Preliminary Hydrology Report & Drainage Study

DART SUBMITTAL

Prepared for:
El Encanto Hotel
Santa Barbara, California

December 9, 2008

Tri-Net Engineering

Civil Engineering - Surveying - CAD

EXHIBIT H

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Civil Engineering - Surveying - CAD

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Introduction

The project site is located in Santa Barbara, with Mission Ridge Road against the northerly boundary, Alvarado Place abutting the westerly boundary, and Lasuen Road adjacent to the southerly boundary. The site is a multi-cottage hotel on the hillside. The calculations were preformed to evaluate the 1"/24 hr. storm event.

The existing drainage pattern flows from the north and northeast directions to the south and southwest. The existing storm drain system consists of asphalt berms and swales which drain into catch basins with concrete pipes. The runoff eventually ends up at a catch basin on Lasuen Road, through a combination of overland flow and concrete pipes.

The project proposes a new drainage system, which includes grated catch basins and pipes to be used in combination with grass or gravel-lined swales. The treatment for the 1"/24 hr. storm event will include planter boxes, permeable pavers, open vegetated swales, manmade filters in catch basins, and bioretention area(s) as necessary. The runoff will continue to flow in the same general direction with added catch basins and swales to more efficiently handle the flow.

This report and its calculations will show that the planter boxes, open vegetated swales and permeable pavers are sized appropriately and can handle the 1"/24 hr. storm event.

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Hydrology

Assumptions & Calculations for Determining the Runoff Quantity of the Tributary Areas

1"/ 24 hr. Storm Event

Per direction from Autumn Malanca, of the City of Santa Barbara, we calculated the area of the impermeable surfaces and added them to a 1" runoff to compute the 1"/24 hr storm event.

Watershed Areas:

AREA= Cumulative watershed areas 1 thru 3. Sub-areas combining into catch basins, swales, and pipes to ultimately end up at the catch basin on Lasuen Road.

Watershed Sub-Areas for area "1" totaling 5.161 Acres

1_A = 1.062 Acres	1_{B1} = 0.569 Acres
1_{B2} = 0.372 Acres	1_C = 0.184 Acres
1_D = 0.132 Acres	1_E = 0.372 Acres
1_F = 0.187 Acres	1_G = 0.093 Acres
1_H = 0.191 Acres	1_I = 0.098 Acres
1_J = 0.443 Acres	1_K = 0.125 Acres
1_L = 0.068 Acres	1_M = 0.086 Acres
1_N = 0.419 Acres	1_O = 0.084 Acres
1_P = 0.139 Acres	1_Q = 0.179 Acres
1_R = 0.019 Acres	1_S = 0.339 Acres

Watershed Area for area "2" totaling 3.258 Acres

2_A = 0.479 Acres	2_B = 0.212 Acres
2_C = 0.427 Acres	2_D = 0.707 Acres
2_E = 0.428 Acres	2_F = 0.435 Acres
2_G = 0.570 Acres	

Watershed Area for area "3" totaling 0.620 Acres

Watershed Area for areas "1-3" totaling 9.098 Acres

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Proposed Watershed Runoff Quantities:

$Q_{1"/24\,hr.}$

Q_{1A} = .0030 cfs Q_{1B1} = .0111 cfs

Q_{1B2} = .0107 cfs Q_{1C} = .0050 cfs

Q_{1D} = .0023 cfs Q_{1E} = .0021 cfs

Q_{1F} = .0047 cfs Q_{1G} = .0019 cfs

Q_{1H} = .0006 cfs Q_{1I} = .0016 cfs

Q_{1J} = .0093 cfs Q_{1K} = .0029 cfs

Q_{1L} = .0010 cfs Q_{1M} = .0026 cfs

Q_{1N} = .0039 cfs Q_{1O} = .0008 cfs

Q_{1P} = .0036 cfs Q_{1Q} = .0037 cfs

Q_{1R} = .0002 cfs Q_{1S} = .0050 cfs

Q_{2A} = .0136 cfs Q_{2B} = .0025 cfs

Q_{2C} = .0129 cfs Q_{2D} = .0203 cfs

Q_{2E} = .0010 cfs Q_{2F} = .0038 cfs

Q_{2G} = .0051 cfs

Q_3 = .0003 cfs

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Discussion

The proposed Post Construction BMP's consist of planter boxes at roof drains, permeable pavement/pavers, open vegetated swales, manmade filters at catch basins, and bioretention area(s) as necessary.

