# DRAFT Drainage Analysis for

# Washington Terrace
# Major Subdivision
## a Subdivision of 508-242-044

## Located in:

McKinleyville, California

## Owner:

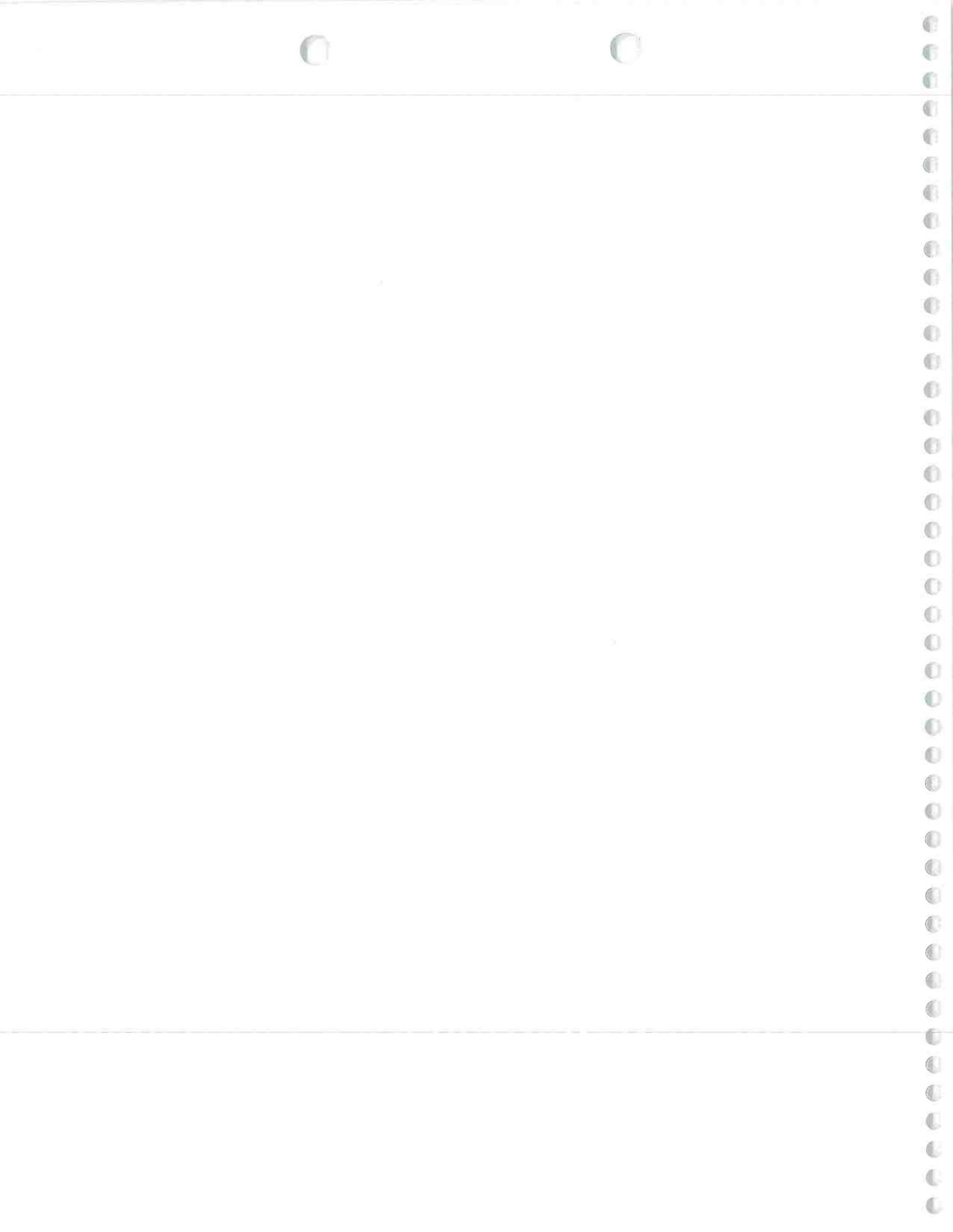James L. Furtado
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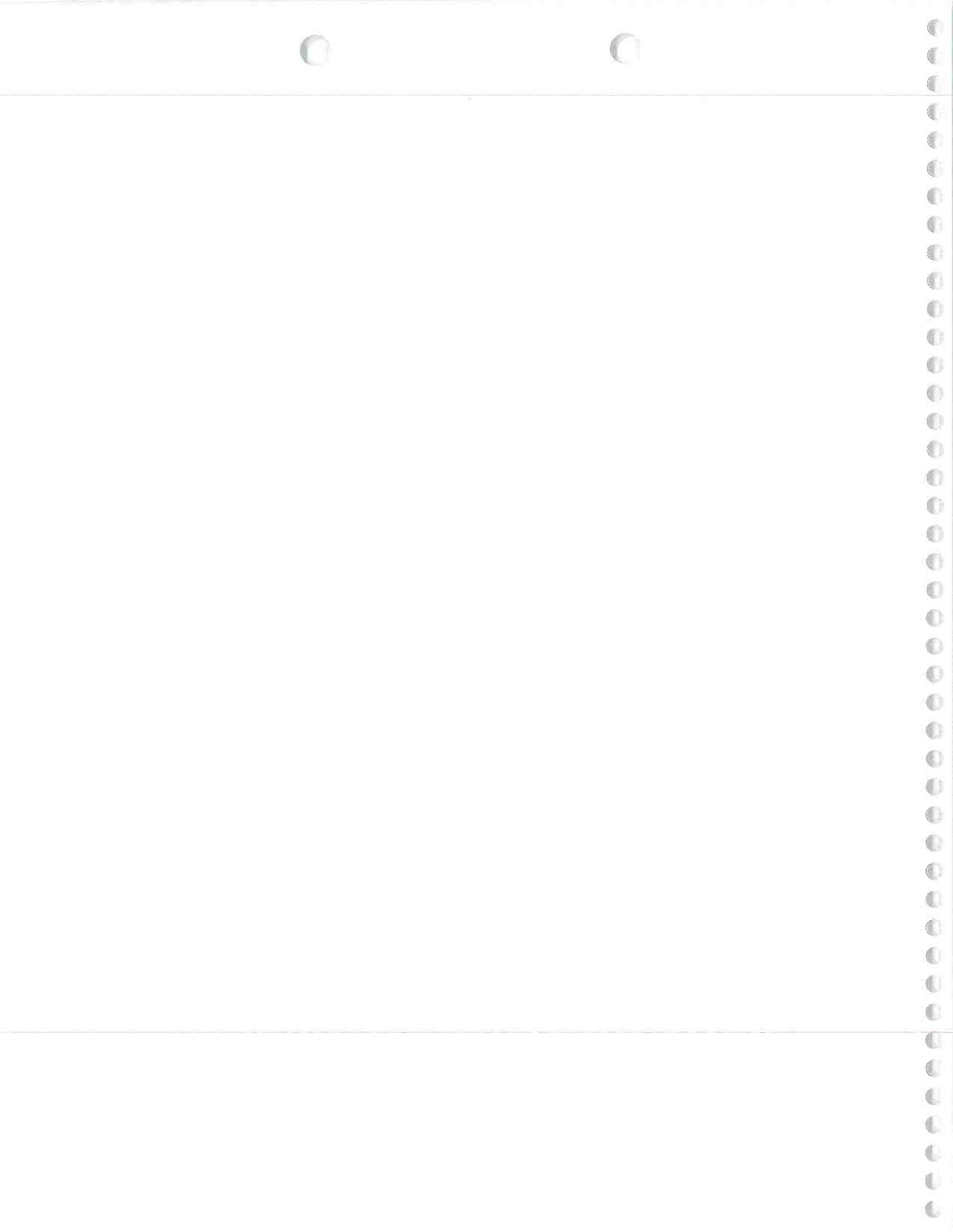
# 1.0 PROJECT OVERVIEW

