Stanford University
Storm Drainage
Detention Master Plan
Supplement

West Campus
Detention Facilities

Submitted in compliance with
Condition of Approval
N.2.b of the
Stanford 2000
General Use Permit

Prepared by Nolte Associates

September 25, 2003

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1. INTRODUCTION

BACKGROUND

Stanford University is preparing a Master Plan for its storm runoff and flood control system. The University is specifically planning those elements of the system that provide protection of campus facilities when flows exceed the capacity of the normal on-site storm drainage system. In December 2001, the University received approval of the Stanford Community Plan/General Use Permit, which approves academic and residential development. Condition of Approval N.2.b of the Stanford 2000 General Use Permit (2000 GUP) required Stanford University to mitigate the potential for increased storm water runoff. In fulfillment of a portion of this requirement, the University has also recently completed a Master Plan for Detention Facilities on the east side of the campus and construction of the Serra at El Camino Detention Basins.

SCOPE OF WORK

This study has been conducted to master plan detention facilities for the west side of the campus (San Francisquito Creek Watershed). This plan will provide regional management of surface runoff and facilitate campus growth that is provided for in the Stanford 2000 General Use Permit, while maximizing the protection of the campus and the surrounding area. This report will present an analysis of runoff and recommendations for new detention facilities that are capable of integrating storm water protection with existing and future campus functions and space needs. Joint use with athletic and recreational activities will be specifically considered. The recommendations will satisfy the condition that storm drainage improvements will be sufficient to ensure that runoff levels will not increase over the existing peak levels and cause downstream flooding.

STUDY AREA

The campus area investigated in this study is illustrated in Figure 1-1.

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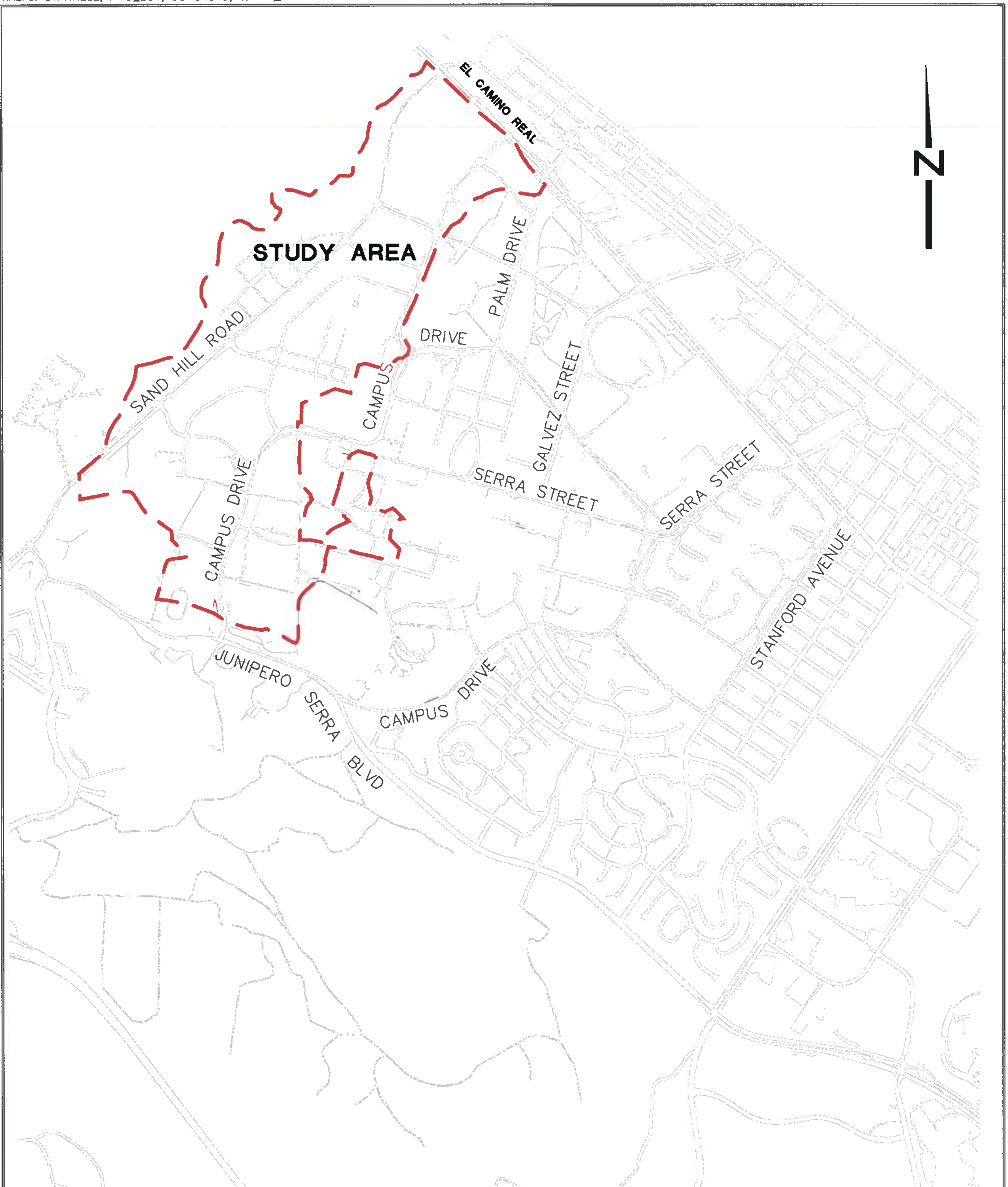

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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 1-1
STUDY AREA

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2. Summary

The campus area covered by this study drains to San Francisquito Creek. The specific limits are presented in Figure 1-1. The campus is continuing to develop, and there is a need to protect both campus facilities and neighboring communities from increases in surface runoff.

The following design criteria are proposed for the Stanford University campus:

1. Runoff from storms up through the 10-year event should be collected and conveyed by storm drainage inlets, pipes, and ditches. At this level, standing water and surface flow of runoff should be minimized.

2. Runoff from storms in excess of the 10-year event, up through the 100-year event, should be managed using established overland flow paths or piped systems that prevent damage to campus facilities.

3. Storm water detention facilities shall be implemented to prevent increases in the peak flow rates, caused by changes in campus surface runoff condition from leaving the campus. The facilities shall provide detention for:

    a. The 10-year event where the storm water flow is directed to downstream piped systems not owned by Stanford. (This criterion is not applicable to the west side of campus since the piped systems affected have adequate capacity and is owned by Stanford.)

    b. Runoff from the campus shall not increase the 100-year peak flow rates leaving the Campus.

    c. Runoff from the campus shall not increase the 100-year peak flow rates in the receiving channel.

    d. Runoff from the campus shall not increase flooding downstream.

On the west side of the Campus, criterion 3c specifically means the peak flow in San Francisquito Creek in the vicinity of the outfall of the Stanford Storm Drain at El Camino Real shall not be increased. Criterion 3d is interpreted as meaning the increase in flows from Stanford shall not cause the flow in San Francisquito Creek to increase during periods when the downstream channel capacity is being exceeded. Specifically, this flow rate in San Francisquito creek has been set by SCVWD at 6100cfs.

The Corps of Engineers' HEC-1 Flood Hydrograph computer program was used to model existing and future runoff and detention storage facilities.

The approved Stanford Community Plan/General Use Permit (2000 GUP) proposes modifications and additions to the campus. Of the total of 623 acres in the study area, approximately 40.96 acres of currently pervious acres (undeveloped and unpaved) in the west campus would be changed to impervious area.

To reduce the projected 100-year peak flow increase in the San Francisquito Creek Watershed to the current level, a total of 2.71 acre-ft of detention storage is recommended.

Six detention systems are recommended to attenuate increases in flows from the west campus development proposed by the approved Stanford Community Plan/General Use Permit (2000 GUP). An additional five locations for mitigation of increases in flow from future development are recommended for land use planning purposes because a very limited number of sites exist which meet the specific hydraulic requirements (i.e. inlet and outlet pipes or flow paths, and tributary flow rates). The proposed facilities are listed in Table 2-1 and the locations are presented in Figure 5-1.

Table 2-1, Summary of Detention Facility Locations and Characteristics

Name/Location	Number	Storage, Ac-ft	Configuration[1]	Primary Subbasin for Protection[3]
Stock Farm Road and	1	0.46	Open Basin	11,13,17
Sand Hill Road Basins	2	0.65	Buried Pipe	11,13,17
Vineyard Road and	3	0.50	Open Basin	[4]
Sand Hill Road Basins	4	0.50	Buried Pipe	[4]
Pasteur Road and	5	0.18	Open Basin	1,3,10,12,15
Sand Hill Road Basins	6	0.42	Open Basin	1,3,10,12,15
Sand Hill Road Basins[2]	7	TBD[2]	Open Basin	Reserve
Sand Hill Road Basins[2]	8	TBD[2]	Open Basin	Reserve
Sand Hill /Searsville[2]	9	TBD[2]	Open Basin	19
Sand Hill Athletic Field[2]	10	TBD[2]	Open Basin	23
Sand Hill Road Basins[2]	11	TBD[2]	Buried Pipe	Reserve

[1]Buried Pipe may be substituted for the Open Basin configuration if desired to accommodate land use requirements.
[2]Future location – size and storm attenuations needs to be determined (TBD) by future engineering.
[3]The attenuation from each basin is applicable to the entire watershed. Primary Subbasins are those subbasins upstream of the detention basin for which the detention basin has maximum efficiency.
[4]These detentions basins provide attenuation for the remainder of the GUP 2000 development and Area 9, 14 and 33.

The specific size and configuration of the facilities will be determined during the design process. For each of these facilities the preferred configuration is an open basin because this is the most cost effective configuration. For each location of the future Sand Hill Basins (7, 8 and 11) an alternate location using a buried pipe configuration in an existing parking lot has also been selected. An open basin can be converted to a buried pipe facility if future land uses justify the cost.

The proposed detention facility locations are large enough to provide flow reductions for current and future growth needs. Each of the facilities may be sized to meet the needs of a specific project or to accommodate several future projects within the watershed. Since the joint use of the sites is a significant factor in determining the size of a facility, any one of the facilities may provide a significant reserve of peak flow attenuation capacity.

The range of capacities of a detention facility to reduce peak flows will be documented at the time the permit for construction of the detention facility is submitted to the County of Santa Clara for approval. This capacity will be equated to a specific number of square feet of impervious area for which the detention facility will attenuate flow and will be designated as a reserve of impervious area for use by future development. This reserve of impervious area will be reduced as campus development projects are constructed. The permit for each individual development project will identify the detention facility that is providing the flow attenuation, state the change in impervious area caused by the project, and indicate the balance in the reserve of impervious area for the identified facility before and after the project. Sample forms for managing the capacity of a facility are presented in Appendix 4. Because the location of the development with respect to a detention basin affects the relative efficiency of the basin to attenuate flow, HEC-1 runs will be conducted as necessary to confirm the reserve that is available in each basin system.

3. DESIGN CRITERIA AND CALCULATION METHODOLOGY

In this section, the design criteria will be presented along with the methodology used to perform the required calculations in this report. The design criteria will include the setting for the facilities that are being protected, the frequency event that is used for planning, and drainage principles that are applicable to these systems. The methodology and assumptions for use in calculating runoff detention volumes using the Corps of Engineers' HEC-1 will also be presented.

In this report, two terms will be used to describe surface runoff or the analysis of runoff. These terms are hydrology and hydraulics. The following definitions are provided for clarity:

- Hydrology refers to the calculation of the quantity of runoff.
- Hydraulics refers to the calculation or quantification of the water conveying capacity of the storm drainage systems.

CAMPUS SETTING

The campus has a long history that is perpetuated in its building and landscape architecture. The quality of this setting must be respected. The development of the campus must also accommodate the realities of storm water runoff and its management.

Drainage facilities require space and occupy land. Drainage facilities should be designed, when possible, to share the land with other uses such as parking, roadways, recreational activities, and open space.

DESIGN STORM EVENT DEFINITION

The level of protection of facilities from flooding is usually defined in terms of the probability of the storm event occurring that would impact the facility. This probability is characterized in terms of the frequency of the event returning or the return frequency for a rainfall event. As an example, an event that has a one percent chance of occurring is an event that would occur as an average of once in every 100 years. This is commonly referred to as a 100-year event. The lower the probability an event has, the larger the event is. A storm that occurs at least once each year is much smaller than a storm that occur an average of once in each 50 years.

DESIGN CRITERIA

The following levels of protection are recommended as design criteria for the Stanford University Campus:

1. Runoff from storms up through the 10-year event should be collected and conveyed by storm drainage inlets, pipes, and ditches. At this level, standing water and surface flow of runoff should be minimized.

2. Runoff from storms in excess of the 10-year event, up through the 100-year event, should be managed using established overland flow paths or piped systems that prevent damage to campus facilities.

3. Storm water detention facilities shall be implemented to prevent increases in the peak flow rates, caused by changes in campus surface runoff condition. The facilities shall provide detention for:

    a. The 10-year event where the storm water flow is directed to downstream piped systems not owned by Stanford. (This criterion is not applicable to the west side of campus since the piped systems effected have adequate capacity and is owned by Stanford.)

    b. Runoff from the campus shall not increase the 100-year peak flow rates leaving the Campus.

    c. Runoff from the campus shall not increase the 100-year peak flow rates in the receiving channel.

    d. Runoff from the campus shall not increase flooding downstream.

The detention facilities shall be designed in accordance with applicable County and City standards, specifically the County of Santa Clara Grading Ordinance.

These design criteria, specifically criterion number 3, implement the Condition of Approval N.2.b of the Stanford 2000 General Use Permit.

During the design process and the acquisition of the grading permits to construct detention basins, these criteria have continued to be interpreted and made specific through discussions between Stanford and Santa Clara County. On the west side of the campus, criterion 3c specifically means the peak flow in San Francisquito Creek in the vicinity of the outfall of the Stanford Storm Drain at El Camino Real shall not be increased. Criterion 3d is interpreted as meaning the increase in flows from Stanford shall not cause the flow in San Francisquito Creek to increase during periods when the downstream channel capacity is being exceeded. Specifically this flow rate in San Francisquito creek has been set by SCVWD at 6100cfs.

