.2 feet with an anisotropic ratio of 50. The cone of depression is larger as the anisotropic ratio increases, but the effect of variable anisotropy becomes increasingly muted at distance from the pumping wells.

Overall, model results show that drawdown is sensitive to the anisotropic ratio.

5.2.3 Specific Yield

A specific yield of 0.15 and 0.20 was simulated.

As with the previous sensitivity simulations, the behavior of the water level response is similar to the base case. The magnitude of the drawdown and the aerial extent of the cone of depression is very similar to the base case. The only difference from the base case is the timing at which the maximum drawdown occurs. When specific yield is lower, maximum drawdown is achieved quicker. As specific yield increases, the time at which maximum drawdown occurs increases because more water is released from storage.

Model results show that drawdown is insensitive to the change in specific yield. This is because the pumped groundwater is mainly from water transmission, due to the high K value, not from the storage change of the aquifer.

5.2.4 Specific Storage

Specific storage values of 4×10^{-5} 1/ft and 7×10^{-5} 1/ft were simulated. Results are very similar to both the base case and specific yield sensitivity simulations. Model results show that drawdown is relatively insensitive to the change in specific storage. This is also because the pumped groundwater is mainly from water transmission, not from the storage change of the aquifer.

Simulation results show that the net effect of project-specific pumping is a cone of depression that extends approximately 1.4 miles to the north, south, and east of the well field and approximately 2.5 miles to the west of the well field. Beyond those distances, drawdown is almost nonexistent, and to the north, south, and east, water levels rise slightly due to BVWSD's positive water balance recharge. Maximum drawdown one-half mile from the pumping wells was simulated to be 5.2 feet to the east, 5.6 feet to the west, 3.9 feet to the north, and 3.9 feet to the south. Accordingly, wells within 0.5 mile of the pumping wells exhibited greater drawdowns, and wells further than 0.5 mile of the pumping wells exhibited lower drawdowns until distances of approximately 1.4 miles to the north, south, and east and 2.5 miles to the west were reached, at which point drawdown would be almost nonexistent. In the base case, using mid-range values of sand percentage and anisotropic ratio, maximum drawdown at the central pumping well is approximately 37 feet, and only approximately 2 feet at a distance of 1 mile from the pumping wells.

Simulation results show that approximately 90 percent of the drawdown occurs during the first 2 to 3 years of pumping. After 2 to 3 years, drawdown gradually continues to increase until maximum drawdown is reached at approximately Year 9. After Year 9, water levels remain relatively stable throughout the remainder of the 25-year simulation. The water level response is cyclic in nature due to the application of recharge for 75 days out of every year. Water levels vary between approximately 1 and 2 feet on an annual basis throughout the duration of the simulation.

Simulation results show that the model is insensitive to the specific yield and specific storage of the aquifer, but sensitive to both horizontal and vertical K, as defined by the sand percentage and anisotropic ratio, respectively.

Particle tracking results show that the net movement of groundwater induced by Project pumping is approximately 0.8 mile towards the well field.

The model was developed to evaluate the potential impacts of pumping on water levels within the aquifer system under and adjacent to the BVWSD Buttonwillow Service Area (i.e., the Buttonwillow Subbasin). Any groundwater model, including this screening-type model, is a simplification of the natural environment and therefore has recognized limitations.

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TABLES

Model Parameter	Model Simulation								
	Base Case	Sensitivity Simulation							
		Sand %		Anisotropy		Specific Yield		Specific Storage	
		Lower End	Upper End	Lower End	Upper End	Lower End	Upper End	Lower End	Upper End
Pumping									
Total Rate (AFY)	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Number of Pumping Wells	3	3	3	3	3	3	3	3	3
Rate per Well (AFY)	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Schedule	constant	constant	constant	constant	constant	constant	constant	constant	constant
Duration (years)	25	25	25	25	25	25	25	25	25
Recharge									
Total Rate (AFY)	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Area (acre)	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750
Rate (ft/year)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Schedule (days/year)	75	75	75	75	75	75	75	75	75
Duration (years)	25	25	25	25	25	25	25	25	25
Hydraulic Conductivity (K)									
K sand (ft/day)	57	57	57	57	57	57	57	57	57
Sand percentage (%)	75	60	90	75	75	75	75	75	75
Horizontal K (ft/day)	42.8	34.2	51.3	42.8	42.8	42.8	42.8	42.8	42.8
Anisotropic ratio	30	30	30	10	50	30	30	30	30
Vertical K (ft/day)	1.9	1.9	1.9	5.7	1.1	1.9	1.9	1.9	1.9
Storage									
Specific Yield	0.18	0.18	0.18	0.18	0.18	0.15	0.20	0.18	0.18
Specific Storage	5.5E-05	5.5E-05	5.5E-05	5.5E-05	5.5E-05	5.5E-05	5.5E-05	4.0E-05	7.0E-05
Simulation Time (years)	25	25	25	25	25	25	25	25	25

Notes:
1. Sensitivity simulations were conducted for the lower end and upper end of the estimated aquifer parameter range.
2. One parameter was modified in each sensitivity simulation (see highlighted parameter).

Table 1: Model Parameters

Results	Model Simulation								
	Base Case	Sensitivity Simulation							
		Sand %		Anisotropy		Specific Yield		Specific Storage	
		Lower End	Upper End	Lower End	Upper End	Lower End	Upper End	Lower End	Upper End
Pumping Wells									
maximum drawdown (ft)	36.9	47.0	30.5	32.3	39.2	36.9	36.9	36.9	36.9
time to maximum drawdown (yr)	9	13	12	8	7	6	12	8	10
200 feet east of pumping wells									
maximum drawdown (ft)	18.5	23.2	15.4	14.3	20.6	18.5	18.4	18.5	18.5
time to maximum drawdown (yr)	19	14	12	9	10	9	7	15	23
1/2 mile east of pumping wells									
maximum drawdown (ft)	5.2	6.5	4.4	3.6	6.2	5.2	5.2	5.2	5.2
time to maximum drawdown (yr)	7	21	9	6	7	5	10	7	8
1 mile east of pumping wells									
maximum drawdown (ft)	2.0	2.4	1.7	1.5	2.4	2.0	2.0	2.0	2.0
time to maximum drawdown (yr)	8	7	6	7	10	5	12	7	9

Notes:

1. Results are summarized for observation points east of the pumping wells because this is the direction in which maximum drawdown occurs within BVWSD.

Table 2: Summary of Simulation Results

FIGURES

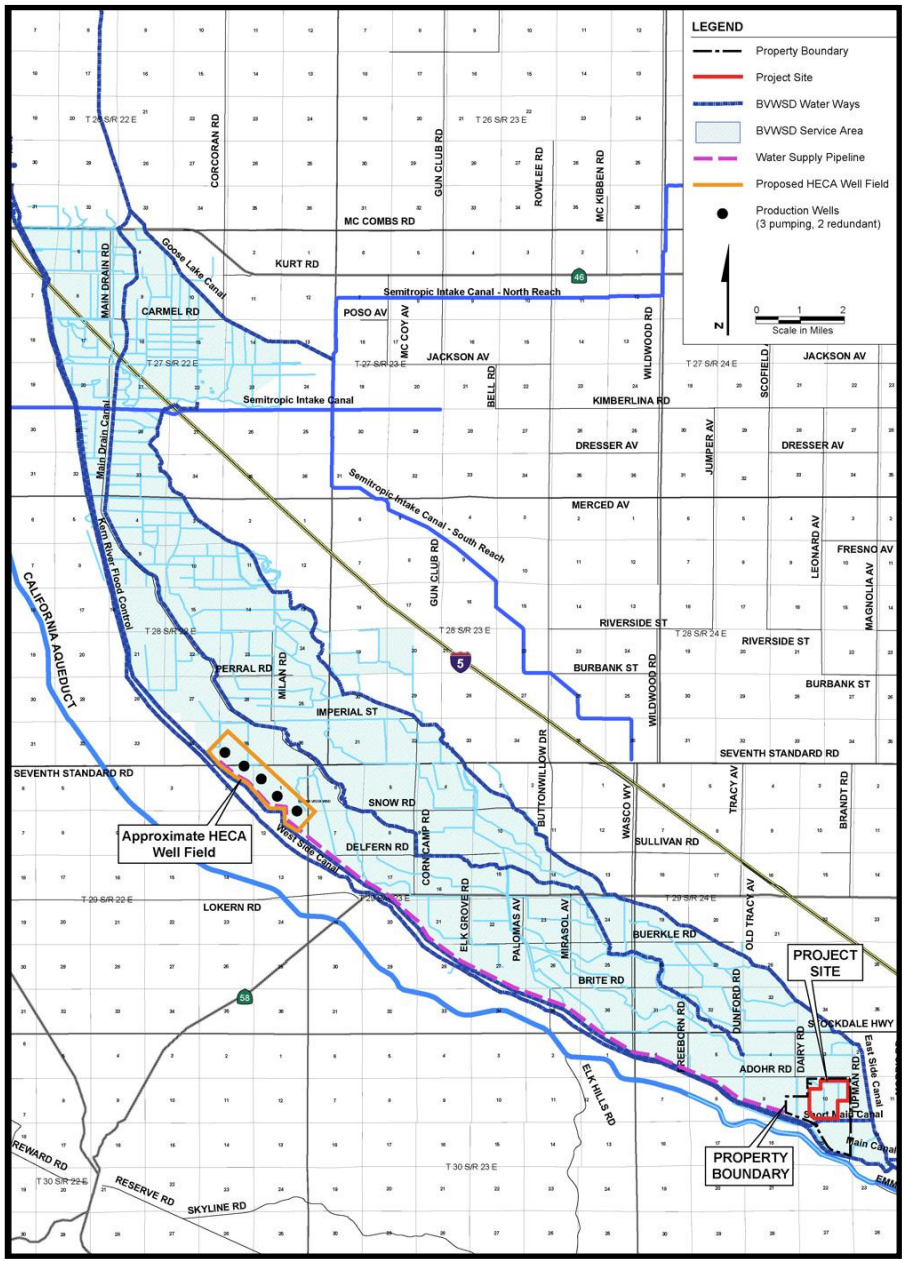


Figure 1: Project Site and Water Supply Well Field Location

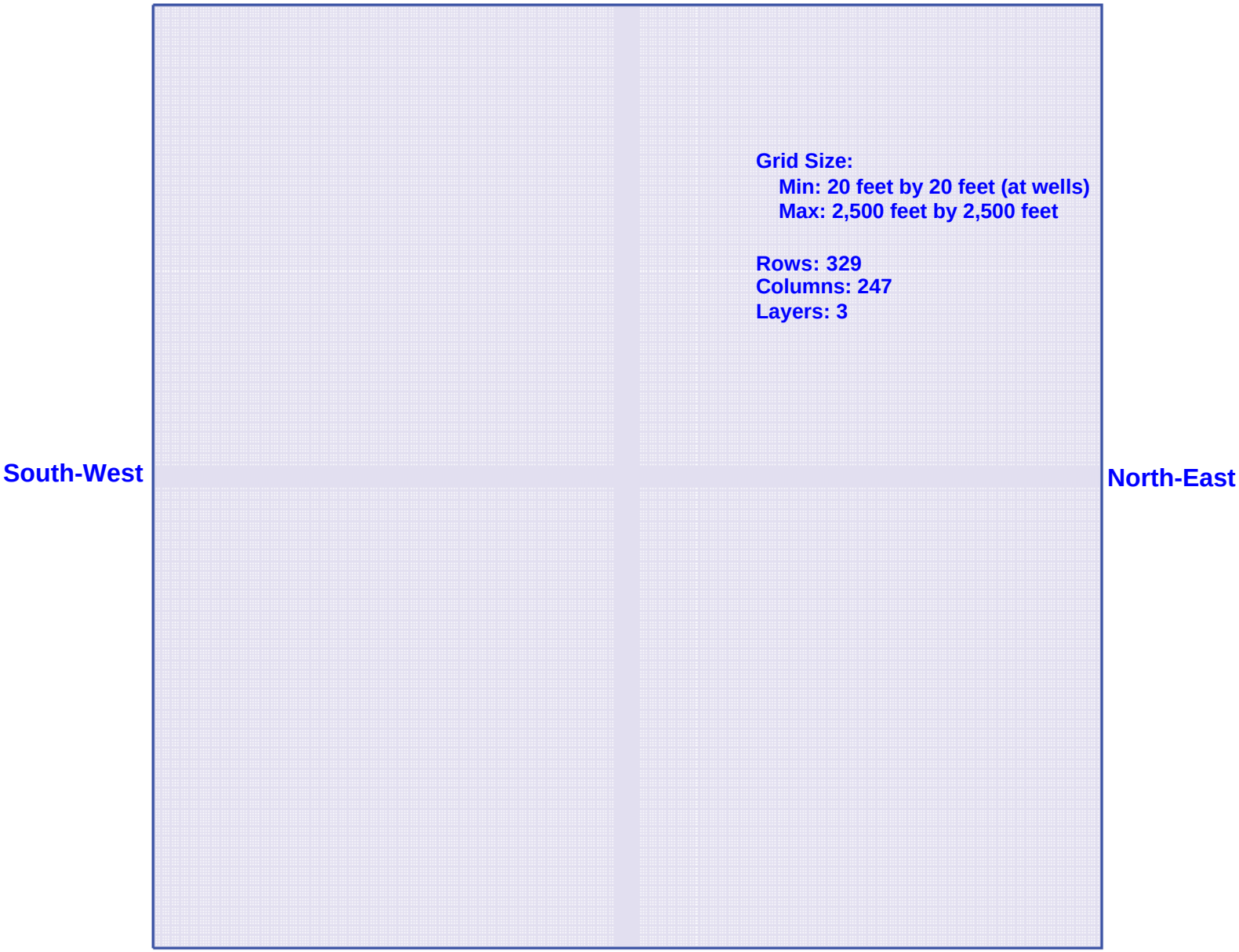


Figure 2: Model Domain and Finite-difference Discretization

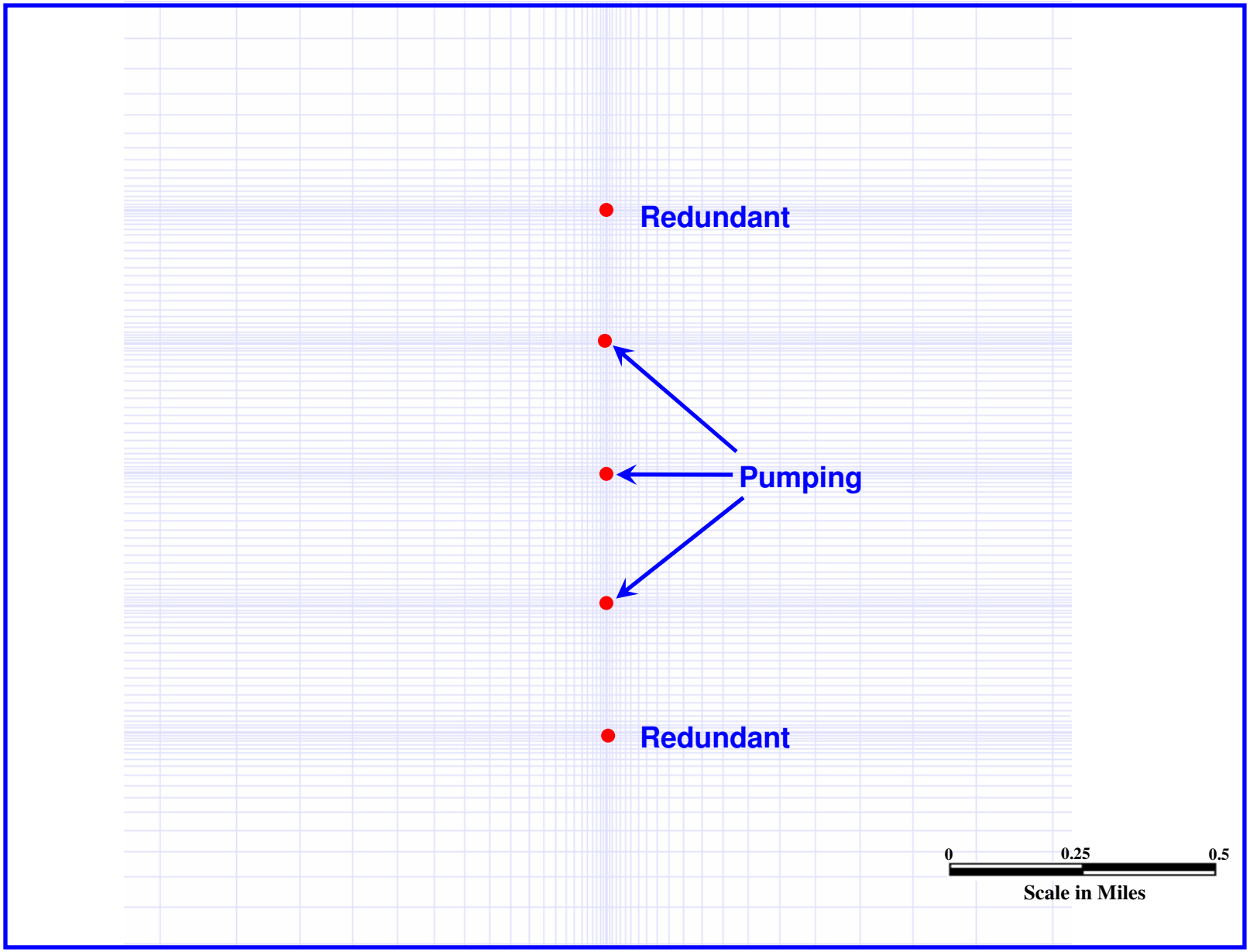


Figure 3: Pumping Well Locations in Model

(Well Spacing = 0.25 mile)

