ENVIRONMENTAL SITE DESIGN (ESD) REDEVELOPMENT EXAMPLES

OCTOBER 2010

MARYLAND

**Redevelopment Example – Gateway Grand, Ocean City**

This example is based on site data for a redevelopment project called Gateway Grand in Ocean City, MD and was designed, approved, and constructed to meet requirements under the 2000 regulations. The new requirements for redevelopment under the 2009 regulations specify that impervious area shall be reduced and/or water quality treatment provided for 50% of the existing impervious area within the project limit of disturbance (LOD). In addition, any net increase in impervious area is to be managed according to new development criteria.

Figure 1 shows conditions on site prior to the redevelopment project. The site is located on Coastal Highway in Ocean City, MD in between 47th and 49th Streets. It is a 4.31 acre commercial area that contained several buildings and gravel and asphalt parking areas. The soil is dominated by made land (MA) HSG C. Manmade soils typical to this area are dredged material with a silty-sand composition. The site contains no wetlands, is above the 100-year floodplain, and is within the 1,000 foot Critical Area's buffer line.

Figure 2 depicts the original proposed conditions. An ocean-front condominium, a restaurant, and parking garage were constructed north of 48th Street. A satellite parking area was constructed south of 48th Street. Redevelopment requirements under the 2000 regulations were addressed by using bioretention and alternative surfaces. The bioretention area provides treatment for rooftop runoff from the parking garage. Alternative surfaces include a combination of pervious pavers and porous asphalt to reduce imperviousness below pre-development conditions.

The process presented below will evaluate additional opportunities for environmental site design (ESD) and provide calculations to show how the project could be designed to comply with the 2009 regulations. The storage requirements are determined by using the ESD_v equation for the impervious areas required for treatment. A P_E of 1.0 inch is used to provide water quality treatment for the existing impervious area within the LOD. To address new development requirements for the net increase in impervious area, a P_E of 2.2 is used. This P_E is derived from Table 5.3 of the Design Manual and is based on the presence of C soils onsite. This example provides just one design option, however, there may be other ways to show compliance with stormwater requirements.
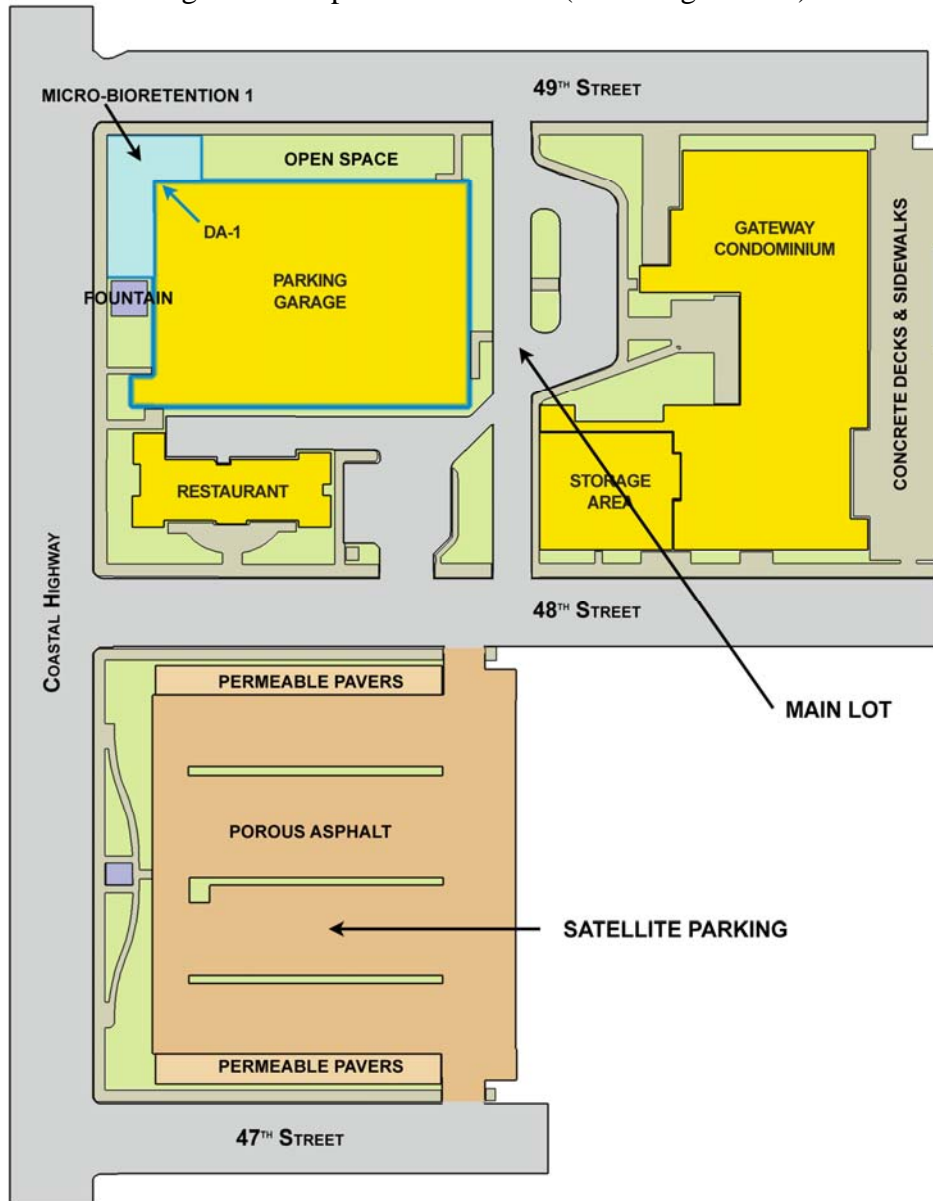
Figure 1. Existing Conditions
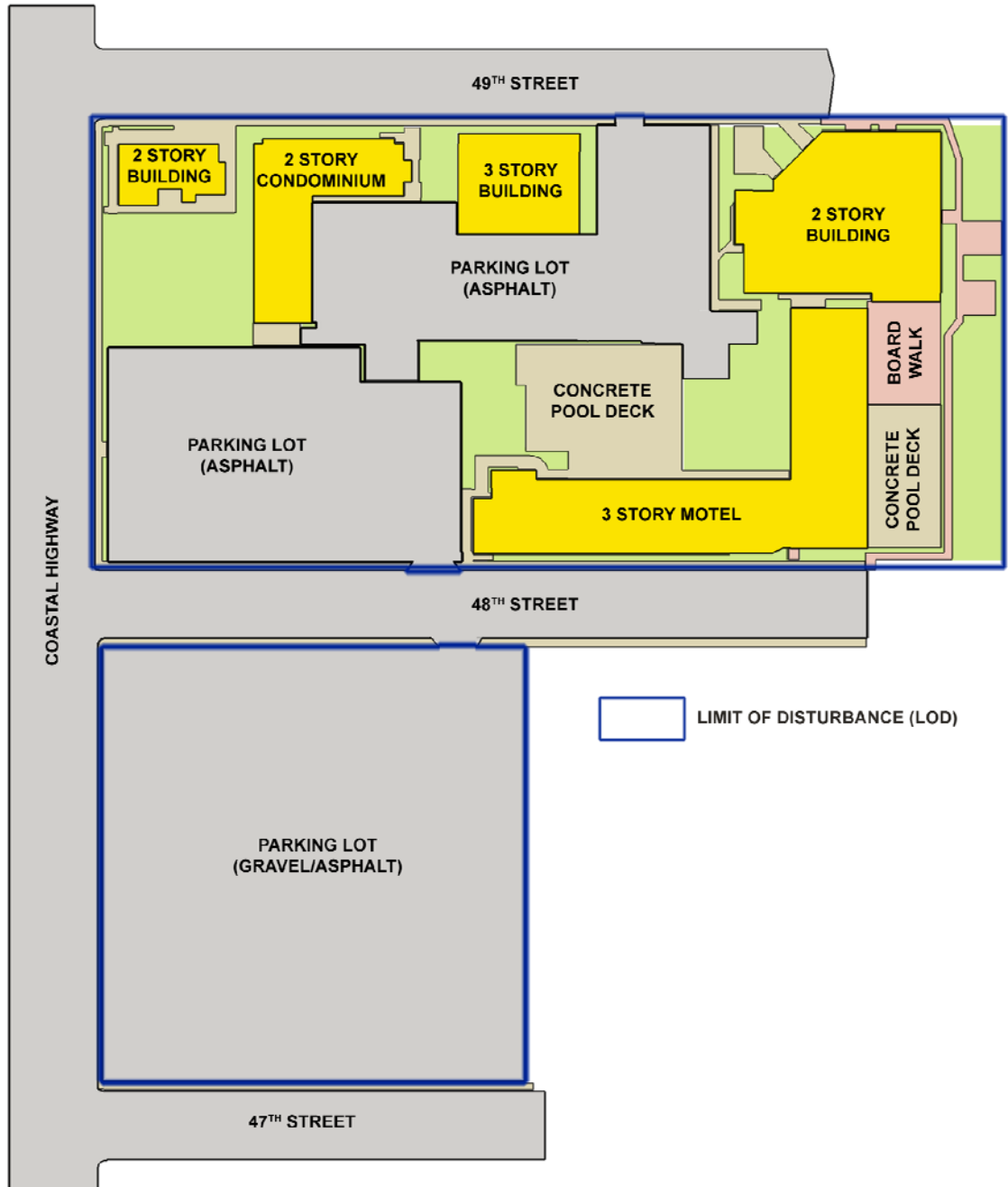
Existing Conditions

