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MEMORANDUM

TO:	Rajeev Hada, City of Palo Alto	DATE:	June 27, 2015
FROM:	Schaaf & Wheeler	JOB #:	PALO.06.14
SUBJECT:	**Palo Alto Drainage Design Standards**		

All drainage facilities shall be designed in accordance with accepted engineering principles and standard practices, and shall conform to these Design Standards. Drainage calculations are required for new subdivisions, development, redevelopment, or site improvements as deemed necessary by the City Engineer. Submittal of drainage calculations shall include the following items:

1. Hydrology and hydraulic calculations together with assumptions, charts, formulas, runoff coefficient, site specific areas, tables, references and methods used, etc.
2. A plan that clearly shows the existing and proposed drainage system, drainage patterns, tributary drainage sub-areas, and peak flow in all pipes.
3. A profile plan showing the hydraulic grade line (HGL) and the proposed storm drain pipe size, slope, length and material.

Design Flow

Per the 2007 Santa Clara County Drainage Manual, the Rational Method shall be used to calculate peak flows and the Unit Hydrograph Method shall be used to calculate flow hydrographs. Each method is described below and summarized in Table 1.

- The Rational Method is useful for estimating flood peaks and stormwater conveyance system design in highly urbanized areas with small watersheds and largely impervious areas, such as Palo Alto. The Rational Method can provide estimates for relating peak discharge to rainfall intensity by multiplying the design rainfall intensity by the watershed area and by a runoff coefficient.
- The Unit Hydrograph Method allows for the development of a flood hydrograph using a design storm, an appropriate infiltration method, and a synthetic unit hydrograph. This method allows for the analysis of complex drainage facilities by taking into account hydrologic losses including evaporation, transpiration, infiltration, surface routing, storage within the watershed, and varying antecedent moisture conditions. The parameters required to develop the flood hydrograph are summarized in Table 1.

Table 1: Method summary

Method	Result	Parameters required	Source
Rational Method	Peak flow	Runoff coefficient	Drainage Manual
		Rainfall intensity	Drainage Manual
		Drainage area	Physical
Unit Hydrograph Method	Flow hydrograph	Basin area	Physical
		Precipitation	Drainage Manual
		Initial abstraction	Equation
		SCS curve number	Drainage Manual
		Percent imperviousness	Physical
		Basin lag	Equation

Design Standards for Inlets, Pipes and Manholes

Applicant shall first determine the pre-development downstream conditions to establish the existing HGL. The design and evaluation of new systems, particularly extensions of existing systems, must be done on a case-by-case basis and these exceptions to the listed criteria for new systems are suggested where new collection systems discharge to existing systems:

With 10-year Design Discharge	Pipes shall be sized to carry the 10-year discharge with HGLs 0.5-foot below inlet grate elevations. When downstream surcharge effects are included, upstream hydraulic grades shall be no higher than the top of curb elevation at any manhole or inlet.
With 100-year Design Discharge	Hydraulic grade shall not exceed the street right-of-way elevation at any location.

New drainage conduits shall be sized based on the design criteria listed in Table 2. The following design criteria are standard practices and City requirements.

1. Projects shall include conceptual storm drain design and C.3 treatment measures as part of the Planning Phase.
2. Manholes shall be no farther than 400 feet apart.
3. Designer shall verify adequate clearances between existing utilities and proposed storm drain pipelines (or required utility relocations) in the public right-of-way prior to the start of construction work.
4. Catch basins shall be spaced so that the maximum width of gutter flow, when flooded, does not exceed eight feet from the face of curb during a 10-year design storm and the travel lane remains dry
5. The City requires that all new catch basins within the public right-of-way be hooded inlets.
6. Drainage flows shall not be pumped into the public system, instead flows shall drain by gravity into the City's system.

7. The City does not typically allow a private storm drain lines to be directly connected to the City's mains. Private lines shall daylight within private property and runoff shall bubble-up to an onsite detention basin or connected to a junction box at the property boundary before connecting to the City system.
8. When a detention basin is required, then the City may allow a direct connection from the basin into the City's system.
9. If a private line is permitted to connect into the City's main lines, applicant shall verify that the pipe has adequate cover and does extend into the pavement section.
10. The following pipe materials are allowed within the public right-of-way, HDPE, and RCP. The City may allow C900 PVC on a case-by-case basis.
11. Inlets in the public right-of-way shall be marked with a creek-specific "No Dumping" medallions provided by the City. Private inlets shall be marked with a creek-specific "No Dumping" message using painted stencils (stencil provided by the City), thermoplastic material, or medallions (owner's discretion as to method of labeling).

