Appendix B – Example Designs

Design examples for each method are outlined below. Two separate sites are used for the examples. The first site, shown below, is located adjacent to the Guadalupe River and provides examples of stormwater treatment using bioretention, permeable pavement (pavers), cisterns and a riparian buffer. The second site is an existing parking lot redesigned to use a vegetated filter strip to treat stormwater runoff. The examples do not include subsurface utility engineering (SUE) surveys of existing utility conflicts and should only be referenced as fictitious examples. This is the level of design required to be submitted as the **Project Drawing**. The **Project Drawing** can be done by hand.

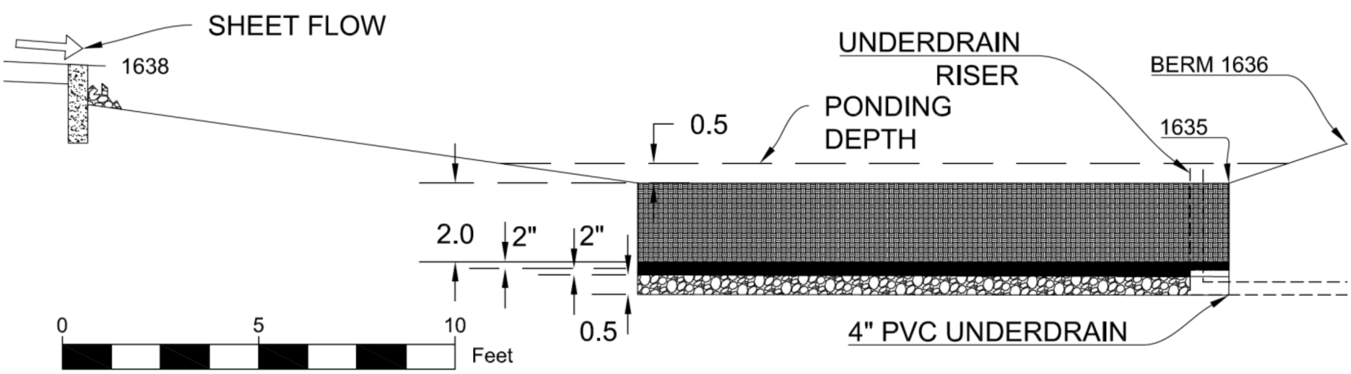
Bioretention – Site 1

A parcel is developed to include a building, entry drive, and parking. The goal of this project is to maximize the treatment of stormwater runoff using as many methods as possible. After laying out the new design, a bioretention area is selected to treat the runoff from part of the drive and parking area. The soil report for this site shows most of the site is Hydrologic Soil Group D. This means the soils are mostly clay with insufficient infiltration rate to soak up the runoff, therefore an underdrain is added. Underdrains must either daylight downslope or connect to an existing stormwater network. In this case the underdrain can daylight downslope.

The first step is to determine the target volume as shown below:

Target Volume (cubic feet) = *drainage area (square feet) x treatment rainfall (feet) [Equation 1]*
= 4124 SF x 0.125 F
= 515.5 CF

Since the goal is to maximize treatment, the bioretention area is designed to treat 100% of the Target Volume. The Treated Volume is calculated using equations B-1-2 and B-1-3 on pages 169 - 170 of the San Antonio River Basin Low Impact Development Technical Design Guidance Manual 3rd Edition. as shown below. The cross-section shown below is used for this example and meets all required dimensions.



First, calculate the equivalent depth (Deq). *[Equation 2]*

Deq = *(Dsurface) + (nmedia x Dmedia) + (ngravel x Dgravel)*

Where nmedia = 0.35 for bioretetion soil and sand
ngravel = 0.4 for #2, #57 stone

Deq = 0.5 F [ponding] + (0.35 x 2 F) [BR soil] + (0.35 x 0.17 F) [sand] + (0.4 x 0.17) [#2 stone] + (0.4 x 0.5 F) [#57 stone]
= 0.5 F + 0.7 F + .0595 F + .068 F + 0.2
= 1.53 F

Next, calculate the required treatment area (A).

A = *Volume / equivalent depth*

In this case we want to treat the entire target volume, so Volume = Target Volume.