Location:	Ocean City, MD; Gateway Grand, 48th St. Condominium
Soil Types:	100% HSG C, Made Land
Land Use:	Commercial
Site Area:	187,750 sq. ft. = 4.31 acres
Existing Impervious Area:	162,960 sq. ft. = 3.74 acres

Figure 2. Proposed Conditions (2000 Regulations)

Proposed Layout (2000 Regulations)

Site Area:	187,750 sq. ft. = 4.31 acres
Proposed Hard Surfaces:	156,774 sq. ft. = 3.60 acres
Alternative Surfaces:	
Satellite Parking:	46,053 sq. ft. = 1.06 acres (porous and permeable pavers)
Proposed Impervious Area:	3.60 acres – 1.06 acres = 2.54 acres
Impervious Area Reduction:	3.74 acres – 2.54 acres = 1.2 acres
Bioretention (DA 1):	Treating parking garage runoff (0.53 acres)

Concept Plan Design and Computations

The site data shown above will be used during Concept Plan design to calculate the stormwater requirements under the 2009 regulations. Options for implementing ESD will be re-evaluated in order to meet the MEP standard. The information presented below will assist designers and review authorities when preparing and evaluating Concept Plans for compliance with stormwater requirements.

Step 1 - Determine Stormwater Management Requirements (2009 Regulations)

Determine ESD_v Targets for 2009 Redevelopment Regulations:

Redevelopment:

> Redevelopment means, any construction, alteration, or improvement performed on sites where existing land use is commercial, industrial, or multifamily residential and the existing site impervious area exceeds 40 percent. Using existing conditions data, determine whether the project will be regulated as redevelopment or new development.
>
> Calculate percent site impervious area for existing conditions:
>
> Existing Impervious Area = 3.74 acres
> Site Area = 4.31 acres
> I = 3.74 ac/4.31 ac = 86%
> Existing Site $I > 40\%$.
>
> Because existing site imperviousness is greater than 40%, the project is subject to redevelopment requirements. Therefore, the project design must either decrease existing imperviousness within the LOD by 50% or provide water quality treatment for an equivalent area. This means that impervious area reduction and/or water quality treatment shall be provided for 50% of 3.74 acres or 1.87 acres.

New Development:

> Stormwater management shall be addressed according to the new development requirements in the Design Manual for any net increase in impervious area. Using proposed conditions data, determine whether new development criteria apply to any net increase in impervious area:
>
> Existing Impervious Area = 3.74 acres
> Proposed Impervious Area = 2.54 acres
>
> Because the project will use porous and permeable pavements, impervious area will decrease from 3.74 acres to 2.54 acres, with a total reduction of 1.20 acres. Therefore, new development criteria will not apply to this project.

Compute ESD Targets for Redevelopment

Provide impervious area reduction and/or water quality treatment for 50% of existing impervious area within the project LOD. This is equal to 50% of 3.74 acres, or 1.87 acres. The project will reduce imperviousness by 1.2 acres, therefore, water quality treatment is required for 0.67 acres (1.87 acres – 1.2 acres).

Compute ESD_v for water quality treatment of 0.67 acres. The target rainfall amount (P_E) is 1.0 inch. ESD_v is calculated as follows:

$$ESD_v = (P_E)(R_v)(A)/12$$

P_E = 1.0 inch
R_v = 0.05 + (0.009) (I); I = 100%
R_v = 0.05 + (0.009 x 100) = 0.95
A = 0.67 acres

ESD_v = (1)(0.95)(0.67)/12
ESD_v = 0.053 ac – ft. x 43,560 sq. ft./acre = 2,308.7 cu. ft., use 2,310 cu. ft.