## 1.1 Project Location

The project site is located in McKinleyville, an unincorporated town in Humboldt County, California. The site is located just off of Highway 101 via School Road with access provided from Washington Avenue. The project is on AP Number 508-242-044 on the property known as 1700 Washington Avenue.



**Location Map (Not To Scale)**

## 1.2 Project Description

This project develops an approximately 7.6 (gross) single acre parcel into forty (40) residential parcels, ranging in size between approximately 3800 s.f. to 7500 s.f. in size. Public utilities including sewer, water, electrical, gas, cable tv, and telephone are located east of the project along Washington Avenue, a public roadway located in an existing easement granted to the County of Humboldt over this parcel. This project will require grading, installation of new utilities, construction of roads, stormwater management, and related infrastructure. The existing parcel is surrounded by the Washington Garden Subdivision to the north, School Ridge Subdivision to the west, larger lot single family residences to the east across Washington Avenue, and a non-developed parcel to the South.

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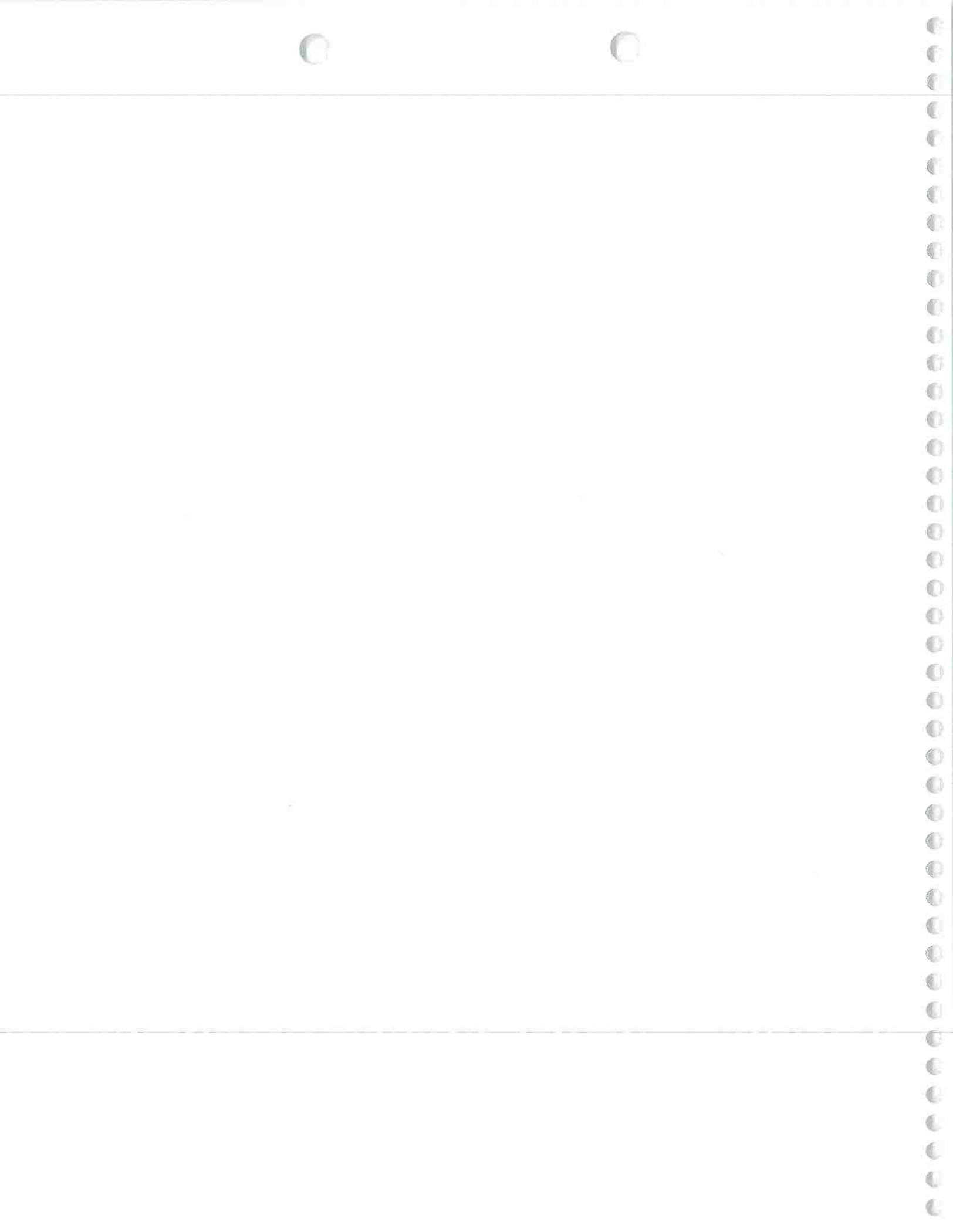
The proposed development on the subject parcel and this adjacent parcel to the south were previously owned by the McKinleyville Unified School District as one contiguous parcel until subdivided as part of a previous project. Due to the presence of a seismic fault, the southerly parcel was donated to McKinleyville Community Services District for use as a future public park and potentially a recreational BMX track.