STUDY AREA DRAINAGE FEATURES

The study area is drained by the storm drainage system, as illustrated in Figure 3-1. This drainage system was originally designed for a 10-year event. The design appears to have been conservative. The design anticipated growth as well as expansion to provide service to adjacent areas not currently connected to the west campus storm drainage system. During the process of developing the campus, the areas anticipated for connection to the piped storm drain system in adjacent watersheds have not been connected and will not be connected to the west campus piped drainage system in the future. In addition, this Storm Drain Master Plan is planning the attenuation of peak flow events, which increases the ability of the storm drainage system to manage storms that are larger than anticipated by the original design. The existing storm drain capacity has been reviewed and the large diameter pipes that exist in this system have the capacity to handle the 100-year flows after attenuation of the peak flow rates as calculated by HEC-1 of 2000 GUP development using the methodology described below.

CALCULATION METHODOLOGIES

The Corps of Engineers' HEC-1 model will be used for runoff calculations, detention facility performance analysis, and detention volume calculations.

Detention Calculation Methodology

Detention of surface runoff is the process of absorbing peak flow rate from an area by storage, and then releasing the flow in a controlled manner at a lower flow rate. This process reduces the impact of a high peak flow on downstream drainage facilities. The Corps of Engineers' HEC-1 Flood Hydrograph computer program model (P.C. version 4.0.3E, dated June 1992) was used to model detention storage facilities. The volume of runoff and the variation in the runoff over time are the most important elements in analyzing the size and effectiveness of storm water detention.

The HEC-1 model, therefore, does not use the Rational Method (a surface runoff calculation procedure) to determine peak flow rates. The HEC-1 model uses a design storm for rainfall and uses the characteristics of the watershed for calculating runoff over time. This calculation is generally appropriate for larger watersheds. The characteristics of the watershed can be determined and adjusted through a calibration process using stream gage data. Santa Clara Valley Water District (SCVWD) has developed and calibrated watershed data for most of Santa Clara County.

The study area covers a portion of the San Francisquito Creek Watershed. The area was modeled using the procedures outlined in SCVWD Hydrology Procedures. dated December 1998. The drainage areas were defined based on the local topography of the ground surface, the storm drain system configuration, and the probable locations that may be used for detention facilities. The drainage area configuration and general

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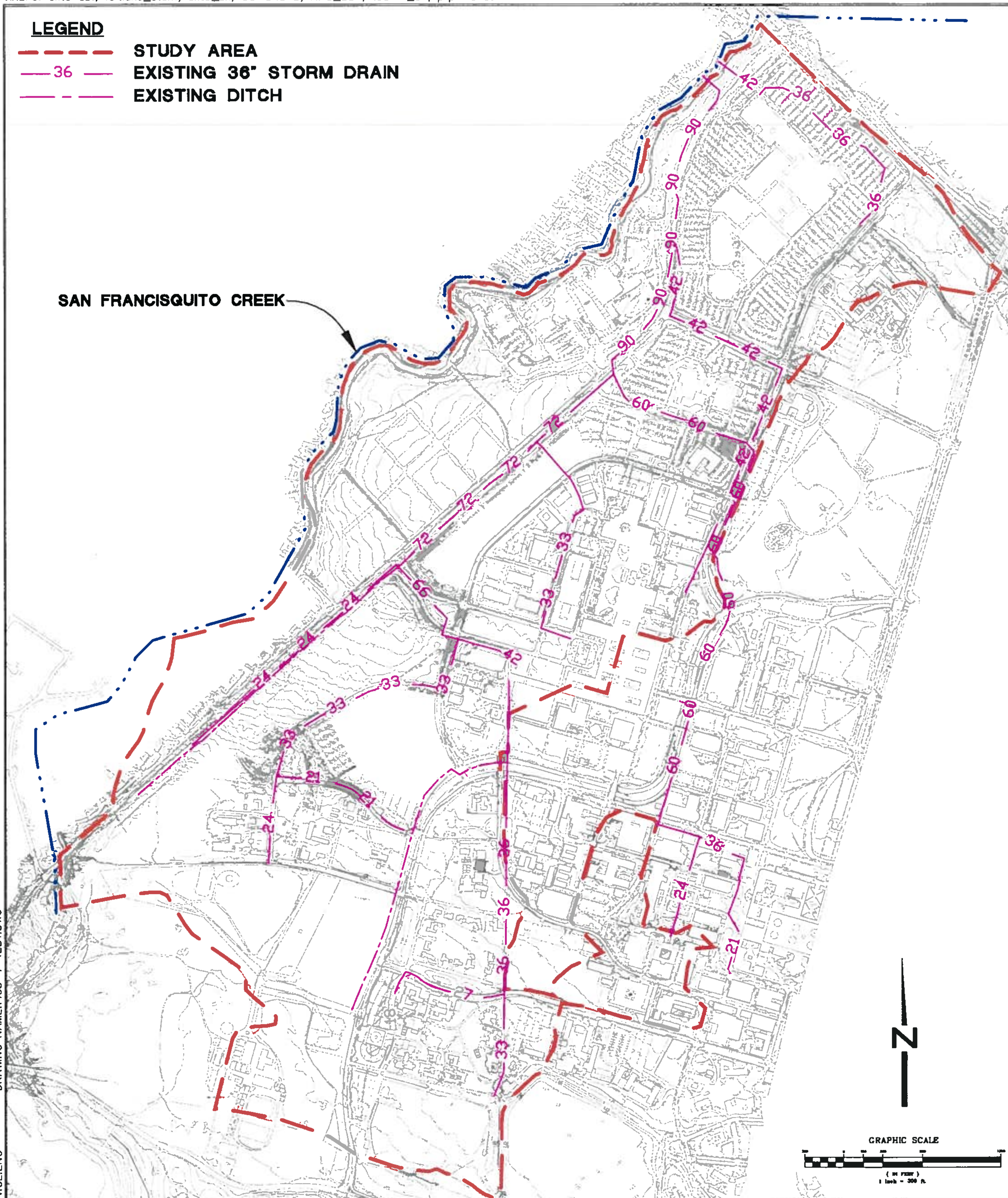

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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 3-1
PIPE STORM DRAINAGE SYSTEM

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characteristics are presented in Figure 3-2. The numerical values used for each area and the supporting tables as defined by the SCVWD's methodology are presented in Appendix 2.

The rainfall data used in the model for both 100-year and 10-year design storms have been acquired and analyzed. The SCVWD design storms are synthesized storm events with 24-hour duration. The pattern of rainfall generally reflects previous high intensity events that have caused flooding in this area. The design event can be described as an event with low to moderate intensities for a period of approximately 15 hours, followed by the intensities increasing sharply to a peak in 3 hours, and then tapering off and stopping in the remaining 6 hours of the event. A typical runoff hydrograph calculated using the design storm is presented in Figure 3-3. The type of event illustrated is typical of the area, creating saturated surface conditions. The low to moderate intensity portion of the hydrograph can significantly consume the effective volume of a detention facility prior to containment of the peak flow and must be planned for in the design process.

The flow rates for the existing condition from this new HEC-1 model developed using the procedures described above were compared with flow rates calculated by the previous SCVWD HEC-1 model using a prorated area. The two models calculated the same flow rate for the study area.

The two most significant model parameters, which are specifically applicable to the Stanford campus and to the specific analysis being performed, are the pervious area and the impervious area. Pervious areas are typically areas like open fields, undeveloped land, and parks. Impervious areas are typically parking lots, roads, sidewalks, and building roofs. As an area develops, the use of the land often changes from pervious areas, like open space, to roads and roofs, and the runoff correspondingly increases. However, development that changes a parking lot to a building does not necessarily increase the runoff.

Detailed Design Analysis

The HEC-1 model is intended for the calculation of runoff from watersheds. The model has limited ability to model complex detention basin systems. To design a basin, the analysis of HEC-1 has been supplemented by the use of PondPack, developed by Haestead Methods. This more detailed model has the ability to analyze the orifices, wiers, pipes, and other features used in basins as well as to consider submerged or non-submerged inlet and outlet conditions of these various elements of the basin system. The hydrograph developed by HEC-1 at the diversion structure is extracted from HEC-1 and used as the input to PondPack. PondPack will develop one or more output hydrographs based on the physical configuration of the drain system overflow structures and other hydraulic elements at the downstream end of the basin system. The output hydrograph(s) is then returned to the HEC-1 model to complete the analysis.

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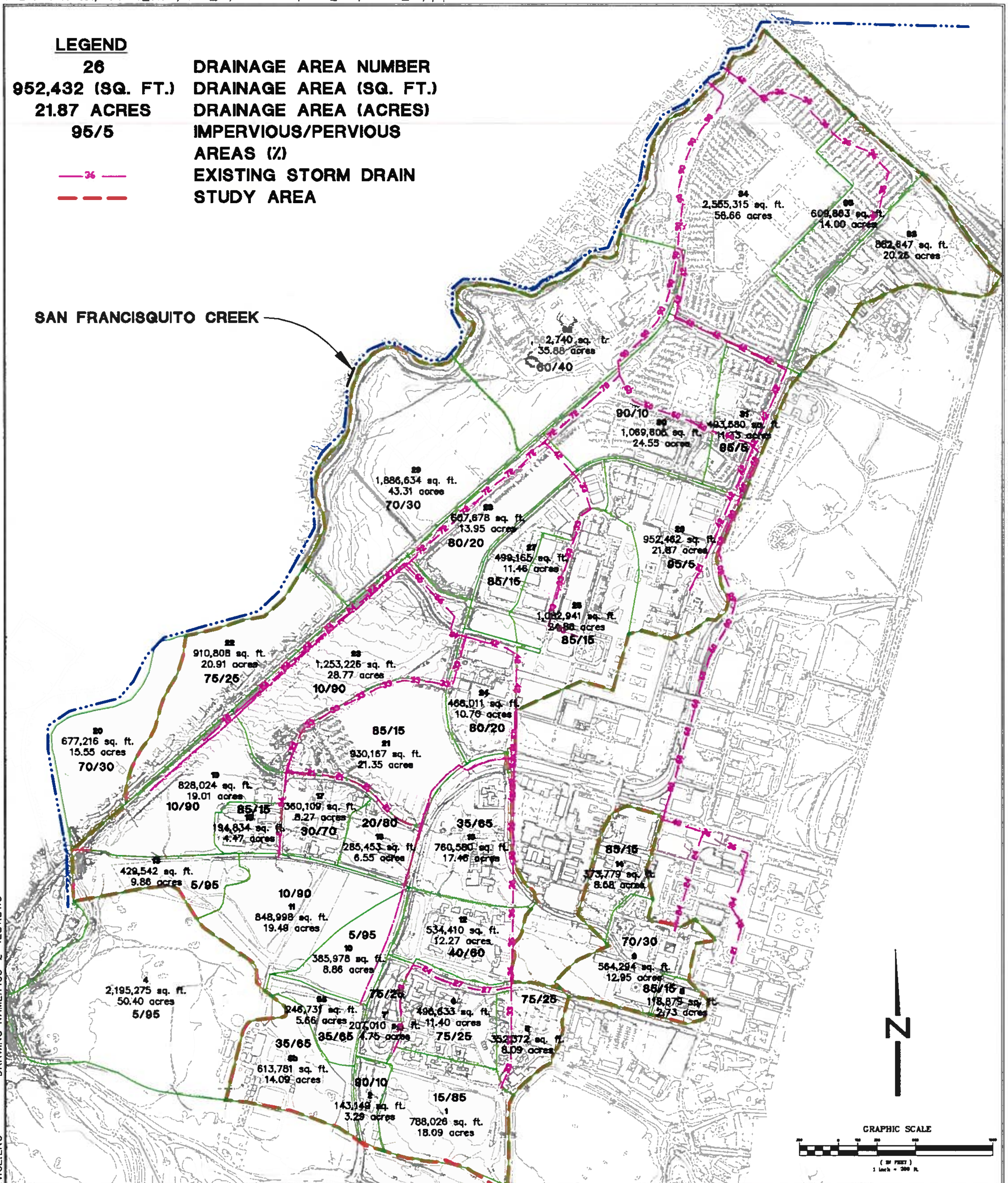

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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 3-2
WEST CAMPUS 2001 DEVELOPMENT

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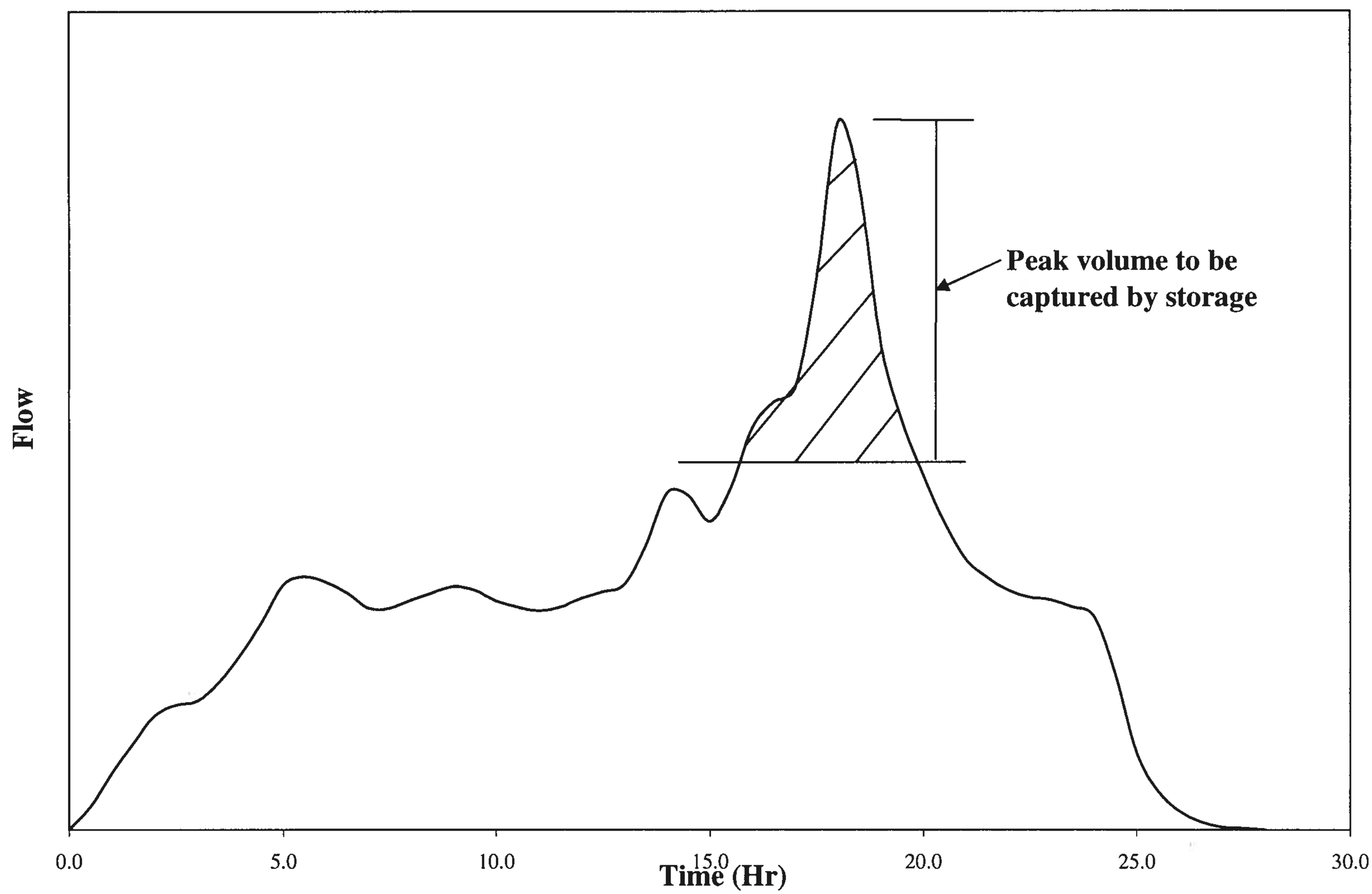
Figure 3-3. Typical Runoff Hydrograph



4. EXISTING DRAINAGE SYSTEMS

The purpose of this chapter is to describe the existing drainage systems and tributary drainage areas. This discussion will provide a framework for the analysis that is required. The natural drainage boundaries controlled by the topography of the West campus Drainage Area will be presented. This description will be followed by a presentation of off-campus systems and on-campus systems. Off-campus systems are major drainage works that are operated and maintained by others. On-campus systems are operated and maintained by the University. A discussion of the probable growth will also be presented for the 2000 GUP development.