Implement ESD practices to the MEP to capture and treat 2,310 cu. ft. of runoff from 0.67 acres of impervious area.

A Summary of Requirements for this project:

- Redevelopment:
    - Provide impervious area reduction and/or water quality treatment for 50% of existing impervious area within the project LOD (50% of 3.74 acres = 1.87 acres).
    - The project reduces imperviousness by 1.2 acres.
    - Water Quality treatment is required for 0.67 acres (1.87 acres – 1.20 acres).
    - Total ESD_v for 0.67 acres = 2,310 cu. ft.
- New Development: There is a net decrease in impervious area, therefore, new development criteria do not apply to this project.

Step 2 – Preliminary ESD Options

The original design has met the 2000 regulations by using alternative surfaces and bioretention (see Figure 2). The project was re-evaluated in order to meet additional storage requirements under the new 2009 regulations. The options that will be evaluated in this example include maximizing storage in the bioretention facility and using vegetated areas around the site for ESD. However, other ESD options could be used to show compliance with management requirements.

Due to the varied nature of site constraints on redevelopment projects, it is expected that some flexibility will be necessary when applying ESD criteria from the Design Manual. This will allow greater success for implementing ESD on redevelopment projects. When this is done, the

rationale should be based on engineering documentation and best professional judgment that confirms the ultimate success of any practice used. These decisions should be made by the local approving agency on a case by case basis.

For this example, the drainage area limit of 10,000 sq ft. for alternative surfaces has been exceeded. This was considered a reasonable adjustment because of the success with these practices throughout Ocean City. In addition, the drainage area criteria for micro-bioretention has been exceeded by 3,500 sq. ft. The limits in the Design Manual were specified based on the assumption that an individual practice would store runoff for storms up to the 1-year, 24 hour rainfall event (2.7 inches of rainfall on average in Maryland). Because this project is only held to redevelopment standards, only 50% of the water quality volume is required for storage. Therefore, it was not necessary to restrict the drainage area to the micro-bioretention practice to that allowed for new development standards.

Step 3 – Preliminary Design

Concept Design – Use micro-bioretention (M-6)

Drainage Area 1 (DA 1)

During the Concept Plan process, Equations 5.1 through 5.3 in the Design Manual may be used to provide a quick estimate of the amount of rainfall that may be treated in a given practice when the surface area and drainage area information is known. Equation 5.2 for micro-bioretention is written as follows:

$$P_E = 15 \times \frac{A_f}{DA}, \text{ where}$$

P_E = rainfall amount in inches treated, 1.0 inch
A_f = the surface area of the ESD practice
DA = the drainage area to the practice, 0.67 acres

This equation can also be used to estimate the surface area needed to treat 0.67 acres of impervious area. Using a P_E of 1.0 inch and a DA of 0.67 acres, the equation may be solved for A_f to estimate the area needed for an ESD practice to meet management requirements. The surface area of the ESD practice is solved as follows:

$$A_f = DA \times \frac{P_E}{15}$$

A_f = 0.045 acres or 1,945 sq. ft.

Concept Design Assessment

According to the plans (Figures 2 and 3), the micro-bioretention area has a surface area of 2,300 sq. ft and therefore exceeds the minimum surface area of 1,945 sq. ft calculated above. Because the surface area (A_f) estimates are conservative, a reviewer may conclude that the required ESD

volumes could be provided as long as the minimum depths specified for each practice are used. Therefore, the information above shows that management requirements can be met by using the micro-bioretention practice shown in DA 1. Local review agencies, may ask for additional information at this step if there is concern over the feasibility of the proposed strategy. For example, a quick estimate of the proposed storage volume could be provided as shown below. The dimensions of the micro-bioretention facility may be estimated as follows:

Surface area (A_f) = 2,300 sq. ft.
Ponding depth = 0.5 feet
Filter depth = 2.5 feet.

The estimated volume is calculated as follows:

Volume = $[(A_f)(\text{ponding depth})] + [(A_f)(\text{depth}_{filter})(\text{porosity of media } 0.4)]$
Volume = (2,300)(0.5) + (2,300)(2.5)(0.4)
Volume = 1,150 + 2,300 = 3,450 cu. ft.

The concept shows that management requirements to provide 2,310 cu. ft storage (see page 5) can be met by using the proposed micro-bioretention facility. Site Development plans will provide final dimensions of practices and more complete information to verify that the proposed strategy will meet management requirements. See Figure 3 for the proposed layout of the project.

Site Development Plan Design and Computations

The site development phase includes more detailed design for both stormwater management and erosion and sediment control. At this point, the final layout and grading for proposed buildings, roadways, parking, utilities, and other structures are used to finalize the stormwater design. Any comments and feedback from the review of the Concept Plan should be incorporated into this design phase.

Step 4 – ESD Practice Design

Site Development Design – micro-bioretention (M-6)

Drainage Area 1 (DA 1)

As the design for the project continues more specific information on the impact of underground structures on ESD facilities become available. It was determined that the parking garage support pier foundation would eliminate 1,492 cu. ft. of storage from the micro-bioretention area. That volume must be subtracted from the total storage in the micro-bioretention area as follows:

Total micro-bioretention volume – support piers = 3,450 cu. ft. – 1,492 cu. ft. = 1,958 cu. ft.

Step 5 –Design Assessment

o **Determine if ESD Targets are Met:**

The loss of storage as a result of the garage foundation piers will mean that the required storage volumes will not be met in the proposed micro-bioretention in DA 1. The required storage volume of 2,310 cu. ft. is not achieved with the proposed design that only provides 1,958 cu. ft. of storage. This means that 352 cu. ft. of additional storage is still required.

o **Evaluate Additional ESD Opportunities:**

After recognizing the limitations described above, this project will need to be re-evaluated for ESD implementation. Several options exist to provide additional storage by using the available landscaped areas on site. The landscaped areas at the front entrance of the condominium can provide additional storage and treatment for rooftop runoff from the condominium and the storage area. A micro-bioretention facility can be used at this location and noted as DA 2 on Figure 3 on page 10.

Drainage Area 2 (DA 2)

The total drainage area to this ESD practice is 0.14 acres. This includes rooftop runoff from the front of the condominium and part of the storage area. The surface area of the practice will be 375 square feet, the ponding depth will be 0.5 feet, and the filter depth will be 2.5 feet. The volume is calculated as follows:

Volume = (A_f)(ponding depth) + (A_f) (depth$_{filter}$)(porosity of media 0.4)
Volume = (375)(0.5) + (375)(2.5)(0.4)
Volume = 187.5 + 375 = 562.5 cu. ft.

