# DETENTION BASIN GUIDELINES

Prepared by

Contra Costa County Flood Control
and Water Conservation District

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# DETENTION BASIN DESIGN GUIDELINE

## PURPOSE

The following guidelines have been established to simplify the design and subsequent maintenance of detention basins within Contra Costa County. It is important to remember that these are just guidelines and that extenuating circumstances may require that changes be made in the standards for any one particular basin. Please remember that any deviation from this set of guidelines will be subject to approval by Contra Costa County engineering staff.

## INTRODUCTION

The detention basin is rapidly becoming a major alternative in flood control improvements. The basin is versatile in that it allows:

A. For reduced outflows so that existing downstream creeks of low capacity need no or little modification;

B. The basin to become a wetlands mitigation bank;

C. The basin to become an attractive open space park; and

D. The basin to be expanded should there be an increase of inflow from the watershed above.

The Flood Control District staff has visited a number of basins in other counties and has gathered experience in the design, construction and performance of basins in this county. The following information is a summary of this experience and staff will use this summary, or guidelines, in county projects as well as in the review of basin projects proposed by other agencies and private owners.

## CHOICE OF LOCATION

When choosing a location for a basin, the following factors should be taken into consideration:

A. Topography: Check for obvious low and high points in the area. Some of the costs for excavation can be saved by using an already low point for a detention basin. The greater the excavation, the higher the costs. Also, look for natural neckings of the watershed if a dam is necessary.

B. Location in the Watershed: Locate the basin far enough down in the reaches of the watershed to most effectively reduce the peak flow by intercepting the greatest number of tributaries to the main creek. However a basin located too low in the watershed will result in upstream channel improvements.

A basin located too high in the watershed allows all downstream lands to drain uncontrolled, which will increase the total flow to an undesirable level. This may result in additional downstream channel improvements or additional downstream basins.

C. Elevation: Consider the difference in elevation between the inlet and outlet to obtain the optimum amount of volume for the minimum of area. Also, consider the best outflow and inflow characteristics possible (i.e. a free outflow and inflow).

D. Property Costs: Consider the cost of prospective property for the basin. Lower property costs, help to lower basin costs.

E. Outlets: Concrete outlet pipes should not flow at greater than 10 feet per second at the outlet, without an energy dissipator or adequate creek protection downstream.

F. Groundwater Table: Determine the elevation of the ground water table. If possible, avoid any location where the ground water table is higher than the bottom elevation of the basin. Groundwater flow can have a significant effect on the construction and operation of a detention basin.

G. Visibility: For safety and ease of policing, the basin should be situated so that it is visible by police patrols. Whenever possible, a road should be located along at least one side of the basin.

## BASIN SIZE

Basin size varies with the amount of inflow, allowable outflow, existing soil conditions, freeboard requirements and secondary uses. These variables are further discussed below.

### Inflow

Inflow is a function of the size and shape of the watershed above the basin, its existing and projected future land use and the design storm frequency and duration.

The relationship between size of watershed and design storm frequency is as follows:

Watershed size zero to one square miles - 10-year frequency;
Watershed size one to four square miles - 25-year frequency; and
Watershed size four or more square miles - 100-year frequency, with two (2) feet freeboard.

The duration of a storm needs to be considered to determine inflow. Generally, the high intensity-short duration storms tend to determine basin size. However, basin performance must also be checked for the low intensity - long duration storms. These latter storms generate a higher flow volume (over a longer time) and, depending on the outflow provisions for a specific basin, may therefore influence basin size by the need for rapid basin draw-down or dewatering.

## Allowable Outflow

The allowable outflow from a basin is determined by the size of the existing drainage facilities downstream. If the material costs and the environmental and social costs for expanding these facilities are high, a large basin may be required to reduce outflows to acceptable levels downstream.

The amount of outflow can be regulated with a variable opening gate or a fixed outfall structure. The District prefers the latter. Such a structure must include an outfall pipe of a size and length that will give positive control on the outfall head. A typical fixed outfall structure consists of a principal spillway and an emergency spillway. The principal spillway regulates the design discharge from the watershed above at a water level in the basin that does not exceed a certain maximum elevation. The emergency spillway is used to relieve the basin of extra runoff which could threaten the integrity of the basin. In some cases, it is used in conjunction with the primary spillway. If flow through the emergency spillway is occurring, the combined flow of both the primary and emergency spillways must not exceed the capacity of downstream pipes and floodways.