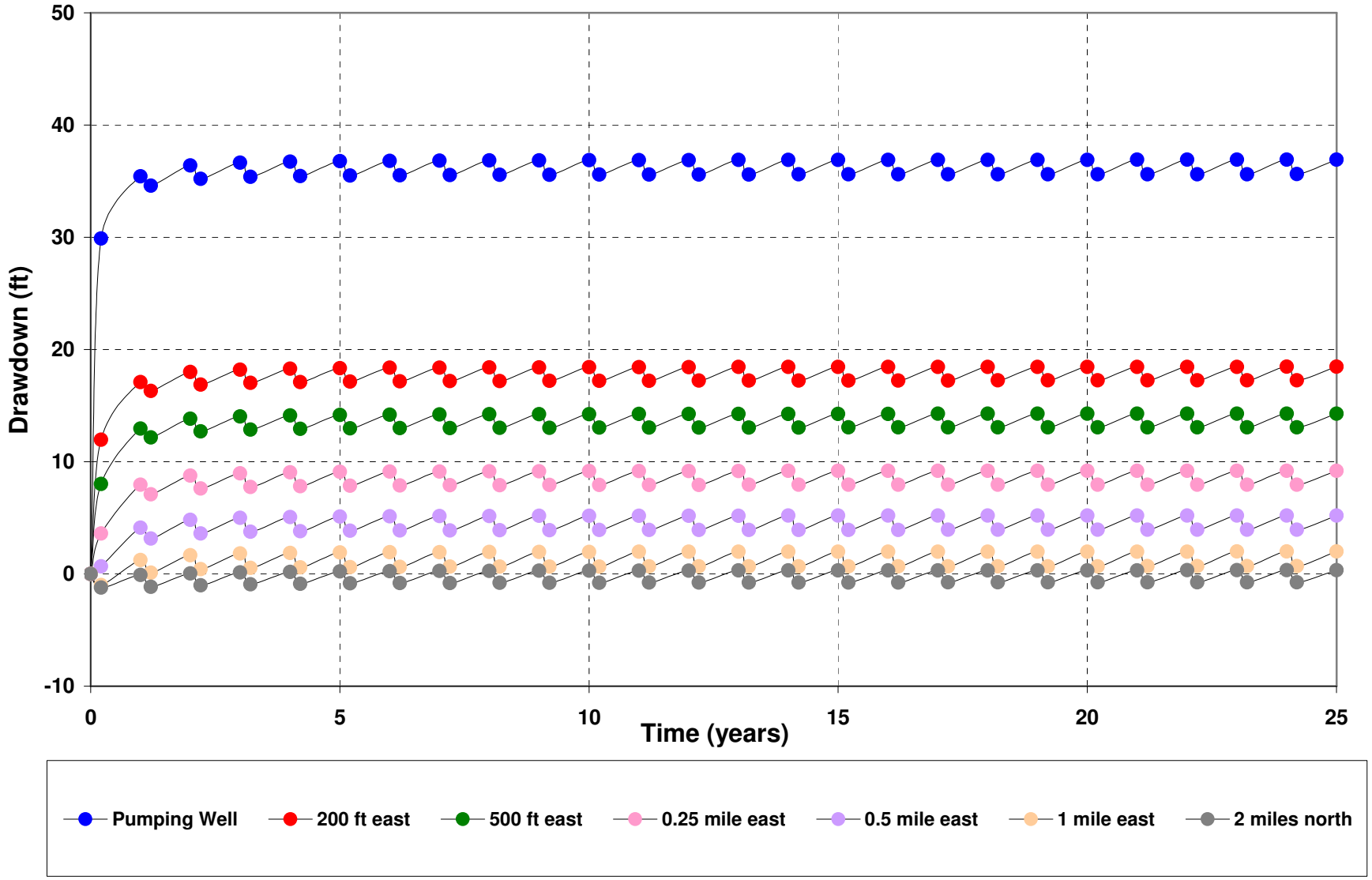


Figure 4: Simulated Drawdown at Select Observation Points

Base Case

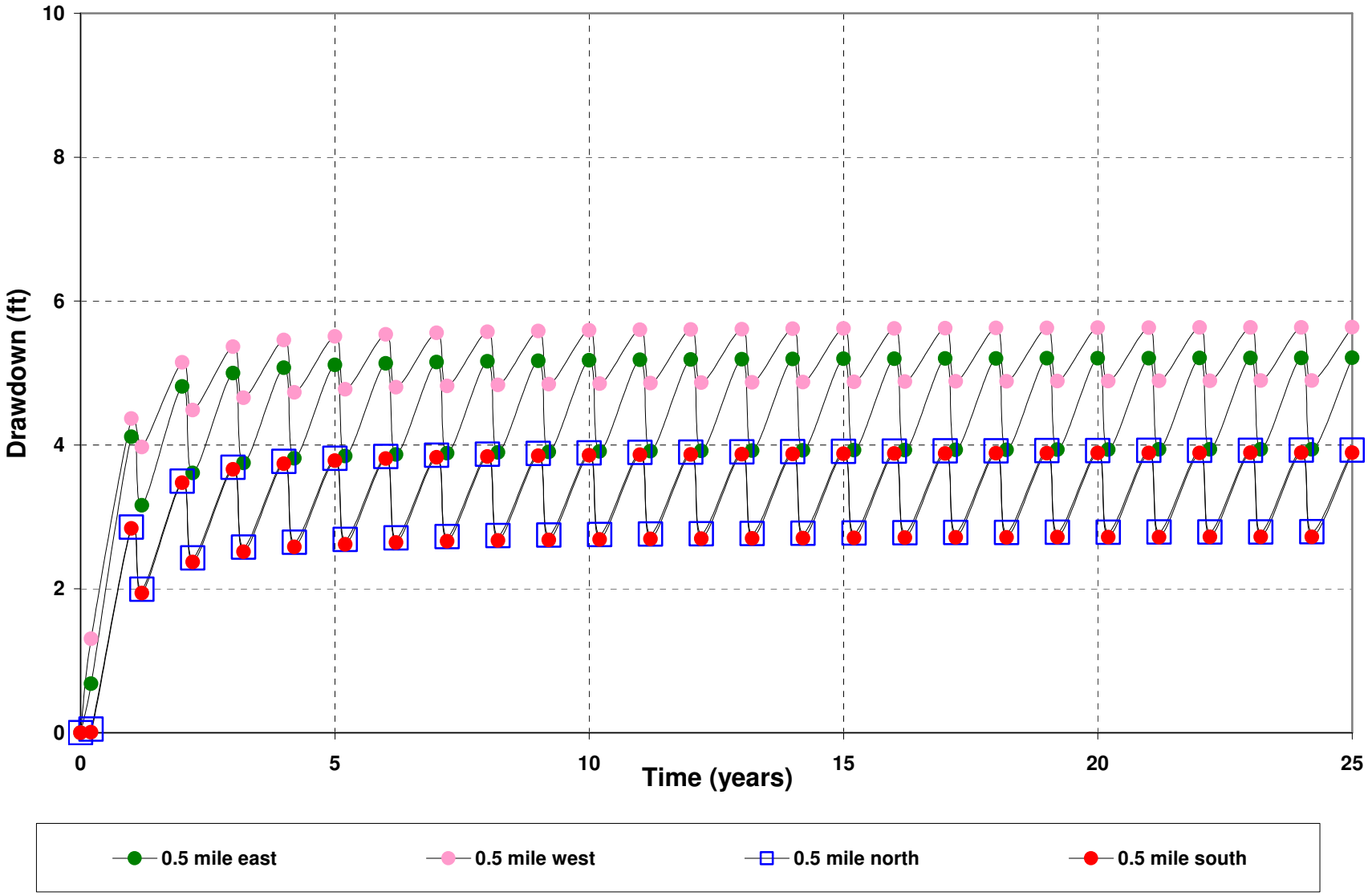
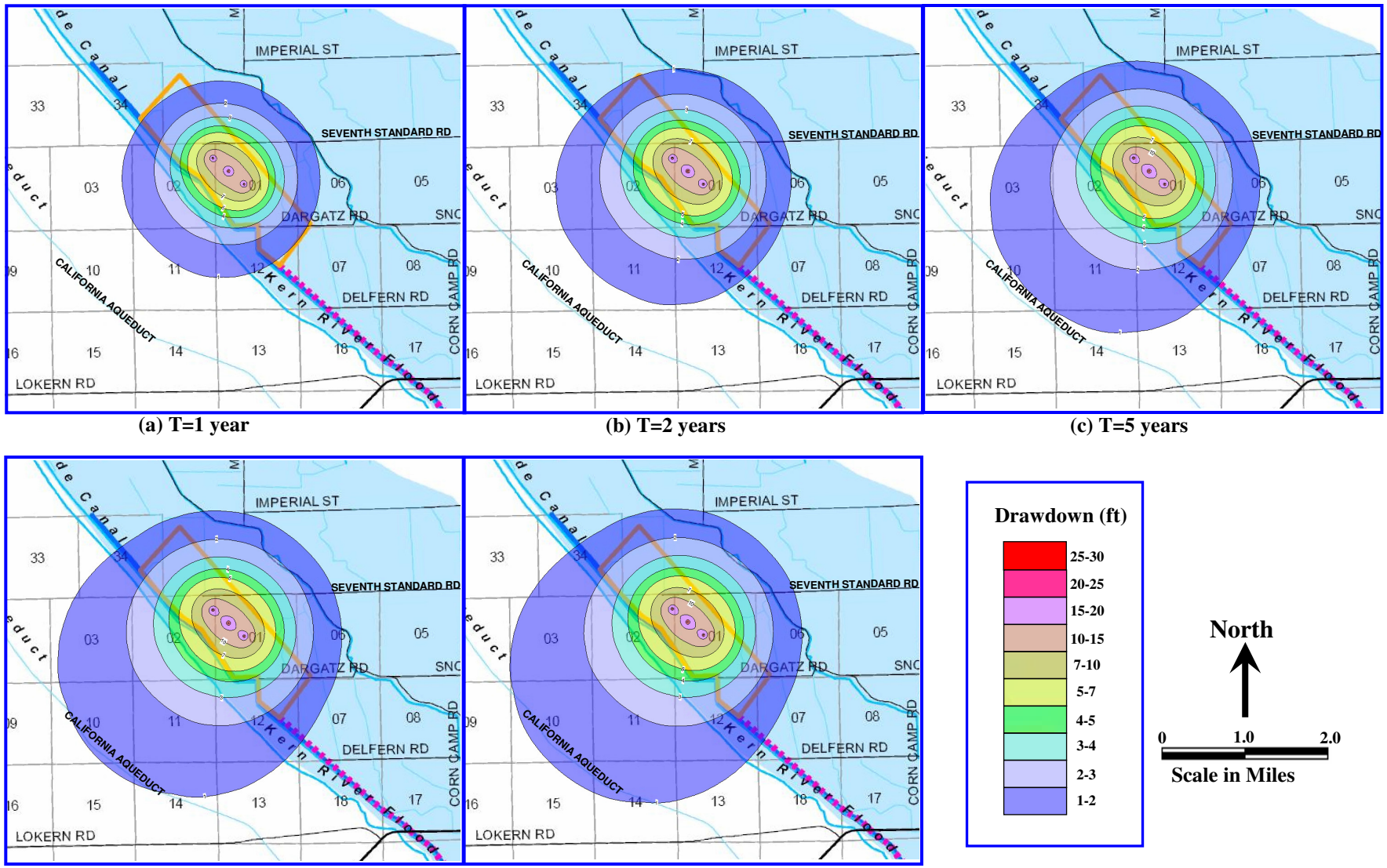


Figure 5: Simulated Drawdown at 0.5 Mile from the Pumping Wells in East, West, North, and South Directions - Base Case

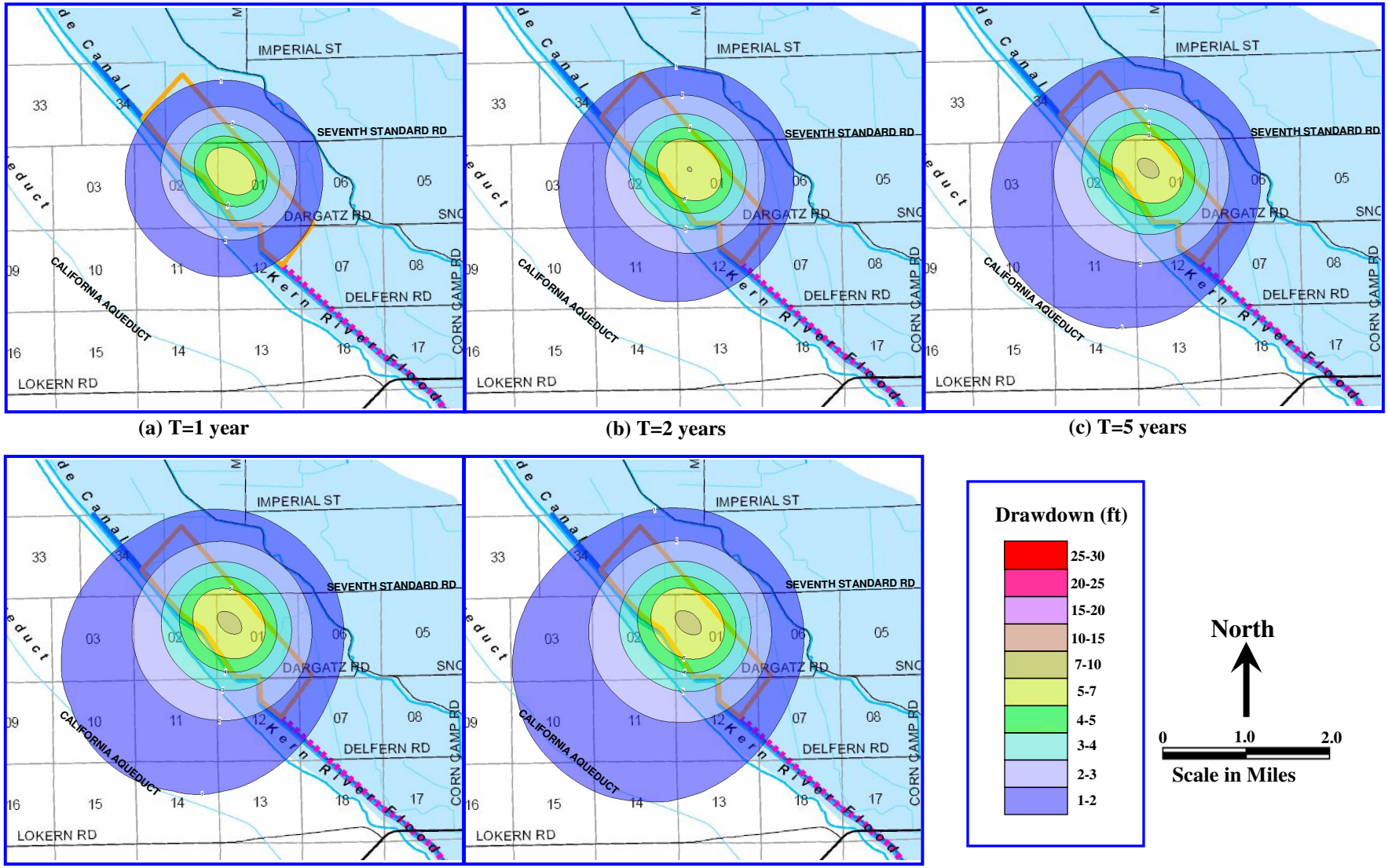


(a) T=1 year (b) T=2 years (c) T=5 years

(d) T=10 year (e) T=25 years

Figure 6: Contour Maps of Simulated Drawdown in Shallow Zone (Model Layer 1) at Various Times – Base Case

(Contour intervals = 1, 2, 3, 4, 5, 7, 10, 15, 20, 25, and 30 ft)

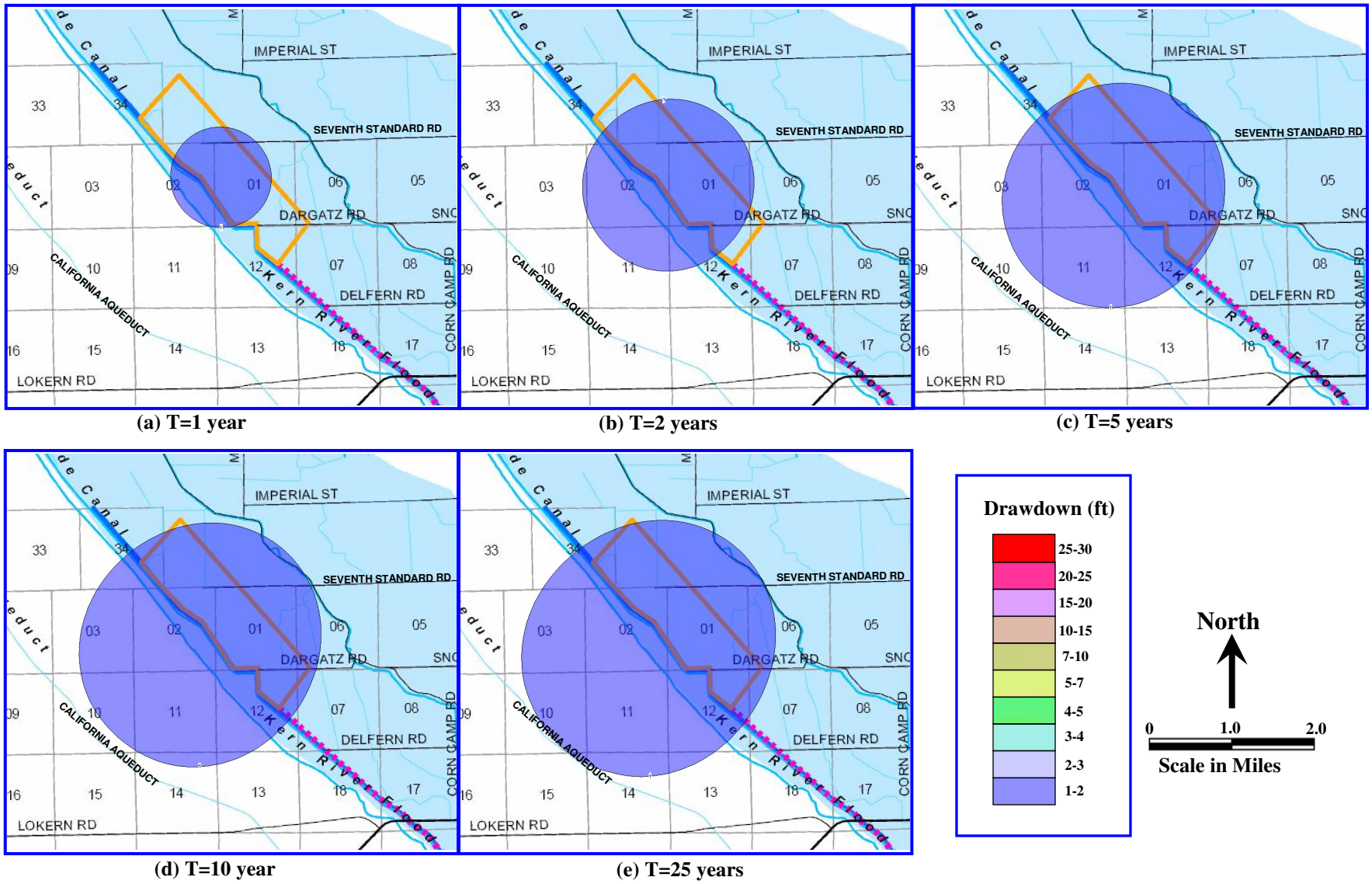


(a) T=1 year (b) T=2 years (c) T=5 years

(d) T=10 year (e) T=25 years

Figure 7: Contour Maps of Simulated Drawdown in Deep Zone (Model Layer 2) at Various Times – Base Case

(Contour intervals = 1, 2, 3, 4, 5, 7, 10, 15, 20, 25, and 30 ft)



(a) T=1 year (b) T=2 years (c) T=5 years

(d) T=10 year (e) T=25 years

Figure 8: Contour Maps of Simulated Drawdown in Deeper Zone (Model Layer 3) at Various Times – Base Case

(Contour intervals = 1, 2, 3, 4, 5, 7, 10, 15, 20, 25, and 30 ft)

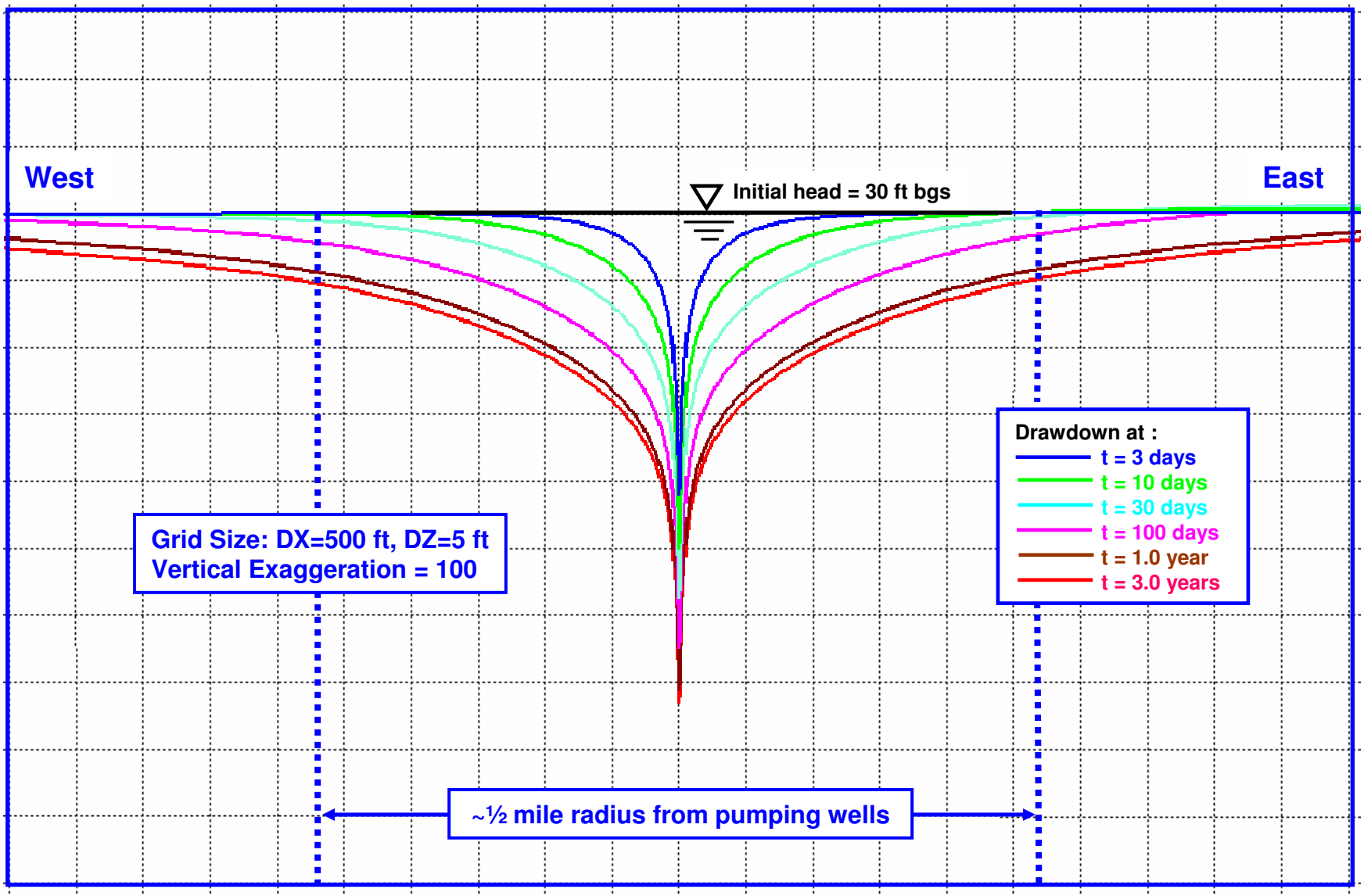


Figure 9: Simulated Groundwater Table Profiles at Various Simulation Times (perpendicular to well line)

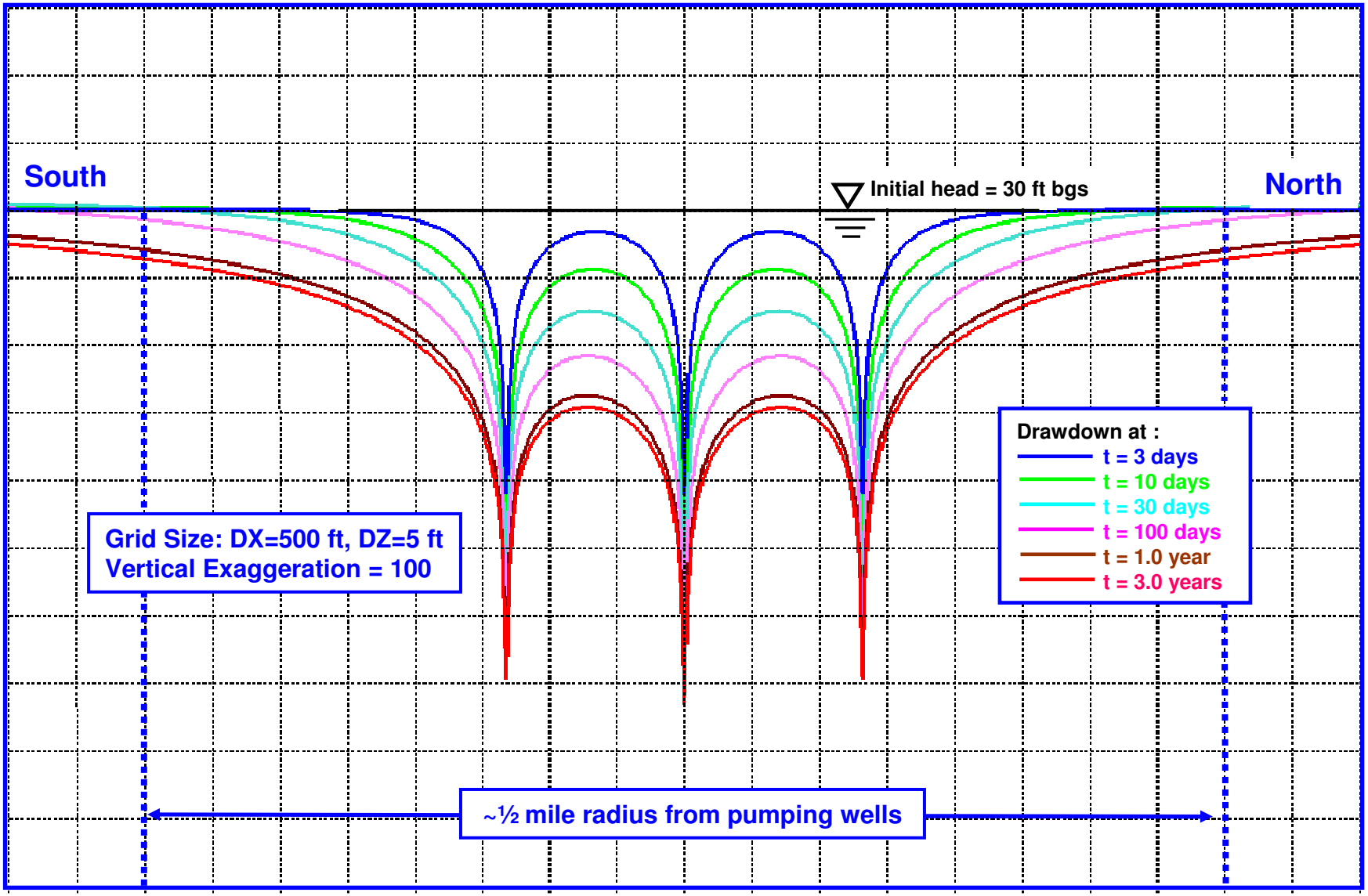


Figure 10: Simulated Groundwater Table Profiles at Various Simulation Times (along well line)

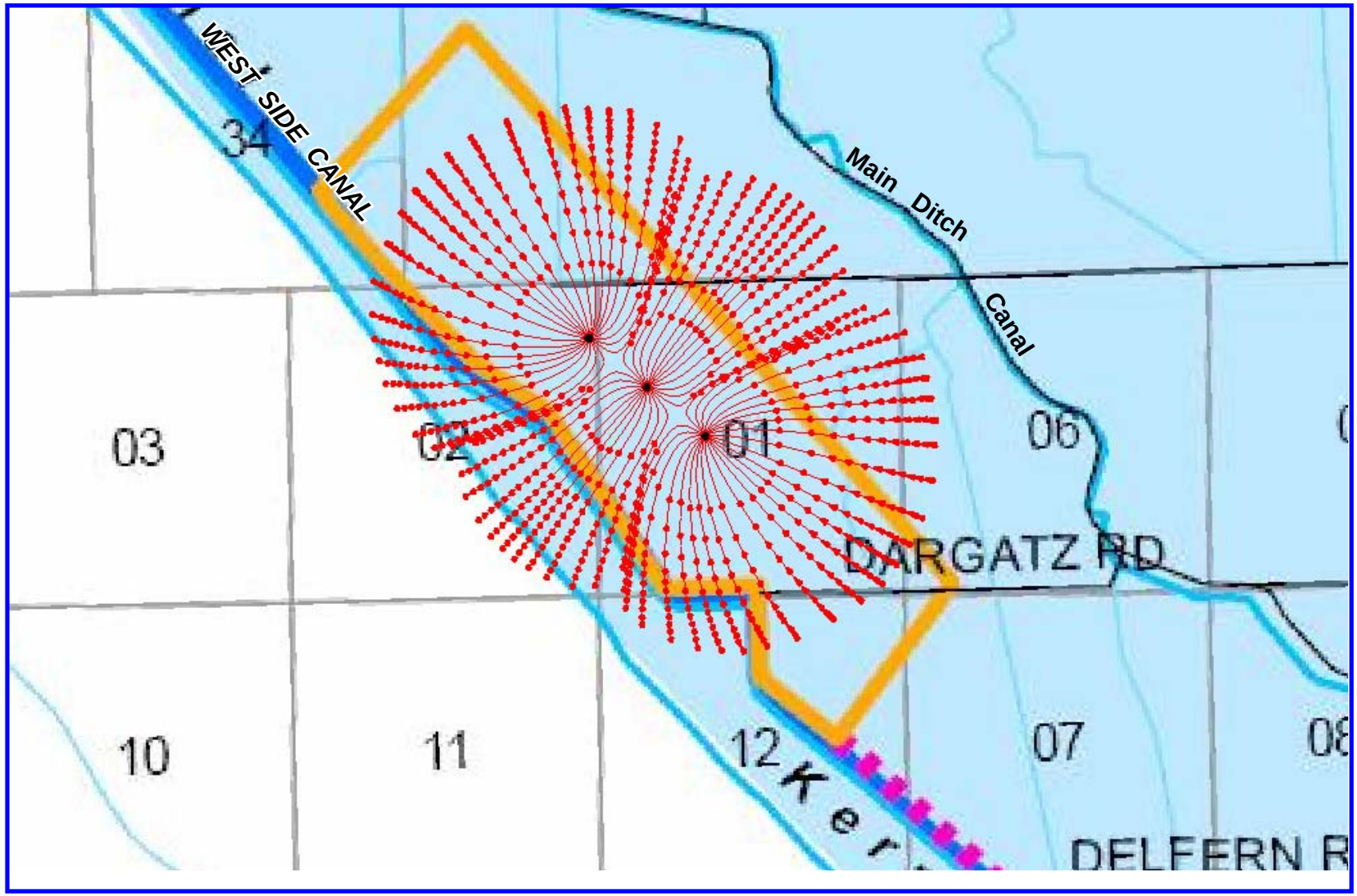


Figure 11: Simulated Groundwater Pathlines Induced by Project Pumping (travel time between arrow intervals = 2.0 years)

