



City of Redwood City Stormwater Pollution Prevention Program

Drainage Guidelines for Residential Development

General Requirements

- A. Plot & Finished Grading Plan must be submitted with Building Permit applications for all new single family residences and additions associated with single family residences. This plan shall be a separate sheet included with the Building Permit submittal and must be prepared by a qualified licensed engineer or architect and be signed by the same.
- B.** The goal of the drainage design is to maintain post-development storm water runoff to pre-development runoff conditions, especially when existing drainage flows onto neighboring properties. (Roof Drains to pervious areas, vegetative filters, grassed swales and infiltrative landscaping)
- C. Use Post-Construction, Best Management Practices (BMP's) with the best technology available as appropriate to control runoff. (See "Blueprint for a Clean Bay")
- D. The use of dry wells is not allowed in the City of Redwood City

Design Criteria

- A. Use "Attachment D" of the Engineering Standards as a checklist for requirements of a plot and finished grading plan
- B. If fill is to be added adjacent to the property lines, grades on neighboring properties will need to be obtained to document any potential impacts to these properties. Site grading shall not impede existing drainage from adjacent properties.
- C. Design the drainage for sheet flow to lawn or pervious landscaped areas of the site, in lieu of area drains and pipe collection systems, wherever possible without creating ponding and erosion.
- D. Show where the roof downspouts are located. These downspouts should direct to approved splash blocks (minimum 2 feet long) that deflect the water away from the building. Show (with arrows) how the water is proposed to move away from the splash blocks.
- E. If a basement is proposed for the project, a drainage plan for a separate subgrade drainage system must be included in this plan. This should also include the method of outlet, and is not to connect sub drain to surface storm drain piping.
- F. Sites which slope away from the street require special design considerations. It is recommended that the designer schedule a pre-design meeting with the City's engineering staff prior to submitting the plans for review.
- G.** For sites exceeding 10% slope, an erosion control plan is required; for excavation more than 50 cubic yards, a separate grading permit may be required.
- H.** See Sample Calculation on Sheet 2 and 3, and Attached Design Concepts 1-4.

SAMPLE LOT DRAINAGE CALCULATION FOR STORMWATER RUN-OFF CONTROL

Notes:

1. Runoff Control - To the extent practicable, maintain post-development peak runoff rate and average volume of runoff at levels that are similar to pre-development levels. The developer must design the proposed project accordingly.
 2. **Design for 10-year storm event** for most residential lots less than 10,000 square feet, use $i=1.75$ in/hr for a rain duration of about 10 minutes, which corresponds to a time of concentration (t_c) of about 10 minutes.
 3. Detention volume is designed based on a modified hydrograph with a rain duration of $3 \times t_c$, which equals to about 30 minutes.
 4. Pump may be used as required with discharge at pre-development rate
 5. Use a value of $K = 0.6$ for orifice diameters from 1.5" to 4" and with a storage pipe diameter of 10" to 24". Use $K=0.7$ if storage diameter < 10".
 6. Use runoff coefficients as follows: Use $C=0.30$ for dirt and lawn. Use $C=0.95$ for roof
 7. When calculating discharge through a grassed swale/lawn area prior to entering an inlet/filter basin, if lawn area is $\geq 2 \times$ roof run-off area, "C" of 0.75 can be used instead of 0.95 for step 2 regarding roof run-off.
 8. Run-off toward the front of the house can use depressed lawn area for filtration/detention in-lieu-of gravel beds.
 9. Storage pipe material shall be PVC, DR rating of 26; and pipe shall have 0.5' minimum cover. Minimum pipe size is 4" with a minimum slope of 0.005.
- SF = square feet = ft^2 , CF = cubic feet = ft^3 , CFS = cubic feet per second = ft^3 , GPM = gallons per minute

Input values in SHADED AREAS ONLY

Figure A: Lot With Existing Structure

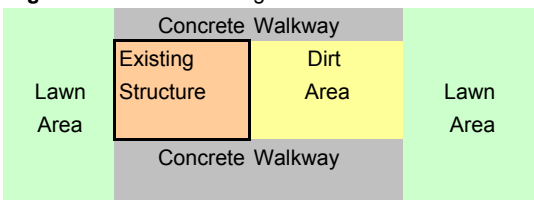
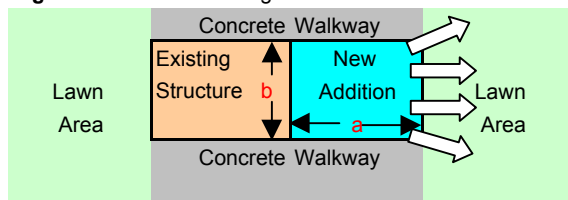


Figure B: Lot with Existing Structure & New Addition



Step 1: New Additional Impervious Roof Area. $A_{imp} = \text{Length} \cdot \text{Width}$

Length of New Impervious Area (ft): a) 40 [40]
 Width of New Impervious Area (ft): b) 50 [50]
 a) 40 [40] x b) 50 [50] = c) 2000 [2000SF] of new roof area

Step 2: The Change in the Run-off Coefficient From New Roof to Existing Lawn. $\Delta C = |C_{roof} - C_{dirt}|$

Run-off Coefficient for Roof: d) 0.95 [0.95]
 Run-off Coefficient for Dirt: e) 0.30 [0.30]
 d) 0.95 [0.95] - e) 0.30 [0.30] = f) 0.65 [0.65]