The micro-bioretention practice in DA 2, provides the additional storage needed as a result of the loss in storage due to the garage support piers.

o **Complete Design:**

The total volume provided in ESD practices in DA 1 and DA 2 is tabulated below. The micro-bioretention practices at DA 1 and DA 2 provide a total of 2,520.5 cu. ft. of storage, which is greater than the required storage of 2,310 cu. ft. Therefore, management requirements for redevelopment are satisfied for this project.

DA 1	0.54 acres	1,958 cu. ft.
DA 2	0.14 acres	562.5 cu. ft.
Total Provided	0.68 acres	2,520.5 cu. ft.
Total Required	0.67 acres	2,310 cu. ft.

The designer has demonstrated that management requirements have been met using ESD practices. If this was not possible, other ESD options would need to be evaluated prior to

considering alternative management practices. At this time, no additional management is required and structural practices are not necessary.

Site development plans should be submitted to the appropriate review agencies and include all stormwater details and computations, erosion and sediment control plans, an overlay plan, and a narrative to support the design. The minimum information outlined on page 5.14 through 5.15 of the Design Manual should be provided. Review authorities may require additional information based on site conditions, and local concerns.

Final Plan Design and Computations

Step 6 – Finalize ESD Design and Address Remaining Stormwater Requirements

After site development plan approval, final designs are prepared by incorporating comments from all appropriate review agencies. The final construction drawings and details for all stormwater practices, hydrology and hydraulic computations, and the final erosion and sediment control plans will be submitted at this time. In addition, the local review authority may consider any flood control concerns and stable conveyance of discharge to downstream waterways or storm drain systems. Overflows from each ESD practice shall be directed to a stable discharge point. Local review will consider whether discharge will be increased to downstream storm drain systems and additional requirements may be specified to address these or other concerns.

Figure 3. Proposed Layout (2009 Regulations)
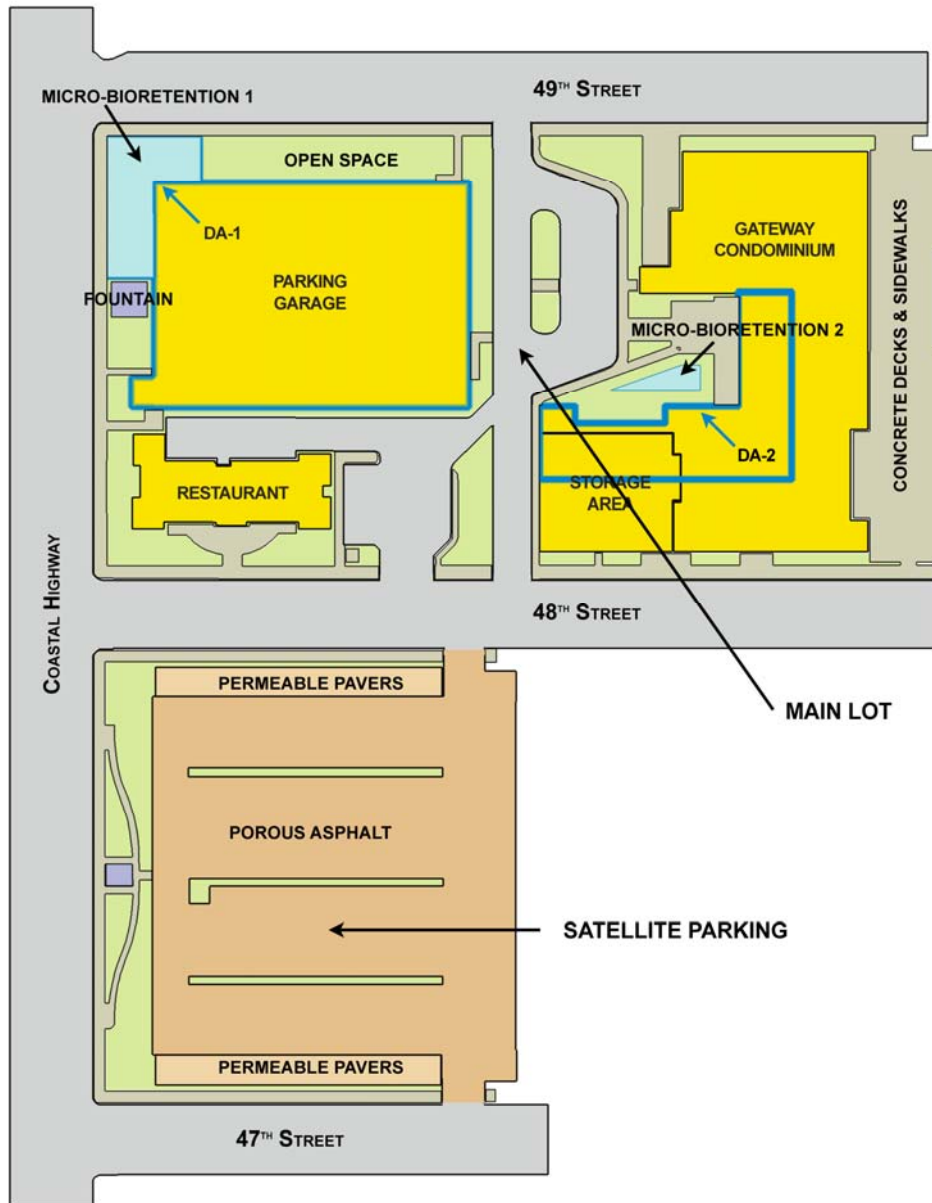
Proposed Layout (2009 Regulations)
        Proposed Hard Surfaces: 156,774 sq. ft. = 3.60 acres
        Alternative Surfaces: 46,053 sq. ft. = 1.06 acres (porous and permeable)
        Proposed Impervious Area: 3.60 acres – 1.06 acres = 2.54 acres

2009 Regulations:
        Treat or reduce 50% Existing Impervious: $(3.74)(0.5)$ = 1.87 acres
        Impervious Area Reduction: 3.74 acres – 2.54 acres = 1.20 acres
        Water Quality Treatment: 1.87 acres – 1.2 acres = 0.67 acres
        Micro – Bioretention (DA 1 + DA 2):   Providing 2,520 cu. ft. storage

Redevelopment Example – Zeta Senior Center, Baltimore City

This example is based on site data for a redevelopment project called the Zeta Senior Center, in Baltimore, MD. This redevelopment project was designed, approved, and constructed to meet requirements under the 2000 regulations. The new requirements for redevelopment under the 2009 regulation specify that impervious area shall be reduced and/or water quality treatment provided for 50% of the existing impervious area within the project limit of disturbance (LOD). In addition, any net increase in impervious area shall be managed according to new development criteria.