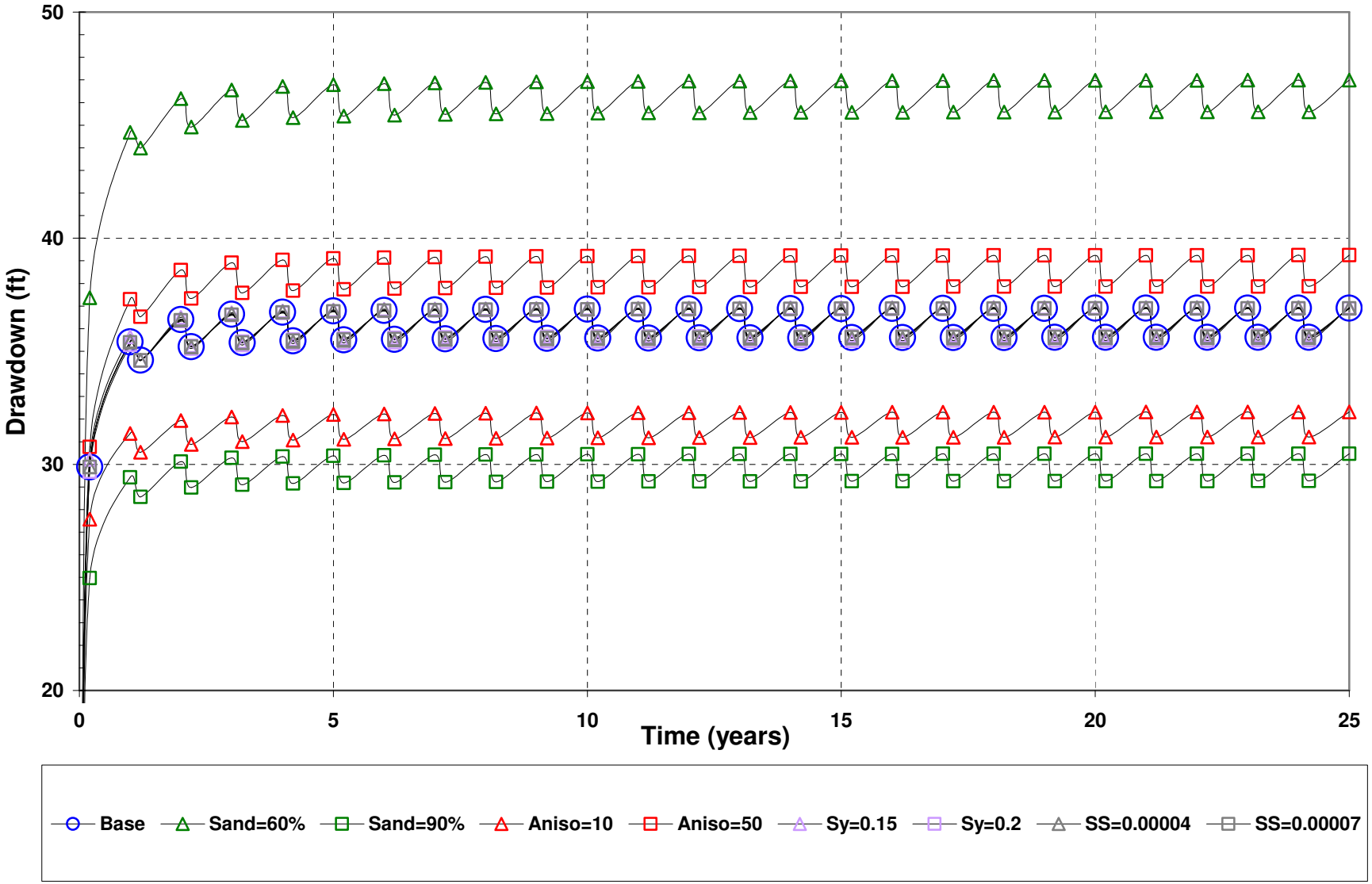


Figure 12: Sensitivity Comparison –

Simulated Drawdown at Pumping Wells

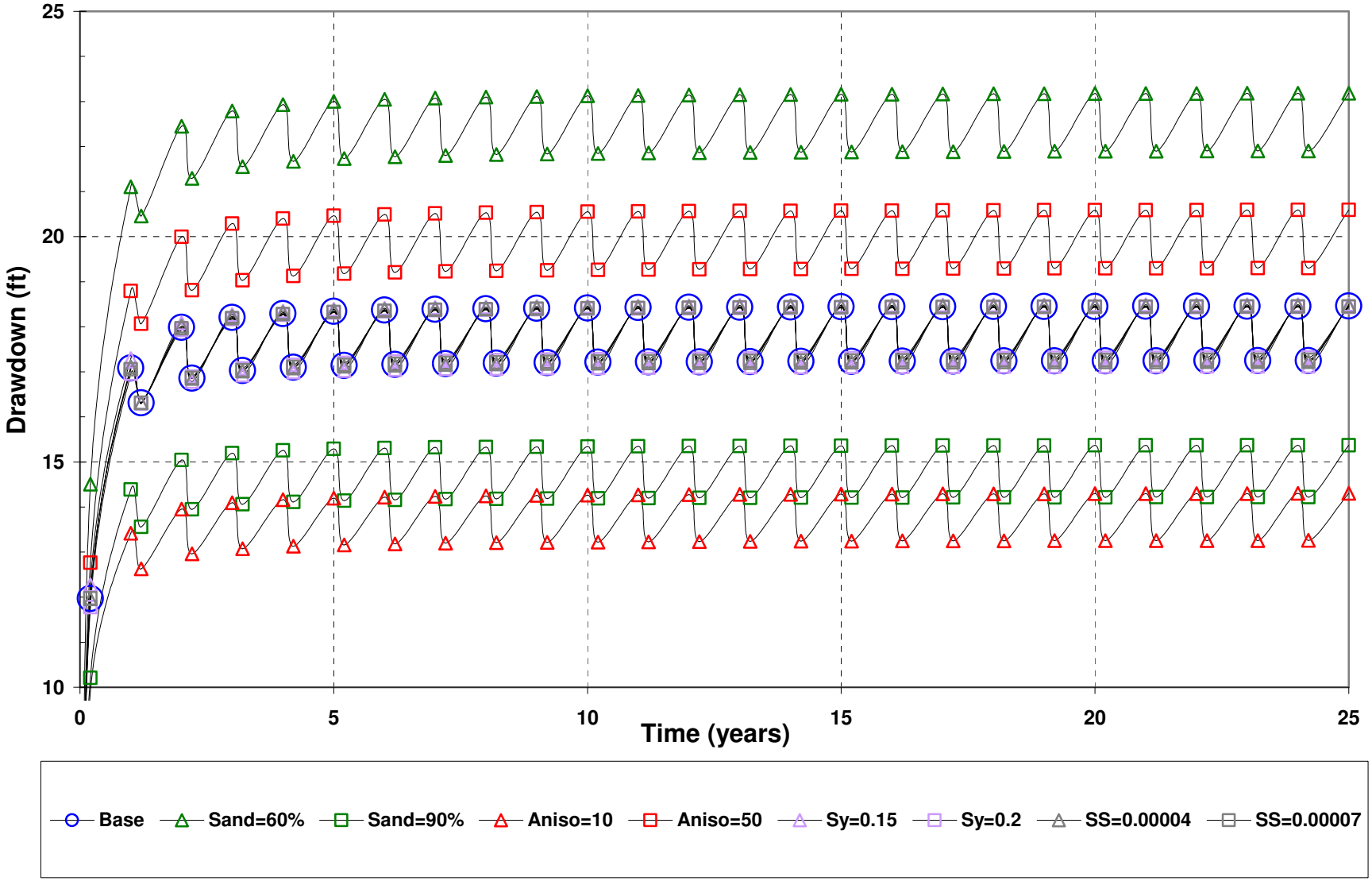


Figure 13: Sensitivity Comparison –

Simulated Drawdown 200 ft East of Pumping Wells

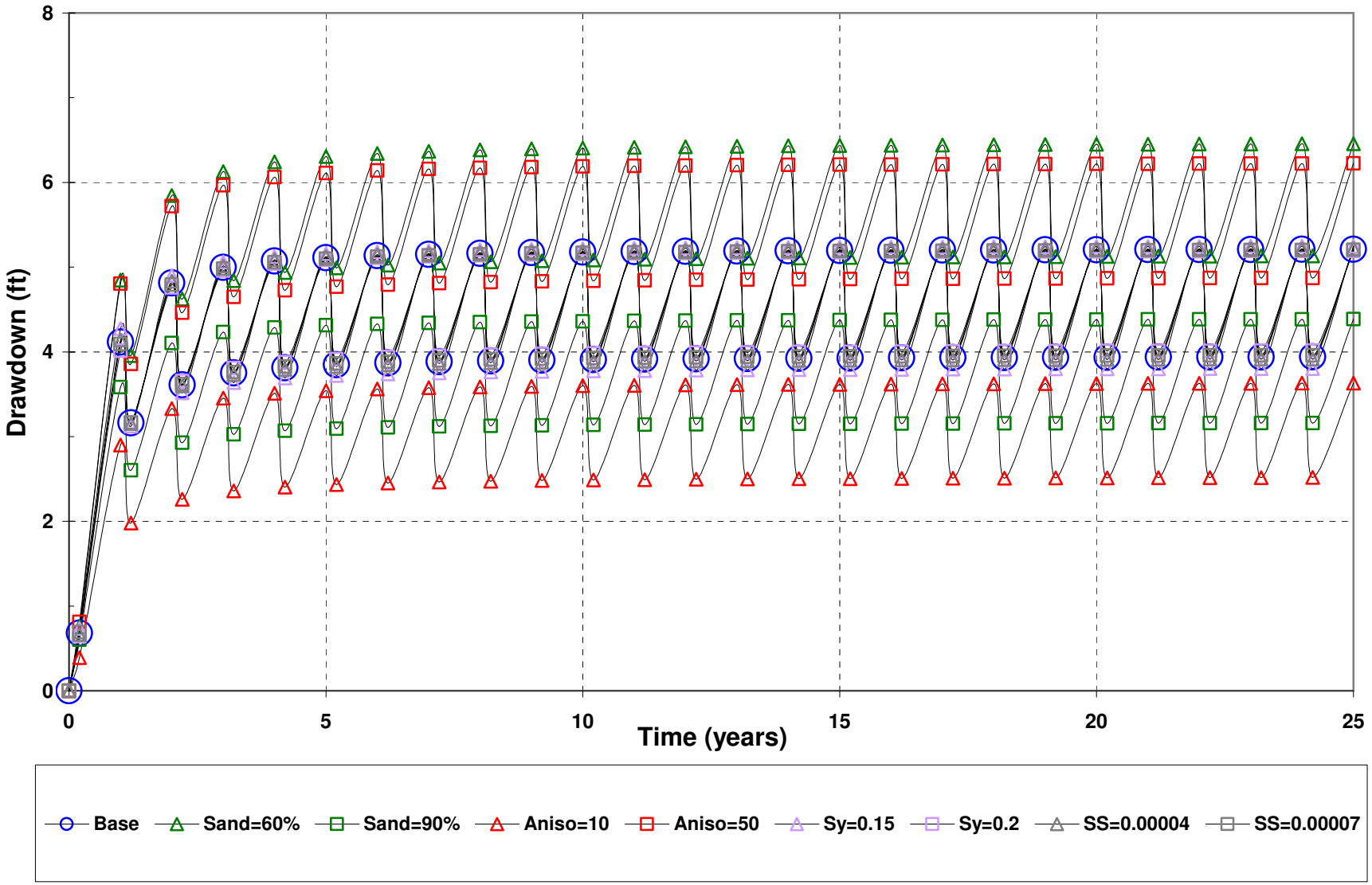


Figure 14: Sensitivity Comparison –

Simulated Drawdown 0.5 Mile East of Pumping Wells

Appendix O3

Hydrology Study

HYDROGEN ENERGY CALIFORNIA (HECA)

KERN COUNTY POWER PROJECT

PRELIMINARY HYDROLOGY STUDY

Rev. No.	Date	By	Checked	Approved
0	05/19/09	P. Fortier	B. Eisenbise	W. Becktel

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Analysis Parameters

Existing Site Parameters

Area:	473 ac
Stream Length:	5,176 ft
High Point Elevation	288 ft
Low Point Elevation	285 ft
Delta Elevation:	3 ft
Slope:	0.0006 ft/ft

Soil Characteristic

Soil Type:	Clay and Silty-Clay
Soil Group:	D

Reference: *Prelimnary Geotechnical Investigations*
Kern County Hydrology Manual - Section C.3 - Hydrologic Soil Group

Rainfall Event

Storm Duration:	24 h
Storm Distribution:	Type 1
Rainfall Depth:	

Storm Frequencies	***Rainfall*** (in)
2-yr	0.9
5-yr	1.2
10-yr	1.4
25-yr	1.6
50-yr	1.8
100-Yr	2.0

Reference: *NOAA Atlas 2 - Volume 11 California*

Ground Cover

Existing:

Drainage Area	***Surface***	***Condition***	***Area***	***Impervious*** [1]	***CN***	***CNw*** [2]
DE	Agricultural Close Seeded	Good	473 ac	3%	85	85

Proposed:

Drainage Area	***Surface***	***Condition***	***Area***	***Impervious*** [1]	***CN***	***CNw*** [2]
DA 1	Grass, Meadow	Good	110 ac	10%	78	80
DA 2	Grass, Meadow	Good	31 ac	10%	78	80
DA 3	Grass, Meadow	Good	144 ac	10%	78	80
DA 4	Process Area, Gravel	Good	76 ac	85%	91	97
DA 5	Grass Meadow	Good	70 ac	40%	78	86
DA 6	Paved, Grass Meadow	Good	13 ac	60%	78	90
DA 7	Process Area, Gravel	Good	11 ac	95%	91	98
DA 8	Process Area, Gravel	Good	15 ac	95%	91	98
DA 9	Process Area, Gravel	Good	3 ac	95%	91	98
Total			**473 ac**			

Reference: *Kern County Hydrology Manual - Figure C-2*

Notes: *1) Impervious surfaces have a CN value of 98*
2) CNw is the weighted CN value of the impervious and pervious surfaces

Analysis Summary Table

Duration: 24-Hour

Existing:	10-Year		50-Year		100-Year	
	Peak Flow	***Hydrograph Vol.***	***Peak Flow***	***Hydrograph Vol.***	***Peak Flow***	***Hydrograph Vol.***
Drainage Area	(cfs)	(ac/ft)	(cfs)	(ac/ft)	(cfs)	(ac/ft)
DE	15.4	15.4	27.1	25.7	33.7	31.3

Proposed:						
	Peak Flow	***Hydrograph Vol.***	***Peak Flow***	***Hydrograph Vol.***	***Peak Flow***	***Hydrograph Vol.***
Drainage Area	(cfs)	(ac/ft)	(cfs)	(ac/ft)	(cfs)	(ac/ft)
DA 1	2.9	2.2	6.5	4.1	8.8	5.2
DA 2	0.9	0.6	1.8	1.1	2.9	1.5
DA 3	3.5	2.9	6.7	4.9	10.2	6.7
DA 4	37.0	6.9	49.9	9.3	56.3	10.6
DA 5	6.8	2.5	12.6	4.1	15.8	5.0
DA 6	3.5	0.7	5.5	1.0	6.7	1.2
DA 7	7.9	1.1	10.5	1.4	11.7	1.6
DA 8	9.1	1.5	12.0	2.0	13.5	2.2
DA 9	2.4	0.3	3.1	0.4	3.5	0.4
Total		**18.5**		**28.3**		**34.4**

Storm Water Retention Volume Kern County

	Rainfall	***% Impervious***	***Area***	***Kern Co. Ret. Volume*** [1]	**Ret. Basin**[2]
Drainage Area	D_{10}	a_i	(ac)	(ac/ft)	ID
DA 1	1.4	10%	110	1.8	Ret #1
DA 2	1.4	10%	31	0.5	Ret #2
DA 3	1.4	10%	144	2.4	Ret #3
DA 4	1.4	85%	76	10.9	Ret #4
DA 5	1.4	40%	70	4.7	Ret #5
DA 6	1.4	60%	13	N/A[3]	Sump #1
DA 7	1.4	95%	15	N/A[3]	Sump #2
DA 8	1.4	95%	11	N/A[3]	Sump #3
DA 9	1.4	95%	3	0.5	Ret #6
Total			**473**	**20.8**	

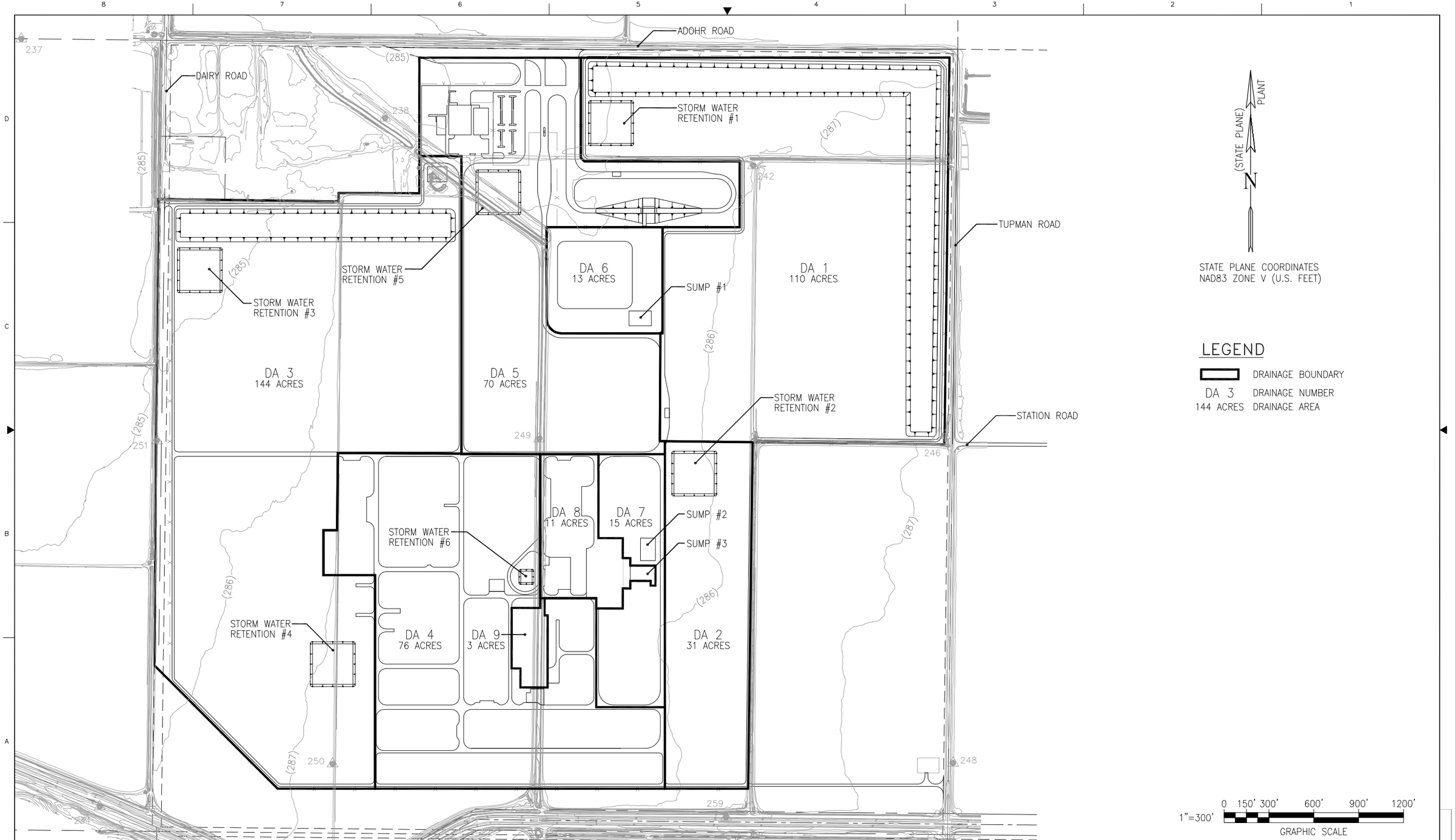
Note:

1) Kern County Hydrology Manual - Section VIII - Retention Basin Design
Section 408.1 -Design Volume:
Runoff Volume from the ISDD five day storm event = 0.12 (D_{10}) (a_i) (Area)
D_{10} = 10 year 24 hour depth of rainfall
a_i = average percentages of impervious
Area = Drainage Area
2) Refer to Civil Hydrology Map, DWG No. SK-HYDRO-01 in Appendix A
3) Runoff draining to sumps will be retained within process units and solid handling areas for reuse.

Key Design Assumptions and Methodologies

The application HydroFlow Storm Sewer 2005 by Inteli Solve has been used for calculations.
Preliminary Geotechnical Investigation, Proposed Hydrogen Energy California Project, Dated March 2009
Kern County Hydrology Manual
NOAA Atlas 2 - Precipitation Frequency Atlas Western United States - Volume 11 California

APPENDIX A – HYDROLOGY MAP



REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	19MAY	INITIAL ISSUE	OD	PMF	BRE

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
SK-250-1001	PRELIMINARY PLOT PLAN
SK-210-1001	PRELIMINARY GRADING PLAN
SK-210-1002	PRELIMINARY DRAINAGE PLAN
SK-210-1003	PRELIMINARY PAVING PLAN

FLUOR

NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF FLUOR AND IS LENT TO THE BORROWER FOR THEIR CONFIDENTIAL USE ONLY, AND IN CONSIDERATION OF THE LOAN OF THIS DRAWING, THE BORROWER PROMISES AND AGREES TO RETURN IT UPON REQUEST AND AGREES THAT IT WILL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS FURNISHED.