## 1.3 Project Topography & Geology

The existing topography on the 7.6 acre parcel is relatively flat and slopes in a northeast direction at slopes ranging 1% to 5%. The property is primarily a grassy field with trees along the southern border of the property. Stormwater runoff within this area generally drains in the form of sheet flow. The site lies on a flat marine terrace and consist of marine deposits of silts, sands, and gravels. Per USDA charts, soils in this area fall under Hydrologic Soil Group B.

The soil onsite has been explored in an Geotechnical Investigation Report by SHN Consulting Engineers and Geologists, Inc. The soil generally consists of dark brown to very dark brown medium dense silty sand and soft to medium stiff sandy silt. Marine terrace deposits condisted of yellowish-brown, medium dense silty sand, medium dense poorly graded sand with silt, and well-graded sand with silt. Topsoil depths are deeper than what is typically found in this area in certain locations due to some previous grading activities when this site and the adjacently owned MCSD parcel were under single ownership.

The project site is located away from the Mad River Fault Zone with the southern portion of the site is blanketed by an Alquist-Priolo Earthquake Fault Setback Zone. An Earthquake Fault Line lies more than 170 feet away from the southern property boundary, and on the MCSD Parcel. Please see the review of fault rupture evaluation by SHN Consulting Engineers and Geologists on file with County Building and Planning department for more information.

Groundwater was not observed in the test pit depths (up to 10 feet) at the time of the report. Thus, being that exploration took place in late spring, groundwater is not expected to be encountered during grading and trenching activities.

Soil percolation rates were not tested as part of the geotechnical report. However, rates are expected to be more than adequate as the soils on-site contain less than 50% fines per SHN soil boring logs, which meets the minimum required soil composition for compliance cited in the Humboldt County Low Impact Development Stormwater Manual. Typical percolation rates for the native sandy clay soils commonly found in the McKinleyville area range between 30-60 minutes per inch. However, compaction by construction equipment, and silt sedimentation during the construction process can greatly compromise this percolation rate.