A = 515.5 CF / 1.53 F
= 336.9 SF

Finally, adjust the dimensions to fit the available site. In this case, the dimensions are set to 16 F x 22 F which equals 352 SF, slightly larger than the required area.

A closer view of the bioretention area shows the modified grading to make room for the bioretention area and the dashed lines show where the underdrain daylights down slope.

Permeable Pavement – Site 1

The entire new drive is treated using permeable pavement. The site has clay soils with Hydrologic Soil Group D, therefore an underdrain is required. There is room to route the underdrain around the tree through the parking lot and daylight it downslope. The design has elected to use permeable interlocking concrete pavers for aesthetics and durability. The new drive and walkway are designed to drain to the permeable pavers. The total area of the drive and walkway is 3630 SF. Note: The area with permeable pavers is still considered impervious for calculating the Target Volume.

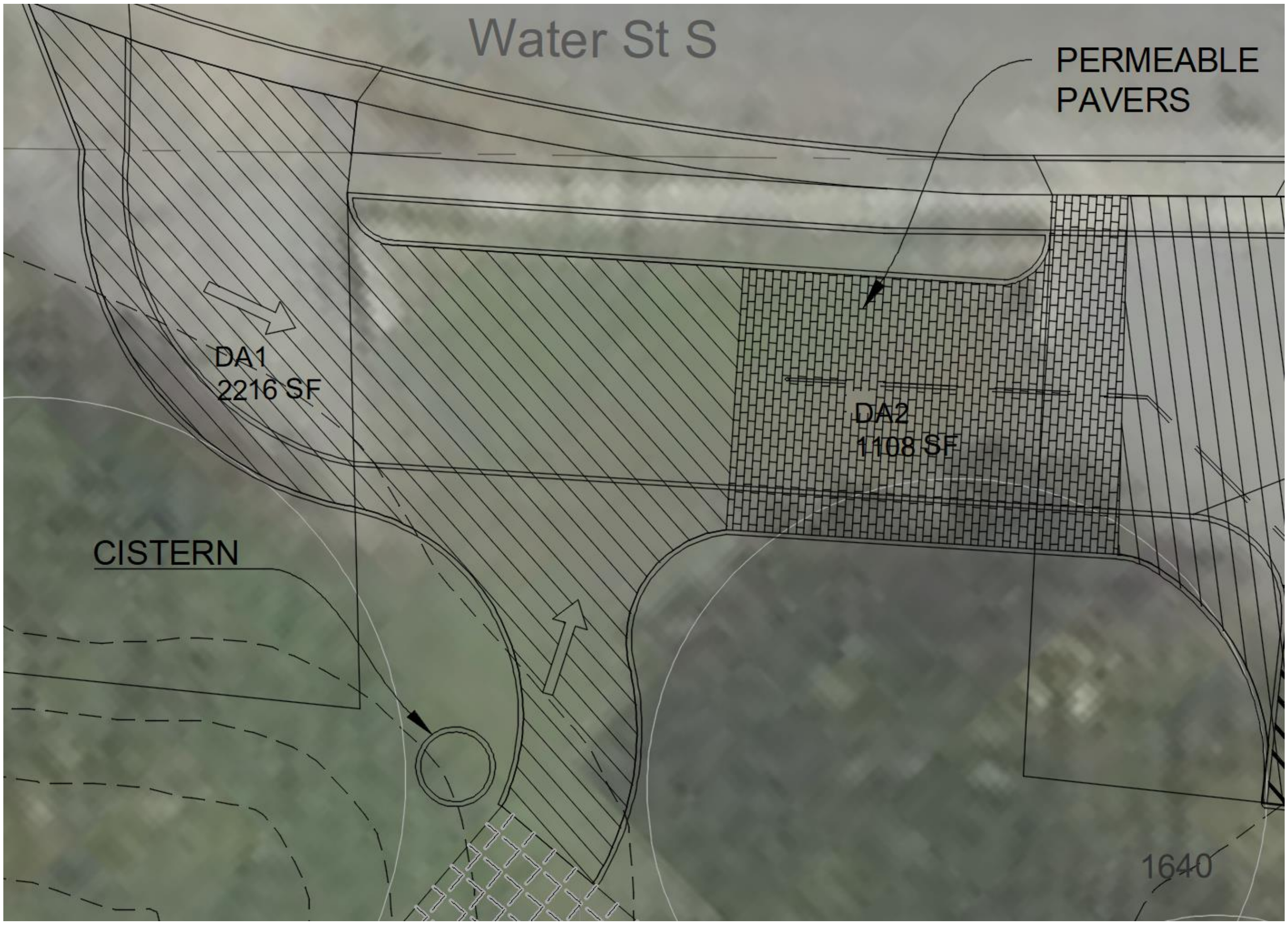
The first step Is to determine the target volume as shown below:

Target Volume (cubic feet) = *drainage area (square feet) x treatment rainfall (feet) [Equation 1]*
= (DA1 + DA2 = 3324 SF) x 0.125 F
= 415.5 CF

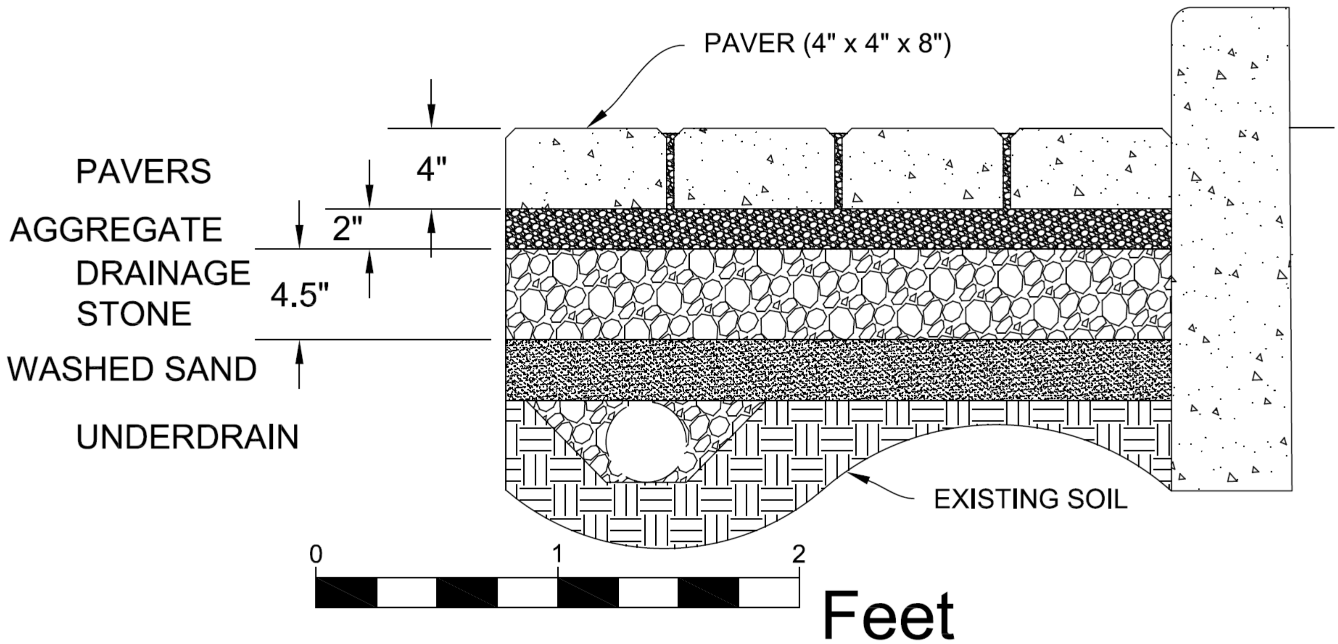
Next, the maximum ratio of drainage area to pervious area is 2:1. Therefore, 1/3 of the total area must be pervious pavers.

Area of pervious pavers (SF) = *1/3 x total treatment area (SF) [Equation 3]*
= 1/3 x 3324 SF
= 1108 SF

The pervious paver boundary is sized to match. Both the impervious drainage area and the pervious area are labeled. See close-up below.