CONTRACT A3RW
DESIGNED BY O.DIAZ
CHECKED BY P.FORTIER
SUPERVISOR B.EISENBISE — APP DATE –
LEAD ENGR/SPEC. — APP DATE –
FLUOR — APP DATE –
CLIENT — APP DATE –

HYDROGEN ENERGY CALIFORNIA
KERN COUNTY POWER PROJECT

CIVIL
PRELIMINARY
HYDROLOGY MAP

SCALE 1:300'
DRAWING NUMBER SK-HYDRO-01
REV A
CAD FILE NAME A3RW-SK-HYDRO-01.DWG

S&P NWA
DST CODE

PLOT DATE:
XREF ATTACHED – YES ☐ NO ☐
MANUAL CHANGES MADE – YES ☐ NO ☐
DWG FILE UPDATED – YES ☐ NO ☐
MODEL UPDATED – YES ☐ NO ☐

APPENDIX B - PRE-DEVELOPMENT ANALYSES

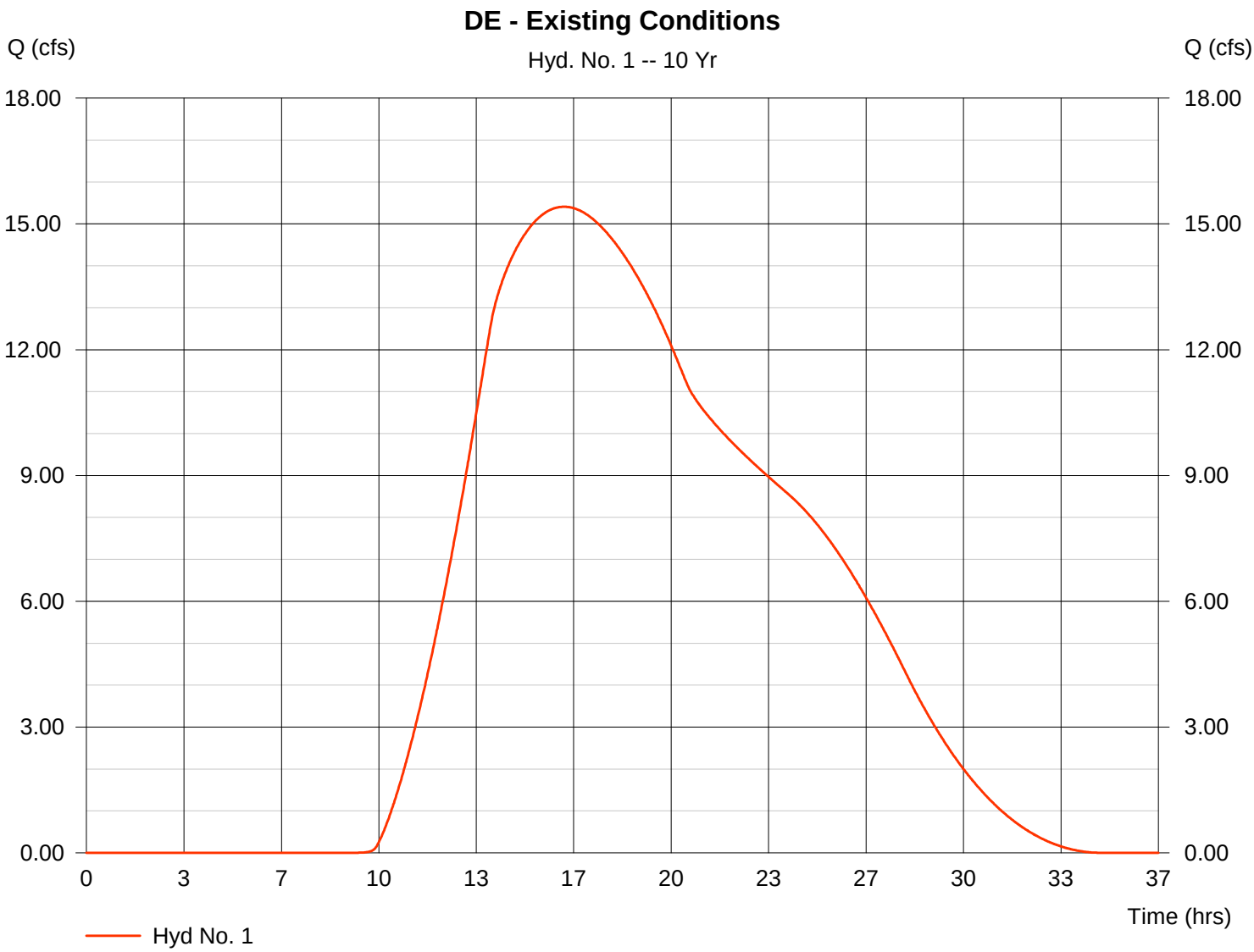
Hydrograph Plot

Hyd. No. 1

DE - Existing Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 15.41 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 473.000 ac	Curve number	= 85
Basin Slope	= 0.1 %	Hydraulic length	= 5175 ft
Tc method	= LAG	Time of conc. (Tc)	= 410.51 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 669,121 cuft



Hydrograph Plot

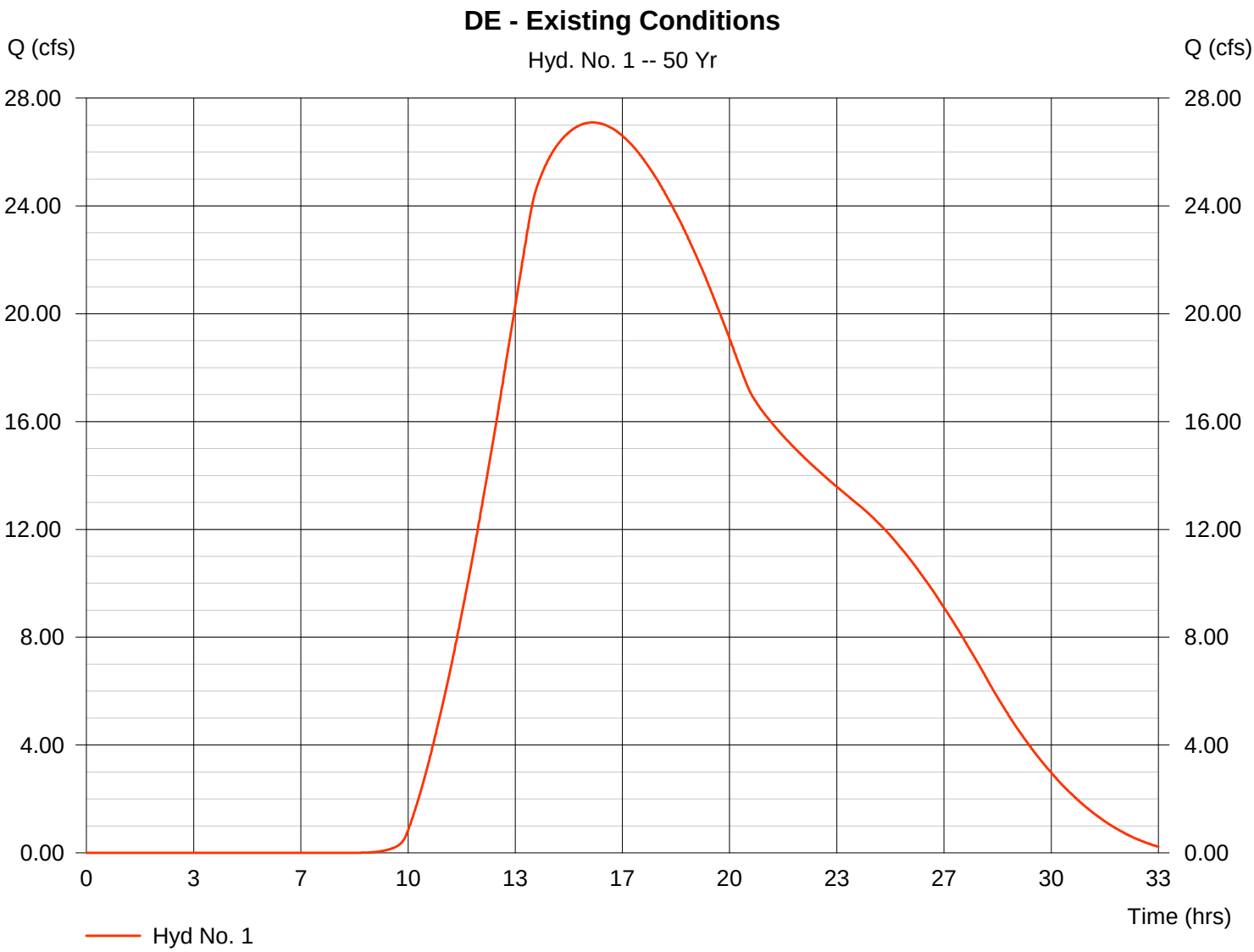
Hydraflow Hydrographs by Intelisolve | Tuesday, May 19 2009, 7:40 AM

Hyd. No. 1

DE - Existing Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 27.10 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 473.000 ac	Curve number	= 85
Basin Slope	= 0.1 %	Hydraulic length	= 5175 ft
Tc method	= LAG	Time of conc. (Tc)	= 410.51 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 1,118,846 cuft



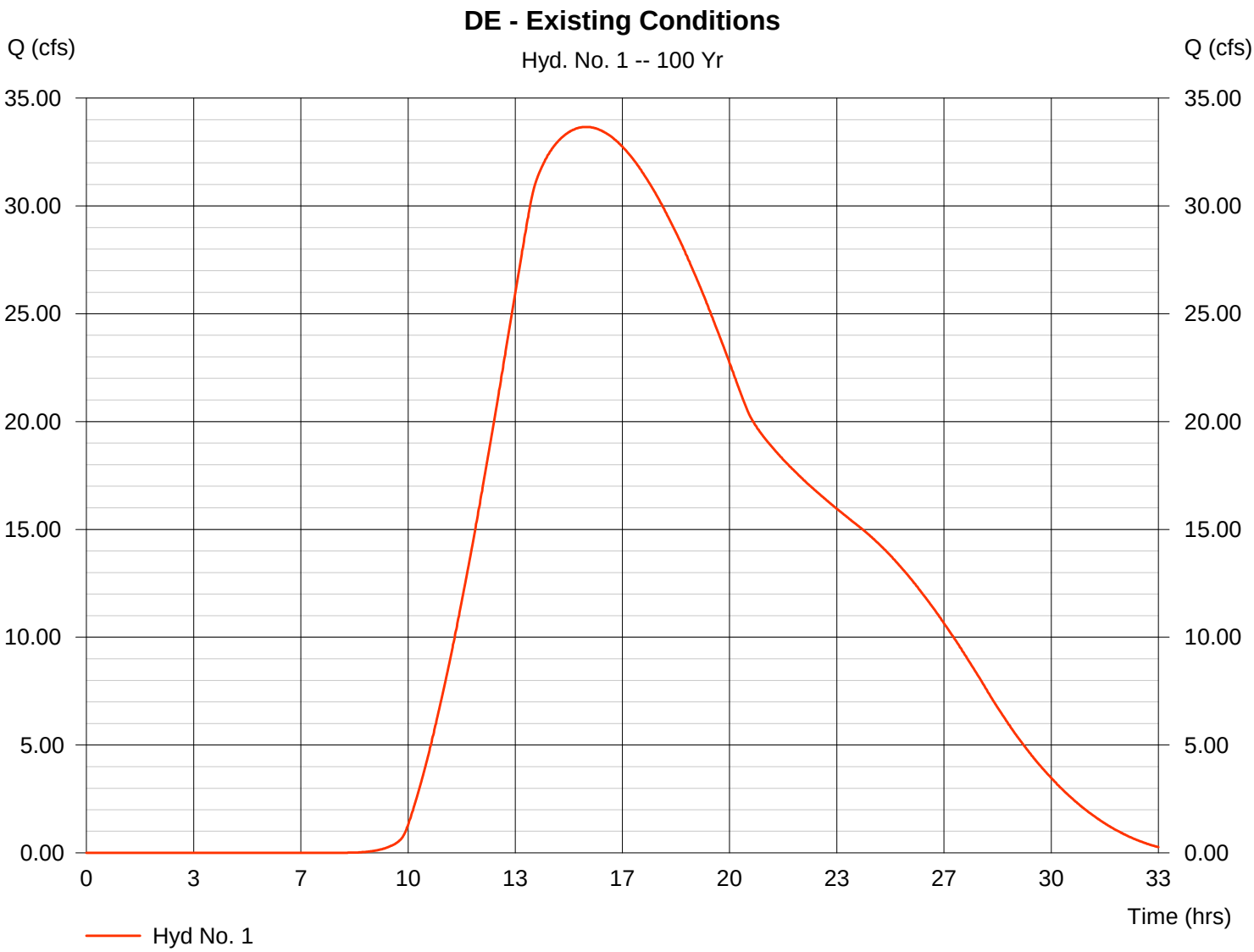
Hydrograph Plot

Hyd. No. 1

DE - Existing Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 33.67 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 473.000 ac	Curve number	= 85
Basin Slope	= 0.1 %	Hydraulic length	= 5175 ft
Tc method	= LAG	Time of conc. (Tc)	= 410.51 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 1,364,523 cuft



APPENDIX C - POST-DEVELOPMENT ANALYSES

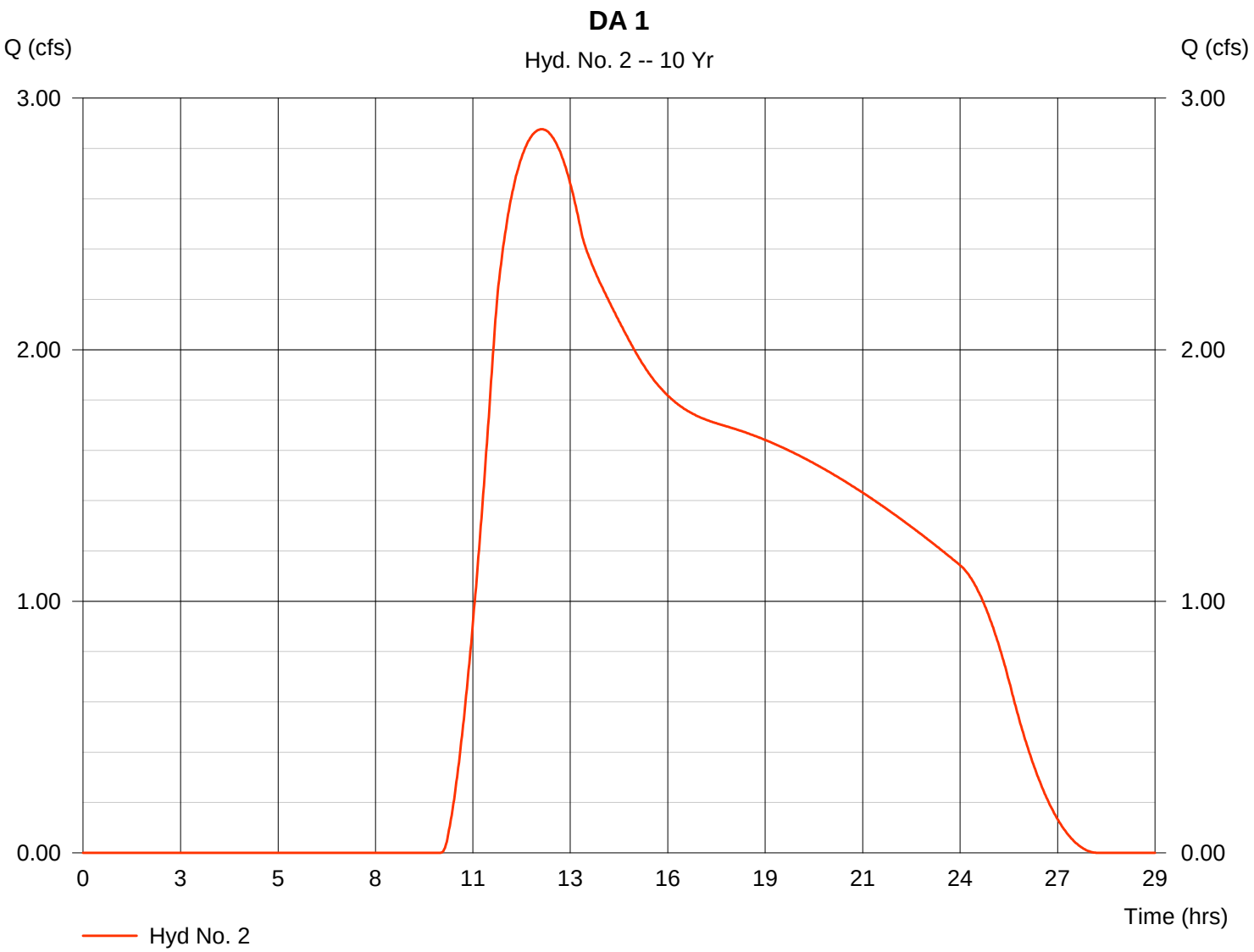
Hydrograph Plot

Hyd. No. 2

DA 1

Hydrograph type	= SCS Runoff	Peak discharge	= 2.88 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 110.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 3100 ft
Tc method	= LAG	Time of conc. (Tc)	= 143.71 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 95,267 cuft



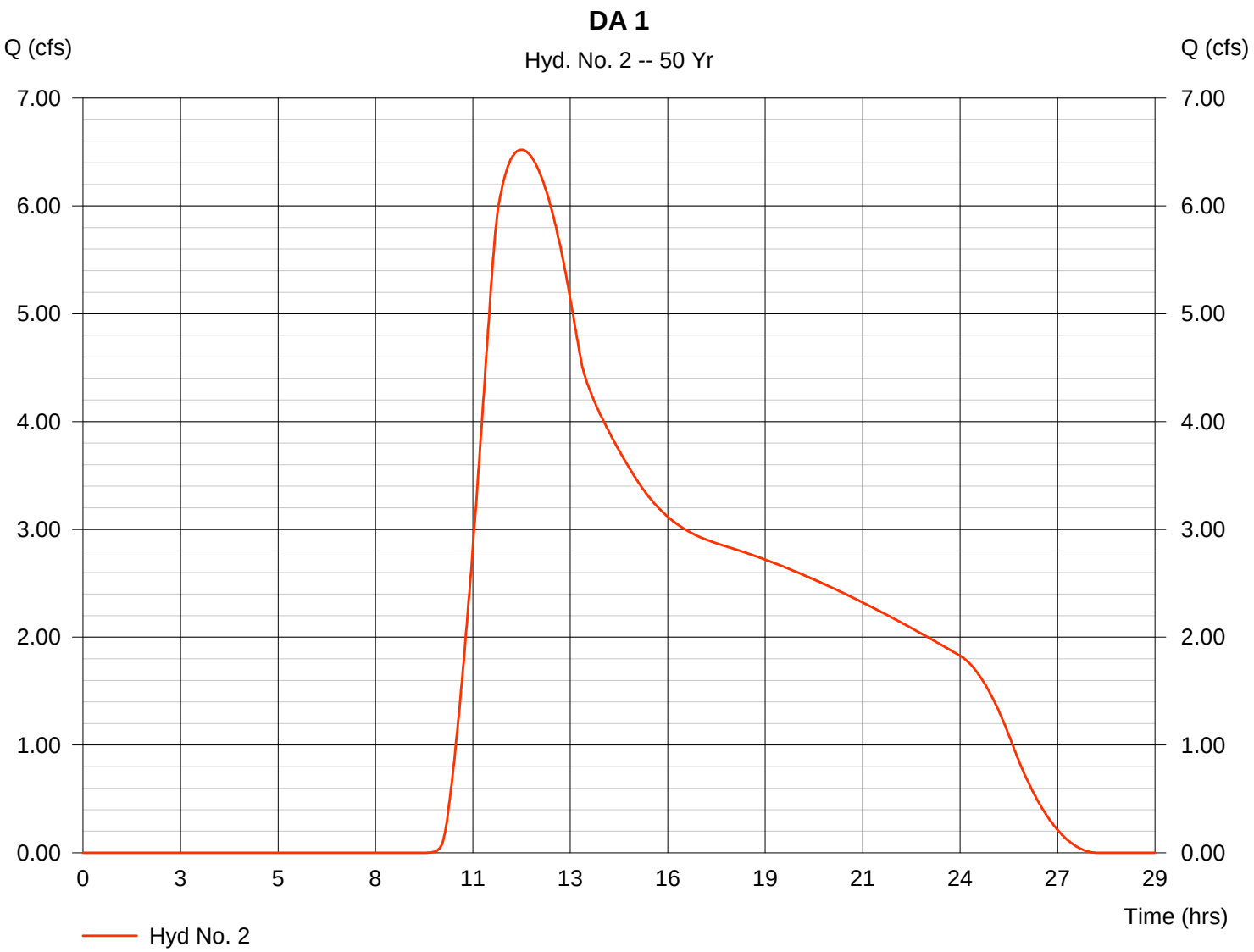
Hydrograph Plot

Hyd. No. 2

DA 1

Hydrograph type	= SCS Runoff	Peak discharge	= 6.52 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 110.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 3100 ft
Tc method	= LAG	Time of conc. (Tc)	= 143.71 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 177,845 cuft



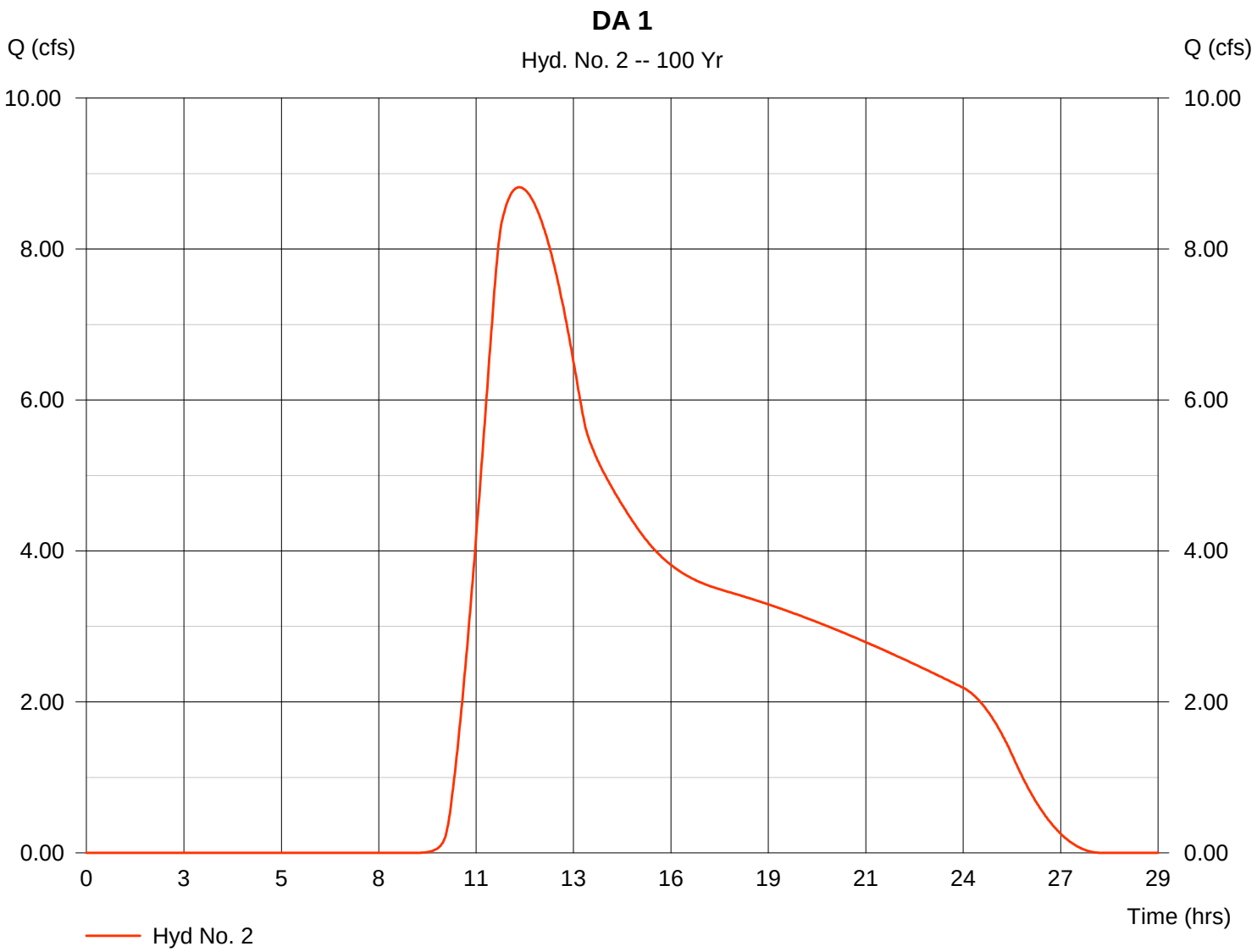
Hydrograph Plot

Hyd. No. 2

DA 1

Hydrograph type	= SCS Runoff	Peak discharge	= 8.82 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 110.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 3100 ft
Tc method	= LAG	Time of conc. (Tc)	= 143.71 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 224,937 cuft