The interaction between basin size, inflow and outflow has been computer modelled using the generally available HEC-1 program. The District will provide the flood hydrograph for a fee.

## Freeboard Requirements

Regardless of the size of the watershed upstream of a basin, the 100-year storm must be routed through the basin and the basin sized so that the maximum water surface elevation (due to a 100-year storm) is two (2) feet below the lowest point along the top of the basin. The District prefers basins that fully contain the inflow from a 100-year storm without spillage over the emergency spillway. If flows over the emergency spillway do occur, provisions must be made or be in place that will convey such flows safely.

The maximum water surface elevation in a basin expected from a 25-year storm must be a minimum of fifteen (15) inches below the maximum water surface elevation expected from a 100-year storm.

Basin Dewater Provisions

The basin and its outfall must be sized so that approximately 70% of the total storage in the basin can be recovered within twenty-four hours of the peak inflow, and approximately 100% of the total storage can be recovered within forty-eight hours of the peak so that enough storage is available to adequately mitigate a subsequent storm.

Secondary Uses

Basin size also varies if secondary use is desired. If the basin is to double as a passive, nature-viewing and permanent pond area, the depth of the pond should not be counted as a flow storage area. Also, if the basin is to be used as an active playfield, the basin bottom, or a portion of it, should be raised to avoid constant inundation. Additionally, the basin side slopes should be flattened to allow turfing and mowing and use by the public.

## BASIN BOTTOM

The basin outflow pipe invert should be located a minimum of three (3) feet below the basin bottom at the outflow point. The District prefers this depth to be greater if possible. This allows for the installation of a low flow pipe between inflow and outflow plus positive grading of the basin bottom to assure that no pooling in the basin bottom occurs.

If the basin is to serve a dual role as a park, and a low flow channel is to be incorporated in the basin bottom (rather than the low flow pipe) such a channel should have 3:1 side slopes and have a minimum invert slope of $s_o = 0.005$. The low flow channel and/or pipe shall be designed to carry one (1) to three (3) percent of the 100-year peak flow. Basin floors shall be sloped at a minimum of one (1) percent.

Provisions For Sedimentation

The design volume of the basin must be expanded to include the capacity for a five (5) year accumulation of silt. The amount of potential sedimentation in the basin shall be determined by a soils engineer.

## BASIN SIDE SLOPES

Basin side slopes shall be a minimum 4:1 (horizontal to vertical) below the design water surface and 3:1 (horizontal to vertical) above. The soil type will also influence the side slopes. Soft and loose material such as Oakley sand slough easily and are materially impacted by wave actions. Therefore, if this type of material exists at the site, side slopes as flat as 5:1 should be provided, unless otherwise approved by a soils engineer. Conversely, basins to be excavated into areas with rock strata should have steeper side slopes to minimize the amount of costly excavation required. If for any reason, it is believed that the soil may present problems a soils test may be needed. This test may also be helpful in determining whether or not the lower soils strata will support plant growth without special treatment.

If the basin has a secondary use, such as a park, side slopes should be 4:1 (horizontal to vertical) or flatter to support turf, planting and irrigation system and the maintenance there of.

## LEVEE/EMBANKMENTS

Any levee and/or embankment shall be designed under the supervision of a soils engineer. The top width of any levee constructed to retain water at any time, shall be eighteen (18) feet wide. The slopes of the levee shall not be steeper than two (2) horizontal to one (1) vertical. The toe of the levee shall be placed at least two (2) feet back from the top of bank of the basin. Levees shall not obstruct the storm flow in streets or flowage easements from entering the basin.

The District recommends that basins that require levees to detain water be avoided. The maintenance of such levees to prevent failure due to erosion and plant and rodent action usually outweighs the initial advantage of placing them. Levees that provide the necessary freeboard are acceptable.

## GEOTECHNICAL REQUIREMENTS

Any detention basin design must be accompanied by a soils report. This report should address allowable safe basin slopes with respect to liquefaction, rapid draw down, wave action and so forth. Additionally, the report should also address sedimentation transport from areas above the basin and allowable bearing pressures where structures are to be placed. The soils report must address the level of the water table and the effects of the basin excavation on the water table. Will nearby wells be affected and how is the basin bottom to remain dry? These are just some of the questions that must be addressed.