Planter Boxes

Planter boxes will be placed at roof drains where feasible. General calculations were completed for the Mission Village area by using the bioretention worksheet (see Appendix A, sheets 1 & 2). The worksheet calculated an area of 310 ft^2 would be required to treat the runoff from the roof drains. The area of the 20 proposed planters totals 386 ft^2, which is more than adequate to treat all the runoff from the Mission Village roof tops.

Permeable Pavement/Pavers

Permeable pavement and/or pavers will be incorporated throughout the site. General calculations were completed for the Mission Village area by using the permeable pavers worksheet (see Appendix A, sheets 3 & 4). The worksheet calculates an area of 320 ft^3 would be required to treat the remainder of the runoff. The Mission Village area has 4,255 ft^3 of treatment area. The Mission Village area is more than adequate to handle the 1" storm event. Calculations were also done for the main entrance area (see Appendix A, sheets 5 & 6). Per the worksheets an area of 8,815 ft^3 is required for treatment. The main entrance has an available area of 8,599 ft^3 for treatment. Therefore this would indicate an additional area of 216 ft^3 would be required, however the additional 216 ft^3 could easily be handled by the 3" of road base under the 1" of sand. Man made filters will also be implemented at the main entrance.

Open Vegetated Swales/Sheetflow

Open vegetated swales will be implemented throughout the site. These swales, even though not quantifiable, will help with filtration, infiltration, and sediment dropout. Also, there is a vegetated sheetflow next to the pool, which helps in filtration, infiltration and sediment dropout without concentration which can cause erosion on such a steep slope.

Manmade Filters

Manmade filters will be inserted in catch basins in parking lots and other areas were more natural BMP methods are not practical. These filters will be implemented in areas where hydrocarbons, grease and oil will be an issue.

Bioretention Area(s)

Bioretention area(s) will be used to treat the remainder of the runoff when all other BMP options have been exhausted.

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Conclusion

We have determined that the proposed BMP's will be sufficient to treat the 1"/24 hr. frequency storm. In the event that a larger frequency storm should occur the site is designed to direct the runoff away from the structures, and continue southwesterly down the hill, to eventually end up at the catch basin located on Lasuen Road. The catch basin on Lasuen Road has a local depression for temporary ponding and with the new grading and drainage design there should not be ponding from a 25-year storm event.

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APPENDIX A

Bioretention Worksheet

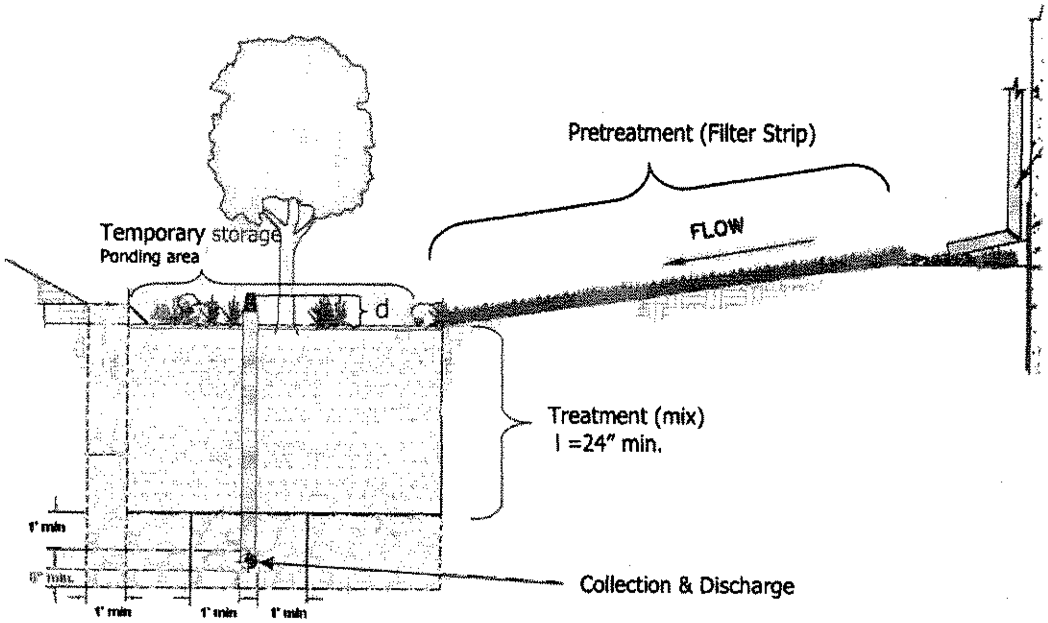

Figure D-1: Bioretention Area Cross-Section

Refer to Figure D-1 and Figure 6-2 for the description of the geometric variables.