Step 3: Discharge Rate of Additional Impervious Area. $\Delta Q = A_{imp} \cdot i \cdot \Delta C$

Note: $i = 1.75$ at $t_c = 10$ Minutes for a 10 year storm event.

c) 2000 [2000SF] X 1 acre X 1.75 X f) 0.65 [0.65] = g) 0.052 [0.052CFS]
 43560 SF or in GPM g₁) 23 [23gpm]

Step 4: Determine storage/detention volume. $V = \Delta Q \cdot 1.5 \cdot t_c$

Note: if in CFS must convert t_c to seconds. However if in GPM, then there is no need for a conversion.

g) 0.052 [0.052CFS] X 1.5 X 10minute X 60 second / minute = h) 47 [47CF]

Option 1 : Gravel Bed Method With Filtration as Detention Device. (See Design Guide Sheet 4.)

Step 5: Determine required size of gravel bed. $V_{\text{gravel bed}} = V \div 0.4$

- Proposed storage by shallow gravel bed method with 40% of the void accounted for water content, so the required size is: h) 47 [47CF] \div 0.4 = j) 118 [118CF]

Step 6: Estimate Dimensions of Shallow Gravel Bed By Finding Area of Bed. $V_{\text{gravel bed}} \div 2\text{ft} = A_{\text{gravel bed}}$

Note: Maximum depth of bed is limited at 2 feet and bed must be kept 5 feet minimum away from nearest property line and any tree.

Area of the Gravel Bed: j) 118 [118CF] \div 2 = k) 59 [59SF]

Now Select any equivalent dimensions which satisfy the estimated area of 59SF.

EXAMPLES: 6' width and 9.83' length. OR 4' width and 14.75' length. OR 3' width and 19.7' length.

Option 2 : Storage Pipe Method as Filtration and Detention Devices. (See Design Guide Sheet 3.)

Step 7: Pipe Storage Length.(Choose size to fit field condition.) Input Trial Diameter in l).

Storage Pipe Diameter(inches):l) 12 [12] in

Step 8: Calculate Cross Sectional Area of Pipe Using Trial Diameter. $\text{Cross Section} = \pi * d^2 \div 4 \div 144\text{in}^2 / \text{ft}^2$
3.14159 X l) 12 [12]in X l) 12 [12]in \div 4 \div 144 = m) 0.79 [0.79SF]

Step 9: Trial Pipe Length. (check size to fit field condition.)

h) 47 [47]CF \div m) 0.79 [0.79]SF = n) 60 [60] ft

Step 10: A Variable Hydraulic Head = Height Difference From High to Low Point(Discharge Orifice) of Pipe. (Input values in o) and p)

Highest Pipe Upstream Overflow Elevation:(feet) o) 100 [100]ft

Lowest Pipe Invert Elevation:(feet) p) 98 [98]ft

o) 100 [100]ft - p) 98 [98]ft = q) 2 [2] ft

Step 11: Velocity of Discharge Through the Orifice. $\text{Velocity} = K \cdot \text{square root of quantity } (2 \cdot g \cdot h)$

2 X 32.2 X q) 2 [2]ft = r) 128.8 [128.8]

0.6 X square root of r) = s) 7 [7] ft/second

Step 12: Discharge Rate of Pre-Developmental Area. $Q_{\text{pre}} = A_{\text{imp}} \cdot i \cdot C_{\text{pre}}$

c) 2000 [2000SF] X 1 acre X 1.75 X t) 0.30 [0.30] = u) 0.024 [0.024CFS]
43560 SF or in GPM = u₁) 11 [11 GPM]

Step 13: Cross Section of Discharge Orifice. (orifice cross section = $Q_{\text{pre}} \div \text{Velocity}$)

(Use restrictor plate(prefer) or small pipe if it does not affect long term maintenance.)

u) 0.024 [0.024CFS] \div s) 7 [7]ft/sec = v) 0.004 [0.004]ft² OR 0.5 [0.5]in²

Step 14: Diameter of Orifice. $\text{Diameter} = \text{Square Root of quantity } (\text{orifice area} \cdot 144\text{in}^2 / \text{ft}^2 \cdot 4 \div \pi)$

v) 0.004 [0.004]ft² X 144 X 4 \div 3.14159 = w) 0.65 [0.65] in²
square root of w) = x) 0.8 [0.8]inch so say approximately 1 [1]inch

Step 15: Input Trial Length L(ft) For Design of Weir Overflow Height

y) 2 [2]ft

Step 16: Weir Overflow Height. $H = (Q_{\text{post}} \div C \div L)^{2/3}$ Where C = 3. Determine H