## MAINTENANCE REQUIREMENTS

### Access

A fifteen foot wide access road shall be provided between the basin and a publicly maintained road. The longitudinal slope of this road shall not exceed 10 percent.

Access roads with a longitudinal slope greater than 10 percent shall be paved with asphaltic concrete or other surfacing. The structural section shall be designed to withstand the loads imposed by a 35 ton truck mounted crane. If one portion of the road requires asphalt the total length of the road shall be so paved. Access roads with a longitudinal slope of less than 10 percent shall be paved with crushed run gravel unless otherwise directed by the Chief Engineer or designee.

The cross slope of the road shall be 2 percent and sloped away from the low ground adjacent to the road.

Wherever possible the basin's primary perimeter access strip shall be located on the basin side slopes approximately 18 inches above the basin floor. The secondary basin perimeter access shall be outside the excavation limits. Both of these strips shall be at least 15 feet in width and graded to be passable by maintenance vehicles. A minimum 6 foot strip shall be provided along the top of the basin.

Any storm water concentrated due to the grading of the access strip(s) shall be conveyed to a point of adequate discharge in a manner acceptable to the District. The facilities handling the concentrated storm water shall be considered as storm drains and shall be designed. A B-50 outlet structure is required if the pipe discharges into a channel or the detention basin. Erosion protection shall be installed at the lower terminus of the pipe.

If a basin is to double as a park during the dry months, it must have at least three (3) public points of access.

## TRASH RACK

All trash racks shall be designed to be readily accessible by hand or by a piece of medium sized equipment. Access must be from above the trash rack so the loose material can be removed upward.

The trash rack should be designed at a 45 degree slope to allow debris to float up as water in the basin rises. The net flow area of the trash rack shall be one-half of the design discharge of the outfall. If a basin is located in a residential area and the safety of children is a major concern, the bar spacing should not exceed 6 inches.

## FENCING

The property on which the detention basin is located shall be fenced with a double-knuckle 42-inch high, 11 gauge, chain link fence constructed in accordance with Public Works Standard Plan CC 310. At least one 12-foot wide access gate shall be installed at the basin, and another installed at the entry point from the publicly maintained road. The gate at that road shall be set back far enough to allow the maintenance vehicles to park off the road while the gate is being opened.

The gate at the publicly maintained road shall have side panels or other devices to prevent vehicles from driving around the gate. These devices must be concurred to by the District.

The gates shall be equipped with a locking feature acceptable to the District. The District will furnish the necessary lock(s).
Detention basin perimeter fencing in rural areas may consist of a fence having hogwire at the bottom and three (3) strands of smooth wire above. Backyard fencing shall be 72 inch chain link. All headwalls and other vertical dropoffs higher than three (3) feet should be fenced with 42 inch chain link fence as specified above. Slope fencing must be approved by the District and will be justified only in highly visible locations. A three (3) foot flat area adjacent to such slope fencing will be required.

## LAND RIGHTS

All access roads to the basin as well as the basin property shall be held in fee title by the District.

## LANDSCAPING

The District requires detention basins to blend in with its natural surroundings. As a minimum, basin side slopes and bottom shall be seeded to result in a full natural grass cover. Basin side slopes shall be planted with groups of bushes and/or trees of a spacing and species approximating existing vegetation on property adjacent to the basin. Irrigation water shall be provided via a water line along the top of the basin with hose bibs provided every 400 feet. The District views the above as "basic landscaping and irrigation system". It is recommended that existing top soil be saved before basin excavation is begun. This top soil should be spread on the basin bottom and sides and worked in to provide suitable environment for landscaping. Invasive plants and plants such as willows and blackberries shall not be allowed.

All landscaping and irrigation plans shall be reviewed by the District.

The basic landscaping and irrigation system is eligible for credit and reimbursement where

detention basins are located in approved drainage fee areas. Any landscaping and irrigation system in excess of the basic improvements will not be eligible for reimbursement.

If a basin is to double as a park, extra landscaping needs to be provided to screen private residences around its perimeter.