Table 2: Summary of Design Standards based on standard practice

Condition	Design Criteria
New Systems	10-year HGL 0.5' below cover or inlet grate
New Systems	100-year shall not exceed street right of way elevation
Closed Conduits	Max. Velocity = or < 15 ft/sec
Closed Conduits	Min. Velocity = or > 2 ft/sec
New Closed Conduits	Min. Slope > 0.002
Earth Channels	Max. Velocity < 5 ft/sec
Lined Channels	Min. Velocity < 10 ft/sec
Earth Channels	Min. Slope > 0.002
Closed Conduit	Min. Pipe Size 12-inches
Improvements to existing	Min. Pipe Size 12-inches or as directed by the City.

Design Standards for Single Family Residences

Palo Alto requires that all development projects avoid discharging directly into the City's storm drain system. Since the residential projects make-up a large portion of development, property owners and applicants are encouraged to implement the following drainage design standards to minimize the negative impact into the City's storm drain system and downstream properties.

1. Conceptual stormwater drainage design and C.3 treatment measures shall be considered and planned for during the project planning phase.
2. Roofs shall be designed to manage rain runoff so that it lands within the private property.
3. Install downspouts with splashblocks to direct discharge away from the building foundation.
4. Downspouts may be allowed to be hard-piped into a system with a bubbler or dissipation device that discharges within private property
5. Roof gutters, pipes, or downspouts shall not be made of copper material.
6. Bubblers or dissipation devices shall not be installed closer than 10-feet from the back of walk or 3-feet from the side or rear sideyards.
7. Minimize impervious surfaces to encourage additional onsite infiltration. Where feasible install permeable pavement such as crushed aggregate, turf block, unit pavers, pervious concrete, or permeable asphalt instead of traditional concrete or asphalt.

8. The drainage system for lightwells and stairwells that are associated with basements shall be independent from the site drainage system that collects downspouts and area drains. Both drain systems shall discharge within private property.
9. Basement perimeter drains are not permitted west of Foothill Expressway.
10. Drainage across property lines shall not exceed that which existed prior to grading. Plans shall include grades along the property line and within swales to verify runoff is not crossing property lines.
11. Storm drain pipelines under structures are prohibited.
12. New structures that are located on a hillside will also be subject to excessive runoff or potential flooding. Therefore, runoff shall be managed to drain around the proposed structures to avoid drainage into the foundation or flooding the living area.
13. Additional City policies and guidelines are also available on Public Works' webpage.

Outfalls

Where storm drain collection systems discharge to receiving waters, analyses shall assume that the peak of local runoff coincides with the 10-year peak stage at the collection system outfall.

Storage Facilities

There are two basic categories of stormwater storage: detention and retention. Detention generally refers to the temporary storage of incoming runoff that exceeds the permissible release. After the storm event, the facility empties and returns to its natural function; such as a parking lot, rooftop, or park. Retention facilities, on the other hand, hold on to the excess runoff for an indefinite period. Natural ponds and lakes exemplify retention facilities where water levels change only through evaporation, infiltration and additional storm runoff.

Determination of the impact of a detention basin on downstream areas shall be made on a case-by-case basis. Routing a flow hydrograph through a storage basin generally delays the peak and reduces the maximum discharge. The delayed peak may have a detrimental impact on downstream areas if the timing is such that the combined discharges downstream are greater than the combined discharge that would have resulted if the detention basin did not exist. Detention basins also tend to increase the duration of flow at downstream locations.

Design Criteria for Detention Facilities

Properly designed, constructed, and maintained stormwater storage facilities can reduce peak flows, thereby better utilizing the capacity of downstream conveyance facilities. Such facilities can also potentially mitigate the need for system upgrades. The efficacy of any detention facility, as well as ancillary improvements in the quality of storm runoff to receiving waters, shall be evaluated on a case-by-case basis. However, some general design criteria should be applied to every basin:

1. A 24-hour 10-year storm shall be used to size detention basins (basins with an outlet to the City system). If no disposal other than evaporation or percolation is provided (retention), a 24-hour 100-year storm shall be used.
2. Basins shall meet the requirements of the Santa Clara County Drainage Manual.
3. Private basins shall be maintained by the property owner; assurances for the continued maintenance of its capacity shall be provided to the City through a maintenance agreement.
4. Basins shall be sized so that their output flow does not exceed the design capacity of downstream facilities. 10 year post development runoff shall not exceed the 10 year pre development runoff. Excess post development runoff shall be mitigated in the detention basin.
5. Infiltration capacity shall not be considered when designing detention basins.