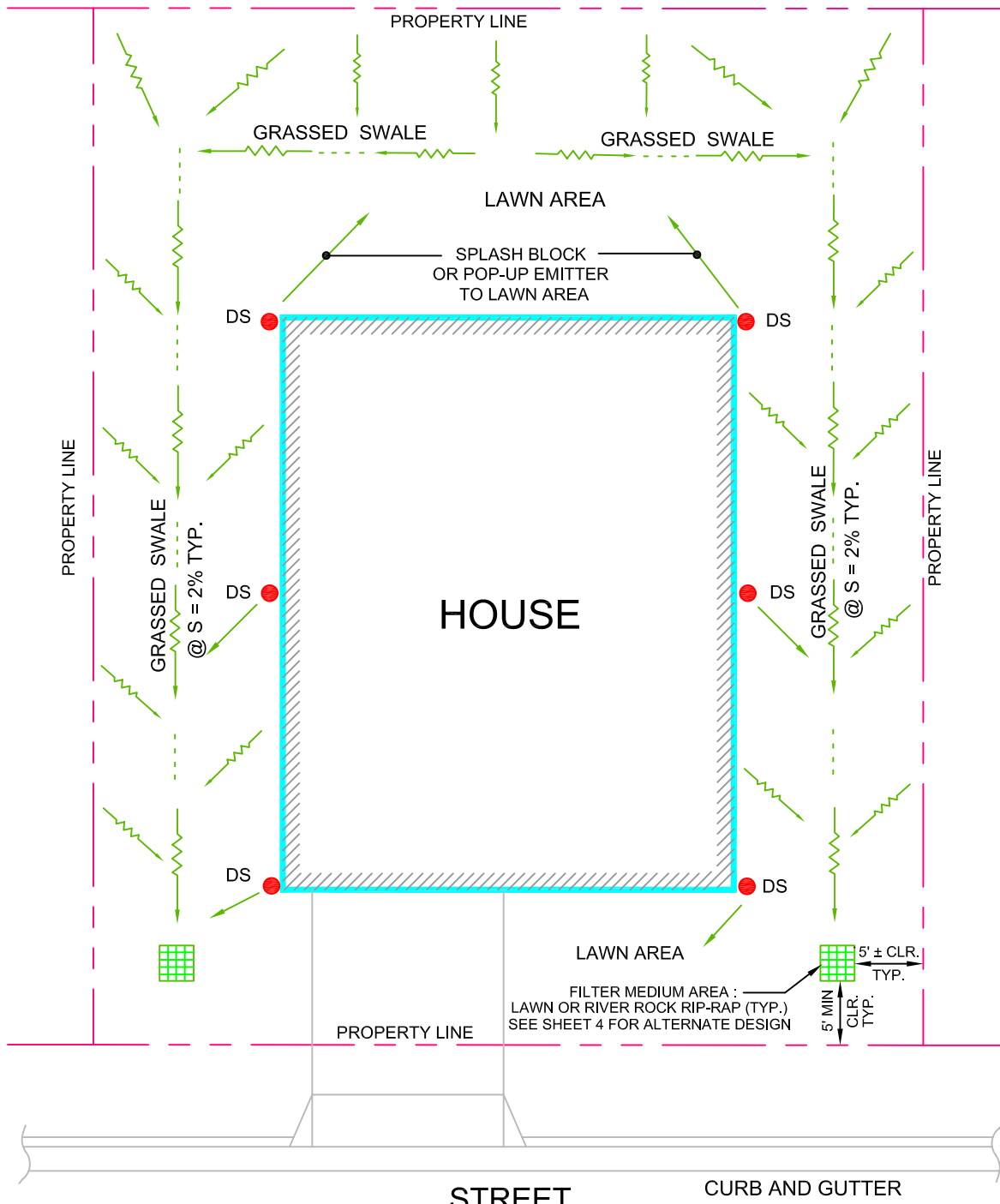
g) 0.052 [0.052]CFS \div 3 \div y) 2 [2]ft = z) 0.0087 [0.0087]

Step 17: Conclude Calculations for Weir Overflow Height H. $H = 0.0087^{2/3}$

z) 0.0087 [0.0087]^{2/3} = a₁) 0.042 [0.042]ft or 0.508 [0.508]in

LEGEND:

-  - SHEET FLOW
-  - SPLASH BLOCK
-  - GRASSED SWALE
-  - FILTER MEDIUM AREA:
LAWN OR RIVER ROCK RIP-RAP
- - SEE ATTACHMENT D FOR MORE DETAILS
- - GRADING AND DRAINAGE PLAN REQUIRED