The cross-section profile for this type of paver is shown below.



The paver is 4” thick, the typical depth of the installation aggregate is 2”, the depth of the drainage stone layer is determined using the following equation.

Ddrainagestone = *Target Volume (CF) / Area of permeable pavement (SF)*
= 415.5 CF / 1108 SF
= 0.375 F = 4.5 “

This is the minimum depth for the drainage stone layer. A civil engineer may modify this section to meet load requirements. The entire pervious area must be surrounded by flush curb or full curb; these serve as edge restraints to protect the edge and keep the pavers from moving.

Rainwater Harvesting / Cistern – Site 1

The roof of the new building is designed so the whole roof slopes toward the front of the building. This allows the entire roof drainage to be collected along one edge. A gutter designed with a high point at the mid-point of the gutter divides roof drainage so that half flows one way and half the other. Two cisterns, one on each side, are placed at the corner of the building to capture runoff. The building and cisterns are shown below.

In order to size each cistern, first calculate the Target Volume.

Target Volume (cubic feet) = *drainage area (square feet) x treatment rainfall (feet)*
= roof area SF x 0.125 F
= 4644 SF x 0.125
= 580.5 CF

Cisterns are usually specified in gallons. Here is the conversion.

580.5 CF x 7.48 gal./CF = 4312 gal.

Divide this number by 2 since there are 2 cisterns.

4312 gal / 2 cisterns = 2171.1 gal. / cistern

A quick search online produces a simple metal cistern with a capacity of 2200 gal. The dimensions of this cistern are 7' diameter – 7'-8" height.

A cistern that exerts more than 2000 pounds / square foot requires a concrete foundation. Calculate the pressure exerted by each cistern using the equations below.

Weight of Cistern = *Capacity (gal.) x 8.32 (pounds/gal.)*
= 2200 gal. x 8.32 pounds/gal.
= 18304 pounds

Contact area (SF) = *area of circle* = π *(diameter (F)/2)*^{2}
= π $(7/2)^2$
= 38.5 SF

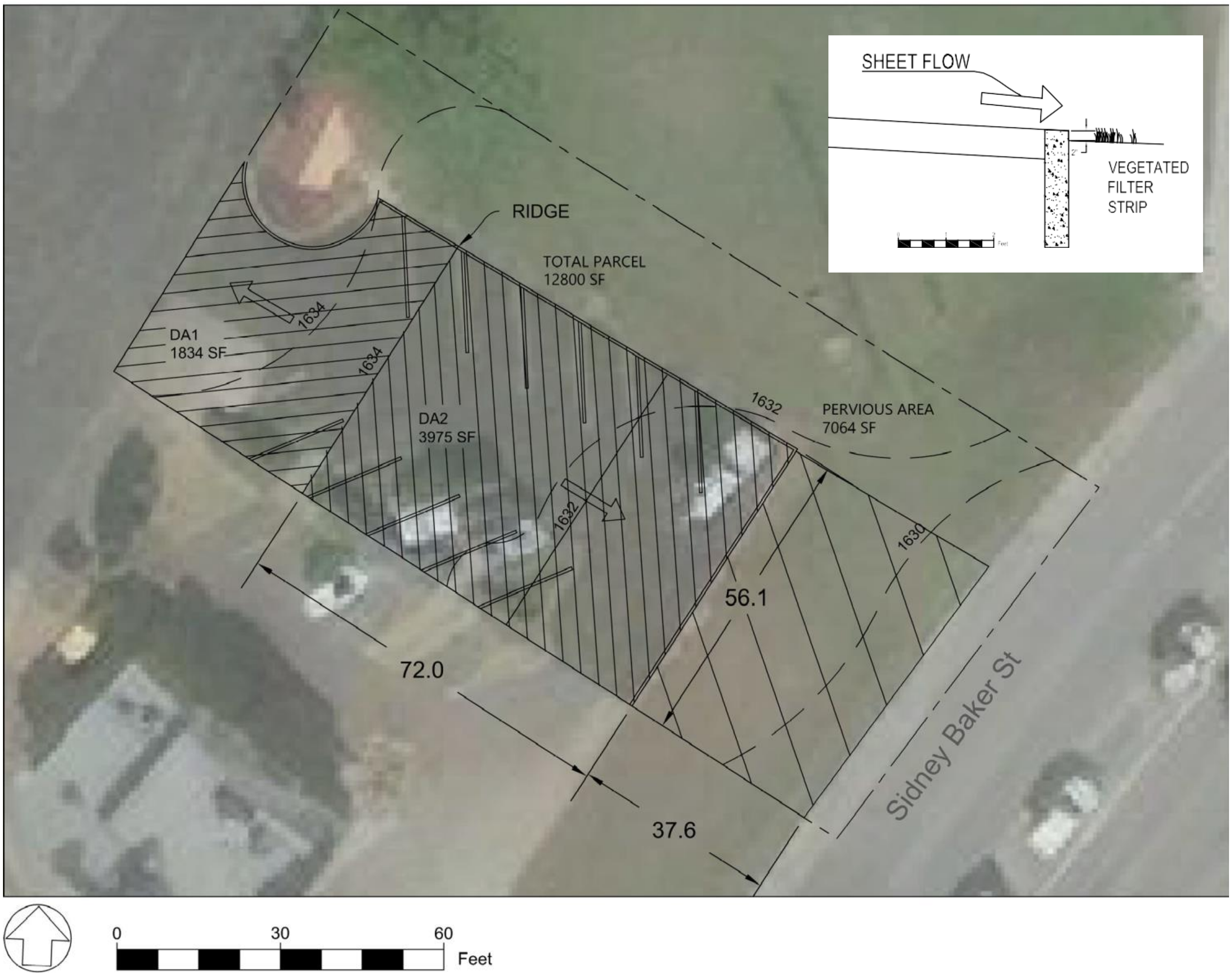
Pressure exerted by Cistern (pounds / SF) = *Weight of Cistern (pounds) / contact area (SF)*
= 18304 pounds / 38.5 SF
= 475 pounds / SF