6. The design procedure outlines in Section 6.3.3 of the County Manual shall be followed for detention basin design.
7. Underground detention facilities (pipes or structures) shall be sized according to the criteria herein.
8. Retention basis shall be equipped with an emergency overflow section capable of safely discharging the 100-year peak inflow (should the outlet become blocked, or a storm event larger than the design event occurs), without causing property damage.
9. At least one foot of freeboard over the maximum 100-year water surface elevation shall be provided for excavated retention basins. Three feet of freeboard (minimum) shall be provided where retention basins are created by berms or levees.
10. Retention facilities shall only be used in areas where groundwater tables and percolation rates warrant their construction. Separate approval from the Santa Clara Valley Water District is required, and pond designed shall also be reviewed for conformance with the standards and policies of the Department of Environmental Health.
11. Retention basins shall fully drain within 48 hours of the cessation of a precipitation from a design 100-year 24-hour rainfall event.
12. Maximum side slope for turfed or landscaped basins shall be 4:1.
13. Fencing shall be provided around all basins greater than 3-feet in depth.

Debris Loading

Detention and retention basins will eventually fill up with sediment and other debris, reducing their storage capacity to the point where they will not operate as designed. Therefore, some consideration of debris loading should be made for each basin. Based on work by Schaaf & Wheeler for the Santa Clara Valley Water District, the following empirical relationships are provided as a guideline (debris load per unit drainage area) for use to evaluate debris loading:

Highly urban areas	0.1 acre-foot/mi^2/year
Hillside open space	0.4 acre-foot/mi^2/year

Depending upon the desired frequency of maintenance, some allowance for dead storage should be made to handle sediment and debris using the loading rates given above. Basin sizing should meet City of Palo Alto design guidelines for stormwater quality detention and retention basins.

General Pump Station Criteria

Pump stations are generally considered adequate if there is sufficient pump capacity to discharge design runoff into the receiving waters or if excess flows can be stored without causing property damage.

Capacity

Ideally at least two identical pumps should be installed in every stormwater pump station for some redundancy and ease of maintenance. It is not industry practice to include standby pumps in a stormwater station because providing excess capacity is expensive and generally not justified by the relatively small risk of having a major storm event coincide with a single pump failure. All things considered, installing a larger number of smaller pumps is generally better than a lesser number of large pumps for the same capacity. When individual pumps comprise a smaller percentage of overall pump station capacity, having one pump fail is less detrimental. In terms of redundancy and ease of maintenance, the pumping units within one particular station should be identical.

Pumps and Drivers

A general trend in current pump station design is to use electric motors for primary power rather than direct-drive engines due to noise, ventilation, and air quality considerations. Submersible pumps are also widely used for stormwater applications to reduce the complexity of lift station components. New pumps should be submersible, unless matching an existing pump or other site constraints dictate a more conventional pump.

Operation

Lead and lag pumps should be automatically alternated on every start to minimize pump cycling, equalize the number of operating hours among pumps as practicable, and extend the operating life of the equipment. Sufficient wet well storage must also be available in order to prevent excessive pump cycling for proposed operating levels.

The maximum number of pump starts per hour should be held below the maximum criterion established by pump, motor, and/or engine manufacturers. In the absence of specific data, pump starts should be limited to six per hour. This criterion is based on general limits set by large electric motor manufacturers; diesel engine suppliers also recommend that engines should run at least five to ten minutes at full operating temperatures each time they are started.

Pumping equipment must be specified so that motor or engine nameplate ratings are not exceeded at any point on the pump characteristic curve as far as practicable. Pump performance under different hydraulic conditions should be analyzed to ensure that pumps operate within manufacturers' recommended limits.

Excessive pump wear, vibration, noise, or cavitation could be indicative of more serious hydraulic problems associated with the pump and intake geometries. If any of these issues are noted, the City should contact the pump manufacturer or an engineer.