NOT TO SCALE

**DESIGN
GUIDE**

**CITY OF REDWOOD CITY
ENGINEERING AND CONSTRUCTION**





LOT DRAINAGE - DESIGN CONCEPT NO.1

DATE: 8/18/03
REV. 0

- TYPICAL NEW HOUSE / ADDITIONS -

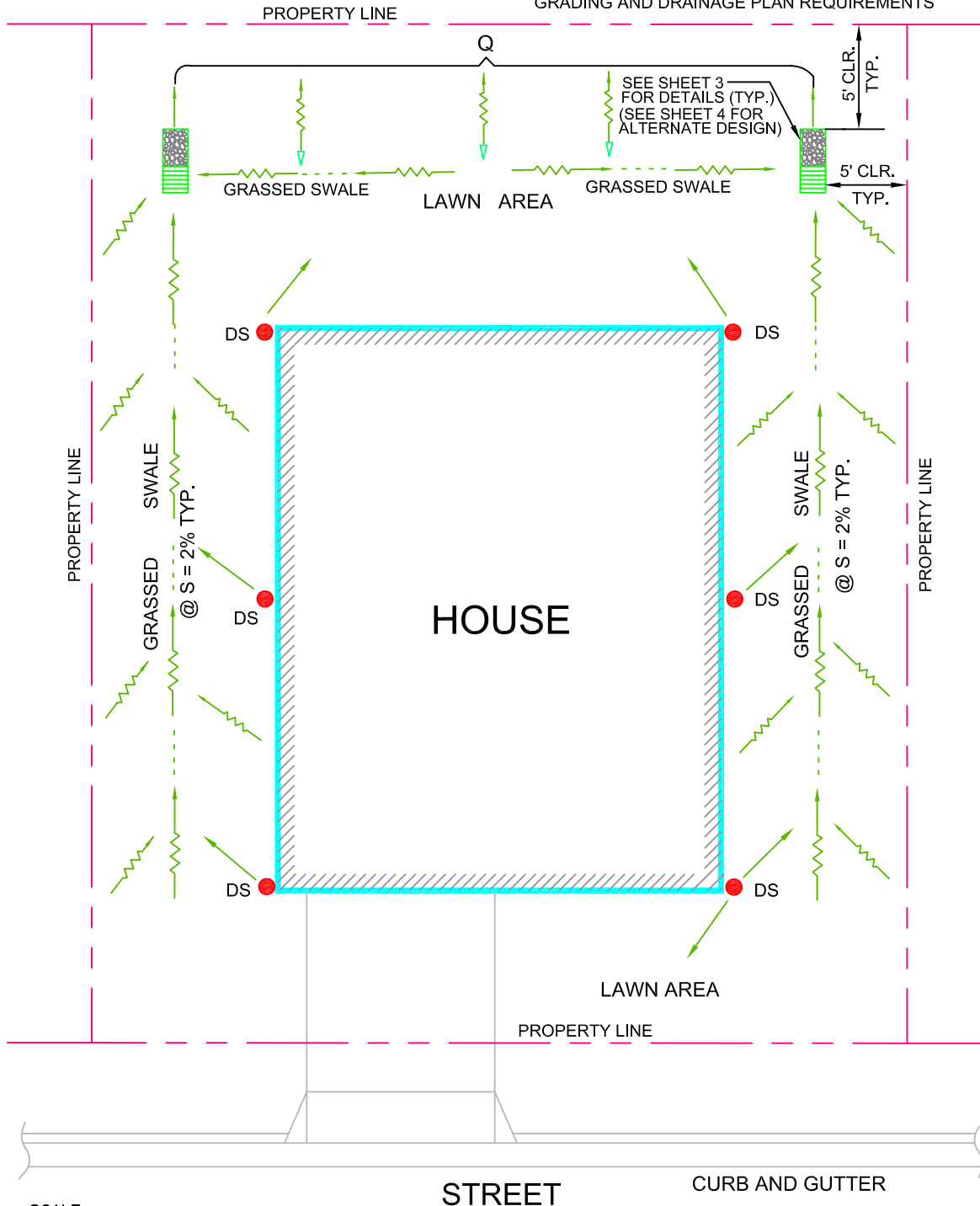
SHT 1 OF 4

LEGEND:

-  - SHEET FLOW
-  - SPLASH BLOCK
-  - GRASSED SWALE
-  - DETENTION AND FILTRATION BASIN

Q - TOTAL POST-DEVELOPMENT RUN-OFF RATE FROM SITE SHALL NOT EXCEED PRE-DEVELOPMENT RATE.
 PROVIDE RUN-OFF CONTROL DEVICES SUCH AS STORAGE PIPES, WEIRS, SLOTTED CONCRETE CURB, AND / OR DETENTION BASIN