Figure 1 below is an aerial photograph of site conditions prior to the redevelopment project. The site is located on Reisterstown Road in between Royce Avenue and Wylie Avenue. Prior to redevelopment, the area was vacant and consisted of asphalt, concrete, gravel, and sparse vegetation areas. The soil is Jackson – Urban land, HSG D. Most of the runoff flows overland toward Reisterstown Road and then to a storm drain at the corner of Wylie Avenue. A small portion of the site will flow to a storm drain at the corner of Reisterstown Road and Royce Avenue.

**Figure 1. Site Conditions before Redevelopment**
Existing Impervious Area = 0.50 acres

The site data for conditions prior to the redevelopment project are as follows:

Location:	Baltimore City, MD
Soil Types:	100% HSG D, Jackson Urban Land
Land Use:	Commercial
Site Area:	0.96 acres
Total Drainage Area:	1.18 acres
Existing Impervious Area:	0.50 acres

The redevelopment consisted of a one story Senior Center building and two small parking areas as shown in Figure 2 below. Impervious area was increased from 0.5 acres to 0.68 acres. A dry swale provides water quality treatment for part of the building and the parking area off of Royce Avenue. Drainage to the dry swale is indicated as drainage area 1 (DA 1). A grass swale provides treatment for runoff from the parking area adjacent to Wylie Avenue. Drainage to the grass swale is indicated as drainage area 2 (DA 2). An underground storage system had also been constructed beneath the Wylie Ave. parking area to provide channel protection and storage for the 100 year storm. This underground system (not shown in the picture below) receives runoff from the portion of the building that does not drain to the dry swale in addition to overflows from the dry swale. All of these practices were designed, approved, and constructed according to the 2000 Regulations.

Figure 2. Redevelopment Proposed Conditions (2000 Regulations)
Proposed Impervious Area = 0.68 acres
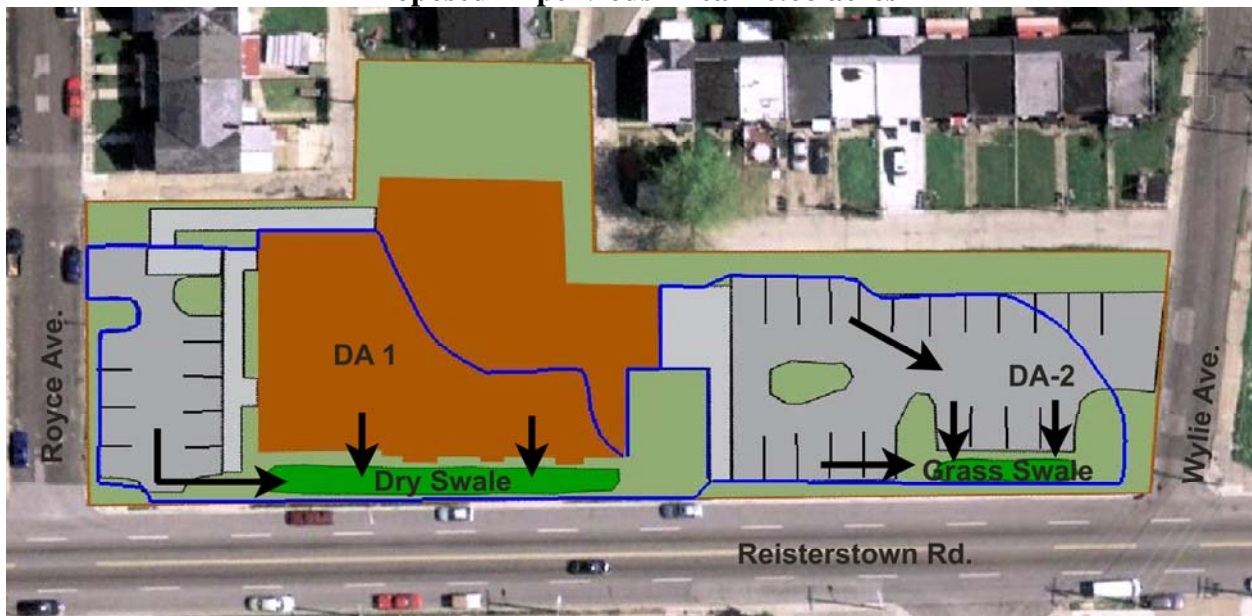
ESD Design According to 2009 Regulations

The information presented below will evaluate additional opportunities for ESD and provide calculations to show how the project could be designed to comply with the 2009 regulations. The storage requirements are determined by using the ESD_v equation for the impervious areas required for treatment. A P_E of 1.0 inch is required to provide water quality treatment for the existing impervious area within the LOD. To address requirements for the net increase in impervious area, a P_E of 2.0 inches is required. This P_E is derived from Table 5.3 of the Design Manual and is based on soil conditions. The following example provides just one design option, however, there may be other ways to show compliance with stormwater requirements.

Concept Plan Design and Computations

The site data shown above will be used for the Concept Plan Design to calculate stormwater requirements under the 2009 Regulations. Options for implementing ESD will be re-evaluated in

order to meet the MEP standard. The information presented below will assist designers and review authorities when preparing and evaluating Concept plans for compliance with stormwater requirements.

Step 1 - Determine Stormwater Management Requirements (2009 Regulations)

Determine ESD_v Targets for 2009 Redevelopment Regulations:

Redevelopment:

> Redevelopment means any construction, alteration, or improvement performed on sites where existing land use is commercial, industrial, or multifamily residential and the existing site impervious area exceeds 40 percent. Using existing conditions data, determine whether the project will be regulated as redevelopment or new development.

> Calculate percent site impervious area for existing conditions:

> Existing Impervious Area = 0.50 acres
> Site Area = 0.96 acres
> %I = 0.50 ac/0.96ac = 52%
> Existing Site I > 40%.

> Because existing site imperviousness is greater than 40%, the project is subject to redevelopment requirements. Therefore, the project shall either decrease existing imperviousness within the LOD by 50% or provide water quality treatment for an equivalent area. This means that impervious area reduction and/or water quality treatment shall be provided for 50% of 0.50 acres or 0.25 acres.