Hydrograph Plot

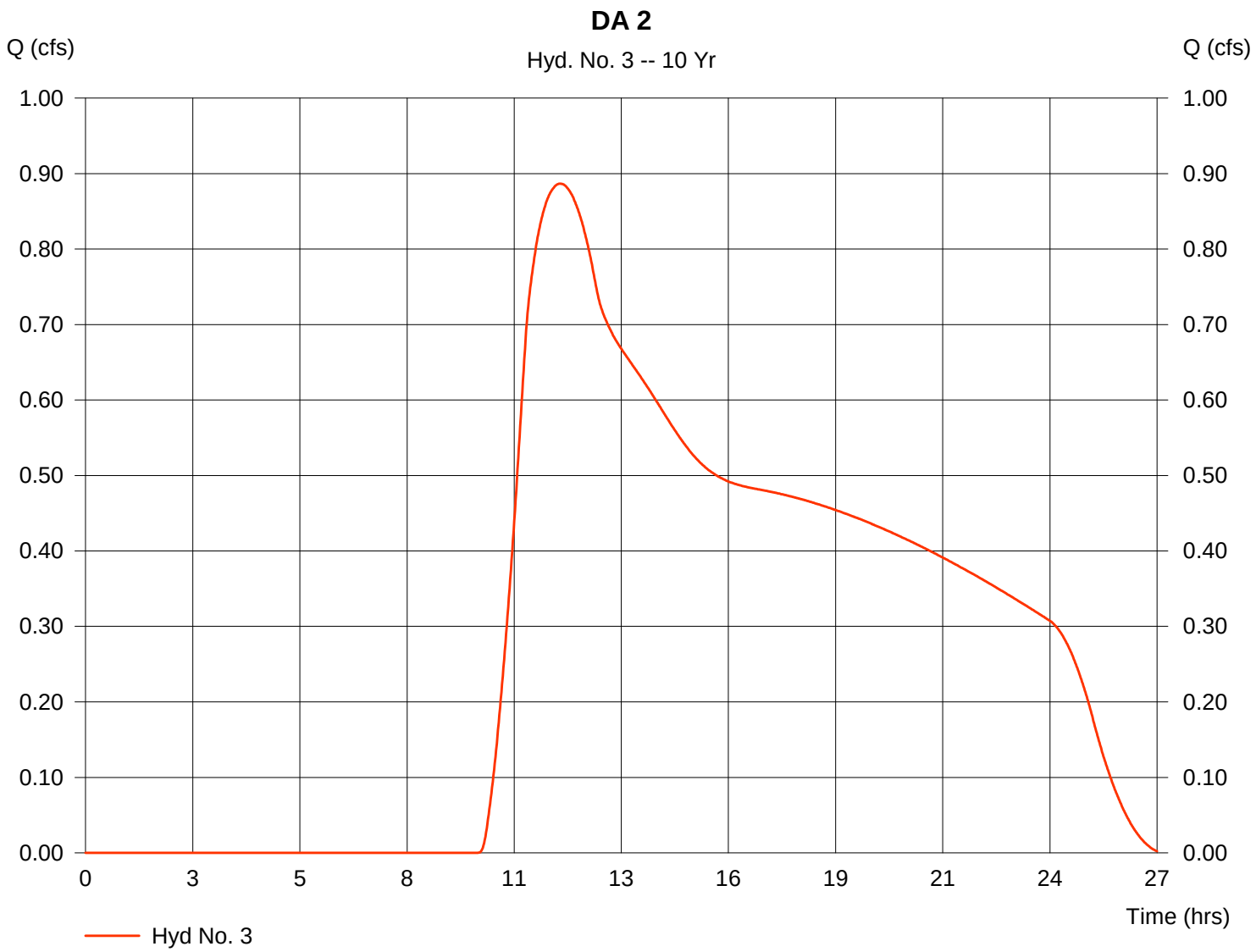
Hydraflow Hydrographs by Intelisolve | Tuesday, May 19 2009, 10:33 AM

Hyd. No. 3

DA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 0.89 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 31.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 2200 ft
Tc method	= LAG	Time of conc. (Tc)	= 109.23 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 26,757 cuft



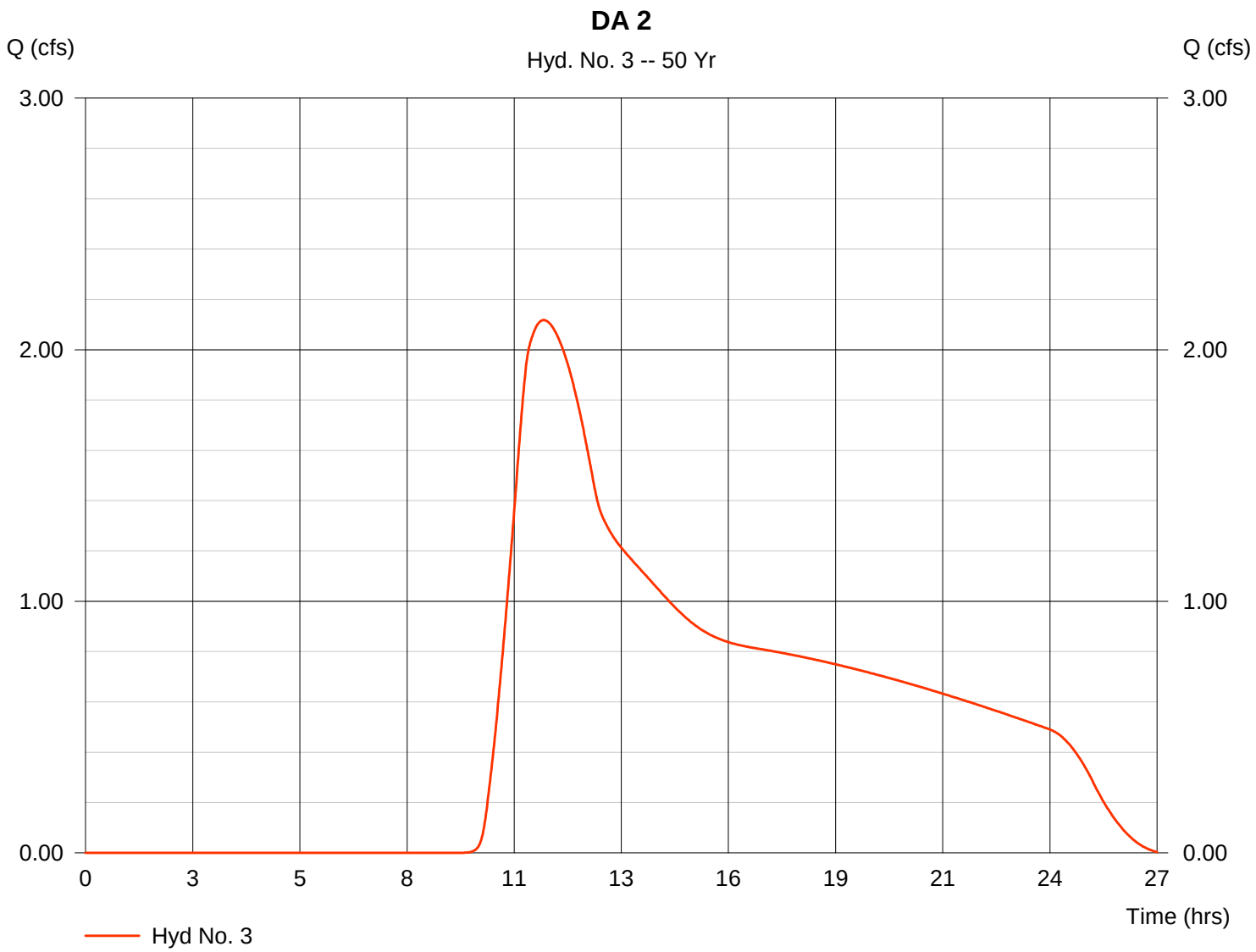
Hydrograph Plot

Hyd. No. 3

DA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 2.12 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 31.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 2200 ft
Tc method	= LAG	Time of conc. (Tc)	= 109.23 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 49,950 cuft



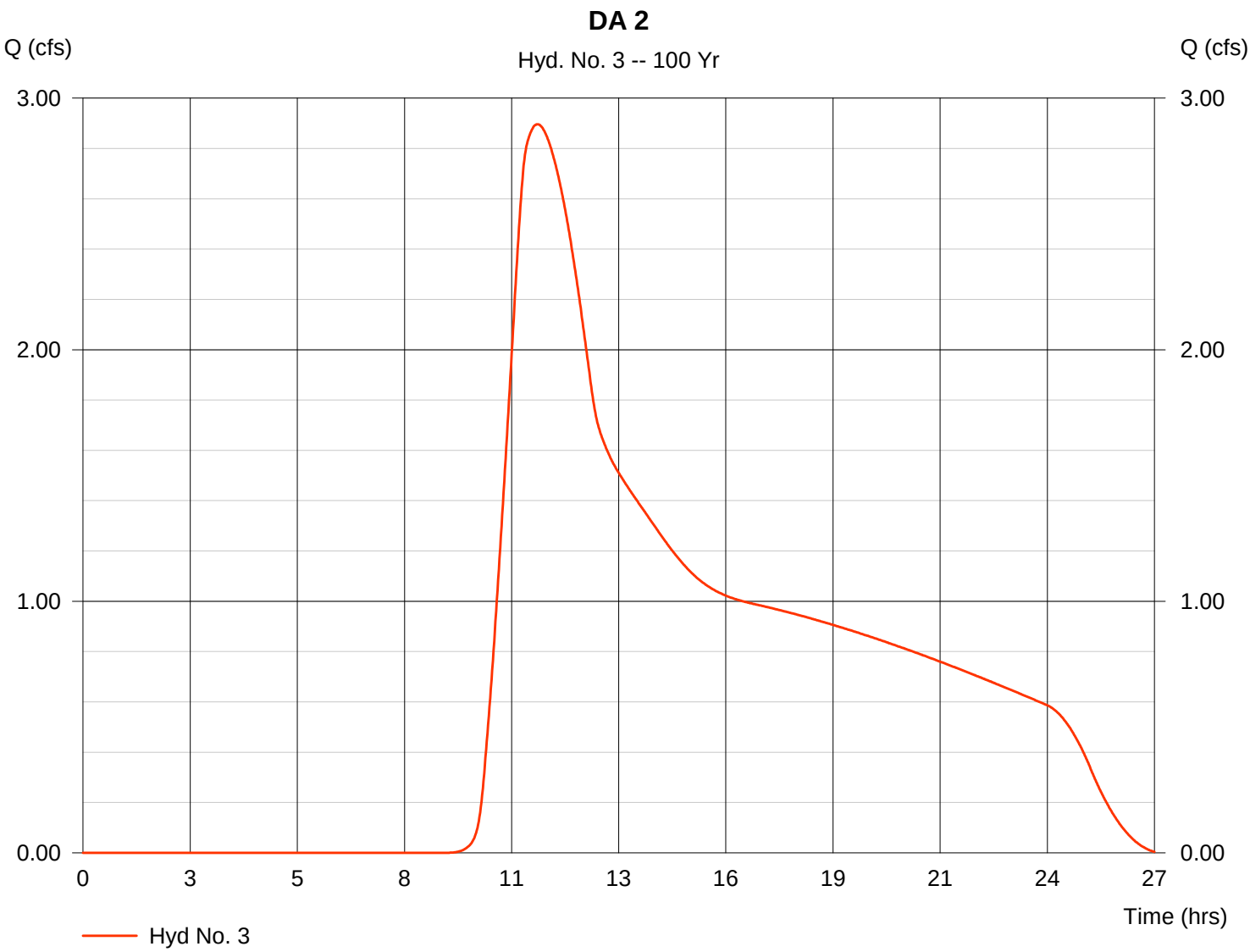
Hydrograph Plot

Hyd. No. 3

DA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 2.90 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 31.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 2200 ft
Tc method	= LAG	Time of conc. (Tc)	= 109.23 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 63,176 cuft



Hydrograph Plot

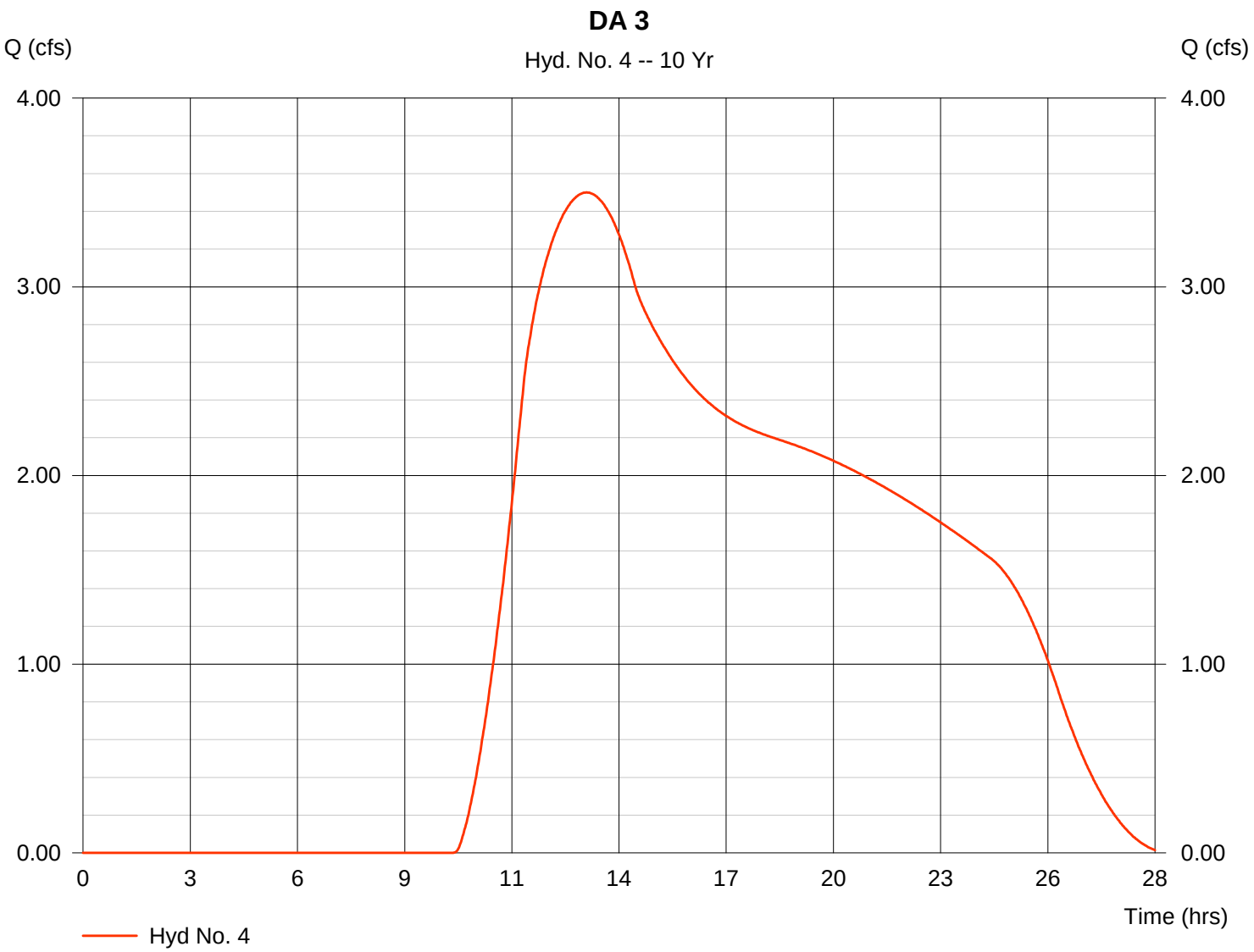
Hydraflow Hydrographs by Intelisolve | Tuesday, May 19 2009, 10:34 AM

Hyd. No. 4

DA 3

Hydrograph type	= SCS Runoff	Peak discharge	= 3.50 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 144.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 4130 ft
Tc method	= LAG	Time of conc. (Tc)	= 180.78 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 124,385 cuft



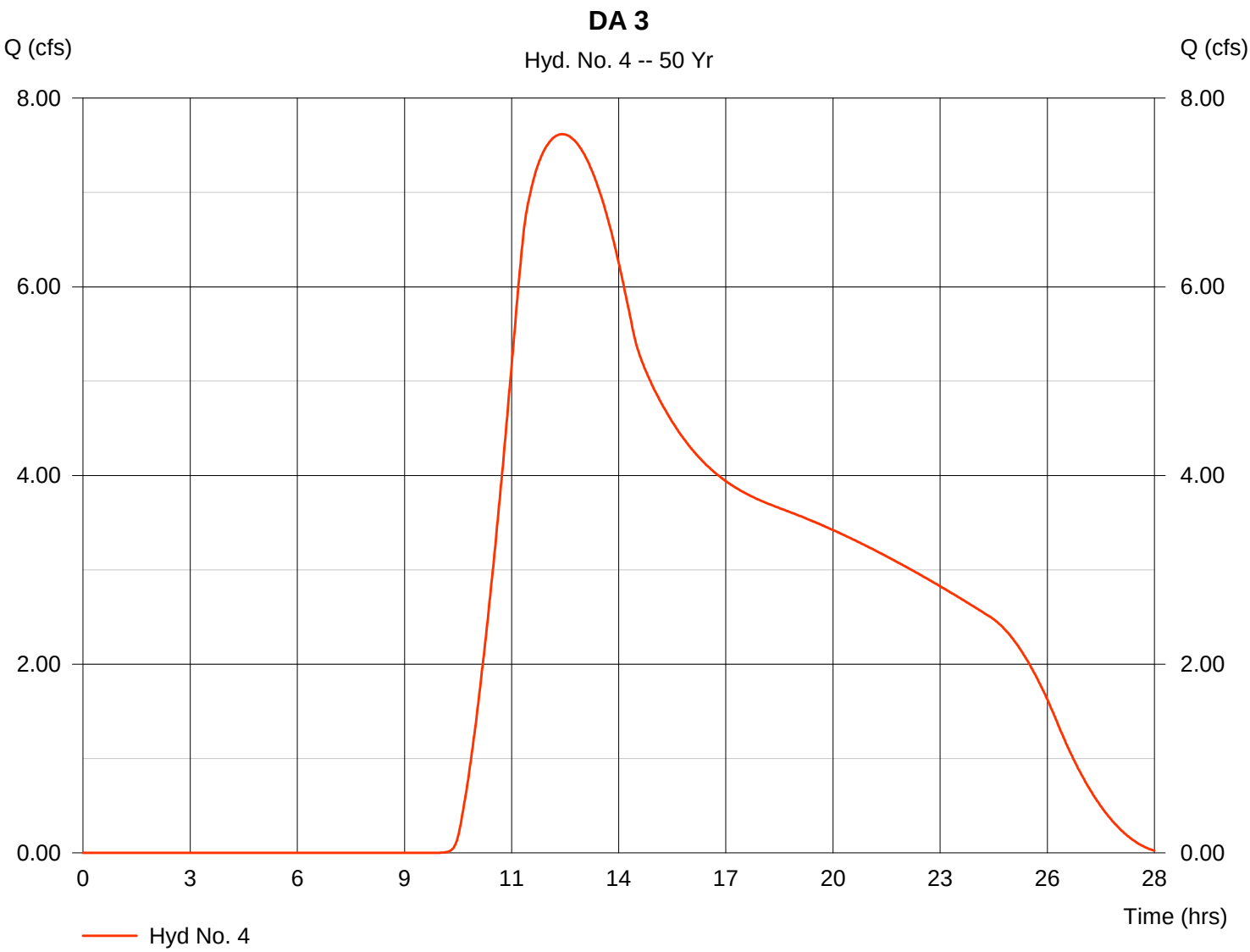
Hydrograph Plot

Hyd. No. 4

DA 3

Hydrograph type	= SCS Runoff	Peak discharge	= 7.62 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 144.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 4130 ft
Tc method	= LAG	Time of conc. (Tc)	= 180.78 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 232,202 cuft



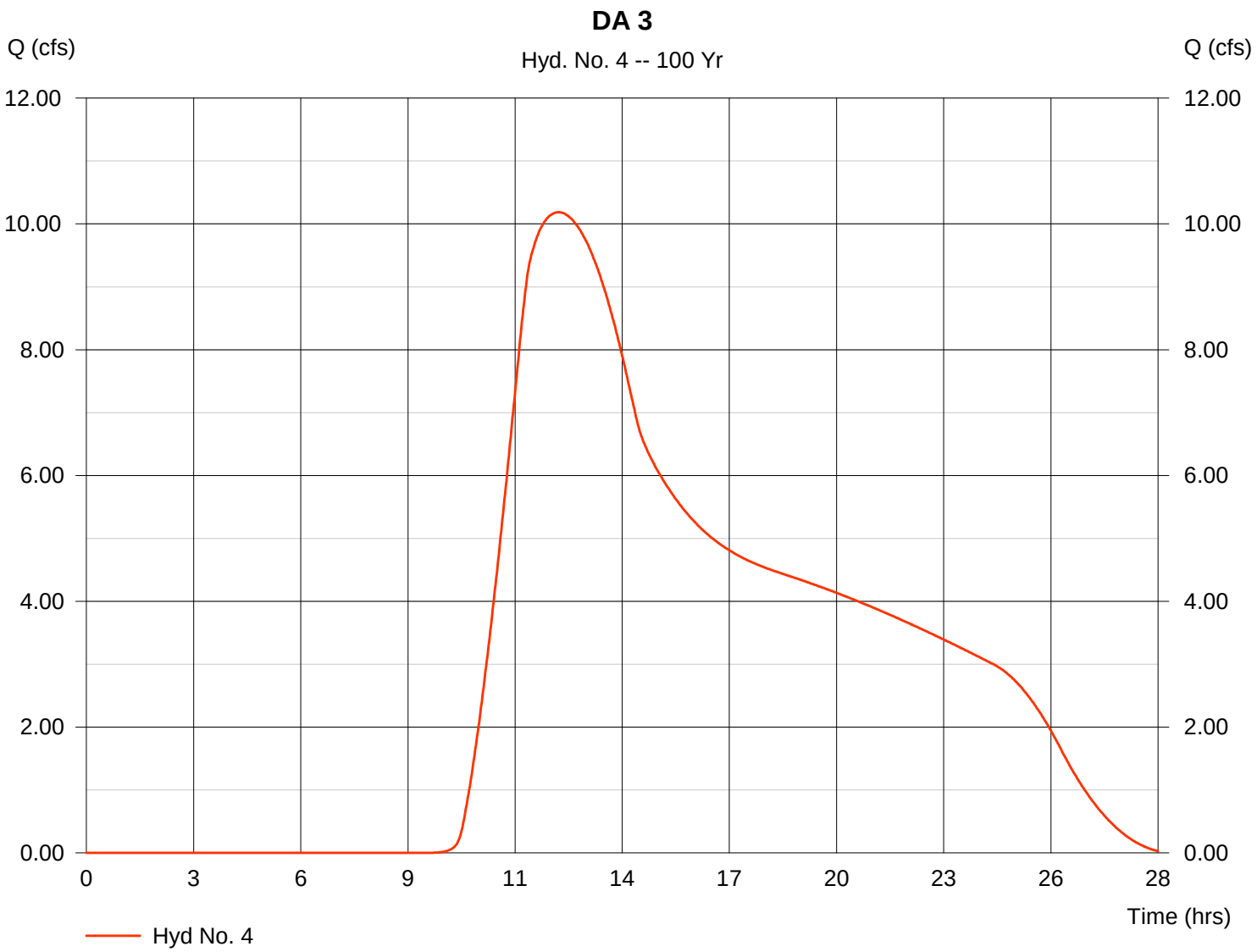
Hydrograph Plot

Hyd. No. 4

DA 3

Hydrograph type	= SCS Runoff	Peak discharge	= 10.19 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 144.000 ac	Curve number	= 80
Basin Slope	= 0.3 %	Hydraulic length	= 4130 ft
Tc method	= LAG	Time of conc. (Tc)	= 180.78 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 293,687 cuft