- SEE ATTACHMENT D AND D - 1 FOR MORE DETAILS AND FOR GRADING AND DRAINAGE PLAN REQUIREMENTS



NOT TO SCALE

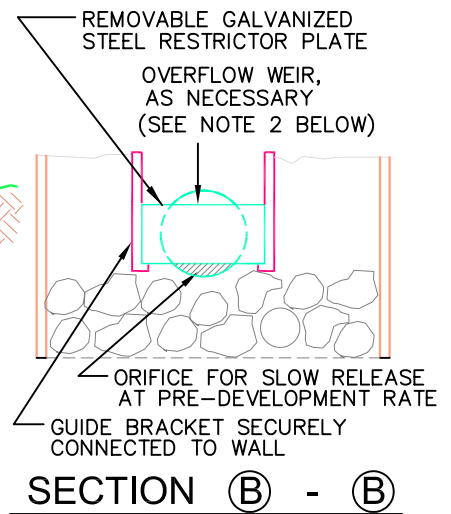
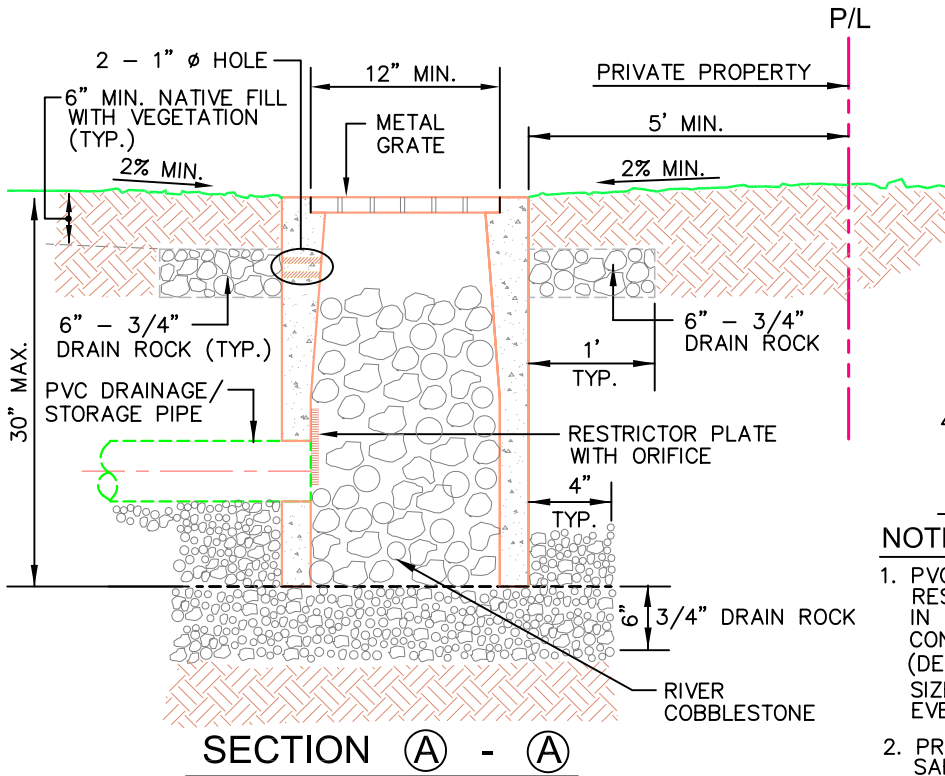
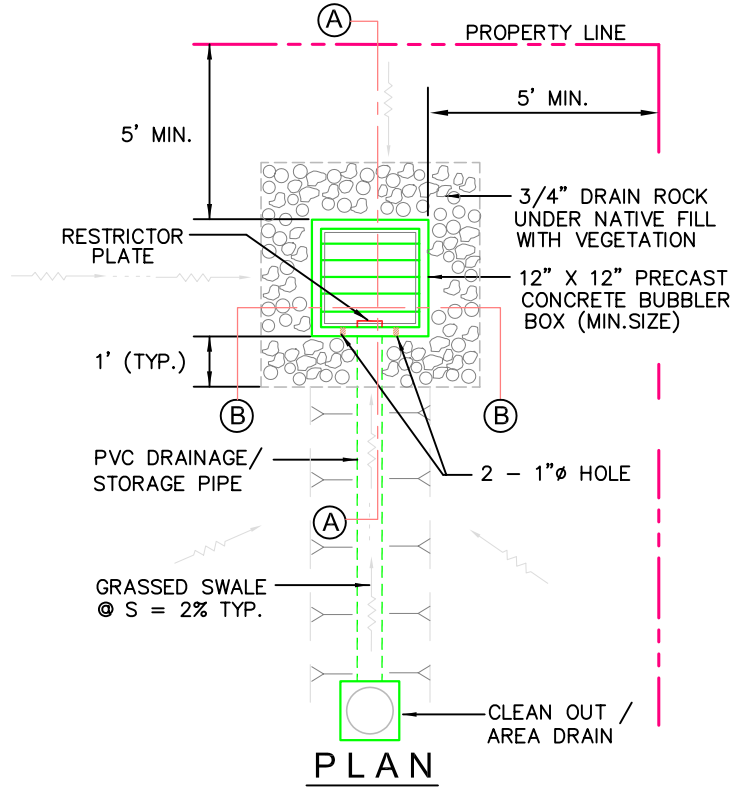
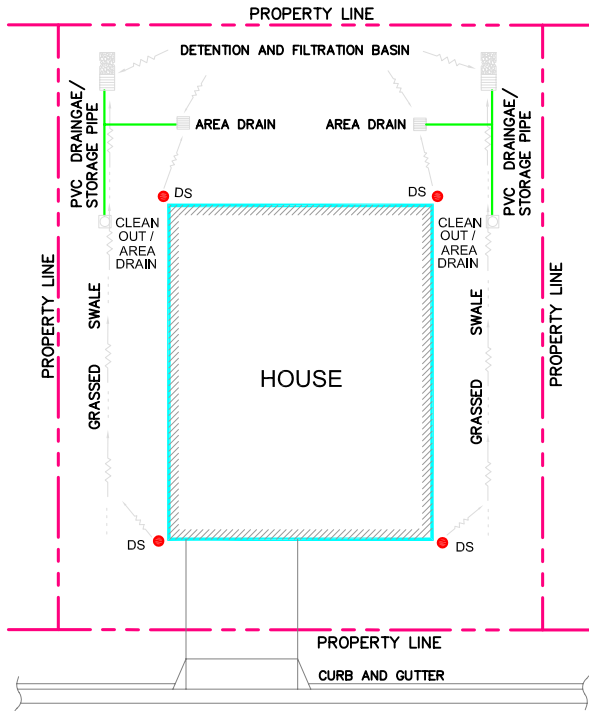
DESIGN GUIDE

**CITY OF REDWOOD CITY
 ENGINEERING AND CONSTRUCTION**

DATE: 8/18/03
 REV. 0

LOT DRAINAGE - DESIGN CONCEPT NO.2
 SITE SLOPE DOWN AWAY FROM STREET
 - NEW HOUSE OR ADDITIONS -

SHT 2 OF 4



NOTE:

1. PVC DRAINAGE/STORAGE PIPE AND RESTRICTOR PLATE WITH ORIFICE ARE IN ADDITION TO GRASSED SWALE TO CONTROL ADDITIONAL RUN-OFF (DETENTION AND SLOW RELEASE) SIZE SYSTEM FOR 10-YEAR STORM EVENT (SEE CITY DESIGN CRITERIA)
2. PROVIDE DESIGN CONSIDERATION FOR SAFE OVERFLOW DISCHARGE OF A 100-YEAR STORM EVENT.