Step 1: Determine design volume reduction, $V_{reduction}$			
1-1. Enter the volume difference between the pre- and post-development conditions for the 25-yr, 24-hr design storm, V_{25}, calculated using SBUH method, Appendix C	V_{25} =	0	ft³
1-2. Enter the volume generated from a one-inch, 24-hr storm event, $V_{one\text{-}inch}$, calculated using SBUH method, Appendix C	$V_{one\text{-}inch}$ =	580	ft³
1-3. Determine design volume reduction which is the larger of V_{25} and $V_{one\text{-}inch}$ and is the volume to be retained on-site	$V_{reduction}$ =	580	ft³
Step 2: Determine storm water quality design volume, V_{wq}			
2-1. Determine the water quality design volume, V_{wq}, using SBUH method, Appendix C (<u>Note</u>: V_{wq} is always equal to $V_{one\text{-}inch}$)	V_{wq} =	580	ft³
Step 3: Determine design volume, V_{design} (for sizing)			
3-1. If underdrain system is used, $V_{design} = V_{wq}$ If there is no underdrain system, V_{design} = the larger of $V_{reduction}$ and V_{wq}	V_{design} =	580	ft³

Step 4: Pretreatment

4-1. If pretreatment is required please go the vegetated filter strip worksheet, Appendix C

Step 5: Calculate bioretention area

5-1. Enter thickness of planting mix (min. 24"), l	l =	24	in
5-2. Enter storage depth (18" max.) above the filter, d	d =	6	in
5-3. Enter infiltration rate (0.375"/hr), k_{design} (Note: infiltration rate of planting media, if no underdrain infiltration rate of native subsoil or fill). If no underdrains, see Step 4 of the Infiltration BMP Worksheet, Appendix D to calculate k_{design}).	k_{design} =	0.375	in/hr
5-4. Enter drawdown time, t	t =	48	hr
5-5. Calculate bioretention area, $A_{sf} = (V_{design} \cdot l)/[(t \cdot k_{design}/12) \cdot (l+d)]$	A_{sf} =	310	ft^2

6-1. Calculate filtered flow rate to be conveyed by the longitudinal drain pipe, $Q_f = k_{design} \cdot A_{sf}/43200$ (Note: for this example, step 6-1 is equivalent to step 5-1 of the Sand Filter Worksheet, Appendix D).	Q_f =	0.002	cfs
6-2. Please follow steps 5-2 through 5-7 of the Sand Filter Worksheet, Appendix D to calculate the underdrain system capacity.			

Step 7: Provide Conveyance Capacity for Flows Higher than Q_{wq}

7-1. An emergency overflow must be provided if the bioretention area is placed online or in the event the surface area becomes clogged.

Permeable Pavement Worksheet

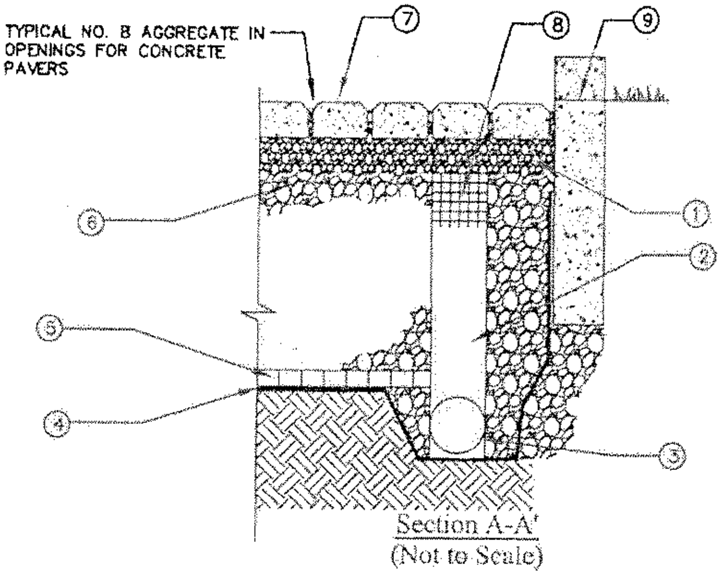

Figure D-6: Permeable Pavement cross-section

Refer to Figures D-6 and Figure 6-16 for a diagrammatic description of the geometric variables.