## 1.4 Project Stormwater Control Overview

The project will manage stormwater by utilizing conventional and low-impact development strategies to treat and control stormwater runoff. This is further discussed in Section 2.0 and Shown on the Stormwater Control Plan in Appendix A1. In summary:
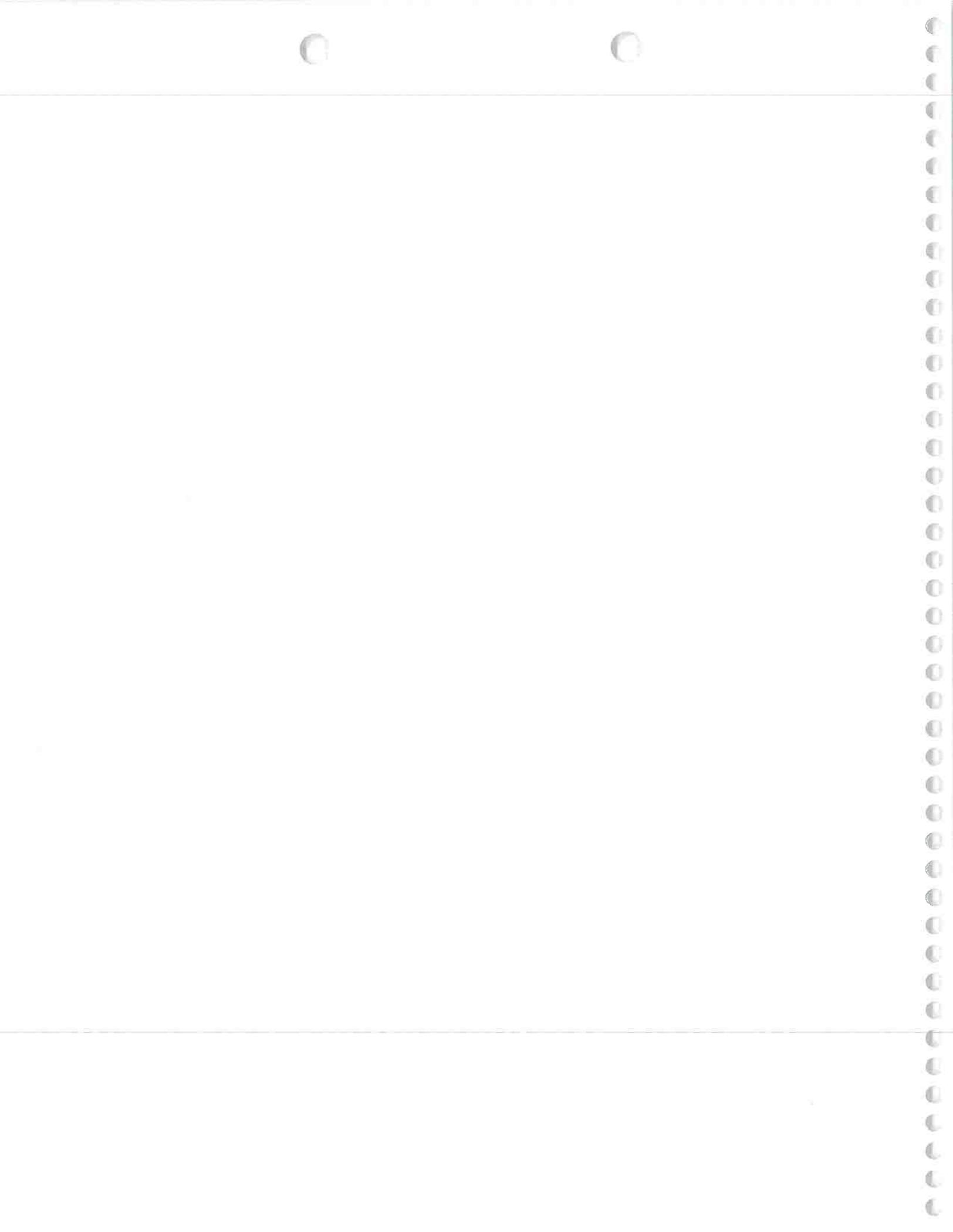
- Lots 2-8 and a portion of Washington Court will drain toward a Vegetated Swale System (Parcel B), which has a terminal overflow drainage inlet structure on the terminal (North) end. Overflow from this swale will run into the Bio-Retention / Overflow Basin.
- Lot 1, Lots 9-20, and a portion of Washington Court, will drain to the street and stormwater collected via two drainage inlets and piping to the Bio-Retention / Overflow Basin area (Parcel C). The basin is sized to provide both stormwater quality and quantity benefits and handling additional runoff not addressed with the various Drainage Management Zones due to site constraints (i.e. smaller lot sizes, reduced street widths) reduction measures.
- Lots 21-22 and a portion of Washington Court and Ascent Place will drain toward a corner Stormwater Planter System at the intersection of these two roadways, with overflow from this system connecting to the storm drain system.
- Lots 23-26 and Lots 27-30 and portions of Ascent Place will drain toward mid-block Stormwater Planter Systems, with overflow from these systems connecting to the storm drain system on each side of the street, respectively.
- Lots 31-33, the front yards of Lots 36-40, and a portion of Ascent Place will drain toward a Corner Stormwater Planter System at the Intersection of Washington Court and Ascent Place, with overflow connecting to the storm drain system.
- Lots 34-40 (from rear of the front yards to back of the lot and a portion of Washington Court will drain toward a Vegetated Swale System (on Parcel A), which has a terminal overflow drainage inlet structure on the North end. Overflow from this swale will run into the Vegetated Swale on Parcel B using a pipe connection under Washington Court.
- Washington Avenue Frontage Improvement drainage will be collected with a new drainage inlet at the intersection of Washington Avenue and Washington Court and related piping to convey flow to the existing drainage inlet on the north end of the project. As the downstream improvements related to the Central Estates channel and basin included accommodations for build out on this project site, and detention for peak flows is being provided as a part of this project, no additional runoff control measures are being planned for these offsite improvements.

## 2.0 STORMWATER CONTROL PLAN (WATER QUALITY)

This section outlines water quality improvements proposed for the subdivision to meet County of Humboldt & State Water Resource Control Board Municipal-Separate-Storm-Sewer requirements (MS4).

### 2.1 Drainage Management Area Descriptions

Per the MS4 requirements, regulated projects such as this subdivision project require implementation of site design measures with the goal of achieving infiltration, evapotranspiration, and harvesting / reuse of the 85th percentile 24-hour storm runoff event on-site in an effort to reduce pollution in receiving waterways. As such, the project site has been divided into drainage management areas (DM's) that utilize stormwater management strategies such as Soil Quality Improvement, Tree Planting, Vegetated Swales, Stormwater Planters

(Micro Bio-retention Cells), and a Bio-retention / Overflow Basin. In addition, trees will be planted overlapping all drainage management areas. The following describes each water quality design approach as related to each Drainage Management Area shown on the Stormwater Control Plan in Appendix A1.

## 2.2   Soil Quality Improvement

Existing topsoil will be set aside during the grading process and stockpiled on-site and covered with a weed barrier material. This topsoil will be reused onsite as much as possible, with a bulk of it loosely placed in the back yards of the future residences. As the site is primarily an existing open grassy field, experience has shown from adjacent past projects that the existing topsoil will be clean and free of deleterious materials and quite suitable for this application.

## 2.3   Tree Planting & Preservation

With minimal existing trees on the site that will need to be removed to accommodate development, the site around the new residential houses will lack tree cover. As such, new street trees will be planted in the landscaping areas adjacent to sidewalks. Street trees help infiltration into subsurface soils, improve air quality, and create an aesthetically pleasing environment. Currently, a total of 37 street trees are proposed in the landscaping plan. Additional trees may be added as the new house layouts are developed.