NOT TO SCALE

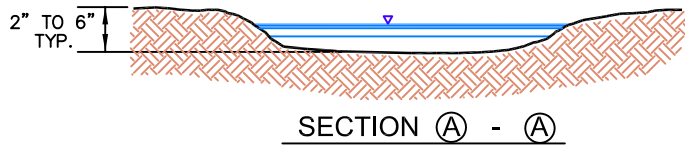
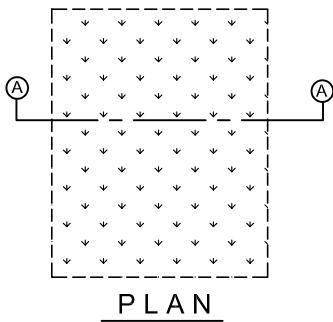
DESIGN GUIDE

**CITY OF REDWOOD CITY
ENGINEERING AND CONSTRUCTION**

DATE: 2/26/04
REV. 1

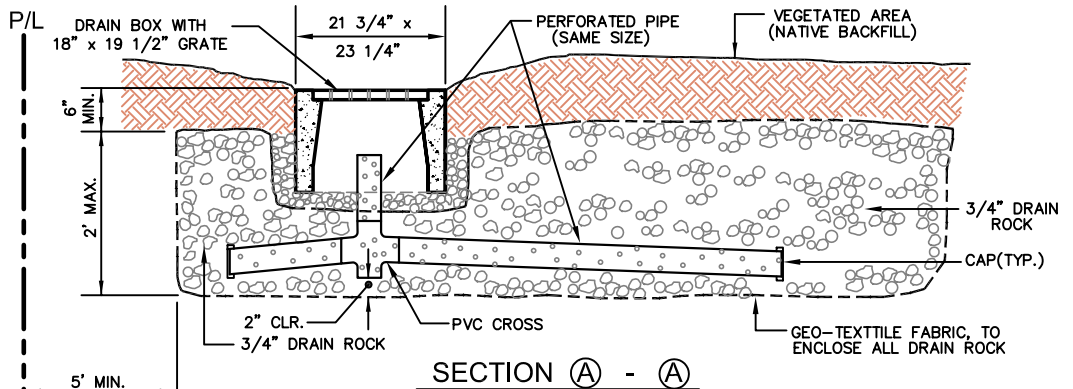
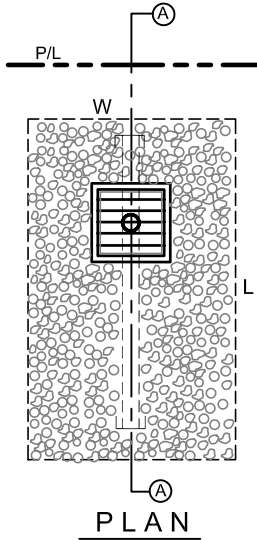
DETENTION AND FILTRATION SYSTEM

SHT 3 OF 4



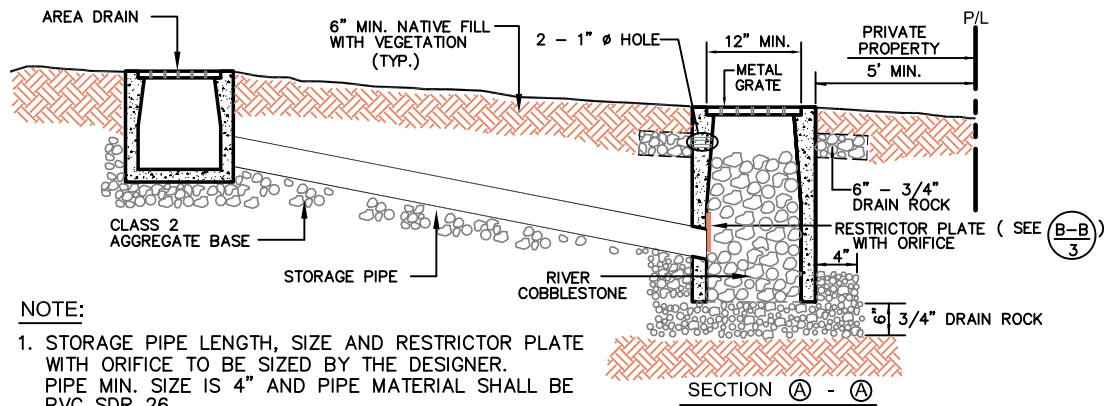
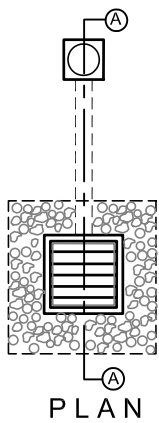
- NOTE:
1. MAXIMIZE THE SIZE OF THE VEGETATED AREA TO ACCOMMODATE MORE STORM WATER.
 2. A SLIGHT DEPRESSION OF THE AREA WOULD CREATE MORE DETENTION CAPACITY TO TREAT STORM WATER.
 3. RECTANGULAR SHAPE IS NOT RESTRICTIVE.

1. LAWN / GRASS / VEGETATED AREA



- NOTE:
1. L & W TO BE SIZED TO ACCOMMODATE A 10-YEAR STORM EVENT. (THIS GRAVEL BED CAN BE USED AS A WATER DETENTION DEVICE.)
 2. WATER DETENTION CAPACITY OF BED IS LIMITED TO 40% OF TOTAL BED VOLUME.