Standby Power

Generators should be present on-site and connected to the power supply with an automatic transfer switch to be considered as available in an emergency under FEMA flood hazard mapping requirements. The use of portable generators, or even permanently parked generators with manual transfer switches, is only feasible where crews may respond to high water alarms during power outages, physically reach the pump station with a generator, and manually restore power before property damage has occurred. Small lift or pump stations that generally handle nuisance flows (flows for which significant property damage would not occur should the pump station fail) do not necessarily require a standby power source.

Stormwater Management

The objective of this section is to prevent future development from increasing flood hazards to existing development and to maintain and improve water quality. Implementing the activities in the section below when managing new developments in Palo Alto may result in obtaining credits from the National Flood Insurance Program (NFIP) through the Community Rating System. The objective of the Community Rating System (CRS) is to reward communities that are doing more than meeting the minimum NFIP requirements to help their citizens prevent or reduce flood losses.

For more information on this program and documentation requirements, see the CRS Coordinator's Manual which is the guidebook for the CRS and sets the criteria for CRS classification. For the full list of documentation requirements, see http://crsresources.org/files/400/450_activity_checklist_may_2013.pdf.

All new developments in the Palo Alto watershed are subject to the following three regulations based on the CRS: stormwater management, watershed master planning, erosion and sediment control, and water quality, as summarized in Table 3.

Table 3. FEMA CRS Regulation summary

Credit	Regulation summary	Size
Stormwater management	Peak runoff from new development shall not be greater than the runoff from the site in its pre-development condition.	All Development Projects except Single Family Residential Buildings
Erosion and sedimentation control	Erosion and sediment control measures shall be taken on land that is disturbed during development	All Development Projects (see PAMC 16.28)
Water quality	New developments must include in the design of their stormwater management facilities appropriate "best management practices" that will improve the quality of water surface.	All development projects (see PAMC 16.11)

Stormwater Management Regulations (SMR)

All new developments in Palo Alto are required to prevent the increase in runoff that results from urbanization. Stormwater management regulations for the City of Palo Alto are made up of the following subcategories:

Size of development

The City requires all new development to ensure that the post-development stormwater discharge will not exceed the amount of runoff under pre-development conditions.

Design storm

At a minimum, the peak runoff from a 10-year storm from new developments shall not be greater than the runoff from the site in its pre-development condition. All discharges from the 10-year storm must be released at rates not exceeding the pre-development peak discharge. Although not required for projects that don't increase runoff through development, controlling the volume of runoff from the 10-year storm using retention is encouraged.

Before development, the developer must submit hydrologic and hydraulic studies showing the nature and extent of runoff under present conditions and with the proposed development for the 10-year storm event.

Low-impact development (LID)

Implementation of low-impact development (LID) practices is required by the MRP for all new developments and redevelopments to control the impacts of development on runoff. Some examples of LID include bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements. For a guide to LID practices applicable in Santa Clara County see *C.3 Stormwater Handbook* produced by the Santa Clara Valley Urban Runoff Pollution Prevention Program. A Tentative Order of the proposed MRP which may be reissued later this year (Fall 2015) is available for review. LID practices in the Tentative Order shall be followed when applicable.

As part of the City's sustainable program, City has a storm water rebate program for installing rain barrels, cisterns, permeable pavers and green roofs. The purpose of this program is to help reduce storm runoffs to our creeks and bay, recharge ground water and keep our creeks and bay clean. Developers are encouraged to take advantage of the City's rebate program. For the City's storm water rebate program, see http://www.cityofpaloalto.org/gov/depts/pwd/stormwater/rebates/

Non-LID development

LID practices may not be feasible for certain projects due to soils conditions, location, project size, etc. If non-LID measures are necessary, the applicant shall submit the request to the City and obtain a formal approval during the initial planning stages of the project.

Erosion and sedimentation control regulations (ESC)

The City requires that erosion and sediment control measures be taken on land that is disturbed during development and at all construction sites within the City. Interim and final erosion and sediment control and storm water pollution prevention plans are required as part of the grading permit application process. Requirements for the erosion and sediment control and storm water pollution prevention plans can be found in the City of Palo Alto Municipal Code Chapter 16.28 Grading and Erosion and Sediment Control.

Water Quality Regulations (WQ)

New developments must include in the design of their stormwater management facilities appropriate measures that will improve the quality of surface water. Site design requirements are detailed in the *C.3 Stormwater Handbook* produced by the Santa Clara Valley Urban Runoff Pollution Prevention Program. Site design measures include reducing the size of impervious areas, rainwater harvesting and use, and tree preservation and planting.