## JOINT USE

If there is a secondary use for the basin (other than flood control) the agency proposing secondary use will have to enter into a joint use agreement with the District in which the terms for liability, policing, maintenance, etc. are set forth.

## CALIFORNIA STATE DIVISION OF DAM SAFETY

Figure 1, attached hereto, shows the approximate boundaries within which a detention basin will not fall under Division of Dam Safety regulations. The parameters are "height of head" (distance between the 100-year water surface and the flowline elevation of the outfall) and capacity (100-year volume in acre-feet). If the proposed detention basin falls outside of the shaded area, the Division of Dam Safety must be consulted for approval of the design.

## REPORT REQUIREMENTS

The District will review all proposed detention basin designs. In order to speed review, the design submitted should contain the following:

Calculation and Graph

1. Watershed Parameters
2. Inflow Hydrograph
3. Stage vs. Storage Curve
4. Stage vs. Discharge Curve
5. Basin Routing (Inflow-outflow hydrographs for various frequencies and durations)
6. Summary Table of All Basin Routings

Map and Drawing

1. Hydrology Map Showing Contours, Basin Location and Watershed Boundaries.
2. Basin Drawings

Drawings should show plan and vertical views with dimensions of all structures.

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Dams and Reservoirs Within the Jurisdiction of the State of California