NATURAL TOPOGRAPHY

The overall runoff pattern through the study area is from the hills toward San Francisco Bay. The flow progresses in a predominately north to northwest direction and is collected in San Francisquito Creek. The general topography is presented in Figure 4-1. The drainage boundaries defined by the existing contour lines and surface terrain features and the piped drainage systems are also presented.

For the purpose of this study a new topographic map was developed. Aerial photographs were taken for mapping purposes in January of 2000 for the western side of the campus. For purposes of mapping, Palm Drive and its extension to the foothills represents the eastern limit of the west campus mapping effort. The new mapping was prepared at a map scale of 1 inch equal to 40 feet, with a 1-foot contour interval. This new mapping effort has been supplemented by the topographic mapping that was performed for the Sand Hill Road projects.

OFF-SITE DRAINAGE SYSTEMS

The drainage facility locations, along with owners of the facility and drainage areas as they relate to the study area, are also presented in Figure 4-1.

The westerly off-site drainage facility is San Francisquito Creek. The westerly portion of the campus drains to San Francisquito Creek. A Caltrans storm drain extends westerly in El Camino Real from University Avenue to San Francisquito Creek. Flows entering the undercrossing of El Camino Real at University Avenue are pumped to the westerly flowing storm drain in El Camino Real.

A significant drainage feature on the southeastern side of the study area is Lake Lagunita. The hills generally drain toward Lake Lagunita. The location and drainage area is specifically noted in Figure 4-1. A storm drain, the Junipero Serra Foothills Storm Drain, has recently been constructed to augment the existing Gerona Ditch to collect flows from the hills south of Lake Lagunita. The arm of the lake, extending to the west, intercepts flows from the hills southwest of the lake. Initial flows from very large storm events that exceed the storage capacity of Lake Lagunita are released by the spillway and are captured by a storm drain that is routed to San Francisquito Creek. Flows from the

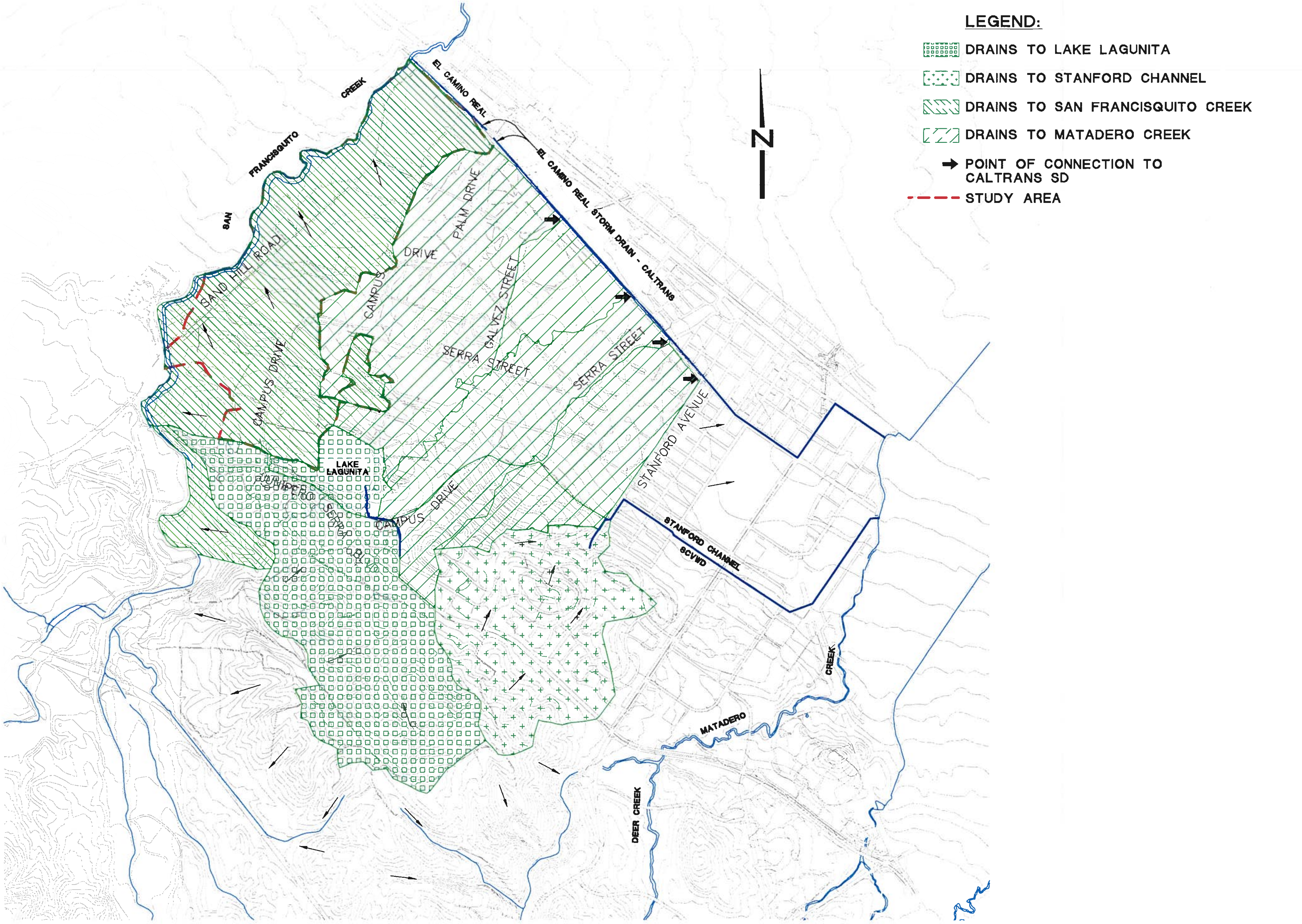


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FIGURE 4-1

OFF-SITE DRAINAGE SYSTEM

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spillway that exceed the storm drain capacity would flow overland across the campus northeasterly toward Matadero Creek.

ON-SITE DRAINAGE SYSTEMS

There are two basic systems for carrying water across the campus. The first system is the existing constructed storm drain inlets, pipes, and ditches. The second system is the overland flow paths, which consists of primary and secondary flow paths. The primary flow paths are generally the roadways, as defined by the elevation of the curb and gutter where they exist. The slope of the ground and other physical features, which impact the movement of water in its travels downhill, define the secondary flow paths.

Considering the combined capability of these two systems, the campus is further divided into subareas. These subareas are internal drainage areas that ultimately drain to either the perimeter of the campus or subareas used to analyze the detention requirements for each specific site where detention facilities will be used to decrease peak flow rate of the runoff. The specific subareas that are included in this study area are the subareas which contribute flows in excess of the 10-year event. Specifically these are:

- Subareas that contribute flows to San Francisquito creek by overland release
- Subareas where the overland release path is intercepted and forced into the piped system at a location where the piped system has adequate capacity to accept the 100-year flow from that subarea.

These subareas and the point where the 100-year flow paths are intercepted are illustrated in Figure 4-2. This Figure also presents the assumed percentage split between pervious and impervious for the existing condition for each subarea.

LAND USE CHANGES

The approved Stanford Community Plan/General Use Permit (2000 GUP) allows modifications and additions to the campus. Increases in the number of residential housing units and academic buildings are proposed. These additions can potentially increase the amount and location of impervious area on the campus, thus increasing the surface runoff.

An estimate of the increase in the impervious area was developed by Parsons for Santa Clara County's Environmental Impact Report for the Stanford Community Plan/General Use Permit. The EIR estimate is based on the following assumptions:

- The square footage of building additions and other improvements allowed by the General Use Permit.
- Estimates of the number of floors in the new structures.

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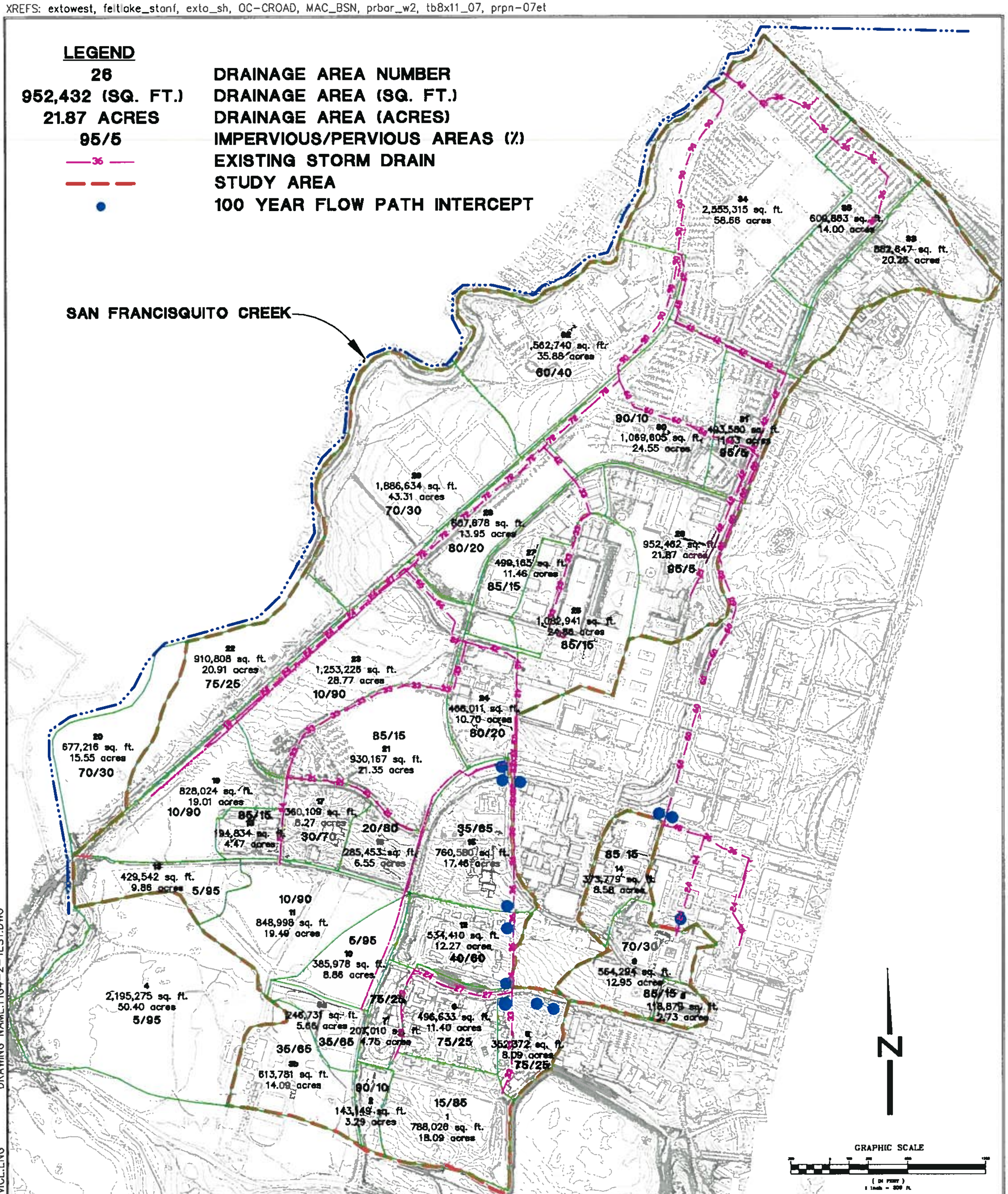

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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 4-2
ON-SITE DRAINAGE SYSTEMS

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- Existing use of the proposed building sites (currently pervious or impervious).

- An increase of 15 percent to the estimated change in impervious area for miscellaneous site modifications.

Additional details of this calculation are presented in Appendix 2.

The assumptions stated are valid and appropriate for infill projects, which is the predominant type of project that will be implemented by the approved 2000 GUP. However, 2000 GUP envisions some major conversions of undeveloped land to residential development. For this type of conversion of vacant land, a more conservative assumption for impervious area is 0.70 times the gross area for medium density residential development and 0.90 times the gross area for higher density development. These assumptions are more appropriate for a master planning effort to account for the area covered by pavement associated with the buildings and the associated roads. These new assumptions will result in a more conservative and realistic plan for detention needs than the assumption used in the EIR. These values used for the detention calculations are compared with the EIR assumptions in Table 4-1.

Table 4-1, Increased Impervious Area for San Francisquito Creek Watershed

Land Use	EIR Assumptions[1]		Detention Calculation Assumption[2]
	sq. ft	Acres	Acres
Academic and Residential Housing	688,960	15.82	38.96
Academic Building	106,303	2.44	1.99
Parking Inventory	169,050	3.88	--[3]
Total (sq. ft.)	964,313	22.14	40.96

1. Based on building sq.ft. plus 15% additional paving.
2. Based on realistic impervious area for new development including roads, walks, driveways, and normal site amenities.
3. Included in academic housing areas.