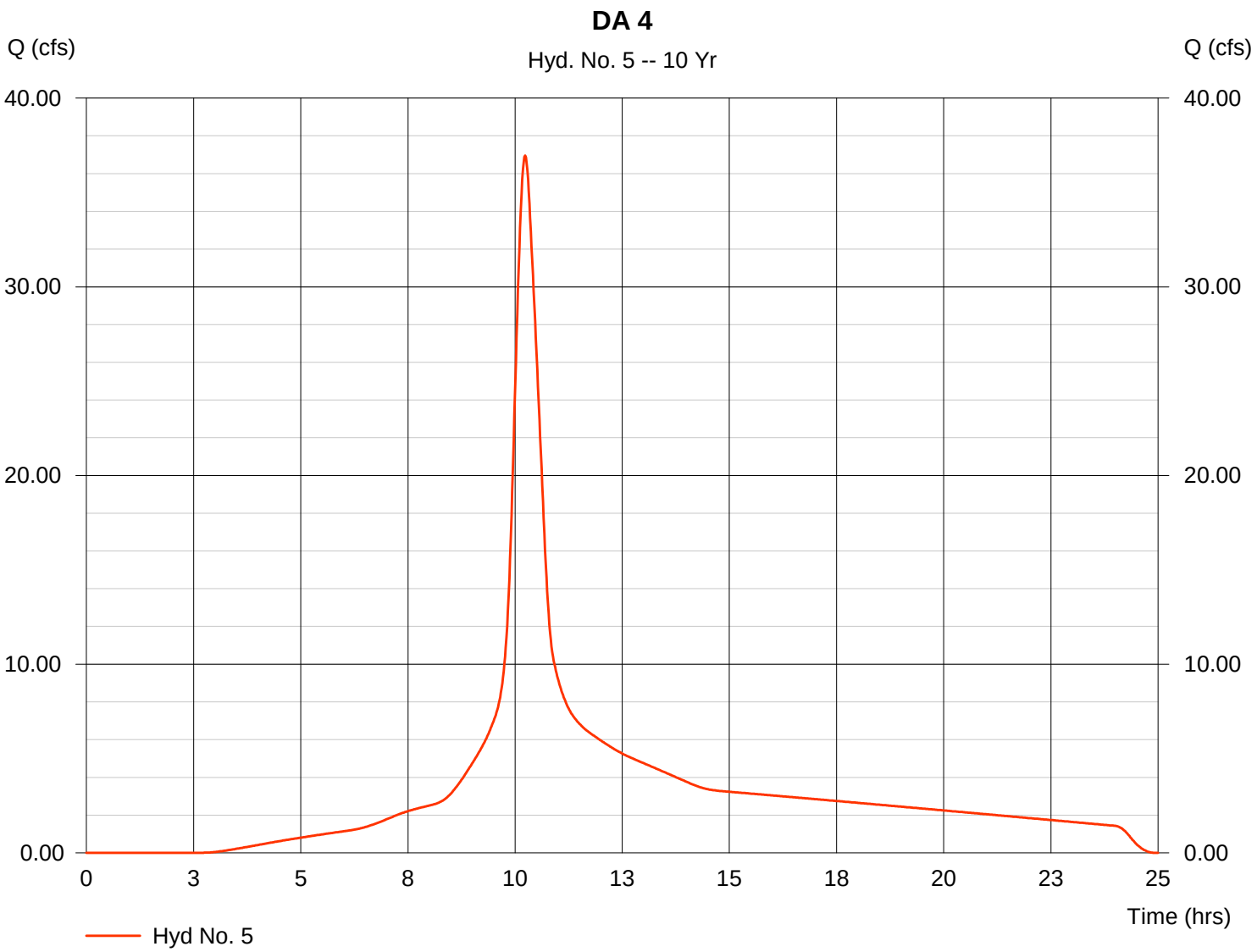
Hydrograph Plot

Hyd. No. 5

DA 4

Hydrograph type	= SCS Runoff	Peak discharge	= 36.95 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 76.000 ac	Curve number	= 97
Basin Slope	= 0.5 %	Hydraulic length	= 1750 ft
Tc method	= LAG	Time of conc. (Tc)	= 35.40 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 299,862 cuft



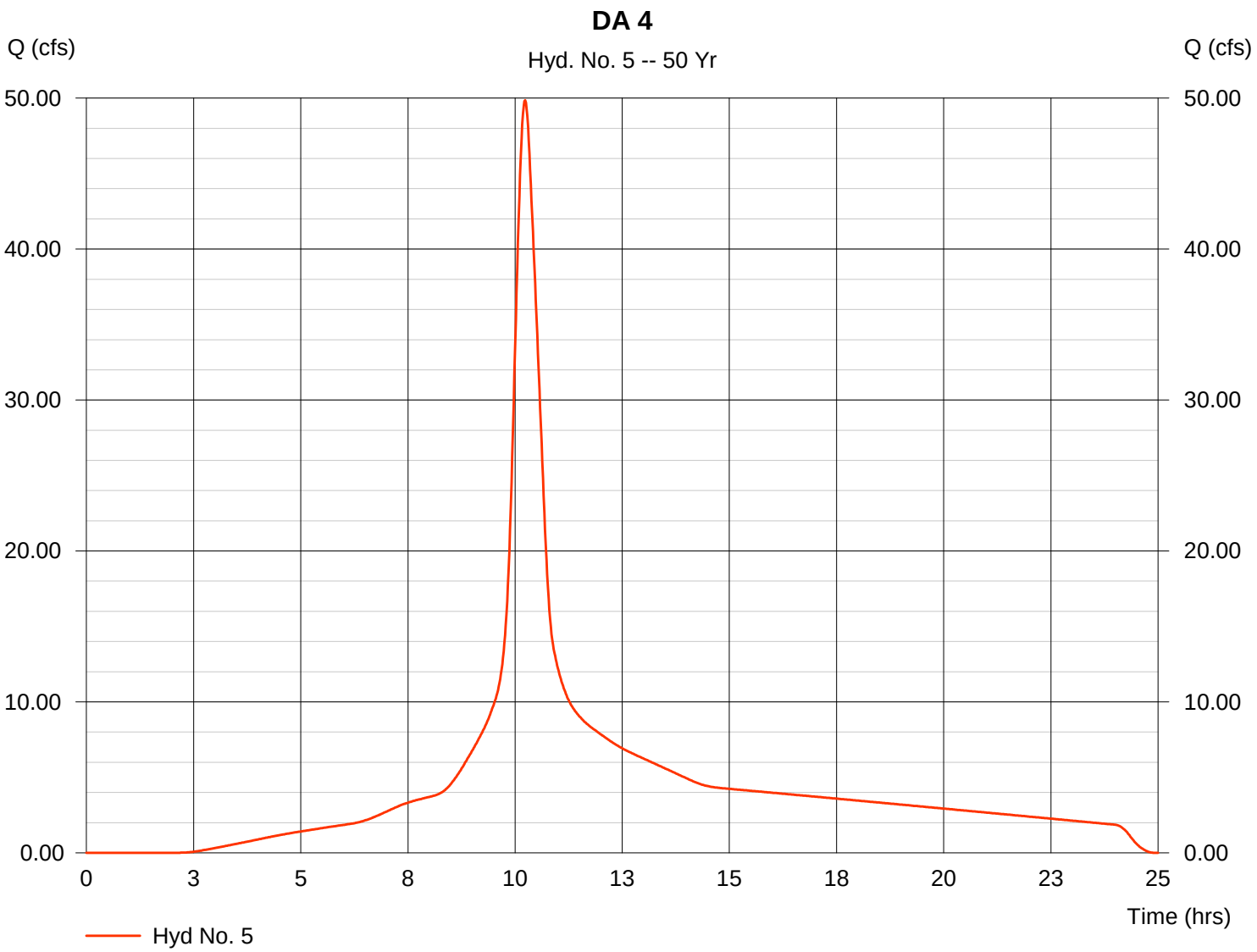
Hydrograph Plot

Hyd. No. 5

DA 4

Hydrograph type	= SCS Runoff	Peak discharge	= 49.86 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 76.000 ac	Curve number	= 97
Basin Slope	= 0.5 %	Hydraulic length	= 1750 ft
Tc method	= LAG	Time of conc. (Tc)	= 35.40 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 407,084 cuft



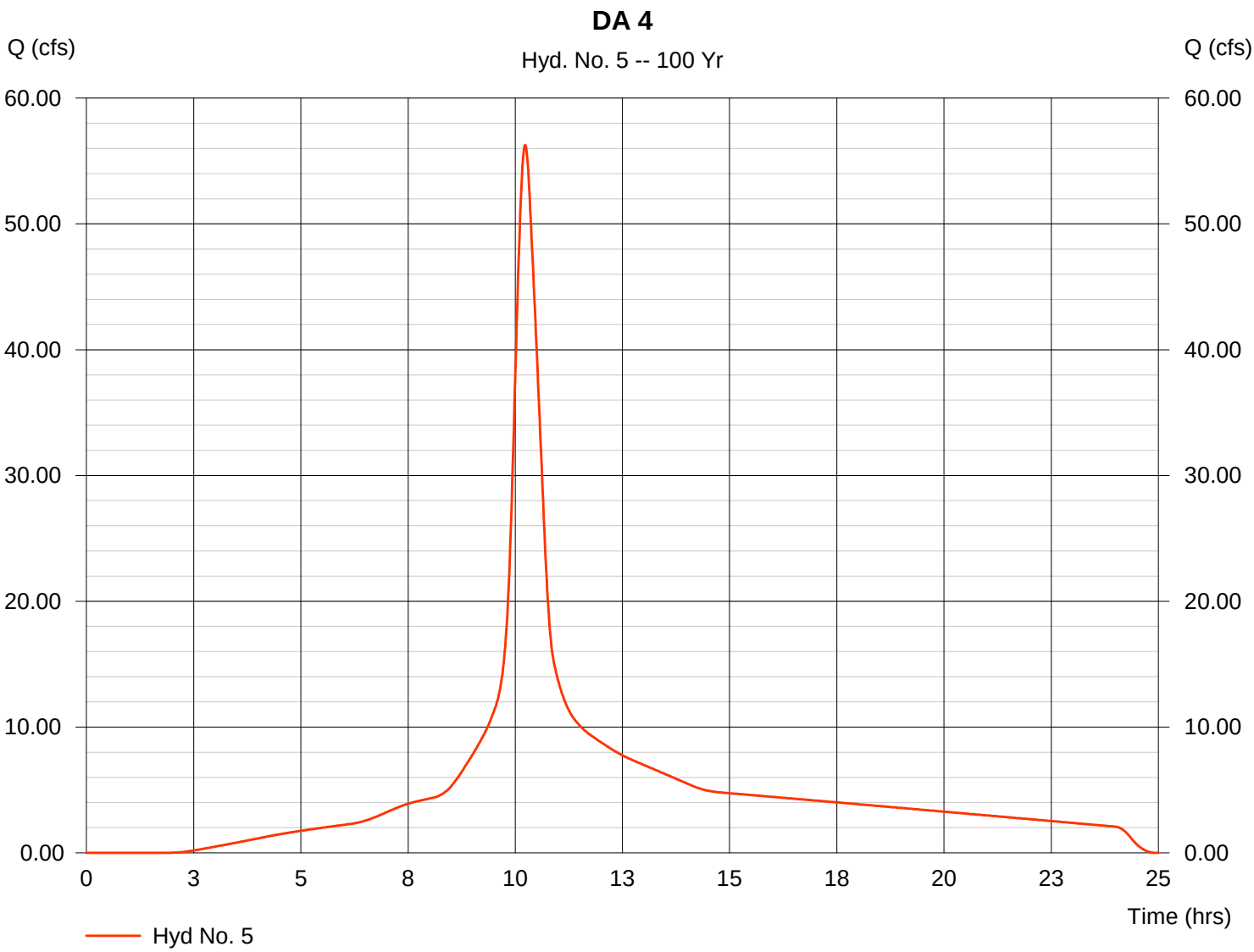
Hydrograph Plot

Hyd. No. 5

DA 4

Hydrograph type	= SCS Runoff	Peak discharge	= 56.28 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 76.000 ac	Curve number	= 97
Basin Slope	= 0.5 %	Hydraulic length	= 1750 ft
Tc method	= LAG	Time of conc. (Tc)	= 35.40 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 461,114 cuft



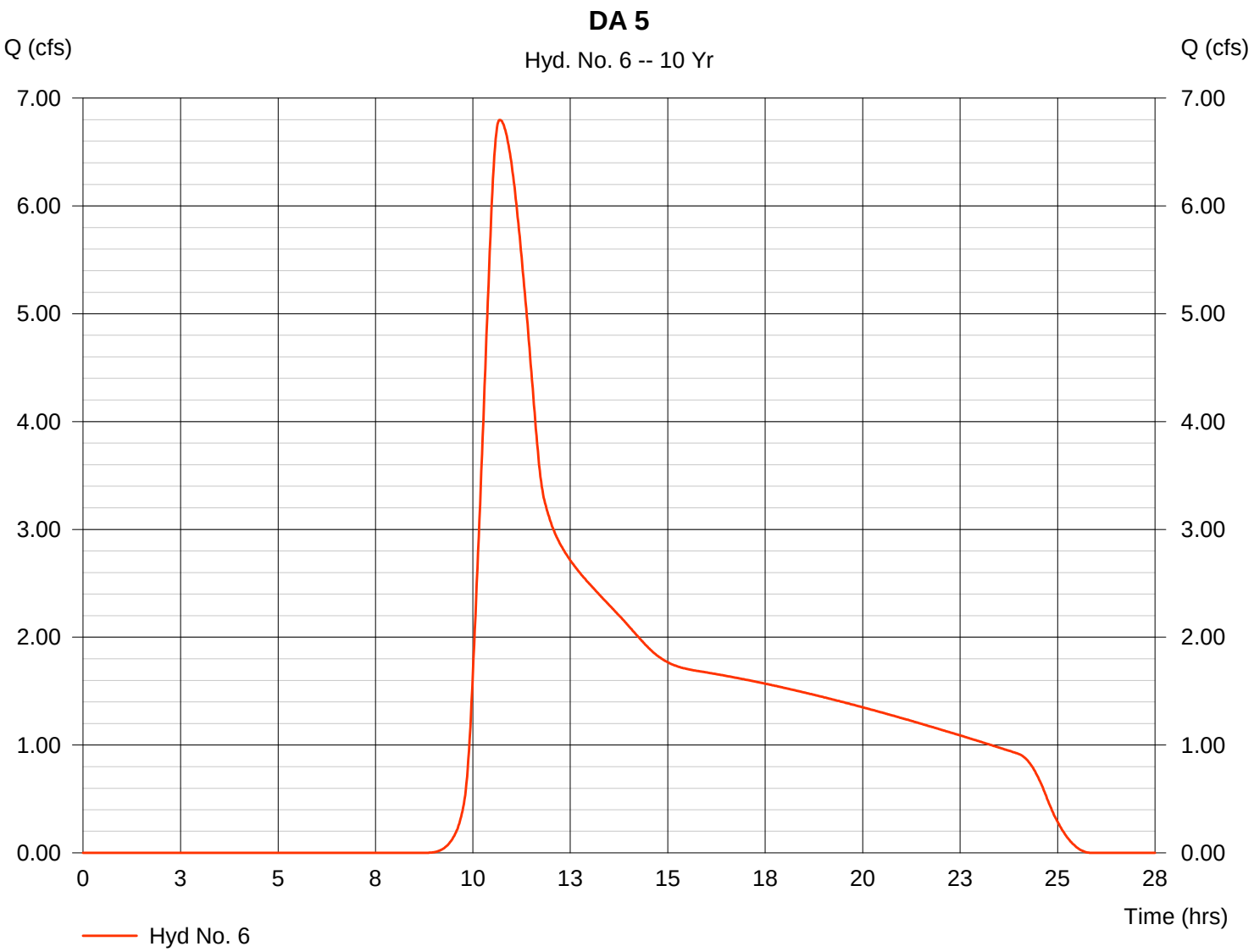
Hydrograph Plot

Hyd. No. 6

DA 5

Hydrograph type	= SCS Runoff	Peak discharge	= 6.80 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 70.000 ac	Curve number	= 86
Basin Slope	= 0.3 %	Hydraulic length	= 1650 ft
Tc method	= LAG	Time of conc. (Tc)	= 71.00 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 108,546 cuft



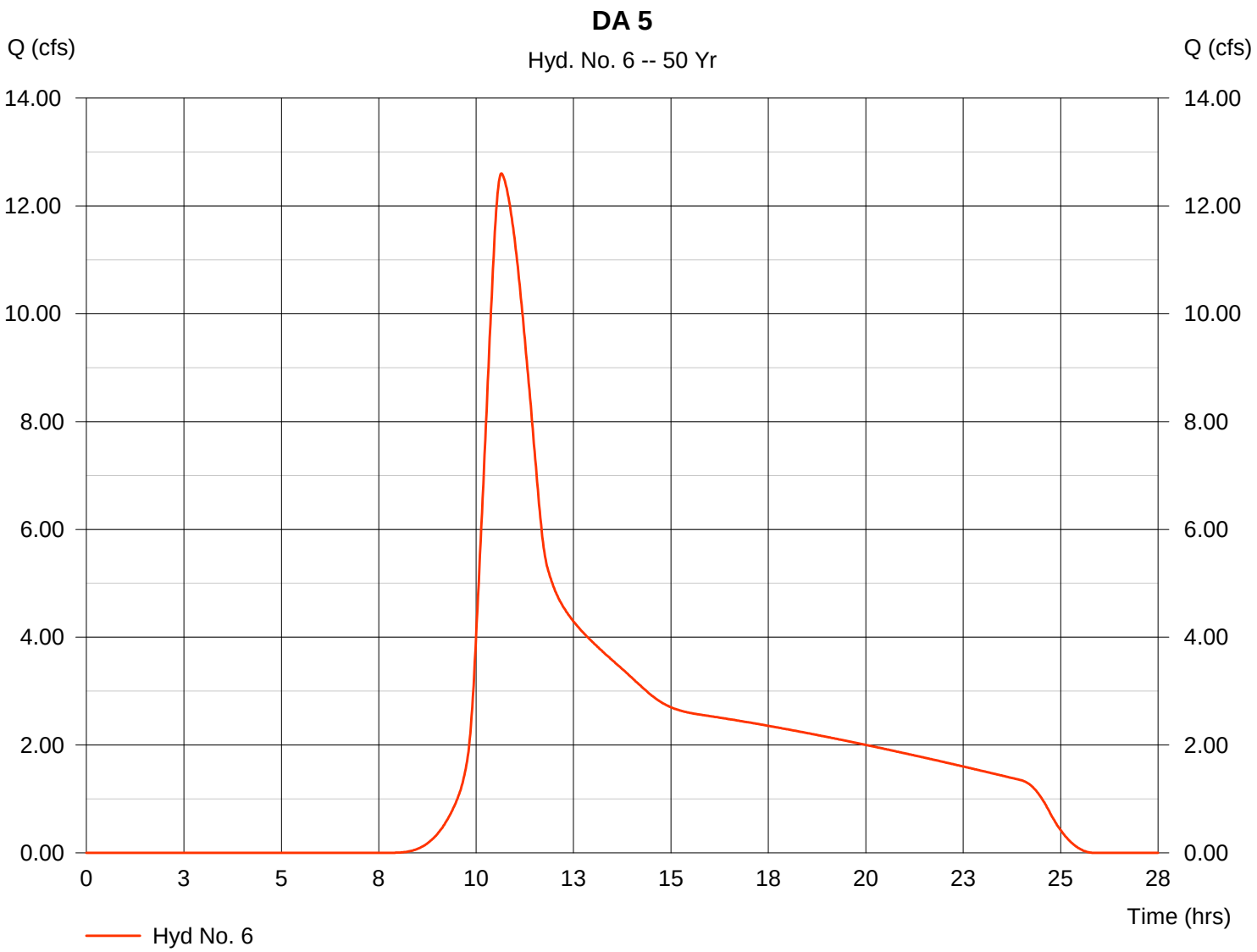
Hydrograph Plot

Hyd. No. 6

DA 5

Hydrograph type	= SCS Runoff	Peak discharge	= 12.60 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 70.000 ac	Curve number	= 86
Basin Slope	= 0.3 %	Hydraulic length	= 1650 ft
Tc method	= LAG	Time of conc. (Tc)	= 71.00 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 178,057 cuft



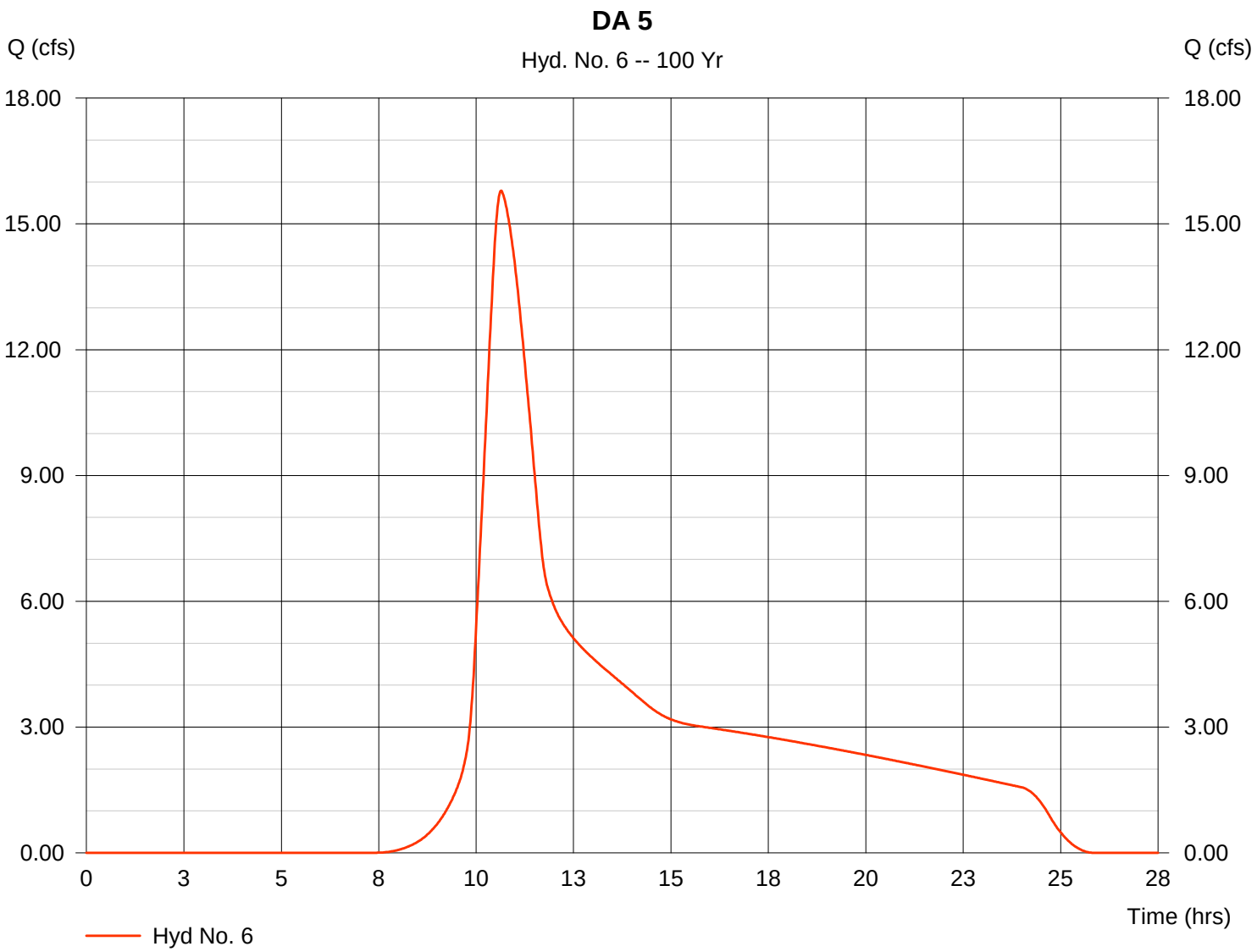
Hydrograph Plot

Hyd. No. 6

DA 5

Hydrograph type	= SCS Runoff	Peak discharge	= 15.79 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 70.000 ac	Curve number	= 86
Basin Slope	= 0.3 %	Hydraulic length	= 1650 ft
Tc method	= LAG	Time of conc. (Tc)	= 71.00 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 215,731 cuft