## 2.4   Vegetated Swale System

This project proposes to capture the runoff from lots 2–8 and 34–40 by using a vegetated swale system as shown:
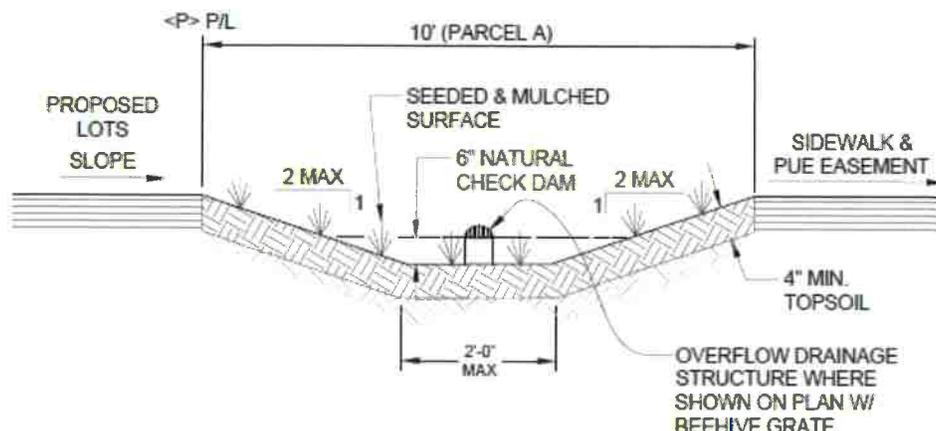


**Typical Vegetated Swale Detail**
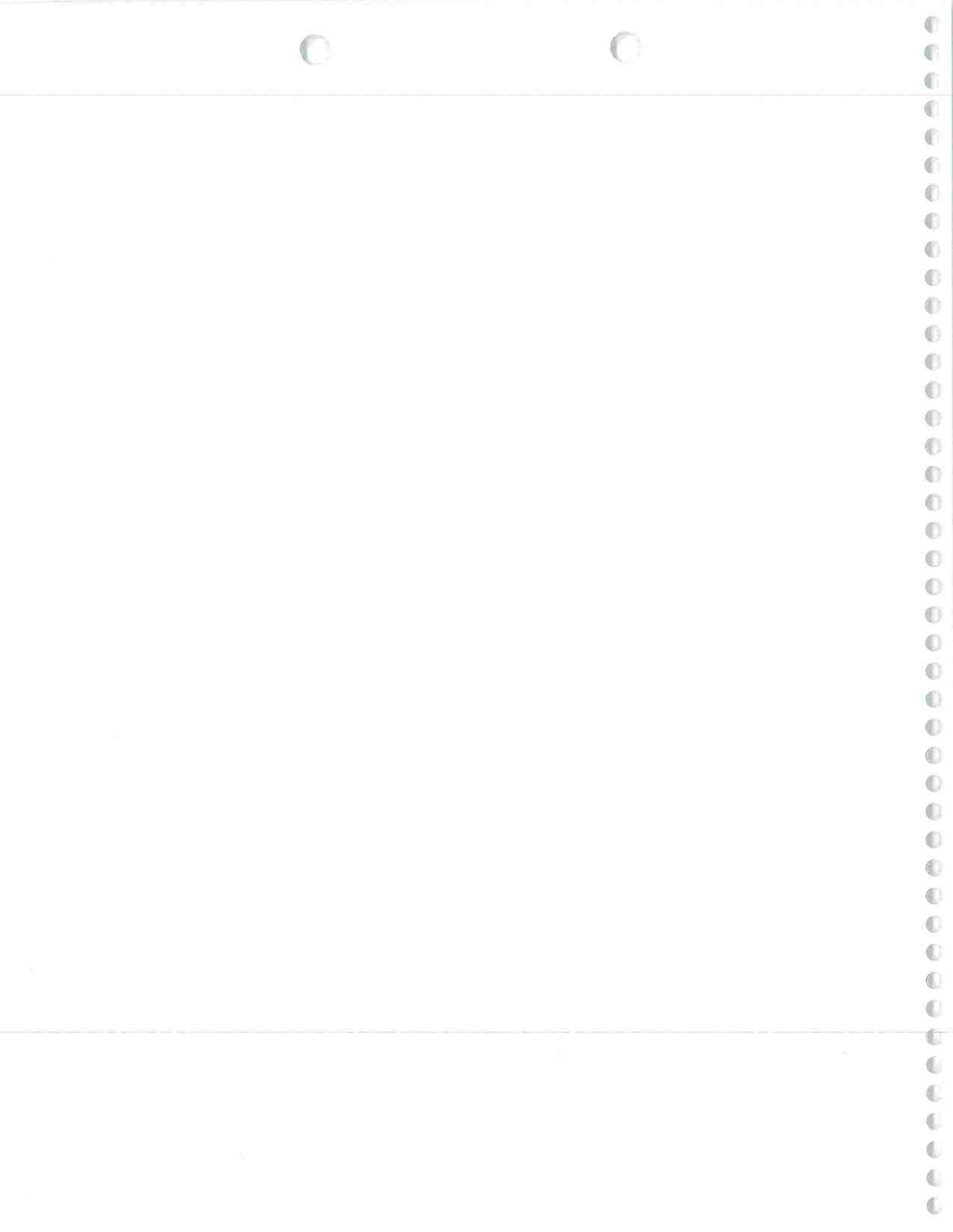
Roof drain downspouts from these lots will discharge onto splash blocks or pop-up emitters to reduce velocity, provide impervious area disconnect, and allow runoff to flow away from foundations along lot edges southerly toward each vegetated swale respectfully.