The total areas for the San Franciquito Creek watershed that have been modeled are presented in Table 4-2. The detailed information for each subarea is presented in Figure 4-3 and Appendix 1. In the table, the comparison is also made for the subareas experiencing infill type development for academic buildings and the subareas affected by residential type development. The acreage change for the areas with academic development is similar to the area change projected in 2000 GUP. The total change in acreage of impervious area for the subareas with residential and parking development is substantially larger, reflecting the more conservative allowance for roads and other impervious supporting areas.

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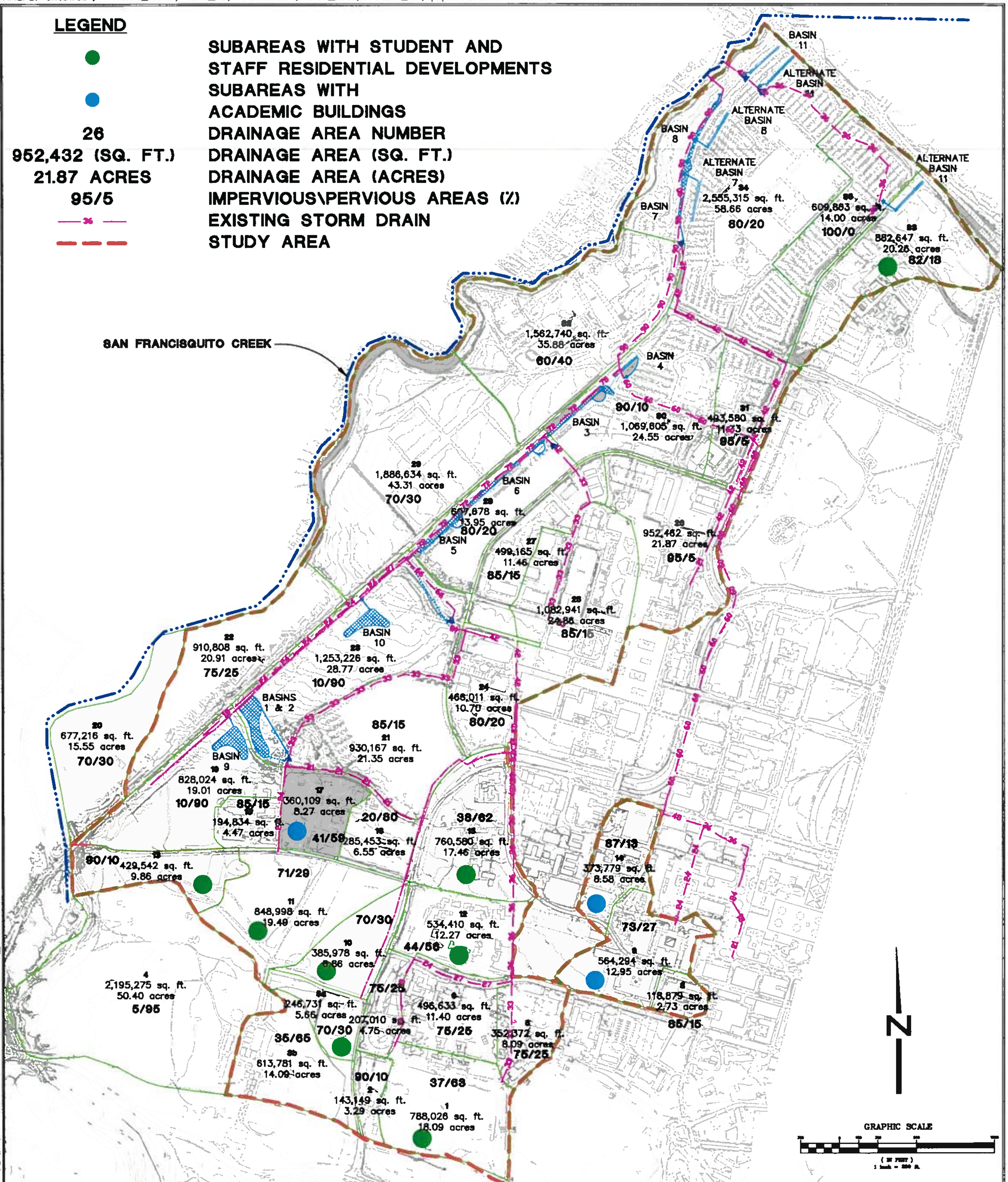

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FIGURE 4-3
WEST CAMPUS 2000 GUP DEVELOPMENT

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Table 4-2, Pervious and Impervious Areas for San Francisquito Creek Watershed

	Existing Condition, Acres	2000 GUP Land Use, Acres
Subareas with Academic and Residential Housing (and Parking)		
Impervious Area	30.51	69.47
Pervious Area	81.36	42.40
Total	111.87	111.87
Subareas with Academic Building		
Impervious Area	24.95	26.94
Pervious Area	22.31	20.32
Total	47.26	47.26
Study Area Total		
Impervious Area	350.08	391.04
Pervious Area	273.60	232.64
Total	623.68	623.68

5. HYDROLOGIC / HYDRAULIC ANALYSIS

The purpose of this chapter is to document the hydrologic / hydraulic analysis and provide an understanding of the analysis used in selecting the recommended improvements. This discussion will identify detention requirements to prevent an increase in peak runoff flow rate to off-campus facilities.

STORAGE DETENTION REQUIREMENTS

The Corps of Engineers' HEC-1 Model was used for the hydrology analysis of the campus. Two scenarios have been studied. The two scenarios are the current condition (Year 2000) and the future condition - 2000 GUP. As discussed earlier, a new model for the west campus portion of the San Francisquito Creek watershed was prepared. The total flow of 339 cfs for the 100-year event existing condition, calculated by the new model, was compared with the existing SCVWD model and provided the same calculated flow rate. To develop the data for the future condition, the numerical value for the developed (impervious) area was increased from that of the existing data by the amounts presented in Chapter 4 and the corresponding decrease in the undeveloped (pervious) area was also made. An analysis of the existing condition and the future condition for the 100-year runoff was then performed. The 10-year storm event was not specifically analyzed since the pipe system is owned by Stanford and has adequate capacity to carry the 100-year event for the existing conditions.

The results for San Francisquito Creek are presented in Table 5-1. The flow for 2000 GUP is increased compared to the current condition.

Table 5-1, HEC-1 Subarea Data and Calculated Flows for San Francisquito Creek

Subarea		2000		2000 GUP	
		Drainage Area (Acres)	Flow (cfs)	Drainage Area (Acres)	Flow (cfs)
			100 yr		100 yr
SF					
	Developed	350		391	
	Undeveloped	274		233	
	Total	624		624	
	Total Flow		339		356
Detention Volume, Acre Feet					2.71
Attenuated Flow					338

The model for San Francisquito Creek was then tested, as presented in Table 5-1, to determine the volume of storage necessary to reduce the peak flow rate for the future condition to the peak flow rate to a level below the flow rate for the existing condition. For this analysis many detention facility location, sizes, and configurations were tested.

This analysis reflects the volume of the facilities at the recommended sites. The facility volume also reflects optimization of the volume available at the recommended sites. To reduce the projected 100-year peak flow for the future developed condition to below the current peak flow, 2.71 acre-ft of detention storage is recommended. This total volume of detention attenuates the flow more than is required by 2000 GUP. This volume of storage is preliminary and is based on the major design criterion 3a, preventing the peak flow from the Stanford Campus from increasing. The implementation and achievement of the compliance with criteria 3b, 3c and 3d may require more or less detention volume.

ALTERNATIVE LOCATIONS

This discussion describes the process used to select detention facility sites and to size the detention storage that is required. Detention sites are chosen based on the ability to modulate flows leaving the individual drainage subbasin, effectiveness of detention at the possible location, feasibility of constructing storage, and existing land usage. Primary sites were open fields and areas adjacent to existing channels and pipes.

Location Criteria

The following criteria are considered in the selection of detention storage sites.

- Location adjacent to a main flow path or pipe.
- Adjacent to flow path or pipe with sufficient capacity/runoff to fill the facility and be adequate to carry away the attenuated runoff without being detrimentally affected by downstream hydraulic conditions.
- Topography that can be developed into a detention site economically.
- Current land use that is capable of being adapted for use as a storage detention facility.
- Capability of being integrated into the overall campus setting and land uses as a detention facility.
- Capability of being designed for the relatively infrequent and seasonal use as a detention facility.
- Capability of being committed to this use.

These detention facilities will only be utilized for a relatively short period during a high intensity rainfall event. The actual flooding will last for less than 48 hours for the 100-year event. Therefore, damage to permanent vegetation like trees or grass is not expected. The time when standing water is present in the detention facilities is also less than the breeding cycle of mosquitoes. If the multiple use of a site includes use as an unpaved parking lot, this use could be delayed for several days until the ground dries out after a major storm event.

Site / Location Interactions

Detention facilities achieve their effectiveness by capturing the peak flow of a rainfall event and releasing the captured flow later in time, effectively altering the shape of the runoff hydrograph downstream of the detention facility.

The peak storm flow rate at any location along a stream, pipe, or flow path is created by combining all of the runoff from the areas upstream of the point of interest. The runoff from the farthest point is adjusted for travel time in channels and pipes, and then combined with the flow from the nearest point to develop the peak flow rate. This time and space interaction must be considered in the design of a detention facility.

The most effective facility is located close to where the attenuation of the peak flow is desired. The most effective facility is also at a location where all or most of the peak flow rate is present.

A detention facility that is remote from the location where the attenuation of the peak flow is desired may be used to reduce flow at a downstream point. The remote detention facility is effective because it reduces the peak flow from the existing development to compensate for development in other areas of the watershed. The remote detention facility requires a modified volume or release rate (possibly modifications to both) to achieve the desired downstream benefit. The modifications will typically result in a significantly larger storage volume than the facility located at the most effective downstream location.

Design Storm Interactions

Similar to the interactions with location, detention facilities are also tailored for the specific level of protection desired. The detention facility is designed to allow water to enter the facility when the flow rate exceeds a predetermined level. Flow rates below the target level are allowed to flow past the facility. The specified level of protection (typically 10-year or 100-year event) usually determines the target level.

The inlet and outlet portions of the detention system are therefore designed to perform and interact differently for the different storm events. A two-stage storage and release system can be designed into a single facility allowing the facility to operate at two different design storm flow rates, or a system using two different storage units can be designed on the same or adjacent sites to accommodate the different desired levels of protection. The specific solution is dependent on site constraints and conditions. This concern can impact site selection and land area requirements and is addressed during the detailed design of the detention system.

In the West Campus area, the criteria for attenuation of the 10-year event is not applicable because the storm drain system is owned by Stanford, has adequate capacity for the 100-year event and discharges directly to San Francisquito Creek.

Sites Selection Process

Based on the above location criteria sites were selected for investigation. Each site was evaluated and a possible facility configuration, volume, inlet configuration, and outlet configuration was developed. The configuration of the facility was then reviewed with the campus Planning Office and other campus stakeholders to determine if the site configuration was feasible.

SITE SPECIFIC RECOMMENDATIONS

Each site is unique and the specific ability to provide protection is dependent on the site location, the site geometry, the flow paths that are being intercepted, and the location of the storm drain for emptying the facility. In the west campus area the available sites are generally linear and multiple basins in series are required to achieve the required volume.

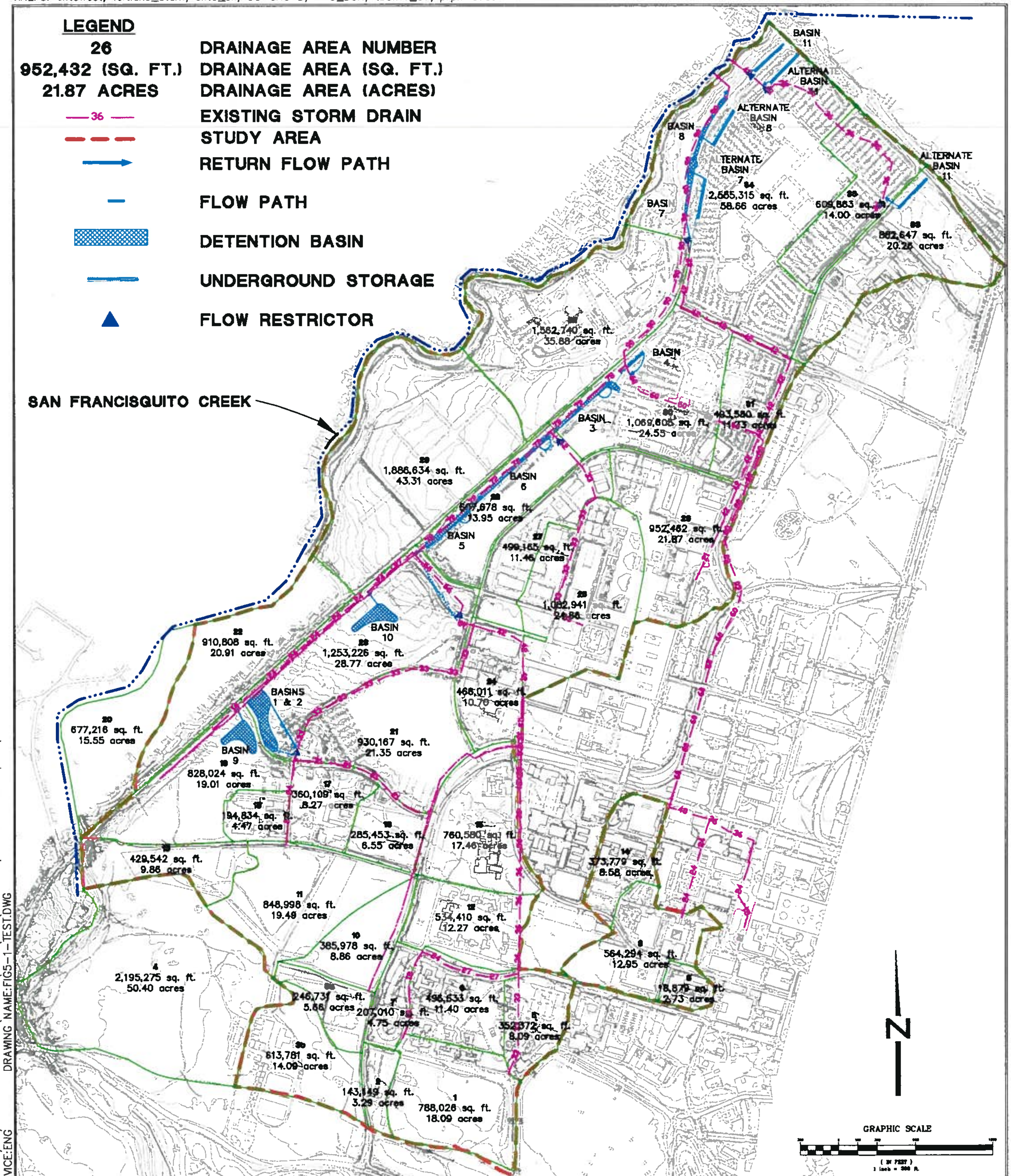
Six detention facility sites are suggested at this time to address the needs of the 2000 GUP. An additional five sites have been identified that meet the site criteria for land use planning purposes. All of the eleven sites are presented in Figure 5-1.