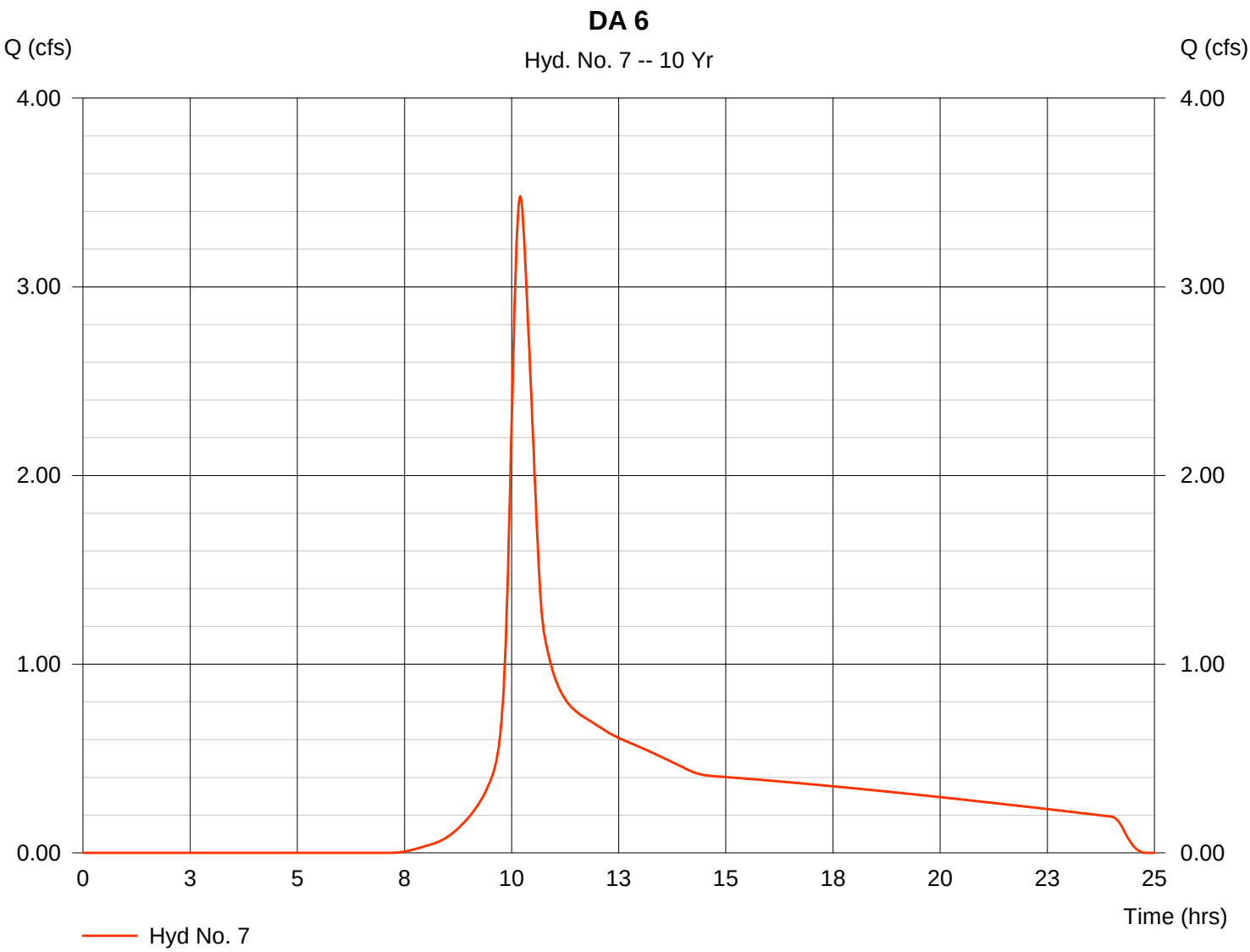
Hydrograph Plot

Hyd. No. 7

DA 6

Hydrograph type	= SCS Runoff	Peak discharge	= 3.48 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 13.000 ac	Curve number	= 90
Basin Slope	= 0.5 %	Hydraulic length	= 950 ft
Tc method	= LAG	Time of conc. (Tc)	= 30.34 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 28,599 cuft



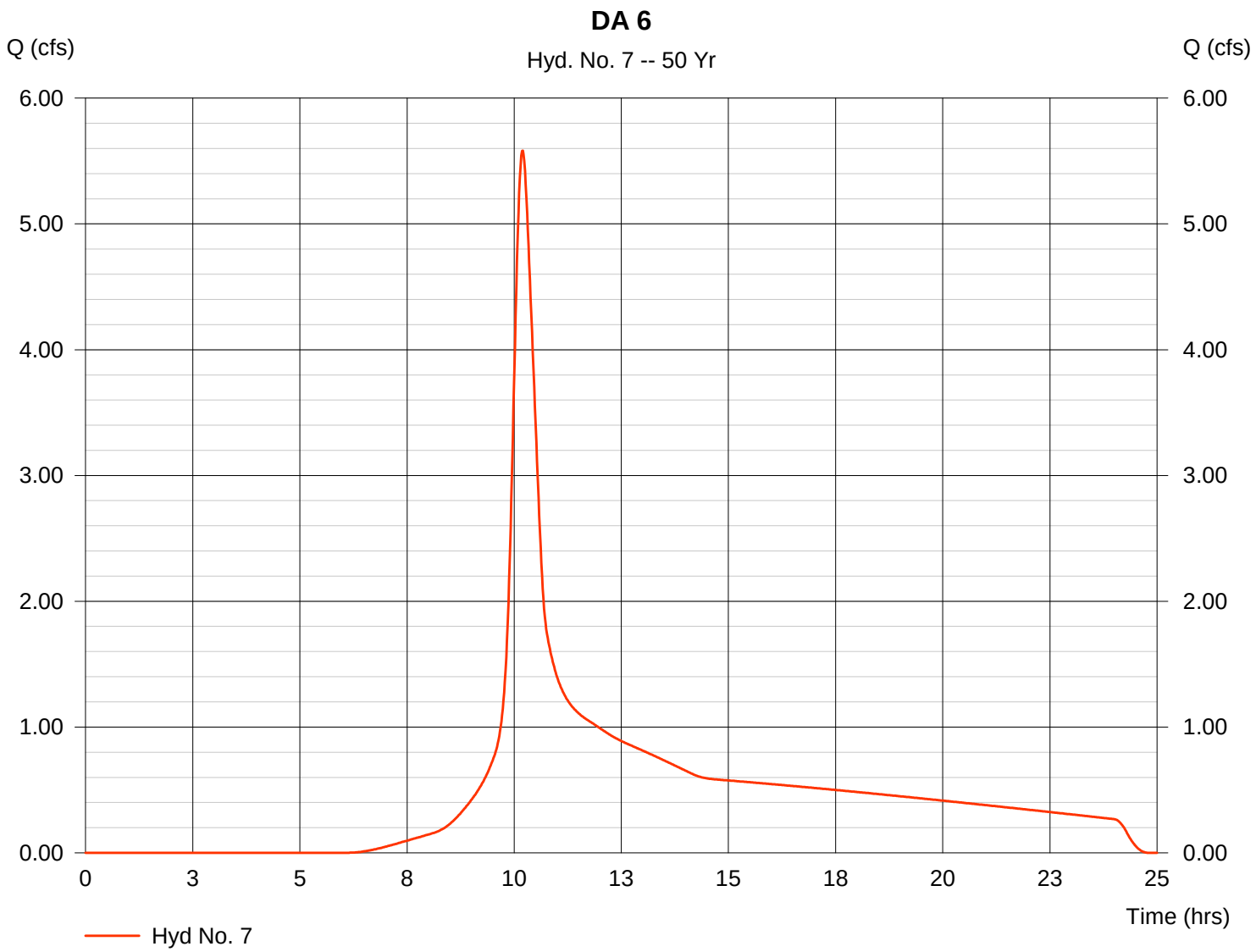
Hydrograph Plot

Hyd. No. 7

DA 6

Hydrograph type	= SCS Runoff	Peak discharge	= 5.58 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 13.000 ac	Curve number	= 90
Basin Slope	= 0.5 %	Hydraulic length	= 950 ft
Tc method	= LAG	Time of conc. (Tc)	= 30.34 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 43,689 cuft



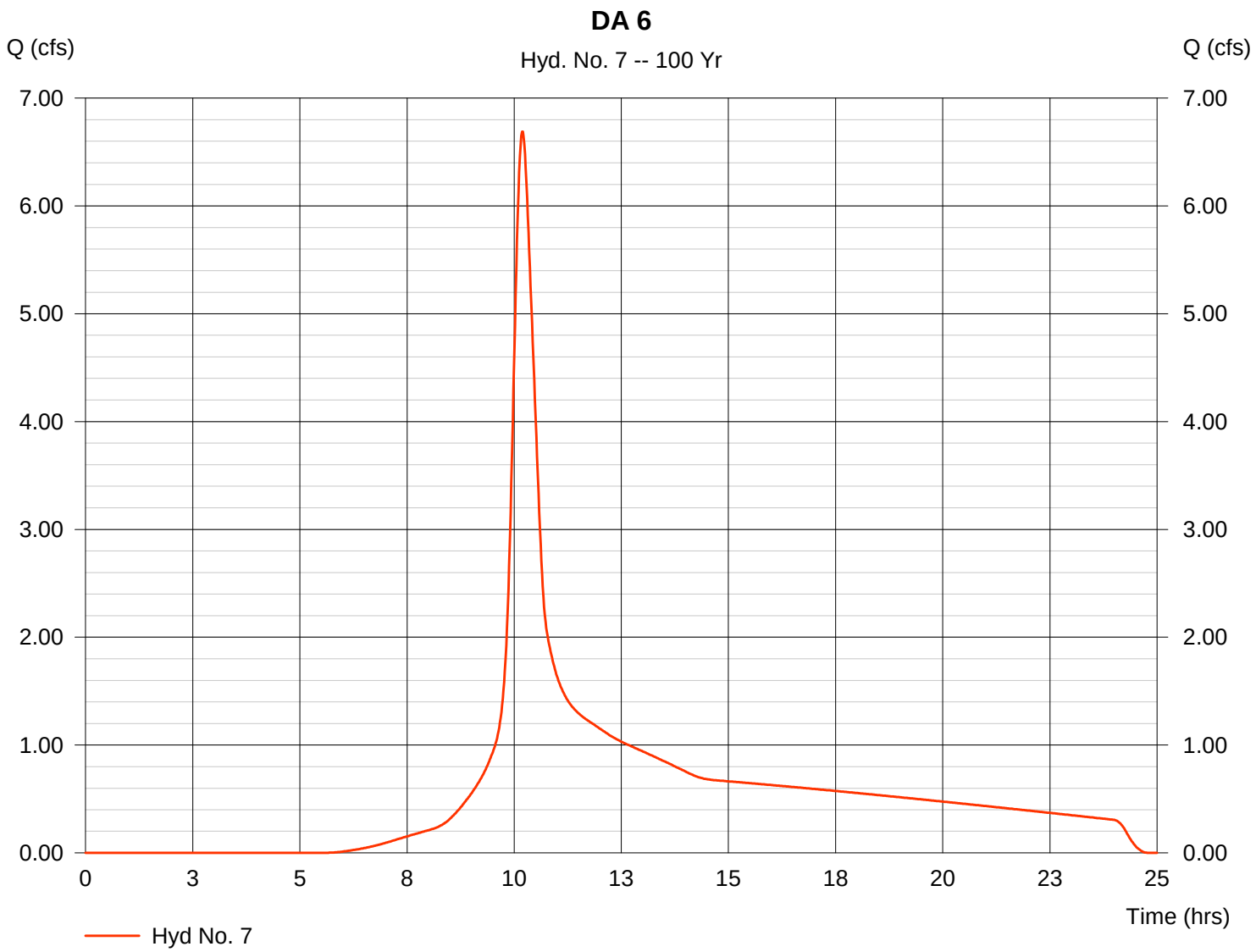
Hydrograph Plot

Hyd. No. 7

DA 6

Hydrograph type	= SCS Runoff	Peak discharge	= 6.69 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 13.000 ac	Curve number	= 90
Basin Slope	= 0.5 %	Hydraulic length	= 950 ft
Tc method	= LAG	Time of conc. (Tc)	= 30.34 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 51,627 cuft



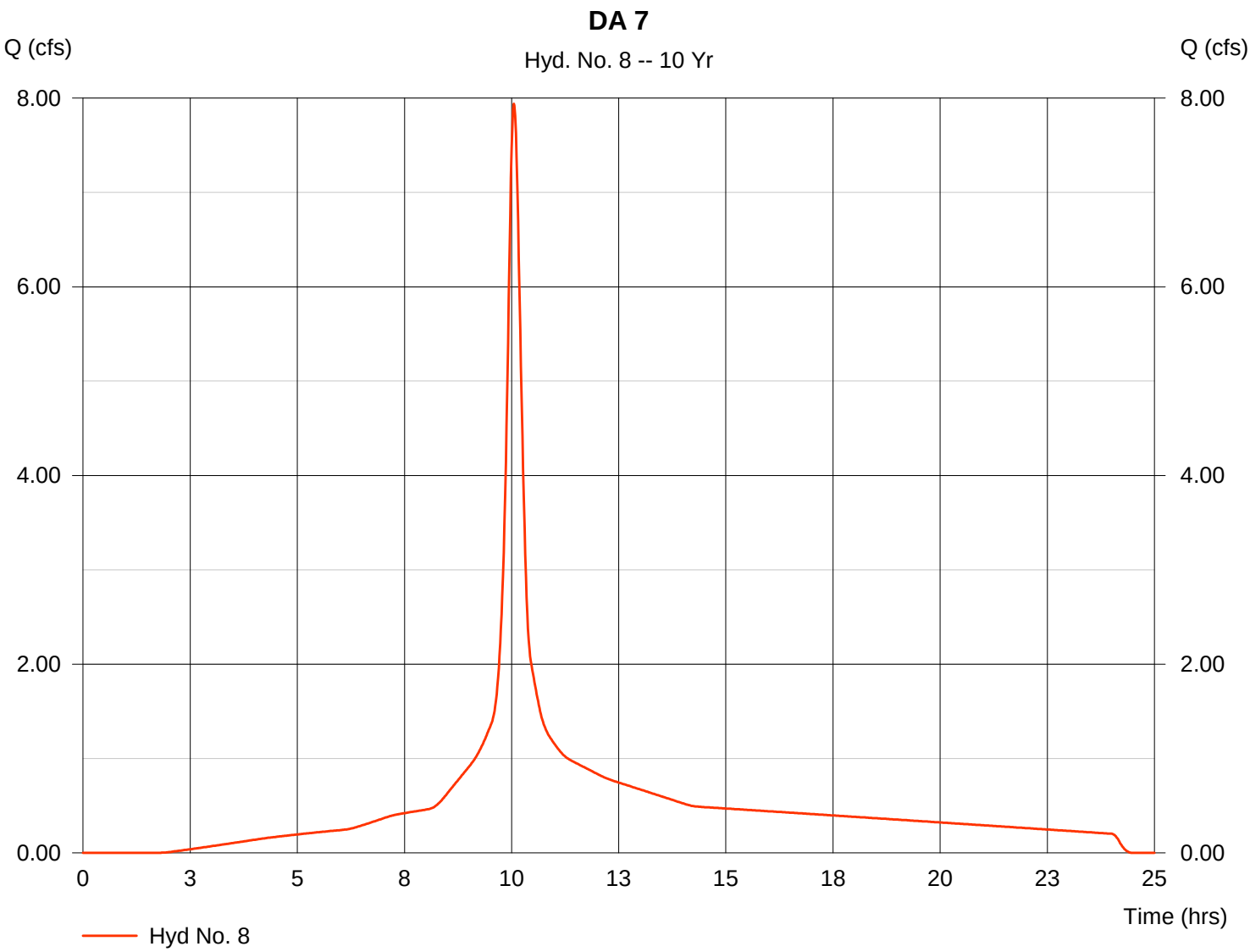
Hydrograph Plot

Hyd. No. 8

DA 7

Hydrograph type	= SCS Runoff	Peak discharge	= 7.94 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 11.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 750 ft
Tc method	= LAG	Time of conc. (Tc)	= 16.95 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 46,651 cuft



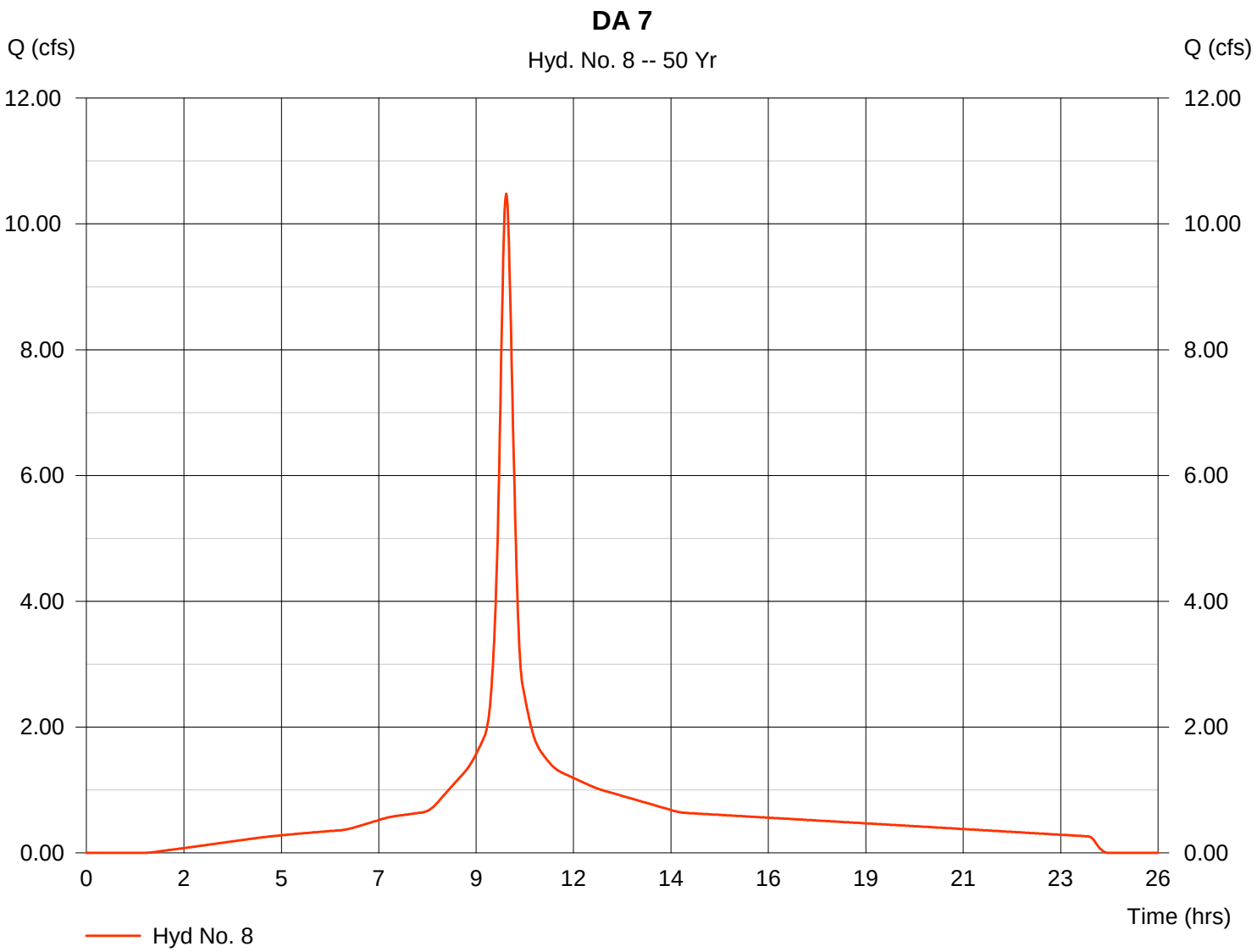
Hydrograph Plot

Hyd. No. 8

DA 7

Hydrograph type	= SCS Runoff	Peak discharge	= 10.48 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 11.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 750 ft
Tc method	= LAG	Time of conc. (Tc)	= 16.95 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 62,227 cuft



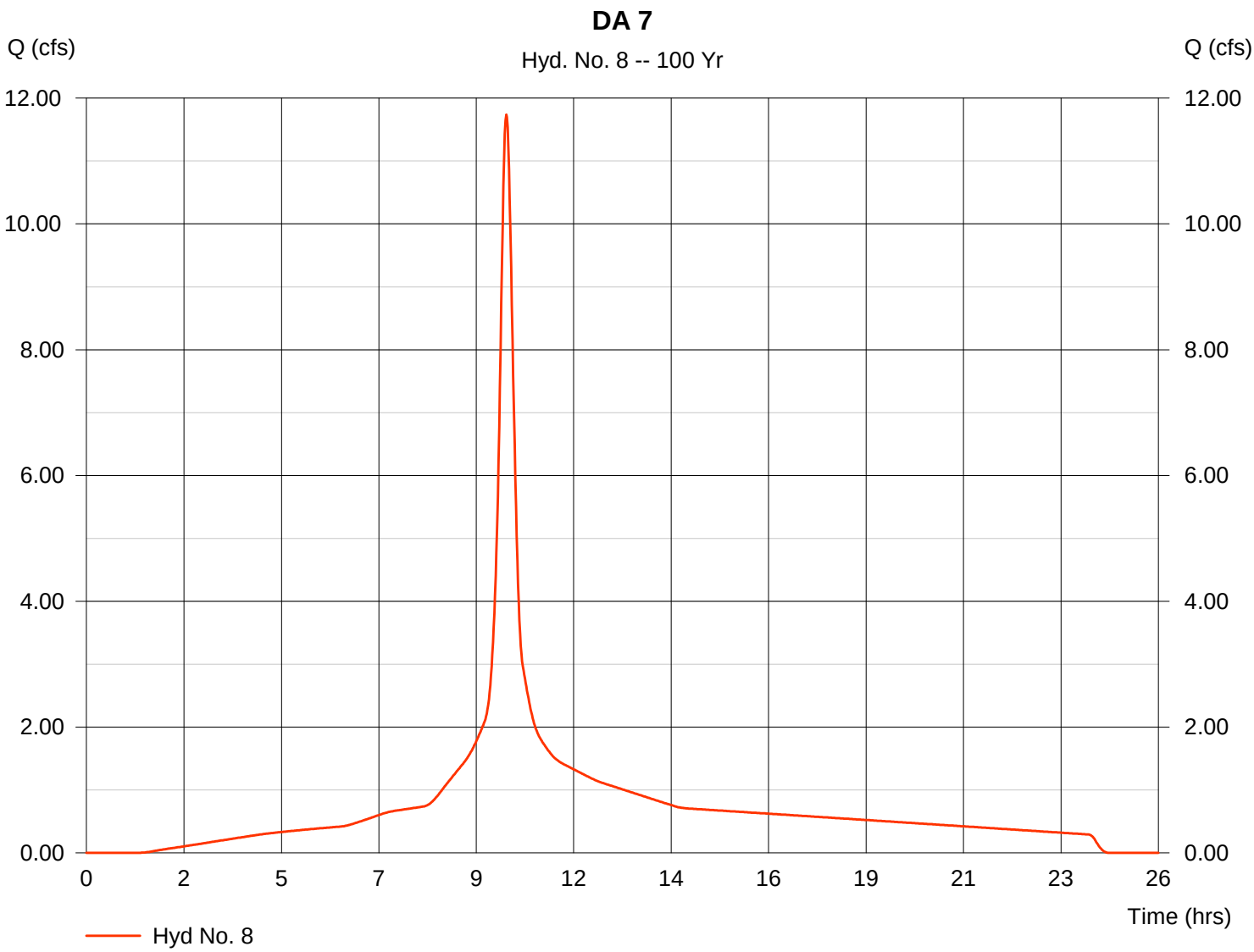
Hydrograph Plot

Hyd. No. 8

DA 7

Hydrograph type	= SCS Runoff	Peak discharge	= 11.74 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 11.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 750 ft
Tc method	= LAG	Time of conc. (Tc)	= 16.95 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 70,045 cuft