The swale will run from north to south on the east side of the site, adjacent to Washington Avenue, and inside a proposed drainage easement. At the terminal end of the swale, a surface drainage inlet with rim set 6" above the bottom of the swale will be used to provide an outlet for excess stormwater during peak flow periods. An underdrain system consisting of perforated drain pipe and drain rock underneath the bottom of the channel is not being proposed for this swale.

Vegetated swale design will consist of a +/- 2-foot maximum deep channel, 2-foot wide bottom, with 6-inch high natural check dams spaced at intervals along the bottom, running in the northerly direction on a 1.5% slope. The southerly segment (Parcel A) will flow toward an overflow drainage inlet set 6" above flow-line then discharge into the northerly segment (Parcel B). The northerly segment will discharge via a second overflow drainage inlet, in kind, into the projects overflow Basin. See Section 5.1 for Swale Capacity Calculations.

## 2.5    Stormwater Planter Systems

The proposed project will utilize Stormwater Planter Systems (micro Bio-Retention cells) in key locations along Ascent Place, please refer to the Stormwater Control Plan in Appendix A1, Bio-Retention Basin are sited in various locations.  The purpose of these systems is for slowing, retaining, filtering, and infiltrating stormwater for the 85th percentile, 24-hour storm event. Typical plan views of mid-block and corner Stormwater Planters are as follows:
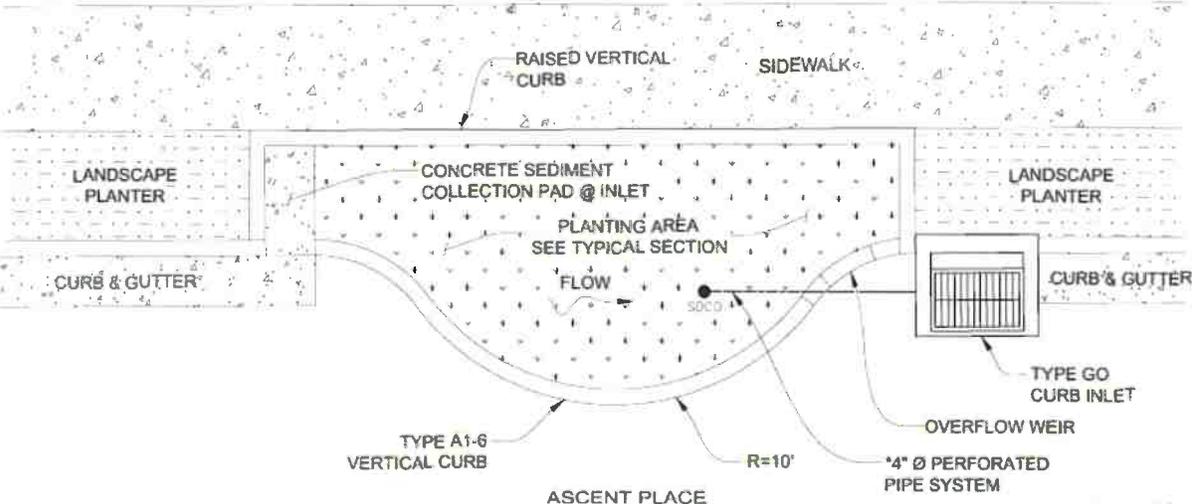