Each cistern can be placed on a gravel foundation.

Provide reference to the proposed cistern including manufacturer, model number and website if available.

Vegetated Filter Strip Design – Site 2

A parcel is developed as a parking lot for an adjacent business. This parcel borders existing turf to the north and east. The designer has decided to treat as much of the parking lot as possible using a vegetated filter strip. Ten parking spaces are required. Angled spaces are used to minimize the total impervious area. A ridge is incorporated into the design forming two distinct impervious drainage areas. The ridge is strategically placed to meet the maximum dimension requirements. Drainage area 2 (DA2) is designed to slope towards the edge that will drain to the vegetated filter strip. The slope is approximately 4.5% and perpendicular to the flush curb edge so stormwater runoff can sheet flow to the vegetated filter strip. Refer to figure below:



This design meets the requirements for an Engineered Filter Strip outlined in the Design Steps from [Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices].

1. Filter strip extends along entire length. Slope of filter strip is less than 20%. The width (distance perpendicular from edge) does not exceed 72 feet.
2. Minimum dimension in direction of flow is greater than 15 feet; shown as 37.6 feet in plan.
3. Vegetated filter strip is completely vegetated with turf.
4. Contributing area is relatively flat and has a level edge.
5. No existing gullies or rills.
6. Top edge has 2 inch drop off to vegetated filter strip.

For this example, the calculation of Treated Volume is shown below.

Treated Volume (cubic feet) *= drainage area (square feet) x treatment rainfall (feet) x 60%*
[Equation 5]
= 3975 SF x 0.125 F x 60%
= 298.13 CF

Riparian Buffer Design Example – Site 1

A parcel is developed adjacent to the Guadalupe River. Other nature-based methods are used to treat stormwater runoff from impervious drainage areas. The designer has decided to maximize treatment by preserving an existing riparian buffer. Refer to the figure below for the boundary of the buffer and calculations.

1. The riparian buffer is adjacent to the Guadalupe River and extends the entire length of the waterfront.
2. The buffer length is approximately 210 feet, and the buffer width is approximately 50 feet.
3. The boundary of restricted activities and inventory activities is shown and labeled on the Project Drawing.