New Development:

> Stormwater management shall be addressed according to the new development requirements in the Design Manual for any net increase in impervious area. Using proposed conditions data, determine whether new development criteria apply to any net increase in impervious area:

> Existing Impervious Area = 0.50 acres
> Proposed Impervious Area = 0.68 acres
> Net increase in impervious area = 0.68 – 0.50 = 0.18 acres

> The project will increase impervious area by 0.18 acres. Stormwater management for 0.18 acres shall be addressed according to new development requirements.

Compute ESD Targets for Redevelopment

Provide impervious area reduction and/or water quality treatment for 50% of existing impervious area within the project LOD. This is equal to 50% of 0.5 acres, or 0.25 acres. The target rainfall

amount for water quality treatment is a (P_E) of 1.0 inch. Compute ESD_v for water quality treatment of 0.25 acres as follows:

$ESD_v = (P_E)(R_v)(A)/12$, where:
$P_E = 1.0$ inch
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \text{ x } 100) = 0.95$
$A = 0.25$ acres

$ESD_v = (1)(0.95)(0.25)/12$
$ESD_v = 0.020$ acre – ft. x 43,560 sq. ft./acre = 862 cu. ft.

Implement ESD practices to the MEP and alternative practices as needed to capture and treat 862 cu. ft. of runoff. This will provide water quality treatment for 50% of existing impervious areas within the LOD.

Compute ESD Targets for New Development

Stormwater management shall be addressed according to new development requirements in the Design Manual for any net increase in impervious area. Therefore, the amount of runoff from the increased imperviousness shall be reduced to a level equivalent to woods in good condition for the 1-year, 24 hour rainfall event. The goal to mimic forested runoff characteristics for new development applies to the net increase in impervious area of 0.18 acres.

This site is located on D soils, and, according to Table 5.3 of the Design Manual, the target rainfall amount, (P_E), is 2.0 inches for 0.18 acres. ESD_v is calculated as follows:

$ESD_v = (P_E)(R_v)(A)/12$, where:
$P_E = 2.0$ inches
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \text{ x } 100) = 0.95$
$A = 0.18$ acres

$ESD_v = (2.0)(.95)(.18)/12$
$ESD_v = 0.029$ acre – ft. x 43,560 sq. ft./acre = 1,241 cu. ft.

According to Chapter 5 in the Design Manual, new development requirements specify that a minimum of 1.0 inch of runoff shall be treated in ESD practices. This minimum storage volume is calculated as follows:

$ESD_v = (P_E)(R_v)(A)/12$, where:
$P_E = 1.0$ inches
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \text{ x } 100) = 0.95$
$A = 0.18$ acres

$ESD_v = (1.0)(0.95)(0.18)/12$
$ESD_v = 0.014$ ac – ft. x 43,560 sq. ft./acre = 620.5 cu. ft., use 621 cu. ft.

Implement ESD to the MEP to capture and treat 1,241 cu. ft. of runoff to address water quality, recharge, and channel protection requirements (for the net increase in impervious area). At a minimum, 621 cu. ft. of storage shall be provided in ESD practices. A combination of ESD or other practices from the Design Manual may be used to satisfy requirements for the increased impervious area.

A Summary of Requirements for this project:

- Redevelopment:
    - Provide impervious area reduction and/or water quality treatment for 50% of existing impervious area within the project LOD (50% of 0.5 acres = 0.25 acres).
    - ESD_v for water quality (P_E = 1.0 inch) for 0.25 acres = 862 cu. ft.
- New Development: New development criteria apply to the net increase in impervious area of 0.18 acres, where P_E = 2.0 inches:
    - ESD_v for 0.18 acres = 1,241 cu. ft.
    - At a minimum, 621 cu. ft. shall be provided in ESD practices.
- Total ESD_v = Redevelopment + New Development = 862 + 1,241 = 2,103 cu. ft.
- Impervious area requiring treatment = $0.25_{existing} + 0.18_{new} = 0.43_{total}$

Step 2 – Preliminary ESD Options

The original design shown on Figure 2 above includes a grass swale and a dry swale for water quality treatment. In order to meet the 2009 regulations, the project was re-evaluated to determine options for implementing ESD practices. However, the use of permeable pavements and infiltration was ruled out because of the presence of D soils.

In evaluating the original design, it was determined that the areas used for the grass swale and dry swale may be expanded to provide greater storage for ESD. Micro-bioretention could be used considering the existing soil conditions. In addition, the parking lot off of Wylie Avenue could be re-graded to allow runoff to drain to the landscaped area on the east side of the lot for micro-bioretention.
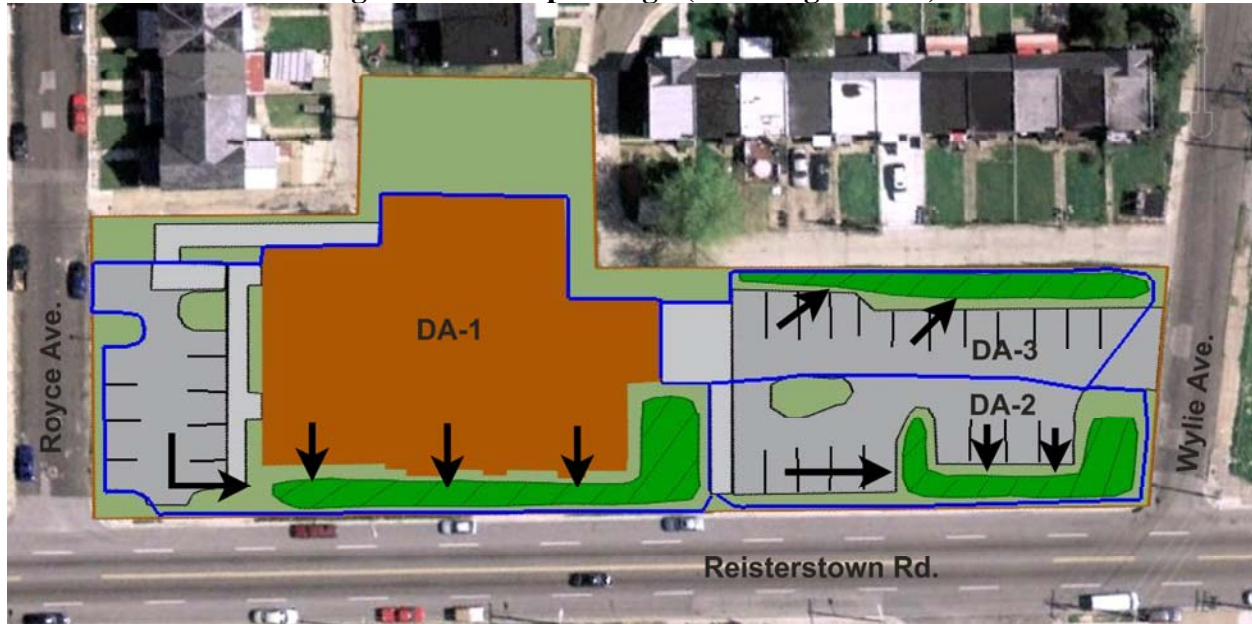
Step 3 – Preliminary Design