**Typical Stormwater Planter Detail (mid-block)**
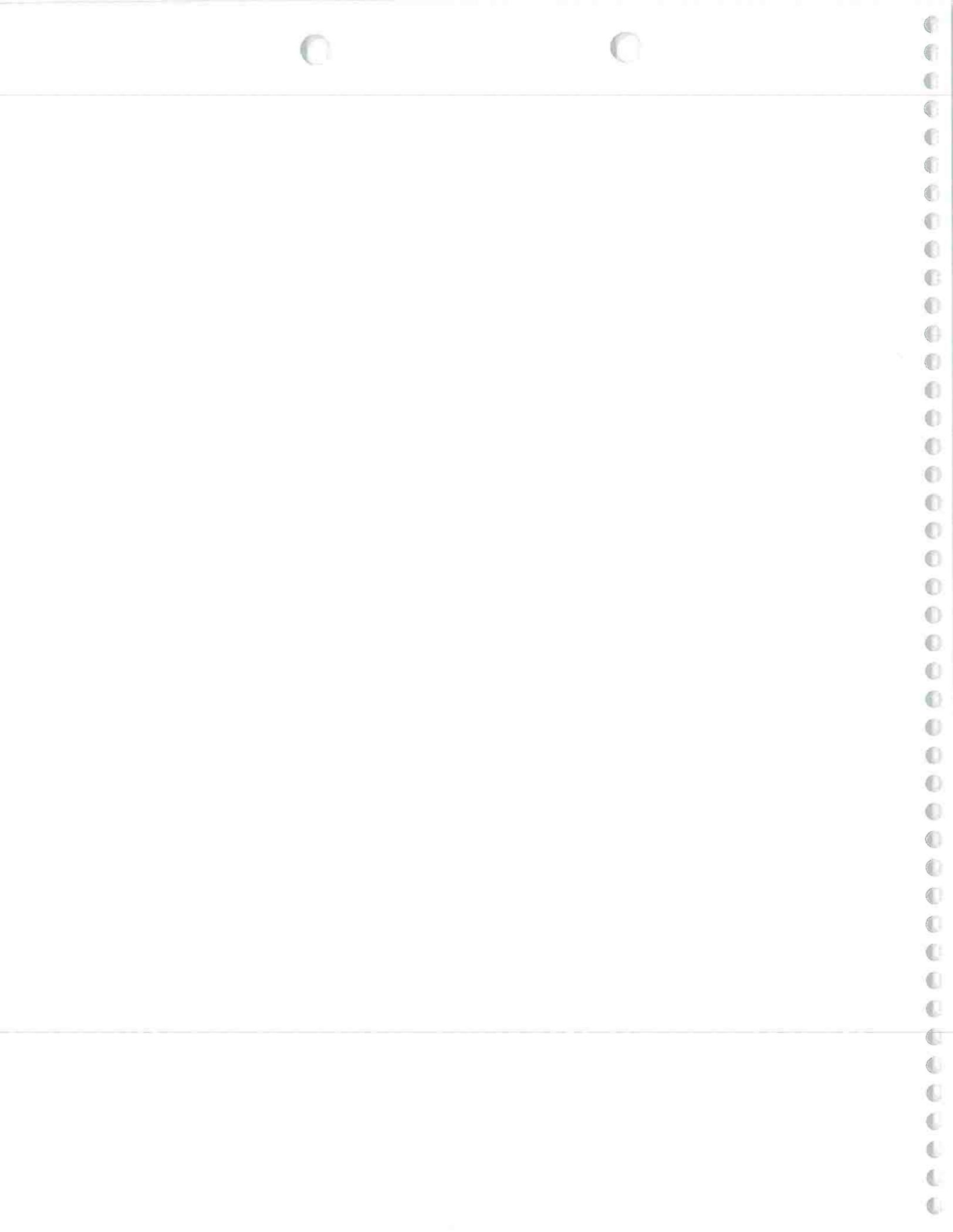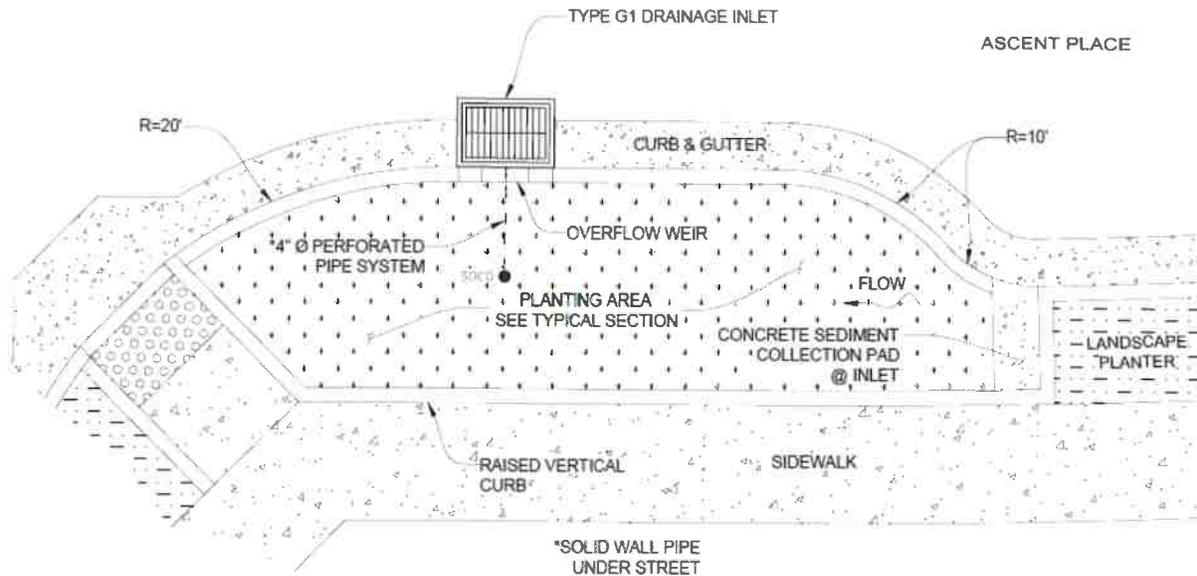
**Typical Stormwater Planter Detail (corner)**

These basins have a footprint of roughly 11 feet wide by 20 feet minimum long (or 220 SF minimum) depending on the type.

A typical Stormwater Planter design includes a depressed and curbed area where stormwater runoff can be detained. The planting area, which creates the Bio-retention infiltration layer for stormwater quality benefits, consists of three layers: A drain rock layer with perforated pipe, a soil media layer, and plantings. A typical section is as shown on the next page.