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION 3 OF WATER CODE

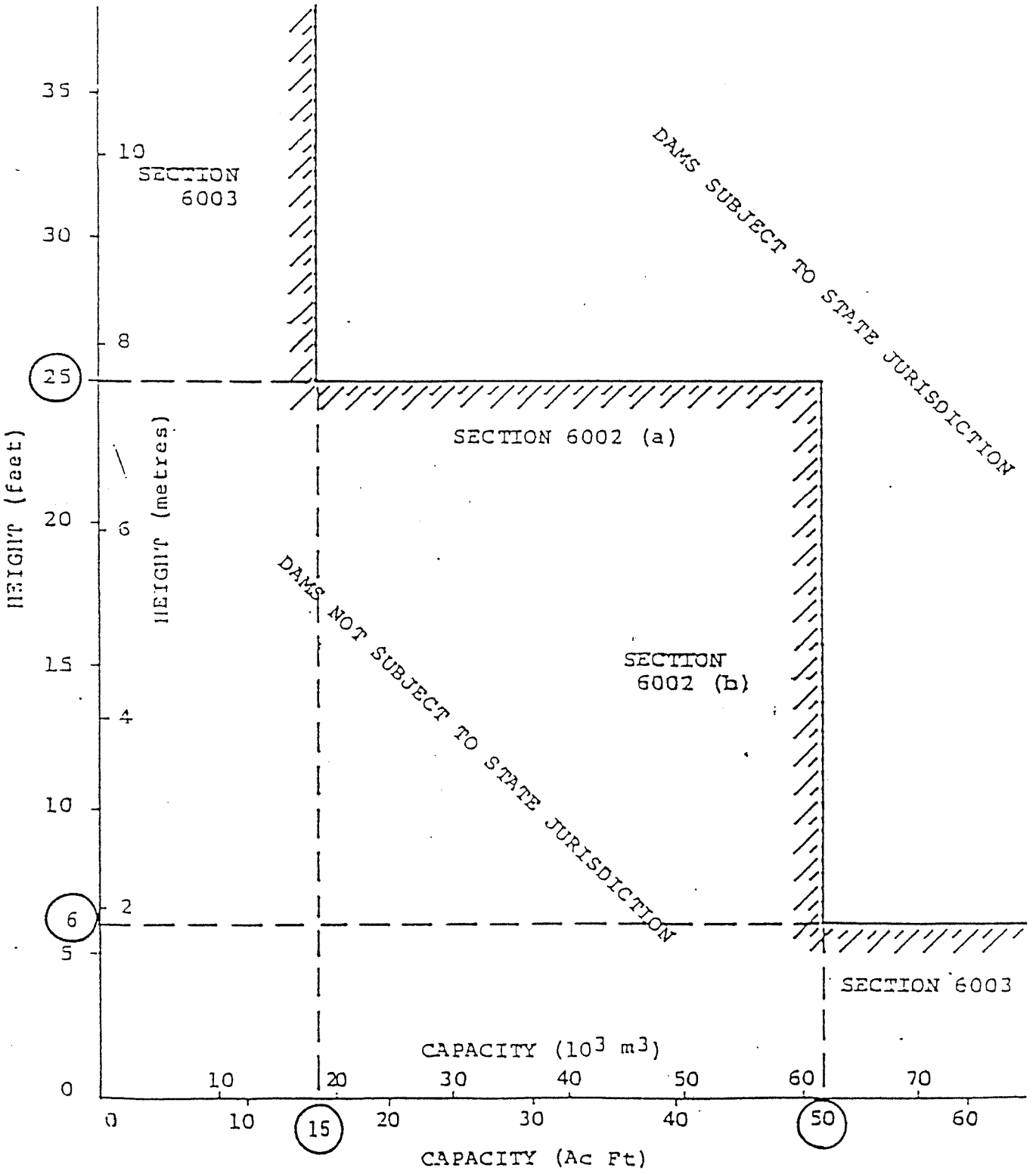


Figure 1

Freeboard Requirements

Regardless of the size of the watershed upstream of a basin, the 100-year storm must be routed through the basin, and the basin sized so that the 100-year water-surface elevation is two (2) feet below the lowest point along the top of the basin.

If the 100-year storm goes over the Emergency Spillway, then the 100-year water-surface elevation should have 2-feet of freeboard from the lowest elevation of the top of the basin. This scenario is for drainage areas less than 4 square miles where the design inflow is for 10 or 25-year storms. For drainage areas 4 or more square miles, the basin should be designed with the 100-year water-surface elevation contained below the crest of the Emergency Spillway. See Figure 1.

The desired basin design will mitigate the 10 or 25-year inflow back to pre-development flow conditions with no flow over the emergency spillway. If the 100-year design storm event flows over the emergency spillway, the resulting water-surface elevation will be at least 2-feet below the lowest elevation of the top of the basin. The maximum water-surface elevation in a basin expected from a 25-year storm must be a minimum of fifteen (15) inches below the maximum water-surface elevation expected from a 100-year storm.

Figure 1.

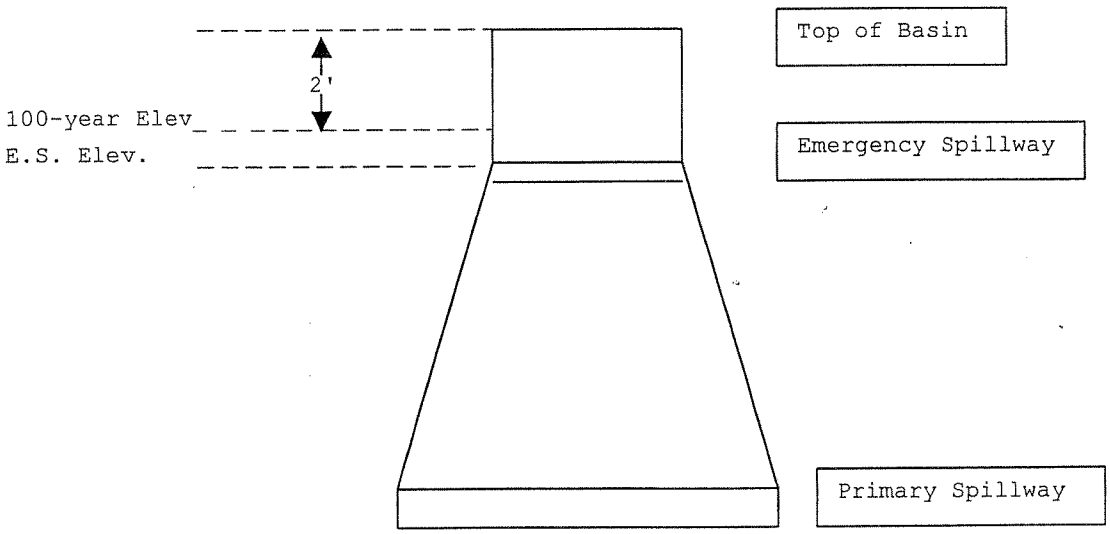


Figure 1 is for drainage areas < four (4) square miles where the design inflows are 10 or 25-year frequencies. If the drainage area is > four (4) square miles then the 100-year water-surface elevation should not top the emergency spillway, and the emergency spillway should be at least two (2) feet below the top of the basin.