## Sizing Worksheet - PT-3 Vegetated Swale

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| Designer:<br>Project Proponent:<br>Date:<br>Project:<br>Location: | | |
| Type of Vegetation: (describe) | ____________________________________ | |
| Outflow Collection: (Check type used or describe "Other") | ___ Grated Inlet<br>___ Subsurface infiltration<br>___ Underdrain Used<br>___ Other ___________________________________ | |
| **Step 1: Determine water quality design flow** | | |
| 1-1. Enter project area (acres), $A_{project}$<br>If this BMP captures runoff from a portion of the project area, enter the tributary area | $A_{project}$ = | acres |
| 1-2. Enter impervious fraction, *Imp* (e.g. 60% = 0.60) | Imp = | |
| 1-3. Determine pervious runoff coefficient using Table C-1, $C_p$ | $C_p$ = | |
| 1-4. Calculate runoff coefficient,<br>$C = 0.95*imp + C_p\,(1-imp)$ | C = | |
| 1-5. Enter design rainfall intensity (in/hr), *i* | i = | in/hr |
| 1-6. Calculate water quality design flow (cfs),<br>$SQDF = CiA_{project}$ | SQDF = | cfs |
| **Step 2: Calculate swale bottom width** | | |
| 2-1. Enter water quality design flow (cfs), *SQDF* | SQDF = | cfs |
| 2-2. Enter Manning's roughness coefficient for shallow flow conditions, $n_{wq} = 0.2$ | $n_{wq}$ = | |
| 2-3. Calculate design flow depth (ft), *y* | y = | ft |
| 2-4. Enter longitudinal slope (ft/ft) (along direction of flow), *s* | s = | ft/ft |
| 2-5. Calculate bottom width of swale (ft),<br>$b = (SQDF*n_{wq})/(1.49y^{1.67}s^{0.5})$ | b = | ft |
| 2-6. If *b* is between 2 and 10 feet, go to Step 3 | | |
| 2-7. If b is less than 2 ft, assume b = 2 ft and recalculate flow depth,<br>$y = ((SQDF*n_{wq})/(2.98\,s^{0.5}))^{1.49}$ | y = | ft |

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| 2-8. If b is greater than 10 ft, one of the following design adjustments must be made (recalculate variables as necessary):<br>Increase the longitudinal slope to a maximum of 0.06 ft/ft.<br>Increase the design flow depth to a maximum of 4 in (0.33 ft).<br>Place a divider lengthwise along the swale bottom (Figure 3-1) at least three-quarters of the swale length (beginning at the inlet). Swale width can be increased to an absolute maximum of 16 feet if a divider is provided. | | |
| **Step 3: Determine design flow velocity** | | |
| 3-1. Enter side slope length per unit height (H:V) (e.g. 3 if side slopes are 3H :1V), *Z* | Z = | |
| 3-2. Enter bottom width of swale (ft), *b* | b = | ft |
| 3-3. Enter design flow depth (ft), *y* | y = | ft |
| 3-4. Calculate the cross-sectional area of flow at design depth (ft$^2$),<br>$A_{wq} = by + Zy^2$ | $A_{wq}$ = | ft$^2$ |
| 3-5. Calculate design flow velocity (ft/s), $V_{wq} = SQDF/ A_{wq}$ | $V_{wq}$ = | ft/s |
| 3-6. If the design flow velocity exceeds 1 ft/s, go back to Step 2 and change one or more of the design parameters to reduce the design flow velocity. If design flow velocity is less than 1 ft/s, proceed to Step 4. | | |
| **Step 4: Calculate swale length** | | |
| 4-1. Enter hydraulic residence time (minutes, minimum 7 min), $t_{hr}$ | $t_{hr}$ = | min |
| 4-2. Calculate swale length (ft), $L = 60t_{hr}V_{wq}$ | L = | ft |
| 4-3. If *L* is too long for the site, proceed to Step 5 to adjust the swale layout<br>If *L* is greater than 100 ft and will fit within the constraints of the site, skip to Step 6<br>If *L* is less than 100 ft, increase the length to a minimum of 100 ft, leaving the bottom width unchanged, and skip to Step 6 | | |
| **Step 5: Adjust swale layout to fit within site constraints** | | |
| 5-1. Enter the bottom width calculated in Step 2 (ft), $b_i = b$ | $b_i$ = | ft |
| 5-2. Enter design flow depth (ft), *y* | y= | ft |
| 5-3. Enter the swale side slope ratio (H:V), *Z* | Z = | ft:ft |
| 5-4. Enter the additional top width above the side slope for the design water depth (ft), $b_{slope} = 2Zy$ | $b_{slope}$ = | ft |
| 5-5. Enter the initial length calculated in Step 4 (ft), $Li = L$ | $L_i$ = | ft |
| 5-6. Calculate the top area at the design treatment depth (ft$^2$),<br>$A_{top} = (b_i + b_{slope}) \times L_i$ | $A_{top}$ = | ft$^2$ |

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| 5-7. Choose a reduced swale length based on site constraints (ft), $L_f$ | $L_f$ = ft |
| 5-8. Calculate the increased bottom width (ft),<br>$b_f = (A_{top}/L_f) - b_{slope}$ | $b_f$ = ft |
| 5-9. Recalculate the cross-sectional area of flow at design depth (ft2),<br>$A_{wq,f} = b_f y + Zy^2$ | $A_{wq,f}$ = ft$^2$ |
| 5-10. Recalculate design flow velocity (ft/s),<br>$V_{wq} = SQDF/ A_{wq}$<br>Revise design as necessary if design flow velocity exceeds 1 ft/s. | $V_{wq}$ = ft/s |
| 5-11. Recalculate the hydraulic residence time (min),<br>$t_{hr} = L_f/(60V_{wq})$<br>Ensure that $t_{hr}$ is greater or equal to 10 minutes. | $t_{hr}$ = min |
| 5-12. When $V_{wq}$ and $t_{hr}$ are recalculated to meet requirements, proceed to Step 6. | |
| **Step 6: Provide conveyance capacity for flows higher than SQDF (if swale is on-line)** | |
| 6-1. If the swale already includes a high-flow bypass to convey flows higher than the water quality design flow rate, skip this step and verify that all parameters meet design requirements to complete sizing | |
| 6-2. If swale does not include a high-flow bypass, determine that the swale can convey flood control design storm peak flows. Calculate the capital peak flow velocity per Ventura County requirements (ft/s), $V_p$ | $V_p$ = ft/s |
| 6-3. If $V_p$ > 3.0 feet per second, return to Step 2 and increase the bottom width or flatten the longitudinal slope as necessary to reduce the flood control design storm peak flow velocity to 3.0 feet per second or less. If the longitudinal slope is flattened, the swale bottom width must be recalculated (Step 2) and must meet all design criteria. | |