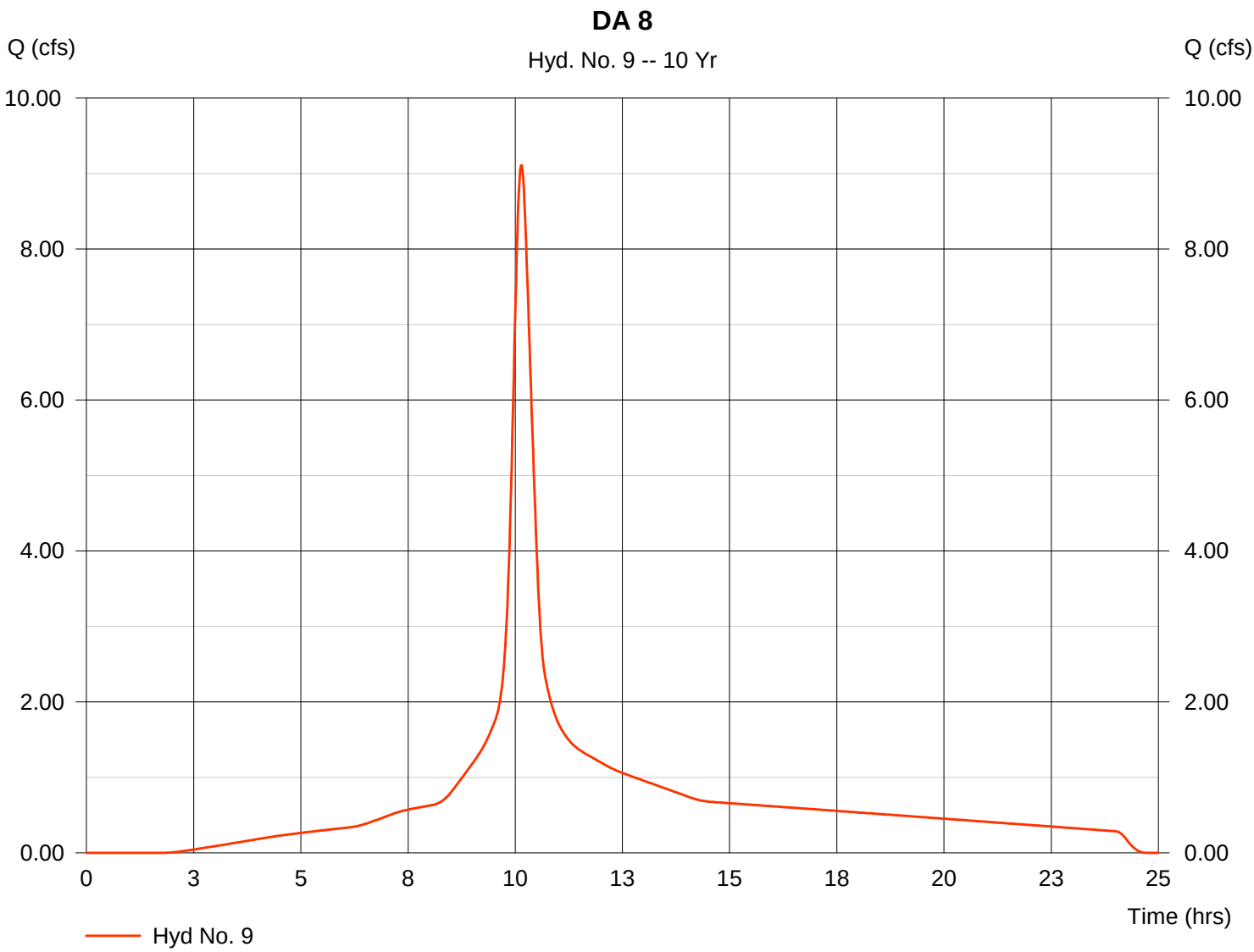
Hydrograph Plot

Hyd. No. 9

DA 8

Hydrograph type	= SCS Runoff	Peak discharge	= 9.11 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 15.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 1250 ft
Tc method	= LAG	Time of conc. (Tc)	= 25.50 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 64,849 cuft



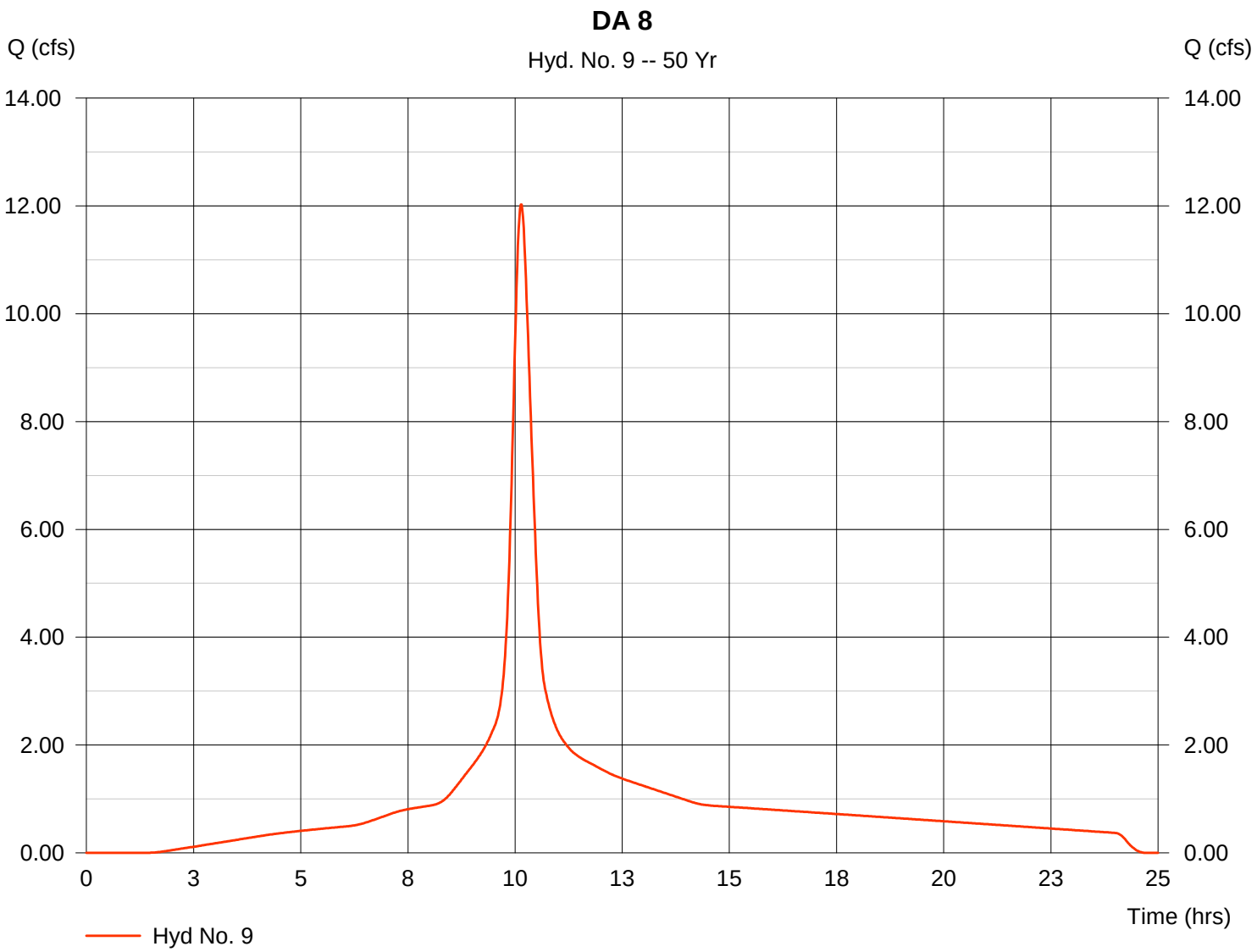
Hydrograph Plot

Hyd. No. 9

DA 8

Hydrograph type	= SCS Runoff	Peak discharge	= 12.03 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 15.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 1250 ft
Tc method	= LAG	Time of conc. (Tc)	= 25.50 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 86,501 cuft



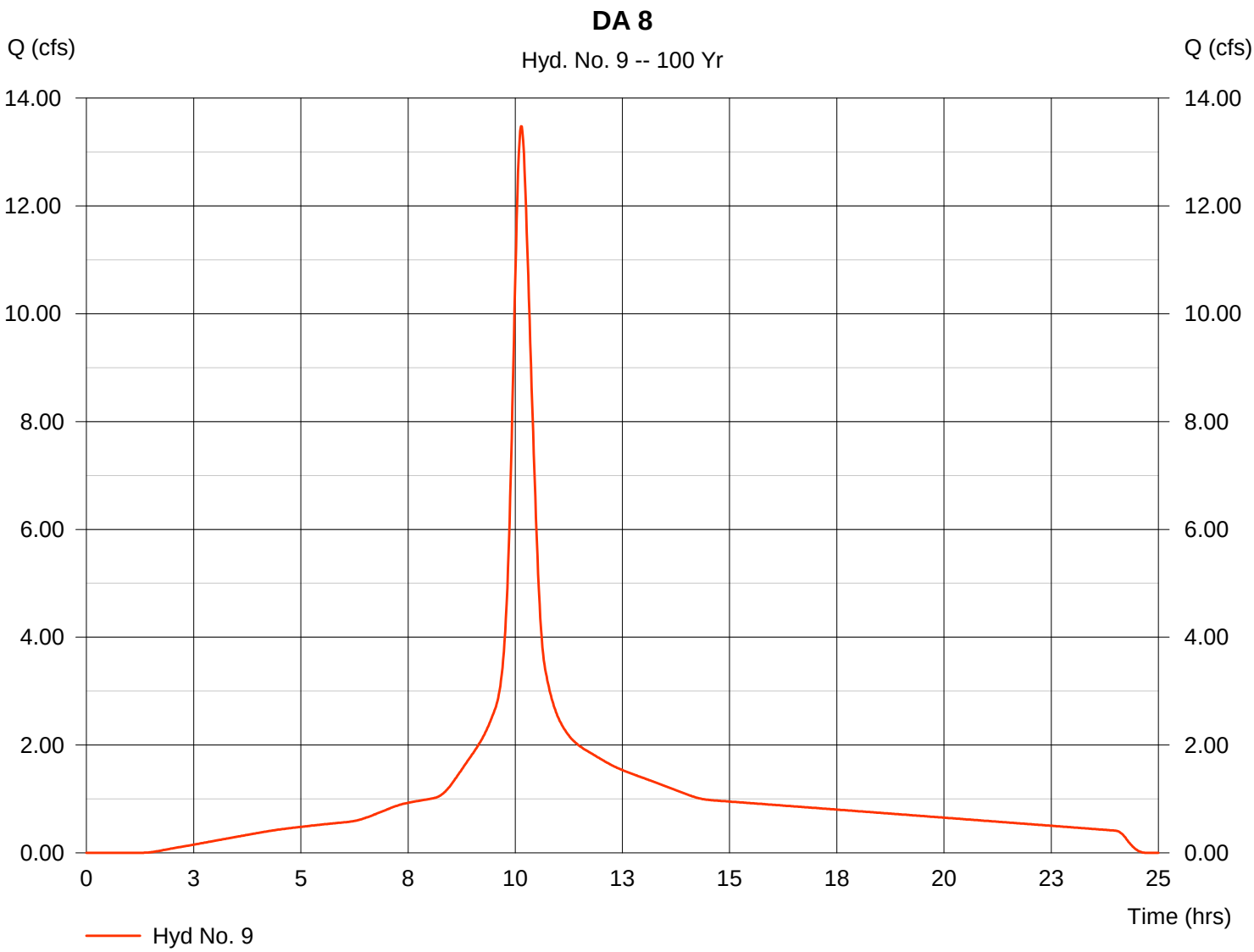
Hydrograph Plot

Hyd. No. 9

DA 8

Hydrograph type	= SCS Runoff	Peak discharge	= 13.48 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 15.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 1250 ft
Tc method	= LAG	Time of conc. (Tc)	= 25.50 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 97,368 cuft



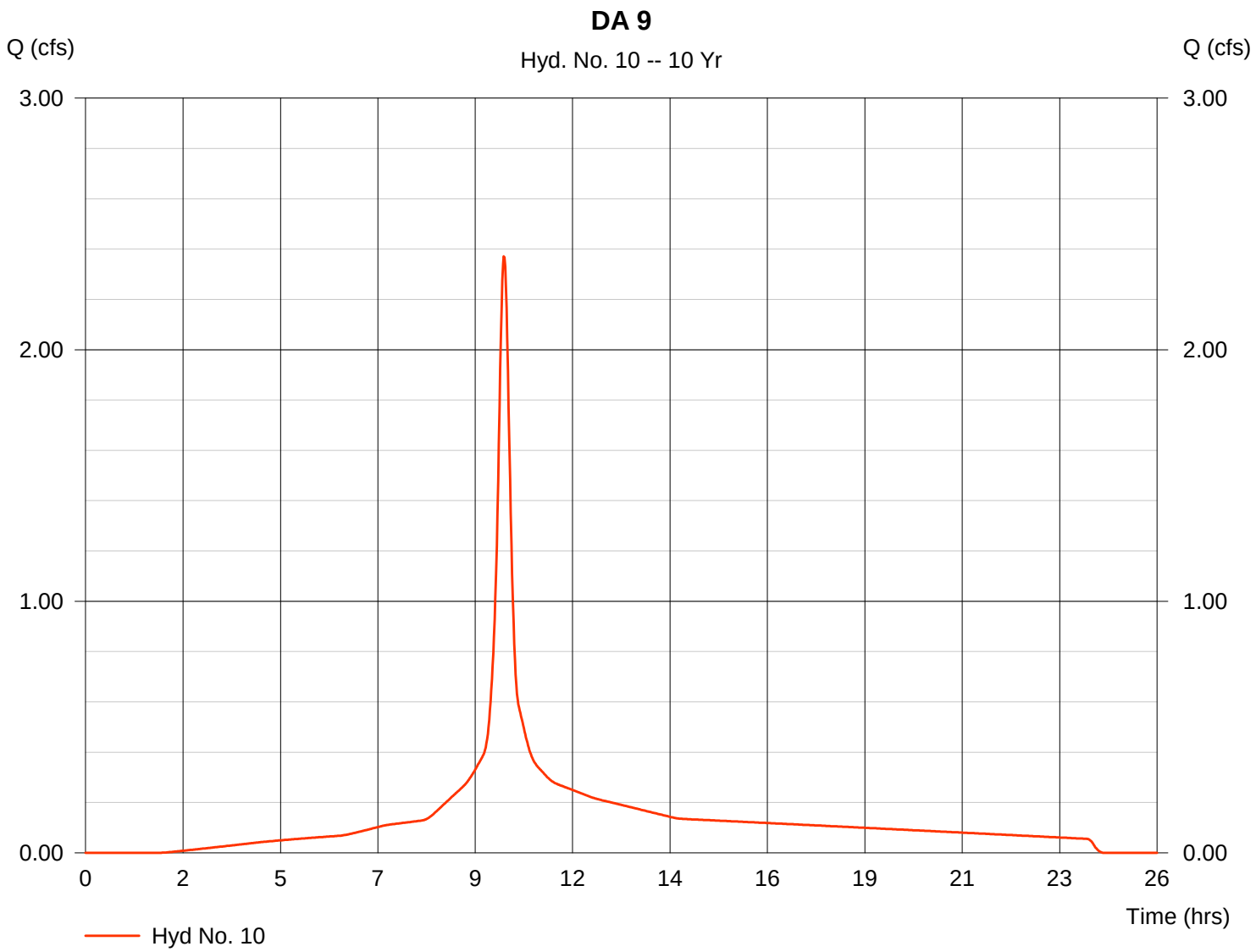
Hydrograph Plot

Hyd. No. 10

DA 9

Hydrograph type	= SCS Runoff	Peak discharge	= 2.37 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 3.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 600 ft
Tc method	= LAG	Time of conc. (Tc)	= 14.18 min
Total precip.	= 1.40 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 12,869 cuft



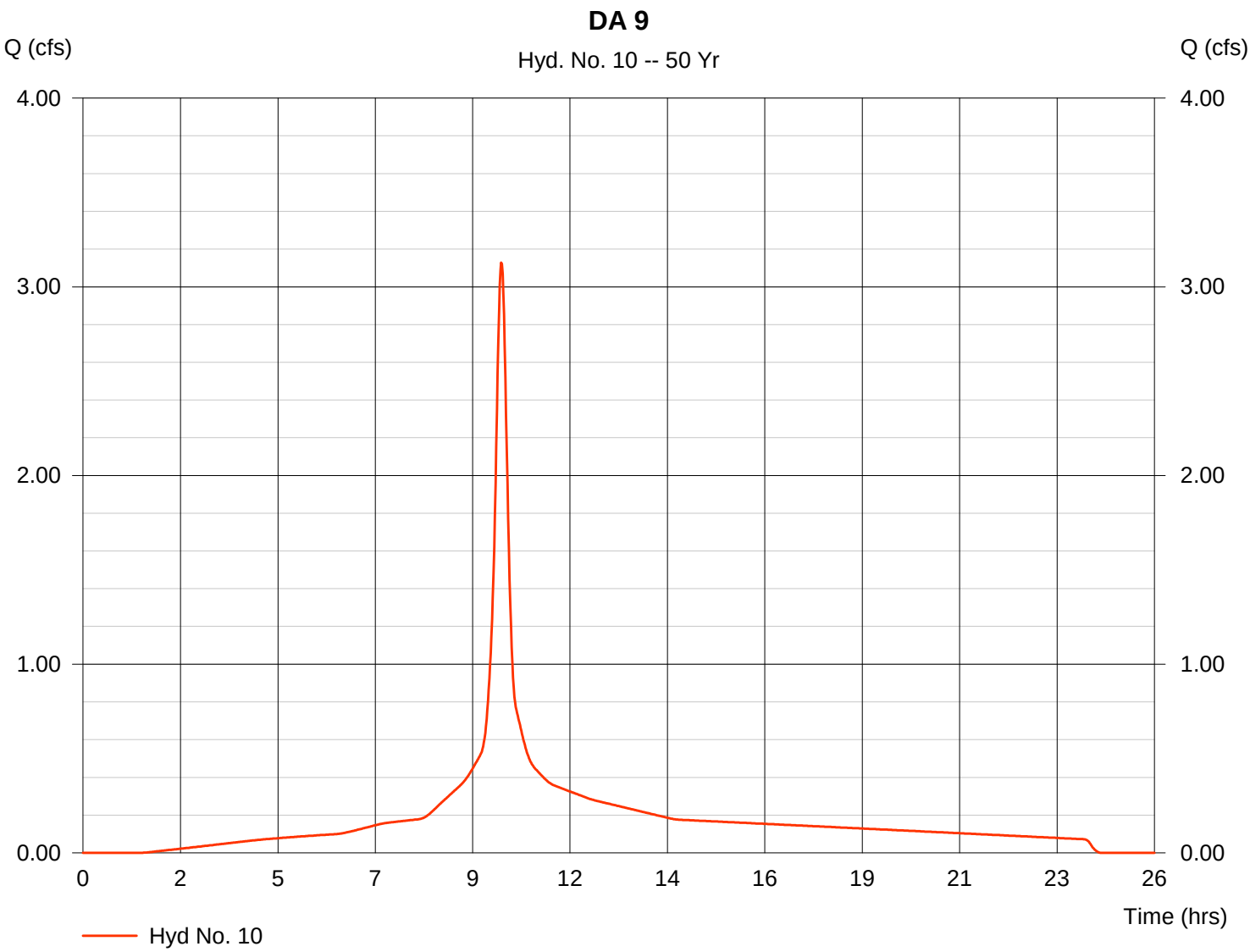
Hydrograph Plot

Hyd. No. 10

DA 9

Hydrograph type	= SCS Runoff	Peak discharge	= 3.13 cfs
Storm frequency	= 50 yrs	Time interval	= 1 min
Drainage area	= 3.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 600 ft
Tc method	= LAG	Time of conc. (Tc)	= 14.18 min
Total precip.	= 1.80 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

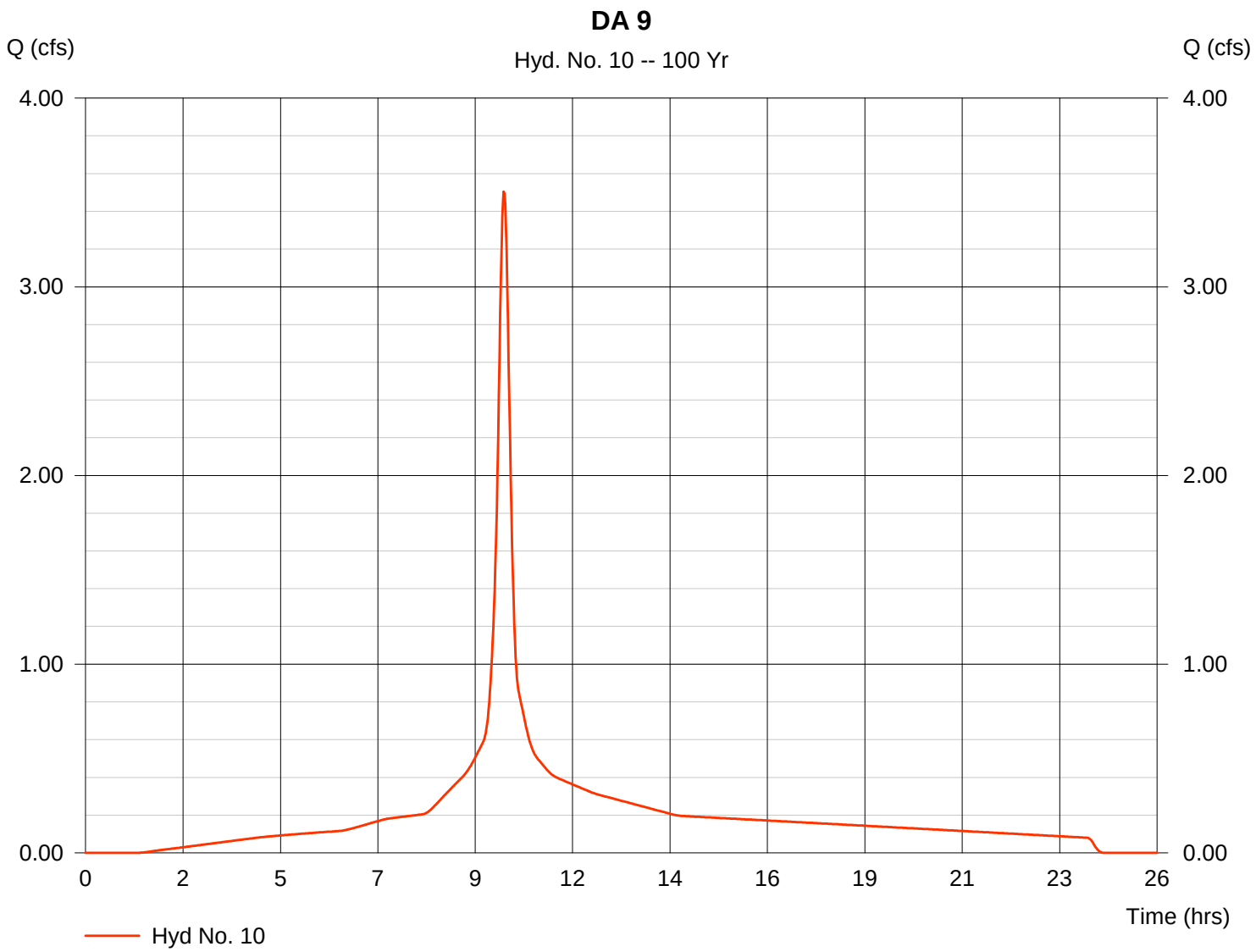
Hydrograph Volume = 17,166 cuft



Hydrograph Plot

Hyd. No. 10

DA 9

Hydrograph type	= SCS Runoff	Peak discharge	= 3.50 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 3.000 ac	Curve number	= 98
Basin Slope	= 0.5 %	Hydraulic length	= 600 ft
Tc method	= LAG	Time of conc. (Tc)	= 14.18 min
Total precip.	= 2.00 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 19,323 cuft