Step 1: Determine design volume reduction, $V_{reduction}$	
1-1. Enter the volume difference between the pre- and post-development conditions for the 25-yr, 24-hr design storm, V_{25}, calculated using SBUH method, Appendix C	V_{25} = 0 ft³
1-2. Enter the volume generated from a one-inch, 24-hr storm event, $V_{one\text{-}inch}$, calculated using SBUH method, Appendix C	$V_{one\text{-}inch}$ = 339 ft³
1-3. Determine design volume reduction which is the larger of V_{25} and $V_{one\text{-}inch}$ and is the volume to be retained on-site	$V_{reduction}$ = 339 ft³
Step 2: Determine storm water quality design volume, V_{wq}	
2-1. Determine the water quality design volume, V_{wq}, using SBUH method, Appendix C (Note: V_{wq} is always equal to $V_{one\text{-}inch}$)	V_{wq} = 339 ft³
Step 3: Determine design volume, V_{design} (for sizing)	
3-1. If no infiltration (i.e., impermeable liner w/ underdrains), $V_{design} = V_{wq}$.	V_{design} = 339 ft³
3-2. If partial infiltration (i.e., permeable liner w/underdrains), $V_{design} = V_{wq}+0.2V_{wq}$	V_{design} = ---- ft³
3-3. If full infiltration (i.e., permeable liner w/ no underdrains), $V_{design} = V_{reduction}$	V_{design} = ---- ft³

Step 4: Calculate design infiltration rate (assume full infiltration, $V_{design} = V_{reduction}$)			
4-1. Enter soil infiltration rate (0.5 in/hr min.), $k_{measured}$	$k_{measured}$ =	2	in/hr
4-2. Enter correction factor for testing (0.3 small scale, 0.5 large scale), F_t	F_t =	0.3	ft
4-3. Enter correction factor for plugging, (0.7 loams-sandy loams, 0.8 fine-loamy sands, 0.9 medium sands, 1.0 coarse sands-cobbles, F_p	F_p =	0.8	
4-4. Enter the depth from the bottom of the facility to the maximum wet-season water table or nearest impervious layer, whichever is less, D	D =	3	ft
4-5. Enter the estimated width of the facility	W =	10	ft
4-6. Calculate the correction factor of geometry (0.25 min, 1.0 max), Fg = 4•D/W +0.05	F_g =	1.25	
4-7. Calculate the design infiltration rate, $k_{design}=k_{measured}F_tF_pF_g$	k_{design} =	0.6	in/hr

Step 6: Determine infiltrating surface area (gravel drainage area)			
6-1. Enter gravel drainage layer porosity, n	n=	0.32	
6-2. Enter depth of gravel drainage layer, l	l =	3	in
6-3. Enter the time to fill the gravel drainage layer with water (Use 2 hours for most designs), T	T =	2	hrs
6-4. Calculate infiltrating surface area for dry wells: $A=V_{design}/(Tk_{design}/12)+n*l))$	A =	320	ft^3

Step 7: Provide conveyance capacity for filter clogging
7-1.The permeable pavement must have an emergency overflow for storm events greater than the design and in the event the permeable pavement becomes clogged.