As stated above, the strategy will be to maximize the dry swale, grass swale, and other landscaped areas to provide as much treatment as possible using micro-bioretention. To determine how much treatment can be achieved in the open spaces available on site, the surface area available for treatment is tabulated. Refer to Figure 3 below for the location and size of ESD practices in each drainage area. This concept will allow all of the building runoff to enter the ESD practice in DA 1. In addition, the runoff from the parking area off of Wylie Avenue will be directed to ESD practices in landscaped areas on the western (DA 2) and eastern (DA 3) portions of the parking lot. The surface area available for micro-bioretention in each drainage

area are tabulated below. The total available surface area for micro-bioretention in all three drainage areas is equal to 1,887 sq. ft.

Surface Area Available for Micro-bioretention

DA 1	0.36 acres	Building and Royce Avenue Parking Lot	770 sq. ft.
DA 2	0.079 acres	Wylie Avenue Parking Lot, West Side	408 sq. ft.
DA 3	0.084 acres	Wylie Avenue Parking Lot, East Side	601 sq. ft.
Total DA	**0.523 acres**		**1,779 sq. ft.**

Figure 3. Concept Design (2009 Regulations)

Preliminary Design Assessment

During the early stages of project planning, Equations 5.1 through 5.3 of the Design Manual can be used to estimate the amount of management that could be achieved on site. When considering the areas available for ESD implementation, a quick estimate of the amount of rainfall (P_E) that could be treated is calculated. This allows an early assessment of the design during Concept reviews and a comparison to ESD_v targets. When using micro-bioretention the P_E treated for 1,779 sq. ft. (calculated above) is determined by using Equation 5.2 as follows:

P_E = 15 inches x $(A_F)/(DA)$, where:
A_f = total surface area of ESD practices, or 1,779 sq. ft.
DA = the total drainage area to all practices, 0.523 acres
P_E = 15 inches x (1,779)/(0.523)(43,560)
P_E = 1.17 inches

By using the P_E treated of 1.17 inches, (calculated above), an estimate of the cumulative volume provided in all ESD practices can be made. Because the ESD practices are directly connected to the impervious areas, the percent imperviousness is 100%. The ESD_v that will be provided if the practices are implemented in the areas shown above can be estimated as follows:

$$ESD_v = \frac{(P_E)(R_v)(A)}{12}$$

P_E = 1.17 inches,
R_v = 0.05 + (0.009) (I); I = 100%
R_v = 0.05 + (0.009 x 100) = 0.95
A = 0.53 acres
ESD_v = (1.17)(0.95)(0.53)/12
ESD_v = 0.049 acre-ft. x 43,560 sq. ft./acre = 2,138 cu. ft.

The concept of using vegetated areas for ESD as tabulated above will provide an ESD_v of approximately 2,138 cu. ft. This is greater than the required ESD_v of 2,103 cu. ft. calculated on page 4 (862 cu. ft. for redevelopment plus 1,241 cu. ft. for new development). The next phase of the design will establish final grading and adjust final dimensions to confirm that the required volumes may be achieved. In addition, drainage areas to each facility need to be finalized to verify that the required impervious areas will drain to ESD practices.

For the purpose of this project, the above information is considered sufficient for the Concept level of review. However, local review authorities may require additional information for an individual project if it is determined that the project as proposed is not feasible or will not meet management requirements. After a comprehensive review of Concept Plans, the local review agencies will provide coordinated feedback to the designer before the project proceeds further. This feedback should be incorporated into future submissions.

Site Development Plan Design and Computations

The Site Development phase includes more detailed design for both stormwater management and erosion and sediment control. At this point, the final layout of buildings, roadways, parking, and other structures are used when finalizing the stormwater management design. Any comments and feedback from the Concept Plan review should be incorporated into this design phase. The next step will be to provide final grading and drainage areas and adjust the dimensions of each ESD practice to provide the required volumes for treatment.

Step 4 - ESD Practice Design

The Concept Design showed that there are enough landscaped areas that could be used to meet the ESD requirements for the site. However, because DA 1 contains the most significant amount of impervious areas, this strategy will start out by maximizing the available storage in the micro-bioretention area in DA 1. Rather than using the minimum filter depths of 2.0 feet, a filter depth of 3.5 feet is proposed. This will allow greater water quality treatment for the largest amount of impervious area on site. This will also allow the ESD practices in DA 2 and DA 3 to be smaller than that shown in the Concept Design. As a result, the revised size of each ESD practice is shown on the Site Development Design below. The final dimensions for each practice are provided in the drainage area calculations to confirm that the required volumes will be achieved.

Figure 4. Site Development Design (2009 Regulations)

DA 1

The Site Development Design is shown in Figure 4 above. DA 1 consists of 0.36 acres of the Senior Center building and parking area on Royce Avenue. The original design at this location provided a dry swale to treat part of the building and the Royce Avenue parking area. Converting the dry swale to a micro-bioretention area will account for additional storage in the filtering media. The drainage area (DA 1) is larger under the new design (compare with Figure 2) as the roof drains from the entire building will drain to the micro-bioretention practice. See Figure 4 above for the revised drainage area and size of the proposed micro-bioretention practice. The volume provided in the micro-bioretention facility is as follows:

DA 1: Micro-bioretention:

> The micro-bioretention has a surface area, (A_f), of 770 sq. ft., the ponding depth is 0.5 feet, and the filter depth is 3.5 feet.

> Volume = [(A_f)(ponding depth)] + [(A_f)(depth$_{filter}$)(porosity of media 0.4)]
> Volume = (770)(0.5) + (770)(3.5)(0.4)
> Volume = 385 + 1,078 = **1,463 cu. ft.**

DA 2

DA 2 consists of 0.079 acres and is located on the west side of the parking area on Wylie Avenue. The runoff will drain to a micro-bioretention facility. See Figure 4 for the revised size

of the ESD practice at this location. The volume provided in the micro-bioretention facility is as follows:

DA 2: Micro-bioretention:

> The micro-bioretention has a surface area, (A_f), of 185 sq. ft., the ponding depth is 0.5 feet, and the filter depth is 2.5 feet.