2. SHALLOW GRAVEL BASIN



- NOTE:
1. STORAGE PIPE LENGTH, SIZE AND RESTRICTOR PLATE WITH ORIFICE TO BE SIZED BY THE DESIGNER. PIPE MIN. SIZE IS 4" AND PIPE MATERIAL SHALL BE PVC SDR 26

3. STORAGE PIPE / BUBBLER BOX

4. ANY ONE OR A COMBINATION OF THESE METHODS CAN BE USED TO ACCOMMODATE A 10-YEAR STORM EVENT. PROVIDE DESIGN CONSIDERATION FOR SAFE OVERFLOW DISCHARGE OF A 100 - YEAR STORM EVENT.

NOT TO SCALE

DESIGN
GUIDE

CITY OF REDWOOD CITY
ENGINEERING AND CONSTRUCTION

DATE: 2/26/04
REV. 1

EXAMPLES OF A
TYPICAL FILTER MEDIUM AREA
(FOR STORM WATER FILTRATION AND/OR DETENTION)

SHT 4 OF 4

ATTACHMENT D

PLOT AND FINISH GRADING PLAN REQUIREMENTS FOR PRIVATE DEVELOPMENT

DESIGN STANDARDS FOR DRAINAGE

1. GENERAL

- A. Drainage - both existing and proposed - is the basic consideration in the design of grading. Providing for adequate drainage onto and off of the proposed site is one of the most important aspects of grading plan design since the best compacted fill or graded slope can be completely nullified by inadequate drainage provisions.
- B. These requirements are based on guidelines listed in Chapter 33 of the Uniform Building Code. These are minimum standards, not maximum provisions, which can guarantee adequate drainage under all conditions. Depending on the topography, layout, or soil conditions, more restrictive requirements may be necessary as determined by the reviewing official.
- C. The designer, in coordination with the soil engineer, must determine the necessities of each individual site on its own merits, and design for problems peculiar to the site. Long-term performance must be considered with enough conservatism in design to take into account the general lack of maintenance received by residential sites.
- D. Grading and drainage plans must be signed, dated and stamped by a registered architect or civil engineer, on the original drawing.
- E. For hillside lots, a geotechnical engineer must submit a certified soils report, and stamp the grading plan.

2. DRAINAGE GRADIENTS

- A. The following minimum gradients for drainage are required for development of private property: (See Attachment "D-1"):

Dirt/Grass - 2%
Asphalt Driveway - 1% (longitudinal flow) 2% (sheet flow)

Portland Cement Concrete...- 0.5% (longitudinal swale); 1% (sheet flow)
Terrace/Interceptor Drains ...- 5%

- B. The following are maximum gradients:

Graded earth swales ... - 6%
Driveways - 20% (See Attachment "E-2")

ATTACHMENT D (Continued)

3. CUT AND FILL SLOPES

- A. All cut and fill slopes shall be no steeper than 2:1; for steeper slopes, a soils engineer must submit a soils report, and stamp, date and sign the original drawing of the grading plan.
- B. Drainage standards for slopes are established to prevent excessive erosion and subsequent instability. No surface water from buildings or pads should be permitted to flow over the slopes. Drainage from the natural slopes above the graded cut slope should be diverted away by a terrace drain or a "V"-ditch. (See Attachment"D-2").

PLAN REQUIREMENTS

- A. A plot and finish grading plan is required to be submitted with all applications for a building permit. The following is a check list of items which as a minimum, must be shown on the plot and finished grading plans:

- ___ 1. The site address.
- ___ 2. The owner's name, address and phone number.
- ___ 3. The names, addresses and phone numbers of the architect, civil engineer, surveyor, or other designer.
- ___ 4. Location of stockpile area for excess dirt.
- ___ 5. The volume of cut and fill needed, (if greater than 50 CY).
- ___ 6. Import or export of dirt involving 50 CY or more requires a dirt hauling permit from the City Traffic Engineer.
- ___ 7. Fully dimensioned property lines and boundaries.
- ___ 8. Vicinity map with enough detail so the site can be easily found.
- ___ 9. North arrow, scale and legend.
- ___ 10. Location of any buildings, structures, driveways, drainage ditches, or element of the project such as pool, patio, tennis court, etc., on or within 15 feet of the property where the work is to be performed.
- ___ 11. Location and height of all retaining walls (note: retaining walls with a height exceeding four feet from the bottom of footing require a special permit per Section 301 of the UBC.
- ___ 12. Accurate contours showing the present topography of the site and adjacent property. Existing and proposed contours shall be shown at intervals of one foot or less on slopes up to five percent, and not more than five feet on slopes in excess of five percent, and shall extent 10 feet across adjoining streets (when said streets are unimproved) and adjoining property lines.
- ___ 13. Elevations, dimensions, locations, extents and slopes of all proposed grading, by contours or other means, including finish curb at points of extension of lot lines and curb return points; finish and existing grade elevations at each principal corner for the structure and points of significant

ATTACHMENT D (Continued)

change of slope; the garage and finished floor elevations; center of driveway elevation at property line and curb face elevations at all lot corners. Note: for subdivision lots, contours and elevations shall be on the same datum as the tentative map and improvement plans.