Main Entrance

Permeable Pavement Worksheet

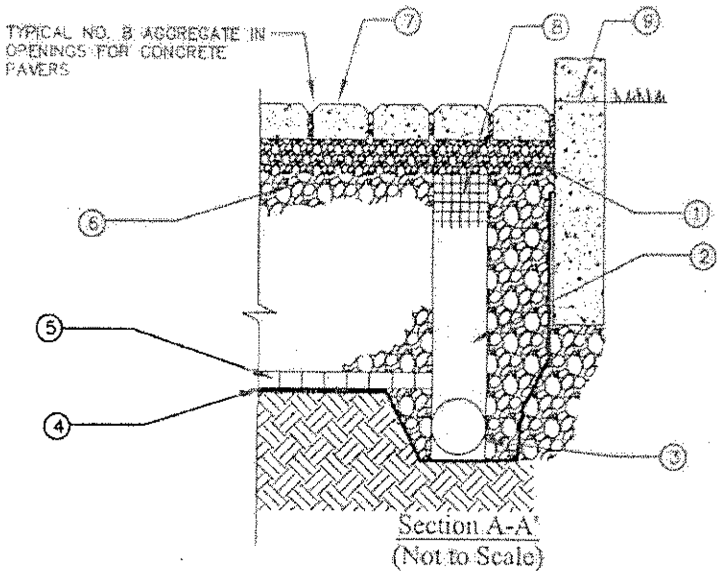

Figure D-6: Permeable Pavement cross-section

Refer to Figures D-6 and Figure 6-16 for a diagrammatic description of the geometric variables.

Step 1: Determine design volume reduction, $V_{reduction}$	
1-1. Enter the volume difference between the pre- and post-development conditions for the 25-yr, 24-hr design storm, V_{25}, calculated using SBUH method, Appendix C	V_{25} = 0 ft^3
1-2. Enter the volume generated from a one-inch, 24-hr storm event, $V_{one\text{-}inch}$, calculated using SBUH method, Appendix C	$V_{one\text{-}inch}$ = 2865 ft^3
1-3. Determine design volume reduction which is the larger of V_{25} and $V_{one\text{-}inch}$ and is the volume to be retained on-site	$V_{reduction}$ = 2865 ft^3

Step 2: Determine storm water quality design volume, V_{wq}	
2-1. Determine the water quality design volume, V_{wq}, using SBUH method, Appendix C (Note: V_{wq} is always equal to $V_{one\text{-}inch}$)	V_{wq} = 2865 ft^3

Step 3: Determine design volume, V_{design} (for sizing)	
3-1. If no infiltration (i.e., impermeable liner w/ underdrains), $V_{design} = V_{wq}$.	V_{design} = ---- ft^3
3-2. If partial infiltration (i.e., permeable liner w/underdrains), $V_{design} = V_{wq} + 0.2V_{wq}$	V_{design} = ---- ft^3
3-3. If full infiltration (i.e., permeable liner w/ no underdrains), $V_{design} = V_{reduction}$	V_{design} = 2865 ft^3

Step 4: Calculate design infiltration rate (assume full infiltration, $V_{design} = V_{reduction}$)		
4-1. Enter soil infiltration rate (0.5 in/hr min.), $k_{measured}$	$k_{measured}$ = 2	in/hr
4-2. Enter correction factor for testing (0.3 small scale, 0.5 large scale), F_t	F_t = 0.3	ft
4-3. Enter correction factor for plugging, (0.7 loams-sandy loams, 0.8 fine-loamy sands, 0.9 medium sands, 1.0 coarse sands-cobbles, F_p	F_p = 0.8	
4-4. Enter the depth from the bottom of the facility to the maximum wet-season water table or nearest impervious layer, whichever is less. D	D = 0.08	ft
4-5. Enter the estimated width of the facility	W = 58	ft
4-6. Calculate the correction factor of geometry (0.25 min, 1.0 max), Fg = 4•D/W +0.05	F_g = 0.06	
4-7. Calculate the design infiltration rate, $k_{design}=k_{measured}F_tF_pF_g$	k_{design} = 0.03	in/hr
Step 5: Determine maximum depth that can be infiltrated		
5-1. Enter drawdown time (72 hrs max.), t	t = 72	hrs
5-2. Calculate max.depth of runoff that can be infiltrated within the t, $d_{max}=k_{design}t/12$	d_{max} = 0.18	ft
Step 6: Determine infiltrating surface area (gravel drainage area)		
6-1. Enter gravel drainage layer porosity, n	n = 0.32	
6-2. Enter depth of gravel drainage layer, l	l = 1	in
6-3. Enter the time to fill the gravel drainage layer with water (Use 2 hours for most designs), T	T = 2	hrs
6-4. Calculate infiltrating surface area for dry wells: $A=V_{design}/(Tk_{design}/12)+n*l))$	A = 8,815	ft[3]
Step 7: Provide conveyance capacity for filter clogging		
7-1.The permeable pavement must have an emergency overflow for storm events greater than the design and in the event the permeable pavement becomes clogged.		