Table 5-2, Summary of Detention Facility Locations and Characteristics

Name/Location	Number	Storage, Ac-ft	Configuration[1]	Primary Subbasin for Protection[3]
Stock Farm Road and	1	0.46	Open Basin	11,13,17
Sand Hill Road Basins	2	0.65	Buried Pipe	11,13,17
Vineyard Road and	3	0.50	Open Basin	[4]
Sand Hill Road Basins	4	0.50	Buried Pipe	[4]
Pasteur Road and	5	0.18	Open Basin	1,3,10,12,15
Sand Hill Road Basins	6	0.42	Open Basin	1,3,10,12,15
Sand Hill Road Basins[2]	7	TBD[2]	Open Basin	Reserve
Sand Hill Road Basins[2]	8	TBD[2]	Open Basin	Reserve
Sand Hill /Searsville[2]	9	TBD[2]	Open Basin	19
Sand Hill Athletic Field[2]	10	TBD[2]	Open Basin	23
Sand Hill Road Basins[2]	11	TBD[2]	Buried Pipe	Reserve

[1]Buried Pipe may be substituted for the Open Basin configuration if desired to accommodate land use requirements.
[2]Future location – size and storm attenuations needs to be determined (TBD) by future engineering.
[3]The attenuation from each basin is applicable to the entire watershed. Primary Subbasins are those subbasins upstream of the detention basin for which the detention basin has maximum efficiency.
[4]These detentions basins provide attenuation for the remainder of the GUP 2000 development and Area 9, 14 and 33.

XREFS: extowest, feltlake_stanf, exto_sh, OC-CROAD, MAC_BSN, tb8x11_07, prpn-07et



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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 5-1
DETENTION BASIN LOCATIONS

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The detention facility sites were chosen based on the benefit to the individual drainage subbasin, downstream location, and existing land usage. Primary sites were open fields, roadside buffer space, and areas adjacent to existing pipes. In several cases suitable sites for open basins were not available and therefore sites for buried pipe detention facilities have been identified. These sites appear to best meet the presented constraints. A summary of the facility characteristics is presented in Table 5-2. The primary tributary areas to each detention basin are presented in Figure 5-2.

In the following discussion, the term "basin" is used to identify either open basins that detain water on the surface or a buried pipe configuration that detains water in a network of buried pipes that may be located below the ground surface.

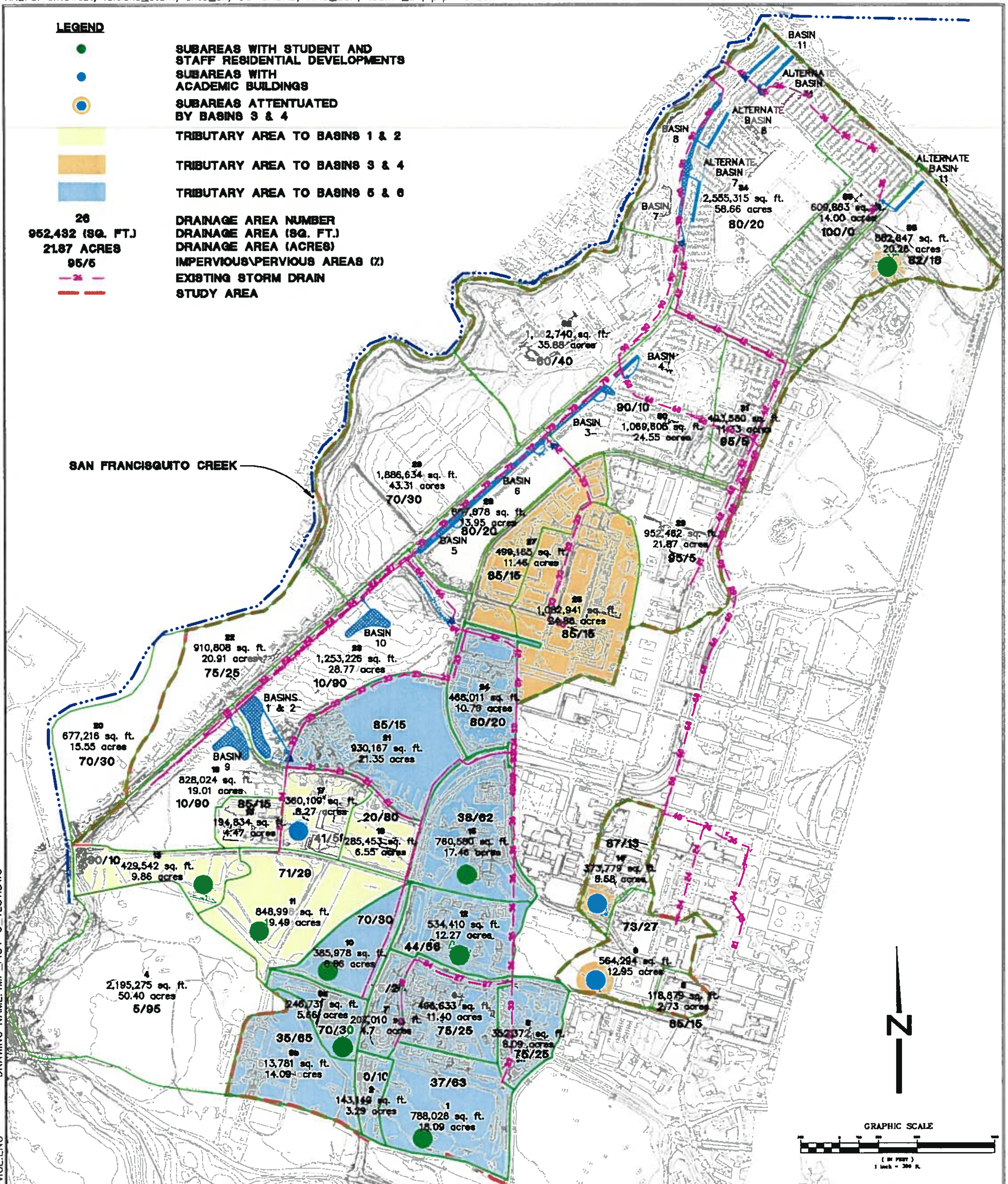
Basins 1 and 2 - Stock Farm and Sand Hill Road

This pair of basins provides 100-year flood protection. The basins will be filled from flow in the storm drain at Stock Farm Road and Oak Road. Flows will return to a storm drain in Oak Road. The basin location has been selected as the first pair of basins to be constructed because the site is relatively open and has not been committed to other land uses. It will be integrated into future land uses and landscape treatment. Basin 2 was planned as a buried pipe configuration, however during the design of the basins an open basin configuration was effectively achieved. This detention basin provides optimum attenuation of the increase in flow from drainage subbasins 11, 13, and 17. A detailed description of the components of the detention basin is provided in Appendix 3 as well as the calculation methodology used during the design process.

Basins 3 and 4 - Vineyard Road and Sand Hill Road

This pair of basins provides 100-year flood protection. The basins will be filled from flow in the storm drain crossing to Sand Hill Road from Welch Road. Flows will return to a storm drain in Sand Hill Road. Basin 3 will be created in the location of the existing road ditch using check dams and land sculpturing around existing large oak trees to create storage volume. Where the existing ground on the easterly side of the ditch is below the curb on Sand Hill Road, low concrete walls may be used to increase the storage volume. All features of the basin will be landscaped to blend with the existing features. Basin 4 has been configured as a buried pipe installation to allow for continued use of the site as a parking lot. The basin location has been selected as the second pair of basins to be constructed because of the efficiency of the inlet location and the opportunity for Basin 3 to use the buffer space along Sand Hill Road for multiple purposes. The site is relatively open and has not been committed to other land uses. This detention basin is serving completely developed subbasins and will provide reductions in flow to accommodate other subbasins without a detention basin down stream as well as supplemental detention capacity for subbasins draining to detention basins 1, 2, 5, and 6.

XREFS: extowest, feltlake_stanf, exto_sh, OC-CROAD, MAC_BSN, tb8x11_07, prpn-07et



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WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 5-2
DETENTION BASINS - TRIBUTARY AREAS

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Basins 5 and 6 – Pasteur Road and Sand Hill Road

This pair of basins provides 100-year flood protection. The basins will be filled from flow in the storm drain at Welch Road and Pasteur Road. Flows will return to a storm drain in Sand Hill Road. The inlet location has been selected at a manhole prior to the storm drain increasing significantly in depth. The basin has been illustrated with a relatively long supply line from the intersection of Welch and Pasteur to the start of the open basin at Sand Hill Road. The Basin 5 location has been selected to continue the land use and design characteristics of Basins 3. These basins also use the buffer space along Sand Hill Road for multiple purposes. The site is relatively open and has not been committed to other land uses. This detention basin provides optimum attenuation of the increase in flow from drainage subbasins 1, 3, 10, 12, and 15.

Basins 7, 8 & 11 – Sand Hill Road

These basins will provide 100-year flood protection. The basins will be filled from flow in the storm drain crossing to Sand Hill Road. Flows will return to a storm drain in Sand Hill Road. For each of these basins the preferred configuration is an open basin since this is the most cost effective configuration. For each basin an alternate location using a buried pipe configuration in an existing parking lot has also been selected. It is important to note that an open basin can be converted to a buried pipe basin in the future if competing future land uses justify the additional cost. These basin locations provide for a reserve of detention capacity.

Basins 9 and 10 – Sand Hill/Searsville

Basins 9 and 10 will provide 100-year flood protection. These Basins are specifically associated with future development of the areas in which they are located. Basin 9 will provide for the future needs of the property between Searsville Road and Stock Farm Road adjacent to Sand Hill Road. Basin 10 will provide for the future development of the Athletic fields. The needs for these basins may never develop.

DETENTION FACILITY CAPACITY USE DOCUMENTATION

Once a location is selected and the requirements for the shared use of the facility are determined, the precise capacity of the facility can be established. The specific ability to reduce peak flows at the downstream end of the watershed can also be calculated based on the established capacity. This calculated reduction in peak flow may be equated to the ability to accommodate a specific amount of conversion of pervious area to impervious area associated with new projects. A facility can therefore be used for a specific project or as a reserve for attenuation of peak flows from several, current or future, projects within the same watershed.

The range of capacities of a detention facility to reduce peak flows will be documented at the time the permit for construction of the detention facility is submitted to the County of Santa Clara for approval. This capacity will be equated to a specific number of square feet of impervious area for which the detention facility will attenuate flow and will be designated as a reserve of impervious area for use by future development. This reserve of impervious area will be reduced as campus development projects are constructed. The permit for each individual development project will identify the detention facility that is providing the flow attenuation, state the change in impervious area caused by the project, and indicate the balance in the reserve of impervious area for the identified facility before and after the project. Sample forms for managing the capacity of a facility are presented in Appendix 4. Because the location of the development with respect to a detention basin affects the relative efficiency of the basin to attenuate flow, HEC-1 runs will be conducted as necessary to confirm the reserve that is available in each basin system.

APPENDIX 1

HEC1 Values - SCVWD Methodology

SJ066307 Stanford West Campus Detention
San Francisquito Watershed
TC and R Calculations