- ___ 14. Adequate drainage notes and specifications. Entire lot drainage pattern and disposition of surface and roof drainage; roof, rear yard, patio, etc., impervious areas drainage is to be collected and conveyed in a closed pipe to the street gutter. Swales with a minimum slope of 2% shall be provided to drain rear to side yards and to the street and to drainage swales, to be a 2% minimum, sloping away from the structure. (See Attachment "D-1" for proper drainage design).
- ___ 15. Detailed plans of all drainage devices, walls, cribbing, or other protective devices to be constructed as part of the proposed work.
- ___ 16. All cut and fill slopes with continuous "daylight" lines.
- ___ 17. Top and toe of all cut and fill slopes.
- ___ 18. Drainage of lot must not flow onto neighboring properties and all drainage shall be conveyed to the public street via a storm drain or approved system.
- ___ 19. Existing easements, streets with center lines, sewer, storm drain and access easements, existing and proposed.
- ___ 20. Location, diameter and dripline of all existing trees 12 inches or more in diameter measured between 6" & 36", both on the property and within the public right-of-way.
- ___ 21. All cut and fill control specifications.
- ___ 22. Provisions for protecting adjacent properties.
- ___ 23. For hillside lots, erosion control and or slope protection.
- ___ 24. Crawl space height must be defined.
- ___ 25. Easements and controlling dimensions.
- ___ 26. Cleanouts at each bend in the underground drain pipe, including the bend at the downspout.
- ___ 27. Tree protection plan for all trees to be retained and a tree removed notes for trees to be removed. (See Heritage Tree Ordinance)

B. DRIVEWAY REQUIREMENTS

- ___ 1. Show driveway location, width and slope.
- ___ 2. Approach must conform to City Standard Details.
- ___ 3. The construction of new driveway requires a permit from Engineering and Construction.

ATTACHMENT D (Continued)

C. SIDEWALK, CURB AND GUTTER REQUIREMENTS

- ___ 1. Show existing curb, gutter, driveways, wheelchair ramps.
- ___ 2. Broken or damaged sidewalk, curb, and gutter must be replaced.
- ___ 3. New sidewalk curb, & gutter must conform to City Standard Details.
- ___ 4. The construction of new sidewalks requires a permit from Engineering and Construction

D. UTILITY REQUIREMENTS

- ___ 1. Show existing and proposed water, sewer, gas, ~~and~~ storm drains, electric, and Cable TV.
- ___ 2. Show appropriate City Details for new water, sewer, & storm drains.
- ___ 3. Work within public right-of-way requires construction permit from Engineering Division.
- ___ 4. Show any easements affecting the property.
- ___ 5. Installation of a new sanitary sewer lateral cleanout, next to right-of-way line, requires a permit from Engineering Division. Obtain this permit prior to issuance of a Building Permit.
- ___ 6. All new utility service lines shall be placed underground.

ATTACHMENT I

FEES AND CHARGES

<u>Permit/Service</u>	<u>Fee/Charge</u>
1. Bid Sets for CIP Projects	
Standard Size	\$25.00 - Picked Up
	\$35.00 - Mailed
Large Size	\$35.00 - Picked Up
	\$45.00 - Mailed
Extra Large	\$45.00 - Picked Up
	\$55.00 - Mailed
2. Engineering Standards (3 Volumes)	
CD Version	\$75.00
On Line	No Charge
3. General Engineering Services	Actual Cost*, \$200
Preliminary Plan Review, Concept	minimum deposit,
Study, Water Availability, etc.	balance refundable
4. Abandonment of Public Easement	\$500.00
5. Final Subdivision Map	Actual Cost*, \$600 min.
6. Civil Improvement Plan Checking	Actual Cost*
7. Final Parcel Map	Actual Cost*, \$600 min.
8. Construction Permit	Actual Cost*
9. Grading Permit	Actual Cost*

* Actual Cost is the direct salary charged for the personnel providing the services described, plus 120% thereof for fringe benefits and overhead expense. Deposits for actual cost services shall be made at time of submittal in the amounts set forth below. Refund of balance will be made after project completion.

DEPOSIT SCHEDULE FOR SERVICES RENDERED AT ACTUAL COST

<u>Estimated Cost of Improvements (ECI)</u>	<u>General Engineering Services</u>	<u>Construction Inspection</u>
Under \$ 5,000	\$250	\$250
\$ 5,000 - \$ 10,000	\$150 + 4% of ECI	\$250 + 8% of ECI
\$10,000 - \$ 50,000	\$250 + 3% of ECI	\$450 + 6% of ECI
\$50,000 - \$100,000	\$750 + 2% of ECI	\$950 + 5% of ECI
\$100,000 - \$200,000	\$1,750 + 1% of ECI	\$1,950 + 4% of ECI
\$200,000 - \$400,000	\$1,950 + 0.9% of ECI	\$2,950 + 3.5% of ECI
\$400,000 - \$600,000	\$2,350 + 0.8% of ECI	\$4,950 + 3% of ECI
\$600,000 - \$800,000	\$2,950 + 0.7% of ECI	\$7,950 + 2.5% of ECI
\$800,000 - \$1,000,000	\$3,750 + 0.6% of ECI	\$11,950 + 2% of ECI
\$1,000,000 - \$1,500,000	\$4,750 + 0.5% of ECI	\$14,450 + 1.7% of ECI
Over \$1,500,000	\$6,250 + 0.4% of ECI	\$18,200 + 1.5% of ECI