> Volume = [(A_f)(ponding depth)] + [(A_f)(depth$_{filter}$)(porosity of media 0.4)]
> Volume = (185)(0.5) + (185)(2.5)(0.4)
> Volume = 92.5 + 185 = **278 cu. ft.**

DA 3

DA 3 consists of 0.084 acres and is located on the east side of the parking area on Wylie Avenue. The runoff will drain to a micro-bioretention practice on the east side of the parking area. See Figure 4 for the re-graded parking area in DA 3. The volume provided in the proposed micro-bioretention facility is as follows:

DA 3: Micro-bioretention:

> The micro-bioretention has a surface area, (A_f), of 300 sq. ft., the ponding depth is 0.5 feet, and the filter depth is 2.0 feet.

> Volume = [(A_f)(ponding depth)] + [(A_f)(depth$_{filter}$)(porosity of media 0.4)]
> Volume = (300)(0.5) + (300)(2)(0.4)
> Volume = 150 + 240 = **390 cu. ft.**

- **Total Volume: DA 1 + DA 2 + DA 3**

Total Volume = 1,463 + 278 + 390 = 2,131 cu. ft.

Step 5 - Design Assessment

o **Determine if ESD Targets are Met:** According to the above information, the total storage provided of 2,131 cu. ft. meets the minimum ESD goal of 2,103 cu. ft. of storage (summarized on page 5). Prior to completing the design, it will be necessary to confirm that each ESD practice is not over-designed, meaning that the storage provided does not exceed the 1-year, 24 hour rain event. In Baltimore City, the 1-year, 24 hour storm is equivalent to 2.7 inches of rain. The actual P_E treated for each drainage area can be calculated by using the ESD_v equation and solving for P_E as shown below:

DA 1

Compute P_E treated:

$P_E = (ESD_v)(12) / (R_v)(A)$, where:
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \times 100) = 0.95$
$A = 0.36$ acres
$ESD_v = 1,463$ cu. ft.

$P_E = (1,463)(12) / (0.95)(0.36)(43,560)$
$P_E = 1.2$ inches

The P_E treated of 1.2 inches is less than the maximum P_E of 2.7 inches. Therefore, the ESD practice in DA 1 is not over-designed for the contributing drainage area.

DA 2

Compute P_E treated:

$P_E = (ESD_v)(12) / (R_v)(A)$, where:
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \times 100) = 0.95$
$A = 0.079$ acres
$ESD_v = 278$ cu. ft.

$P_E = (278)(12) / (0.95)(0.079)(43,560)$
$P_E = 1.0$ inches

The P_E treated of 1.0 inches is less than the maximum P_E of 2.7 inches. Therefore, the ESD practice in DA 2 is not over-designed for the contributing drainage area.

DA 3

Compute P_E treated:

$P_E = (ESD_v)(12) / (R_v)(A)$, where:
$R_v = 0.05 + (0.009) (I); I = 100\%$
$R_v = 0.05 + (0.009 \times 100) = 0.95$
$A = 0.084$ acres
$ESD_v = 390$ cu. ft.

$P_E = (390)(12) / (0.95)(0.084)(43,560)$
$P_E = 1.35$ inches

The P_E treated of 1.35 inches is less than the maximum P_E of 2.7 inches. Therefore, the ESD practice in DA 3 is not over-designed for the contributing drainage area.

A Summary of Requirements for this project (from page 5):

- Redevelopment:
    - Provide impervious area reduction and/or water quality treatment for 50% of existing impervious area within the project LOD (50% of 0.5 acres = 0.25 acres).
    - ESD_v for water quality (P_E = 1.0 inch) for 0.25 acres = 862 cu. ft.
- New Development: New development criteria apply to the net increase in impervious area of 0.18 acres, where P_E = 2.0 inches:
    - Total ESD_v for 0.18 acres = 1,241 cu. ft..
    - At a minimum, 621 cu. ft. shall be provided in ESD practices.
- Total ESD_v = Redevelopment + New Development = 862 + 1,241 = 2,103 cu. ft.
- Impervious area requiring treatment = $0.25_{existing}$ + 0.18_{new} = 0.43_{total}

Summary of Management Provided

- DA 1 (0.36 acres): 1,463 cu. ft.
- DA 2 (0.079 acres): 278 cu. ft.
- DA 3 (0.084 acres): 390 cu. ft.
- Total (0.523 acres): **2,131 cu. ft**.

The total storage provided of 2,131 cu. ft. for 0.523 acres is greater than the required storage of 2,103 cu. ft. for 0.43 acres. The designer has demonstrated that the ESD_v requirements have been met using ESD practices. If this was not possible, other on-site ESD options would need to be evaluated prior to considering alternative management practices.

- **Complete Design:**

Because redevelopment requirements are not as stringent as new development there is flexibility regarding where management could be provided on-site. The above example shows that ESD practices are distributed throughout the site in order to achieve the total volume targets. By maximizing storage available in the largest drainage area, (DA 1) greater water quality treatment is provided for the largest area of imperviousness. In addition, the practices in the smaller drainage areas will provide close to one inch of treatment. Because of the flexibility in applying management throughout the site, review agencies will have the ability to require that redevelopment designs be tailored to address local concerns related to water quality, channel protection, or flood control.

Before submitting the Site Development plans, the designs for all of the ESD techniques and practices should be completed. This includes all pertinent details, standards, and specifications needed to verify the designs. Site Development plans should be submitted to the appropriate review agencies and should include a stormwater plan, erosion and sediment control plan, an overlay plan, and a narrative to support the design. Review agencies may require additional information at this stage depending on site conditions and local concerns.

Final Plan Design and Computations

Step 6 – Finalize ESD Design and Address Remaining Stormwater Requirements

After Site Development Plan approval, Final plans may be prepared to address any comments from the review agency. In this phase, the design of any structural practice necessary to address any remaining channel protection or flood control requirements is completed. For this project, the site is located in an inter-jurisdictional flood hazard watershed, and therefore, management of the 100 year storm is required. The original design complied with these requirements by discharging to underground storage system below the parking area off of Wylie Avenue. This underground system will still be needed to comply with flood hazard requirements.

Final plans will also need to consider stable conveyance of discharge to downstream waterways or storm drain systems. When each ESD practice fills with runoff from its contributing drainage area, the excess will overflow to a control structure within the facility. Overflows can be directed to the proposed underground storage system for stable conveyance. This will ensure that runoff to downstream storm drain systems will not be increased and will allow a stable discharge point for all flows leaving the site.