Basin	Sub-Basin	Land Use	Dev/Undev	A	A	A	A_{st}	W_{st}	L_{st}	A_i	L_i	A_p	L_p	$L_{(c.b.)}$	$L_{(imp)}$	$L_{(perv)}$		n (ovrlnd)	n (street)	S	T_{ci}	$T_{c(c.b.)}$	$T_{c(imp)}$	T_{cp}	$T_{c(perv)}$	R	Ratio
			(%)	(acre)	(sq.mi.)	(ft^2)	(ft^2)	(ft)	(ft)	(ft^2)	(ft)	(ft^2)	(ft)	(ft)	(ft)	(ft)					(hrs)	(hrs)	(hrs)	(hrs)	(hrs)		
San Francisquito																											
2000	1			**18.09**																							
		Dev	0.15	2.71	0.004	118200	23640	50	473	118200	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.85	15.38	0.024	669800						669800	708.33			1208.33		0.5						0.566	**0.738**	**2.214**	0.75
	2			**3.29**																							
		Dev	0.90	2.96	0.005	128981	25796	50	516	128981	100			400	500			0.05	0.02	0.019	0.074	0.093	**0.167**			**0.112**	0.4
		Undev	0.10	0.33	0.001	14331						14331	13.89			513.89		0.5						0.087	**0.254**	**0.763**	0.75
	3			**19.75**																							
		Dev	0.35	6.91	0.011	301109	60222	50	1204	301109	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.65	12.84	0.020	559202						559202	232.14			732.14		0.5						0.413	**0.624**	**1.873**	0.75
	4			**50.40**																							
		Dev	0.05	2.52	0.004	109771	21954	50	439	109771	100			400	500			0.05	0.02	0.016	0.078	0.097	**0.174**			**0.116**	0.4
		Undev	0.95	47.88	0.075	2085653						2085653	2375.00			2875.00		0.5						1.014	**1.188**	**3.585**	0.75
	5			**8.09**																							
		Dev	0.75	6.07	0.009	264300	52860	50	1057	264300	100			400	500			0.05	0.02	0.033	0.065	0.082	**0.147**			**0.098**	0.4
		Undev	0.25	2.02	0.003	88100						88100	41.67			541.67		0.5						0.128	**0.275**	**0.825**	0.75
	6			**11.40**																							
		Dev	0.75	8.55	0.013	372438	74488	50	1490	372438	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.25	2.85	0.004	124146						124146	41.67			541.67		0.5						0.184	**0.396**	**1.187**	0.75
	7			**4.75**																							
		Dev	0.75	3.56	0.006	155183	31037	50	621	155183	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.25	1.19	0.002	51728						51728	41.67			541.67		0.5						0.178	**0.384**	**1.151**	0.75
	8			**2.73**																							
		Dev	0.85	2.32	0.004	101081	20216	50	404	101081	100			400	500			0.05	0.02	0.016	0.078	0.097	**0.174**			**0.116**	0.4
		Undev	0.15	0.41	0.001	17838						17838	22.06			522.06		0.5						0.112	**0.287**	**0.860**	0.75
	9			**12.95**																							
		Dev	0.70	9.07	0.014	394871	78974	50	1579	394871	100			400	500			0.05	0.02	0.020	0.074	0.092	**0.165**			**0.110**	0.4
		Undev	0.30	3.89	0.006	169231						169231	53.57			553.57		0.5						0.162	**0.327**	**0.982**	0.75
	10			**8.86**																							
		Dev	0.05	0.44	0.001	19297	3859	50	77	19297	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.95	8.42	0.013	366645						366645	2375.00			2875.00		0.5						1.193	**1.398**	**4.195**	0.75
	11			**19.49**																							
		Dev	0.10	1.95	0.003	84898	16980	50	340	84898	100			400	500			0.05	0.02	0.011	0.085	0.106	**0.190**			**0.127**	0.4
		Undev	0.90	17.54	0.027	764086						764086	1125.00			1625.00		0.5						0.779	**0.970**	**2.909**	0.75
	12			**12.27**																							
		Dev	0.40	4.91	0.008	213792	42758	50	855	213792	100			400	500			0.05	0.02	0.011	0.085	0.106	**0.190**			**0.127**	0.4
		Undev	0.60	7.36	0.012	320689						320689	187.50			687.50		0.5						0.336	**0.526**	**1.578**	0.75
	13			**9.86**																							
		Dev	0.05	0.49	0.001	21475	4295	50	86	21475	100			400	500			0.05	0.02	0.015	0.079	0.098	**0.177**			**0.118**	0.4
		Undev	0.95	9.37	0.015	408027						408027	2375.00			2875.00		0.5						1.030	**1.206**	**3.619**	0.75
	14			**8.58**																							
		Dev	0.85	7.29	0.011	317683	63537	50	1271	317683	100			400	500			0.05	0.02	0.018	0.075	0.094	**0.169**			**0.113**	0.4
		Undev	0.15	1.29	0.002	56062						56062	22.06			522.06		0.5						0.109	**0.279**	**0.837**	0.75
	15			**17.46**																							
		Dev	0.35	6.11	0.010	266195	53239	50	1065	266195	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.65	11.35	0.018	494362						494362	232.14			732.14		0.5						0.335	**0.507**	**1.521**	0.75
	16			**6.55**																							
		Dev	0.20	1.31	0.002	57064	11413	50	228	57064	100			400	500			0.05	0.02	0.024	0.070	0.088	**0.158**			**0.106**	0.4
		Undev	0.80	5.24	0.008	228254						228254	500.00			1000.00		0.5						0.443	**0.602**	**1.805**	0.75
	17			**8.27**																							
		Dev	0.30	2.48	0.004	108072	21614	50	432	108072	100			400	500			0.05	0.02	0.025	0.070	0.087	**0.157**			**0.105**	0.4
		Undev	0.70	5.79	0.009	252169						252169	291.67			791.67		0.5						0.341	**0.498**	**1.493**	0.75
	18			**4.47**																							
		Dev	0.85	3.80	0.006	165506	33101	50	662	165506	100			400	500			0.05	0.02	0.029	0.067	0.084	**0.152**			**0.101**	0.4
		Undev	0.15	0.67	0.001	29207						29207	22.06			522.06		0.5						0.098	**0.249**	**0.748**	0.75

SJ066307 Stanford West Campus Detention
San Francisquito Watershed
TC and R Calculations

Basin	Sub-Basin	Land Use	Dev/Undev	A	A	A	A_{st}	W_{st}	L_{st}	A_i	L_i	A_p	L_p	$L_{(c.b.)}$	$L_{(imp)}$	$L_{(perv)}$		n (ovrlnd)	n (street)	S	T_{ci}	$T_{c(c.b.)}$	$T_{c(imp)}$	T_{cp}	$T_{c(perv)}$	R	Ratio
			(%)	(acre)	(sq.mi.)	(ft^2)	(ft^2)	(ft)	(ft)	(ft^2)	(ft)	(ft^2)	(ft)	(ft)	(ft)	(ft)					(hrs)	(hrs)	(hrs)	(hrs)	(hrs)		
	19			**19.01**																							
		Dev	0.10	1.90	0.003	82808	16562	50	331	82808	100			400	500			0.05	0.02	0.015	0.079	0.098	**0.177**			**0.118**	0.4
		Undev	0.90	17.11	0.027	745268						745268	1125.00			1625.00		0.5						0.725	**0.902**	**2.705**	0.75
	20			**15.55**																							
		Dev	0.70	10.89	0.017	474151	94830	50	1897	474151	100			400	500			0.05	0.02	0.013	0.081	0.102	**0.183**			**0.122**	0.4
		Undev	0.30	4.67	0.007	203207						203207	53.57			553.57		0.5						0.179	**0.362**	**1.086**	0.75
	21			**21.35**																							
		Dev	0.85	18.15	0.028	790505	158101	50	3162	790505	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.15	3.20	0.005	139501						139501	22.06			522.06		0.5						0.111	**0.283**	**0.848**	0.75
	22			**20.91**																							
		Dev	0.75	15.68	0.025	683130	136626	50	2733	683130	100			400	500			0.05	0.02	0.010	0.087	0.108	**0.195**			**0.130**	0.4
		Undev	0.25	5.23	0.008	227710						227710	41.67			541.67		0.5						0.169	**0.364**	**1.092**	0.75
	23			**28.77**																							
		Dev	0.10	2.88	0.004	125322	25064	50	501	125322	100			400	500			0.05	0.02	0.012	0.083	0.103	**0.186**			**0.124**	0.4
		Undev	0.90	25.89	0.040	1127899						1127899	1125.00			1625.00		0.5						0.764	**0.950**	**2.850**	0.75
	24			**10.70**																							
		Dev	0.80	8.56	0.013	372874	74575	50	1491	372874	100			400	500			0.05	0.02	0.009	0.089	0.111	**0.199**			**0.133**	0.4
		Undev	0.20	2.14	0.003	93218						93218	31.25			531.25		0.5						0.152	**0.351**	**1.053**	0.75
	25			**24.86**																							
		Dev	0.85	21.13	0.033	920466	184093	50	3682	920466	100			400	500			0.05	0.02	0.006	0.098	0.122	**0.219**			**0.146**	0.4
		Undev	0.15	3.73	0.006	162435						162435	22.06			522.06		0.5						0.142	**0.361**	**1.083**	0.75
	26			**21.87**																							
		Dev	0.95	20.78	0.032	905024	181005	50	3620	905024	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.05	1.09	0.002	47633						47633	6.58			506.58		0.5						0.075	**0.280**	**0.840**	0.75
	27			**11.46**																							
		Dev	0.85	9.74	0.015	424318	84864	50	1697	424318	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.15	1.72	0.003	74880						74880	22.06			522.06		0.5						0.137	**0.348**	**1.044**	0.75
	28			**13.95**																							
		Dev	0.80	11.16	0.017	486130	97226	50	1945	486130	100			400	500			0.05	0.02	0.004	0.107	0.134	**0.241**			**0.161**	0.4
		Undev	0.20	2.79	0.004	121532						121532	31.25			531.25		0.5						0.183	**0.425**	**1.274**	0.75
	29			**43.31**																							
		Dev	0.70	30.32	0.047	1320609	264122	50	5282	1320609	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.30	12.99	0.020	565975						565975	53.57			553.57		0.5						0.201	**0.406**	**1.218**	0.75
	30			**24.55**																							
		Dev	0.90	22.10	0.035	962458	192492	50	3850	962458	100			400	500			0.05	0.02	0.005	0.102	0.127	**0.229**			**0.153**	0.4
		Undev	0.10	2.46	0.004	106940						106940	13.89			513.89		0.5						0.119	**0.348**	**1.044**	0.75
	31			**11.33**																							
		Dev	0.95	10.76	0.017	468858	93772	50	1875	468858	100			400	500			0.05	0.02	0.005	0.102	0.127	**0.229**			**0.153**	0.4
		Undev	0.05	0.57	0.001	24677						24677	6.58			506.58		0.5						0.084	**0.313**	**0.938**	0.75
	32			**35.88**																							
		Dev	0.60	21.53	0.034	937760	187552	50	3751	937760	100			400	500			0.05	0.02	0.010	0.087	0.108	**0.195**			**0.130**	0.4
		Undev	0.40	14.35	0.022	625173						625173	83.33			583.33		0.5						0.235	**0.429**	**1.287**	0.75
	33			**20.26**																							
		Dev	0.50	10.13	0.016	441263	88253	50	1765	441263	100			400	500			0.05	0.02	0.006	0.098	0.122	**0.219**			**0.146**	0.4
		Undev	0.50	10.13	0.016	441263						441263	125.00			625.00		0.5						0.320	**0.539**	**1.618**	0.75
	34			**58.66**																							
		Dev	0.80	46.93	0.073	2044184	408837	50	8177	2044184	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.20	11.73	0.018	511046						511046	31.25			531.25		0.5						0.161	**0.372**	**1.117**	0.75
	35			**14.00**																							
		Dev	1.00	14.00	0.022	609840	121968	50	2439	609840	100			400	500			0.05	0.02	0.004	0.107	0.134	**0.241**			**0.161**	0.4
		Undev	0.00	0.00	0.000	0						0	0.00			500.00		0.5						0.000	**0.241**	**0.724**	0.75
			Dev	350.08	0.561																						
			Undev	273.60	0.439																						
				623.68																							
		Residential	Dev	30.51																							
			Undev	81.36		**111.87**																					
		Residential	Dev	**24.95**																							
			Undev	**22.31**		**47.26**																					

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Basin	Sub-Basin	Land Use	Dev/Undev	A	A	A	A_{st}	W_{st}	L_{st}	A_i	L_i	A_p	L_p	$L_{(c.b.)}$	$L_{(imp)}$	$L_{(perv)}$		n (ovrlnd)	n (street)	S	T_{ci}	$T_{c(c.b.)}$	$T_{c(imp)}$	T_{cp}	$T_{c(perv)}$	R	Ratio
			(%)	(acre)	(sq.mi.)	(ft^2)	(ft^2)	(ft)	(ft)	(ft^2)	(ft)	(ft^2)	(ft)	(ft)	(ft)	(ft)					(hrs)	(hrs)	(hrs)	(hrs)	(hrs)		
San Francisquito																											
2010	1			**18.09**																							
		Dev	0.37	6.69	0.010	291560	58312	50	1166	291560	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.63	11.40	0.018	496440						496440	212.84			712.84		0.5						0.322	**0.493**	**1.480**	0.75
	2			**3.29**																							
		Dev	0.90	2.96	0.005	128981	25796	50	516	128981	100			400	500			0.05	0.02	0.019	0.074	0.093	**0.167**			**0.112**	0.4
		Undev	0.10	0.33	0.001	14331						14331	13.89			513.89		0.5						0.087	**0.254**	**0.763**	0.75
	3A			**5.66**																							
		Dev	0.70	3.96	0.006	172585	34517	50	690	172585	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.30	1.70	0.003	73965						73965	53.57			553.57		0.5						0.207	**0.419**	**1.256**	0.75
	3B			**14.09**																							
		Dev	0.35	4.93	0.008	214816	42963	50	859	214816	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.65	9.16	0.014	398944						398944	232.14			732.14		0.5						0.413	**0.624**	**1.873**	0.75
	4			**50.40**																							
		Dev	0.05	2.52	0.004	109771	21954	50	439	109771	100			400	500			0.05	0.02	0.016	0.078	0.097	**0.174**			**0.116**	0.4
		Undev	0.95	47.88	0.075	2085653						2085653	2375.00			2875.00		0.5						1.014	**1.188**	**3.565**	0.75
	5			**8.09**																							
		Dev	0.75	6.07	0.009	264300	52860	50	1057	264300	100			400	500			0.05	0.02	0.033	0.065	0.082	**0.147**			**0.098**	0.4
		Undev	0.25	2.02	0.003	88100						88100	41.67			541.67		0.5						0.128	**0.275**	**0.825**	0.75
	6			**11.40**																							
		Dev	0.75	8.55	0.013	372438	74488	50	1490	372438	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.25	2.85	0.004	124146						124146	41.67			541.67		0.5						0.184	**0.396**	**1.187**	0.75
	7			**4.75**																							
		Dev	0.75	3.56	0.006	155183	31037	50	621	155183	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.25	1.19	0.002	51728						51728	41.67			541.67		0.5						0.178	**0.384**	**1.151**	0.75
	8			**2.73**																							
		Dev	0.85	2.32	0.004	101081	20216	50	404	101081	100			400	500			0.05	0.02	0.016	0.078	0.097	**0.174**			**0.116**	0.4
		Undev	0.15	0.41	0.001	17838						17838	22.06			522.06		0.5						0.112	**0.287**	**0.860**	0.75
	9			**12.95**																							
		Dev	0.73	9.45	0.015	411794	82359	50	1647	411794	100			400	500			0.05	0.02	0.020	0.074	0.092	**0.165**			**0.110**	0.4
		Undev	0.27	3.50	0.005	152308						152308	46.23			546.23		0.5						0.151	**0.316**	**0.949**	0.75
	10			**8.86**																							
		Dev	0.70	6.20	0.010	270159	54032	50	1081	270159	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.30	2.66	0.004	115782						115782	53.57			553.57		0.5						0.201	**0.406**	**1.218**	0.75
	11			**19.49**																							
		Dev	0.71	13.84	0.022	602779	120556	50	2411	602779	100			400	500			0.05	0.02	0.011	0.085	0.106	**0.190**			**0.127**	0.4
		Undev	0.29	5.65	0.009	246205						246205	51.06			551.06		0.5						0.182	**0.372**	**1.117**	0.75
	12			**12.27**																							
		Dev	0.44	5.40	0.008	235172	47034	50	941	235172	100			400	500			0.05	0.02	0.011	0.085	0.106	**0.190**			**0.127**	0.4
		Undev	0.56	6.87	0.011	299309						299309	159.09			659.09		0.5						0.311	**0.501**	**1.503**	0.75
	13			**9.86**																							
		Dev	0.90	8.87	0.014	386551	77310	50	1546	386551	100			400	500			0.05	0.02	0.015	0.079	0.098	**0.177**			**0.118**	0.4
		Undev	0.10	0.99	0.002	42950						42950	13.89			513.89		0.5						0.092	**0.269**	**0.806**	0.75
	14			**8.58**																							
		Dev	0.87	7.46	0.012	325158	65032	50	1301	325158	100			400	500			0.05	0.02	0.018	0.075	0.094	**0.169**			**0.113**	0.4
		Undev	0.13	1.12	0.002	48587						48587	18.68			518.68		0.5						0.101	**0.271**	**0.812**	0.75
	15			**17.46**																							
		Dev	0.38	6.63	0.010	289012	57802	50	1156	289012	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.62	10.83	0.017	471546						471546	203.95			703.95		0.5						0.315	**0.487**	**1.461**	0.75
	16			**6.55**																							
		Dev	0.20	1.31	0.002	57064	11413	50	228	57064	100			400	500			0.05	0.02	0.024	0.070	0.088	**0.158**			**0.106**	0.4
		Undev	0.80	5.24	0.008	228254						228254	500.00			1000.00		0.5						0.443	**0.602**	**1.805**	0.75
	17			**8.27**																							
		Dev	0.41	3.39	0.005	147699	29540	50	591	147699	100			400	500			0.05	0.02	0.025	0.070	0.087	**0.157**			**0.105**	0.4
		Undev	0.59	4.88	0.008	212542						212542	179.88			679.88		0.5						0.272	**0.428**	**1.285**	0.75

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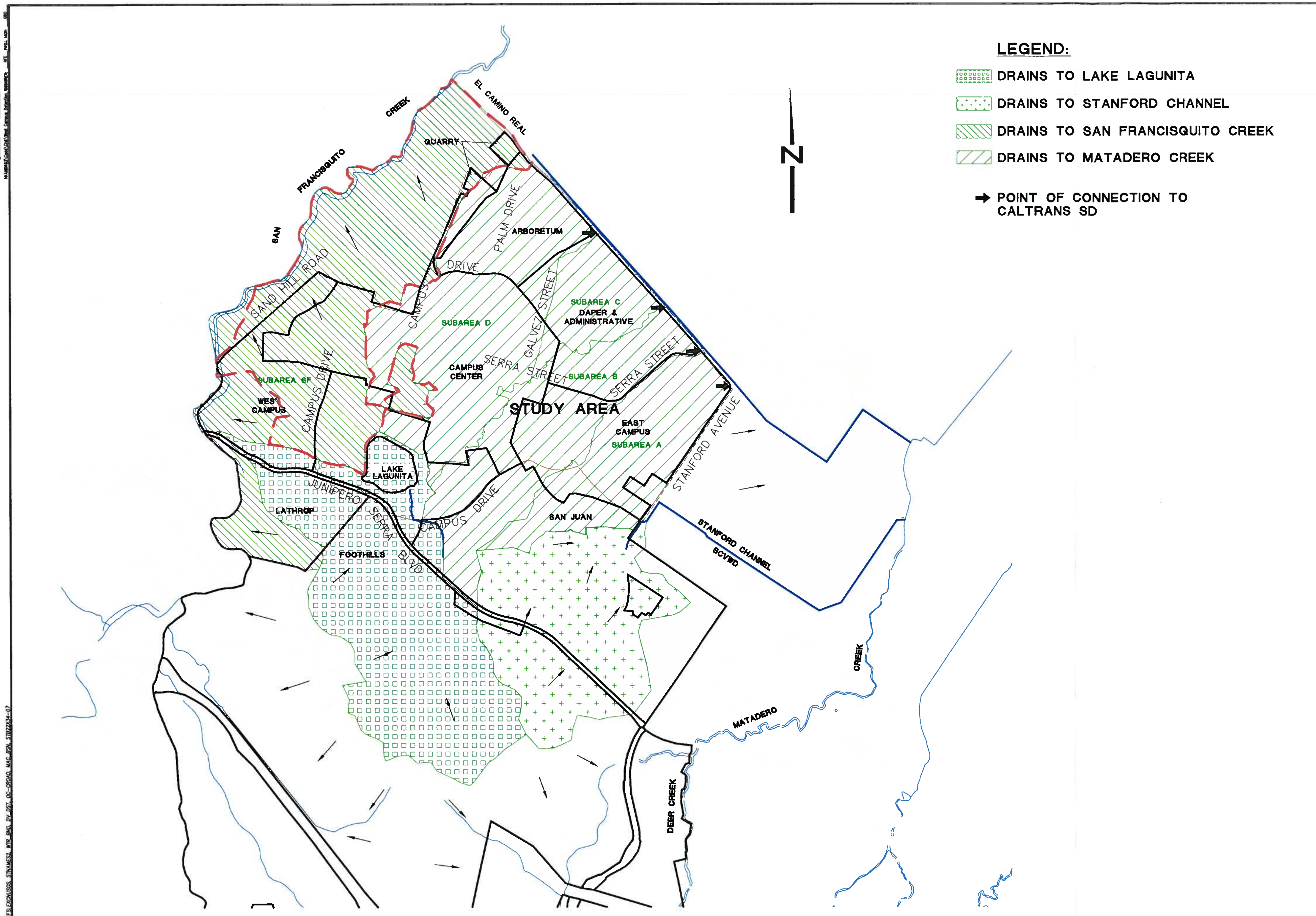
Basin	Sub-Basin	Land Use	Dev/Undev (%)	A (acre)	A (sq.mi.)	A (ft²)	A_{st} (ft²)	W_{st} (ft)	L_{st} (ft)	A_i (ft²)	L_i (ft)	A_p (ft²)	L_p (ft)	$L_{(c.b.)}$ (ft)	$L_{(imp)}$ (ft)	$L_{(perv)}$ (ft)		n (ovrlnd)	n (street)	S	T_{ci} (hrs)	$T_{c(c.b.)}$ (hrs)	$T_{c(imp)}$ (hrs)	T_{cp} (hrs)	$T_{c(perv)}$ (hrs)	R	Ratio
	18			**4.47**																							
		Dev	0.85	3.80	0.006	165506	33101	50	662	165506	100			400	500			0.05	0.02	0.029	0.067	0.084	**0.152**			**0.101**	0.4
		Undev	0.15	0.67	0.001	29207						29207	22.06			522.06		0.5						0.098	**0.249**	**0.748**	0.75
	19			**19.01**																							
		Dev	0.10	1.90	0.003	82808	16562	50	331	82808	100			400	500			0.05	0.02	0.015	0.079	0.098	**0.177**			**0.118**	0.4
		Undev	0.90	17.11	0.027	745268						745268	1125.00			1625.00		0.5						0.725	**0.902**	**2.705**	0.75
	20			**15.55**																							
		Dev	0.70	10.89	0.017	474151	94830	50	1897	474151	100			400	500			0.05	0.02	0.013	0.081	0.102	**0.183**			**0.122**	0.4
		Undev	0.30	4.67	0.007	203207						203207	53.57			553.57		0.5						0.179	**0.362**	**1.086**	0.75
	21			**21.35**																							
		Dev	0.85	18.15	0.028	790505	158101	50	3162	790505	100			400	500			0.05	0.02	0.017	0.076	0.095	**0.172**			**0.115**	0.4
		Undev	0.15	3.20	0.005	139501						139501	22.06			522.06		0.5						0.111	**0.283**	**0.848**	0.75
	22			**20.91**																							
		Dev	0.75	15.68	0.025	683130	136626	50	2733	683130	100			400	500			0.05	0.02	0.010	0.087	0.108	**0.195**			**0.130**	0.4
		Undev	0.25	5.23	0.008	227710						227710	41.67			541.67		0.5						0.169	**0.364**	**1.092**	0.75
	23			**28.77**																							
		Dev	0.10	2.88	0.004	125322	25064	50	501	125322	100			400	500			0.05	0.02	0.012	0.083	0.103	**0.186**			**0.124**	0.4
		Undev	0.90	25.89	0.040	1127899						1127899	1125.00			1625.00		0.5						0.764	**0.950**	**2.850**	0.75
	24			**10.70**																							
		Dev	0.80	8.56	0.013	372874	74575	50	1491	372874	100			400	500			0.05	0.02	0.009	0.089	0.111	**0.199**			**0.133**	0.4
		Undev	0.20	2.14	0.003	93218						93218	31.25			531.25		0.5						0.152	**0.351**	**1.053**	0.75
	25			**24.86**																							
		Dev	0.85	21.13	0.033	920466	184093	50	3682	920466	100			400	500			0.05	0.02	0.006	0.098	0.122	**0.219**			**0.146**	0.4
		Undev	0.15	3.73	0.006	162435						162435	22.06			522.06		0.5						0.142	**0.361**	**1.083**	0.75
	26			**21.87**																							
		Dev	0.95	20.78	0.032	905024	181005	50	3620	905024	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.05	1.09	0.002	47633						47633	6.58			506.58		0.5						0.075	**0.280**	**0.840**	0.75
	27			**11.46**																							
		Dev	0.85	9.74	0.015	424318	84864	50	1697	424318	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.15	1.72	0.003	74880						74880	22.06			522.06		0.5						0.137	**0.348**	**1.044**	0.75
	28			**13.95**																							
		Dev	0.80	11.16	0.017	486130	97226	50	1945	486130	100			400	500			0.05	0.02	0.004	0.107	0.134	**0.241**			**0.161**	0.4
		Undev	0.20	2.79	0.004	121532						121532	31.25			531.25		0.5						0.183	**0.425**	**1.274**	0.75
	29			**43.31**																							
		Dev	0.70	30.32	0.047	1320609	264122	50	5282	1320609	100			400	500			0.05	0.02	0.008	0.091	0.114	**0.205**			**0.137**	0.4
		Undev	0.30	12.99	0.020	565975						565975	53.57			553.57		0.5						0.201	**0.406**	**1.218**	0.75
	30			**24.55**																							
		Dev	0.90	22.10	0.035	962458	192492	50	3850	962458	100			400	500			0.05	0.02	0.005	0.102	0.127	**0.229**			**0.153**	0.4
		Undev	0.10	2.46	0.004	106940						106940	13.89			513.89		0.5						0.119	**0.348**	**1.044**	0.75
	31			**11.33**																							
		Dev	0.95	10.76	0.017	468858	93772	50	1875	468858	100			400	500			0.05	0.02	0.005	0.102	0.127	**0.229**			**0.153**	0.4
		Undev	0.05	0.57	0.001	24677						24677	6.58			506.58		0.5						0.084	**0.313**	**0.938**	0.75
	32			**35.88**																							
		Dev	0.60	21.53	0.034	937760	187552	50	3751	937760	100			400	500			0.05	0.02	0.010	0.087	0.108	**0.195**			**0.130**	0.4
		Undev	0.40	14.35	0.022	625173						625173	83.33			583.33		0.5						0.235	**0.429**	**1.287**	0.75
	33			**20.26**																							
		Dev	0.82	16.61	0.026	723671	144734	50	2895	723671	100			400	500			0.05	0.02	0.006	0.098	0.122	**0.219**			**0.146**	0.4
		Undev	0.18	3.65	0.006	158855						158855	27.44			527.44		0.5						0.157	**0.376**	**1.129**	0.75
	34			**58.66**																							
		Dev	0.80	46.93	0.073	2044184	408837	50	8177	2044184	100			400	500			0.05	0.02	0.007	0.094	0.117	**0.212**			**0.141**	0.4
		Undev	0.20	11.73	0.018	511046						511046	31.25			531.25		0.5						0.161	**0.372**	**1.117**	0.75
	35			**14.00**																							
		Dev	1.00	14.00	0.022	609840	121968	50	2439	609840	100			400	500			0.05	0.02	0.004	0.107	0.134	**0.241**			**0.161**	0.4
		Undev	0.00	0.00	0.000	0						0	0.00			500.00		0.5						0.000	**0.241**	**0.724**	0.75
				391.04	0.627																						
				232.64	0.373																						
				623.68																							
		Residential	Dev	69.47	**38.964**																						
			Undev	42.40	**-38.964**	**111.87**																					
		Academic	Dev	**26.94**	**1.994**	**40.96**																					
			Undev	**20.32**	**-1.994**	**47.26**																					

APPENDIX 2

Impervious Area Allocation to Drainage Basins



WEST CAMPUS STORM DRAINAGE DETENTION MASTER PLAN

APPENDIX - 2

DEV. DISTRICTS & DRAINAGE SYS

PREPARED FOR: STANFORD UNIVERSITY

DATE SUBMITTED: 09/25/03

NOLTE

BEYOND ENGINEERING

1731 NORTH FIRST STREET, SUITE A
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JOB NUMBER
SJ0663.07

Impervious Area Allocation to Drainage Basins

Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undeveloped (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
ACADEMIC CAMPUS HOUSING										
Lagunita	Mayfield	125	500	62,500	3.5	100	17,857	100	17,857	B
	Knoll	200	500	100,000	3.5	100	28,571	100	28,571	SF
	Searsville	250	500	125,000	3.5	50	17,857	100	17,857	SF
	Driving Range	350	500	175,000	3.5	100	50,000	100	50,000	SF
Quarry	Rectangle/ECR	350	1,000	350,000	3	40	46,667	25	11,667	D
								75	35,000	SF
East Campus	Manzanita	100	500	50,000	4	100	12,500	100	12,500	B
	EV infill	725	500	362,500	4	33	29,906	100	29,906	A
	EV @ ECR	250	500	125,000	4	100	31,250	100	31,250	A
Total Academic Campus Housing		2,350					234,609		234,609	
CAMPUS RESIDENTIAL (maximum)										
West Campus		570	2,000	1,140,000	2.5	100	456,000	100	456,000	SF
Lagunita		-13								
East Campus		75	2,000	150,000	2	100	75,000	100	75,000	A
San Juan		40	2,000	80,000	2	100	40,000	100	40,000	A
Total Campus Residential		632							571,000	

Impervious Area Allocation to Drainage Basins

Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undevelope d (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
ACADEMIC/SUPPORT/ATHLETIC/CULTURAL										
Lathrop	Total GSF			20,000						
	Academic			15,000	2	100	7,500	100	7,500	SF
	Athletic & Student Activities			5,000	1	100	5,000	100	5,000	SF
Campus Center	Total GSF			1,590,000						
	Academic & Cultural			1,185,000	4	10	29,625	50	14,813	D
								50	14,813	SF
	Cu;tural			135,000	2	100	90,000	50	45,000	D
								50	45,000	SF
	Academic Support			270,000	3	10	9,000	50	4,500	D
								50	4,500	SF
Quarry	Total GSF			50,000						
	Academic			40,000	3	75	10,000	25	2,500	D
								75	7,500	SF
	Academic Support			10,000	1	75	7,500	25	1,875	D
								75	5,625	SF
DAPER & Administrative	Total GSF			250,000						
	Academic Support			50,000	2	75	18,750	100	18,750	C
	Athletic & Student Activities			200,000	2	75	75,000	100	75,000	C
East Campus	Total GSF			110,000						
	Academic			60,000	3	25	5,000	100	5,000	B
	Academic Support			50,000	2	25	6,250	100	6,250	B
Total Academic				2,020,000			263,625		263,625	

Impervious Area Allocation to Drainage Basins

Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undeveloped (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
PARKING PERMIT INVENTORY										
Lagunita		695	300	208,500	1	100	208,500	50	104,250	SF
								50	104,250	B
Campus Center										
		633	300	189,900	3	100	63,300	100	63,300	D
		-722	300	-216,600	1				0	SF
Quarry		570	300	171,000	1	25	42,750	25	10,688	D
								75	32,063	SF
Arboretum		-134	350	-46,900						
DAPER & Administrative		1,267	300	380,100	1		0		0	C
East Campus		564	300	169,200	1	50	84,600	100	84,600	B
Total Parking		2,873							399,150	
TOTAL INCREASE IN IMPERVIOUS SURFACE AS A RESULT OF GUP APPROVED GENERAL USE PERMIT									**1,468,384**	

Drainage Basin allocation prepared by Nolte. All other Data provided by Stanford University Planning Department

Summary of Drainage Basin Areas
Areas Increased 15 percent for miscellaneous site improvements.

	Acres*1.15	(sf)*1.15	Acres	(sf)	Basin
	4.65	202580	4.04	176,156	A
	6.08	265026	5.29	230,457	B
	2.48	107813	2.15	93,750	C
	4.07	177493	3.54	154,342	D
	21.48	935730	18.68	813,679	SF
Total	38.77	1688641	33.71	1,468,384	

APPENDIX 3

Phase I Basin Design Memorandum

MEMORANDUM

TO: **Kelly Rohlfs** **DATE:** **September 17, 2003**

FROM: **George B. Otte** **PROJ #:** **SJ066312**

SUBJECT: **Phase I Basin Design Memorandum**

This memorandum provides the basis for the hydraulic design of the detention basin systems. The design criteria will first be stated, the components of the basin will then be described and finally, the methodology that allows the designed facilities to be evaluated as to their ability to meet the stated basin system design criteria will be presented.

BASIN SYSTEM DESIGN CRITERIA

These criteria are a restatement of Condition of Approval N.2.b of the Stanford 2000 General Use Permit.

Storm water detention facilities shall be implemented to prevent increases in the peak flow rates caused by changes in campus surface runoff conditions. The facilities shall provide detention for:

a. The 10-year event where the storm water flow are directed to downstream piped systems not owned by Stanford.

b. Runoff from the campus shall not increase the 100-year peak flow rates leaving the Campus.

c. Runoff from the campus shall not increase the 100-year peak flow rates in the receiving channel.

d. Runoff from the campus shall not increase flooding downstream.

During the specific design process and acquisition of the grading permits to construct detention basins, these criteria have continued to be interpreted and made specific through discussions between Stanford and Santa Clara County. On the west side of the Campus, the design criteria stated above specifically means the peak flow in San Francisquito Creek in the vicinity of the outfall of the Stanford Storm Drain at El Camino Real shall not be increased. Criteria d. is interpreted as meaning the increase in flows from Stanford shall not cause the flow in San Francisquito Creek to increase during periods when the downstream channel capacity is being exceeded. Specifically, this flow rate in San Francisquito creek has been set by SCVWD at 6100 cfs.

BASIS OF HYDRAULIC DESIGN

The detention basin has three main components: diversion structure, basins with connecting piping, and drain line. These three components act together to attenuate the peak flow in the storm drain system and ultimately the flow in the receiving stream. These components can be optimized and tailored to meet the specific design criteria.

Diversion Structure

The diversion structure has three components: orifice, basin inlet pipe and overflow weir. The diversion box is located on the storm drain from which flow will be diverted to the basin system.

- Orifice - The orifice, which may be a pipe or a plate, is located at the bottom of the diversion box at the same elevation as the existing storm drain. When the capacity of the orifice is exceeded, flow starts to build in the diversion box until the level of the basin inlet pipes is reached. The size of the orifice determines the initial division between flow downstream and flow to the basins.

- Basin Inlet Pipe - The invert of the basin inlet pipe(s) is critical since it determines the start of flow to the basins. All flow exceeding the orifice capacity is initially diverted to the basins until the height of the overflow weir is reached. The basin inlet pipe(s) is sized considering the amount of volume desired to be diverted to the basin. The flow rate through the orifice continues to increase as a function of depth of water above it. The theoretical best shape for the outlet is an infinitely long weir. Since this is not possible, a compromise is chosen that considers the depth of flow through the pipe and the flow through the orifice.

- Overflow Weir – The overflow weir is used to release some of the peak flow downstream. This devise allows control of the volume of water diverted to the basins and allows some adjustment of the shape of the resulting hydrograph. The elevation of the weir with respect to the depth of flow in the basin inlet pipe determines the limit of flow to the basins and the flow downstream. The precise split is determined by the width of the flow over the overflow weir with respect to the width of the water surface in the basin inlet pipe(s).

This system of elements in the diversion box determines the primary split of flow downstream and the flow to the basins. The maximum elevation of these elements is set at a level such that the water levels created in the upstream storm drain system do not cause flooding upstream of the diversion structure.

This diversion structure reshapes the hydrograph from the typical bell shape hydrograph to a flatter hydrograph with a significantly smaller peak.

Basins and Connecting Piping

The number of basins is determined by the topography of the site and the physical obstacles. Ideally a single basin will do the job, but most sites in the west side of the campus are very limited in size and have significant obstacles like tress and other topographic features. Each basin requires a method to allow the flow to move from one basin to the next, an overflow feature and a drain line.

Simplistically, a basin system would only have overflow weirs, each basin would fill completely, the subsequent basin would only receive flow when the maximum capacity is reached and the drain line would be very small with respect to the flow to and through the basin system. The following variations exist:

- A large connecting pipe allows two or more basins to operate as one basin.
- A small connecting pipe allows flow into the upstream basin to accumulate more rapidly than the downstream basin optimizing the use of the volume in the upstream basin(s).
- The drain pipe must be sized to be self cleansing (12-inch min) or configured so that it drains without being clogged by storm water carried floatables and debris.

For the Phase 1 Detention Basins, the basins function as follows:

- Basins 1 and 2 perform together to capture the required volume. Flows are released from these basins through the overflow weir between Basins 2 and 3. The perforated pipe between Basins 2 and 3 provides drainage. The levels in Basins 1 and 2 equalize through the connecting 24-inch pipe.
- Basins' 3 and 4 performance is similar to Basins 1 and 2. Flows are released from these basins through the overflow weir between Basins 4 and 5. The 12-inch drain pipe between Basins 3 and 4 provides equalization and some attenuation. The perforated pipe between Basin 4 and the manhole provides drainage.
- Basin 5 releases through the overflow inlets any flow that could not be captured by this basin. It also has a drain through a perforated pipe.
- The ultimate drainage of Basins 4 and 5 is controlled by the line valve in the drain line.

Drain Line

The drain line ultimately releases water accumulated in the pond system back to the storm drain system. A typical drain pipe that is releasing directly to an uncontrolled storm drain system, downstream of the diversion structure, delays the flow by approximately 30 minutes. The initial flow that is diverted to the basins up to the capacity of the drain line only experiences this relatively small time delay. In most cases a time delay of several hours is required to achieve the requirements of the system design criteria. There are two ways of achieving this essential time delay: one way is with a line valve which could be open anytime after the storm event, and the second way is to connect the drain line into the diversion structure upstream of the orifice. This second control method causes the water to be limited by the flow through the orifice and the water surface in the diversion structure. The drain line starts releasing when the water surface of the diversion structure recedes lower than the drain pipe. This alternative delays the release by a couple of hours.

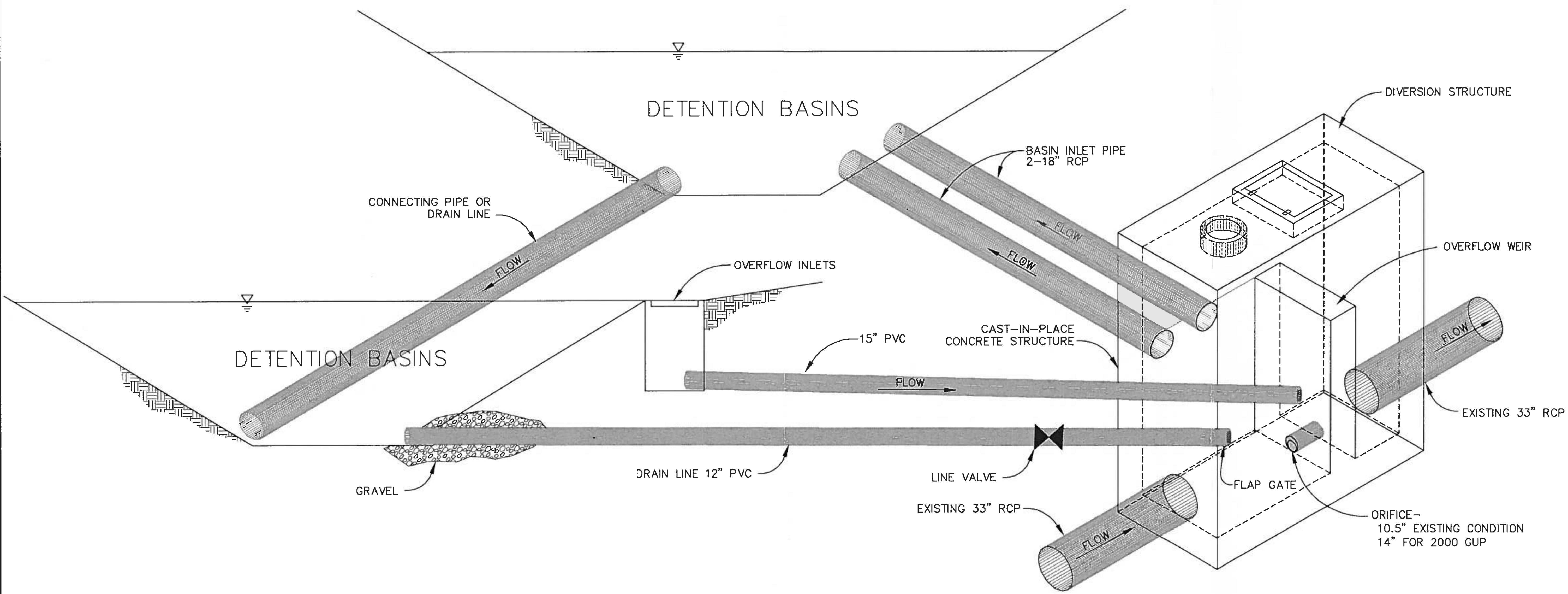
For the Phase 1 Detention Basins, maintaining the peak flow to its existing condition peak flow rate was achieved by the second method. To achieve the delay required by the specific conditions in San Francisquito Creek, a valve in the drain line is required.

Hydrologic/Hydraulic Analysis

The precise calculation of the hydraulic performance of all of the above described components requires consideration of the water surface both upstream and downstream of each orifice, pipe and weir. In addition, this information needs to be calculated for each time step and the mass balance calculated for each time step to determine the volume of water in each basin. This detailed analysis is best managed by computer models. A Haestaed Methods Program named PondPack has been used for the detailed analysis of the performance of the basin system.

A HEC-1 model of the entire campus is used to calculate the flow from the campus and ultimately the flow to San Francisquito Creek. The HEC-1 model has limited ability to handle the complex calculations required for a basin system as designed and is therefore supplemented by the PondPack analysis.

The flow that is used to start the analysis at the diversion structure is provided by the HEC-1 model. The hydrograph created by HEC-1 is entered into PondPack to analyze the interaction between the diversion structure, detention basins, and the drain pipe. The output from PondPack is used to develop the record in HEC-1 that simulates a detention basin diversion structure. PondPack also provides a hydrograph of the drain pipe to complete the HEC-1 model after the flow leaves the basins.



DATE: 09/22/03 TIME: 9:02 a.m. SERVER: SJS1 SERVICE: ENG PATH: N:\SJ0663\Cadd\Civil_12\Exhibits\ DRAWING NAME: ET_PRSDIN.DWG PLOTTING VIEW: NONE DESIGNER: STW PROJ. MGR: GBO	NOLTE BEYOND ENGINEERING 1731 NORTH FIRST STREET, SUITE A. SAN JOSE, CA. 95112 408.392.7200 TEL 408.392.0101 FAX WWW.NOLTE.COM	**DIVERSION STRUCTURE AND BASIN SYSTEM SCHEMATIC** **WEST CAMPUS FLOOD CONTROL** **DETENTION FACILITIES - PHASE 1** **PREPARED FOR: STANFORD UNIVERSITY** **DATE SUBMITTED: 09/19/03**	SHEET NUMBER OF SHEETS JOB NUMBER SJ066312

XREFS: 11x17L

APPENDIX 4

Sample Detention Basin Capacity Tracking Form

Reserve of Impervious Area Summary
West Campus

Detention Basin: Typical Basin at Street and Drive

	100-Year Storm Basin		Project Status	
	Change, sq.ft.	Net Reseve Remaining, sq.ft	Date of Last Change of Status	Status
Reserve of Impervious area at the time of construction of the basin		1000000		
Project A	5000	995000	12/31/2001	Completed
Project B	7500	987500	4/15/2002	ASA Application Pending
Summary				
Initial Reserve		1000000		
Total Change in Impervious Area to date	12500			
Reserve Remaining		987500	4/15/2002	