PLANTINGS
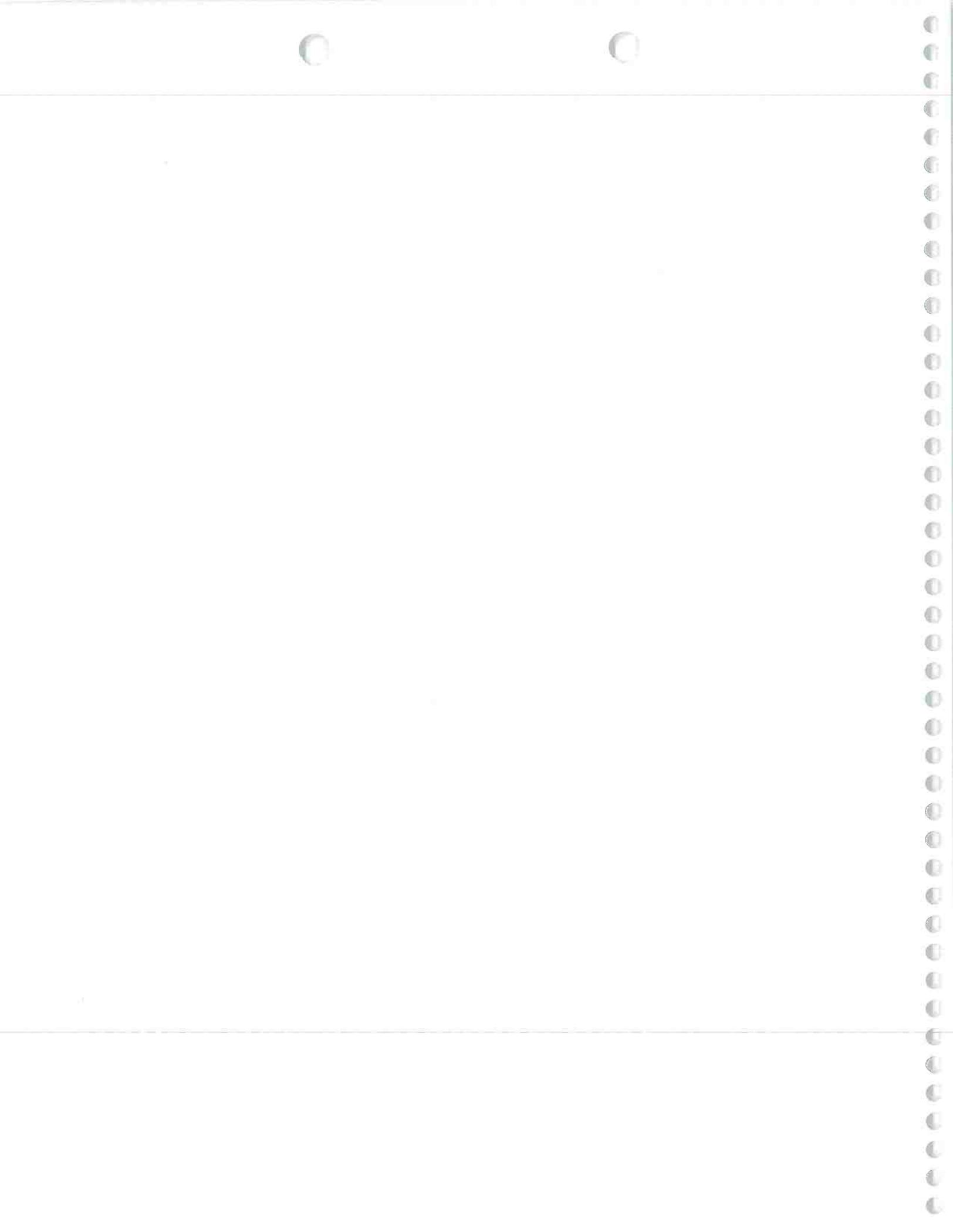
NOTES:

1. TOPSOIL IN BIO-RETENTION AREA SHALL
   MEET THE FOLLOWING CHARACTERISTICS:
   - 60% TO 70% SAND
   - 20% TO 40% COMPOSTED ORGANIC
   MATTER
   - <5% CLAY
   - HAVE A MIN. INFILTRATION RATE = 5" / HR

TSL

TGL

BGL

18" MIN. TOPSOIL,
SEE NOTE 1.

4" PERFORATED SDR 35 PIPE W/
HOLES FACING DOWN, WHERE
SPECIFIED ON PLAN, EXTENDS TO
DRAINAGE STRUCTURE

12" MIN CLASS 3
DRAIN ROCK

SCARIFY UPPER 4"
OF <E> NATIVE
TOPSOIL / SUBGRADE

NOTE: TSL = TOP SOIL LAYER
TGL = TOP GRAVEL LAYER
BGL = BOTTOM OF GRAVEL LAYER / SUBGRADE
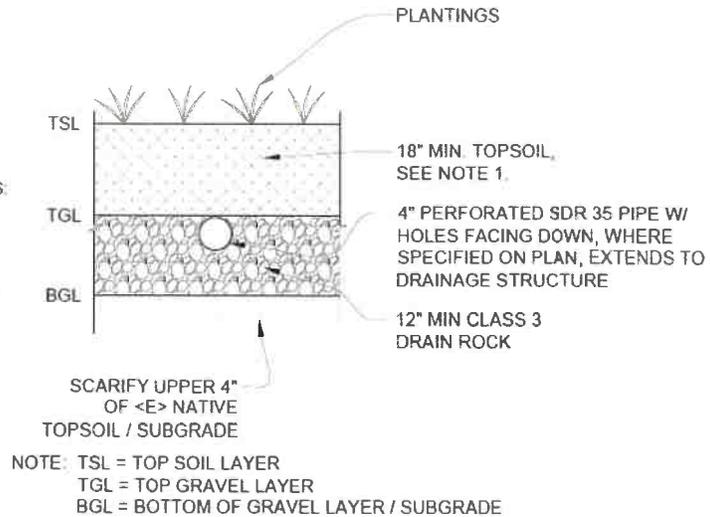
**Typical Bio-Retention Area &
Stormwater Planter Section Detail**

## 2.6    Bio-Retention / Overflow Basin System

A Stormwater Bio-Retention / Overflow Basin System will be designed to treat the 85th percentile 24-hour storm and promote infiltration in the area identified as DM-7 on the stormwater control plan in Appendix A1. This basin is meant to infiltrate the "first flush" of contaminants from the road and other impervious areas after a rain event not addressed by the other drainage management areas. In addition, the basin will limit the proposed project site stormwater discharge to the pre-development flows of a 2-year rainfall event. The pre-development peak flow is the maximum allowable rate at which post-development flow may be released from the constructed project site.  See Section 5.0 for more information and capacity calculations for Peak Runoff Control.

As shown on the Stormwater Control Plan, the Bio-Retention Basin is sited on a lot herein known as "Parcel C", which has a lot size of 9532 s.f. along with 4000 s.f. of bio-retention treatment area provided. This exceeds the site requirements per the Stormwater Control Plan Worksheet calculations in Appendix A2 when taking reductions due to other site measures.

The Bio-Retention basin, which creates the Bio-retention infiltration layer for stormwater quality benefits, consists of three layers: A drain rock layer with perforated pipe, a soil media layer, and plantings. A typical section was shown previous section.
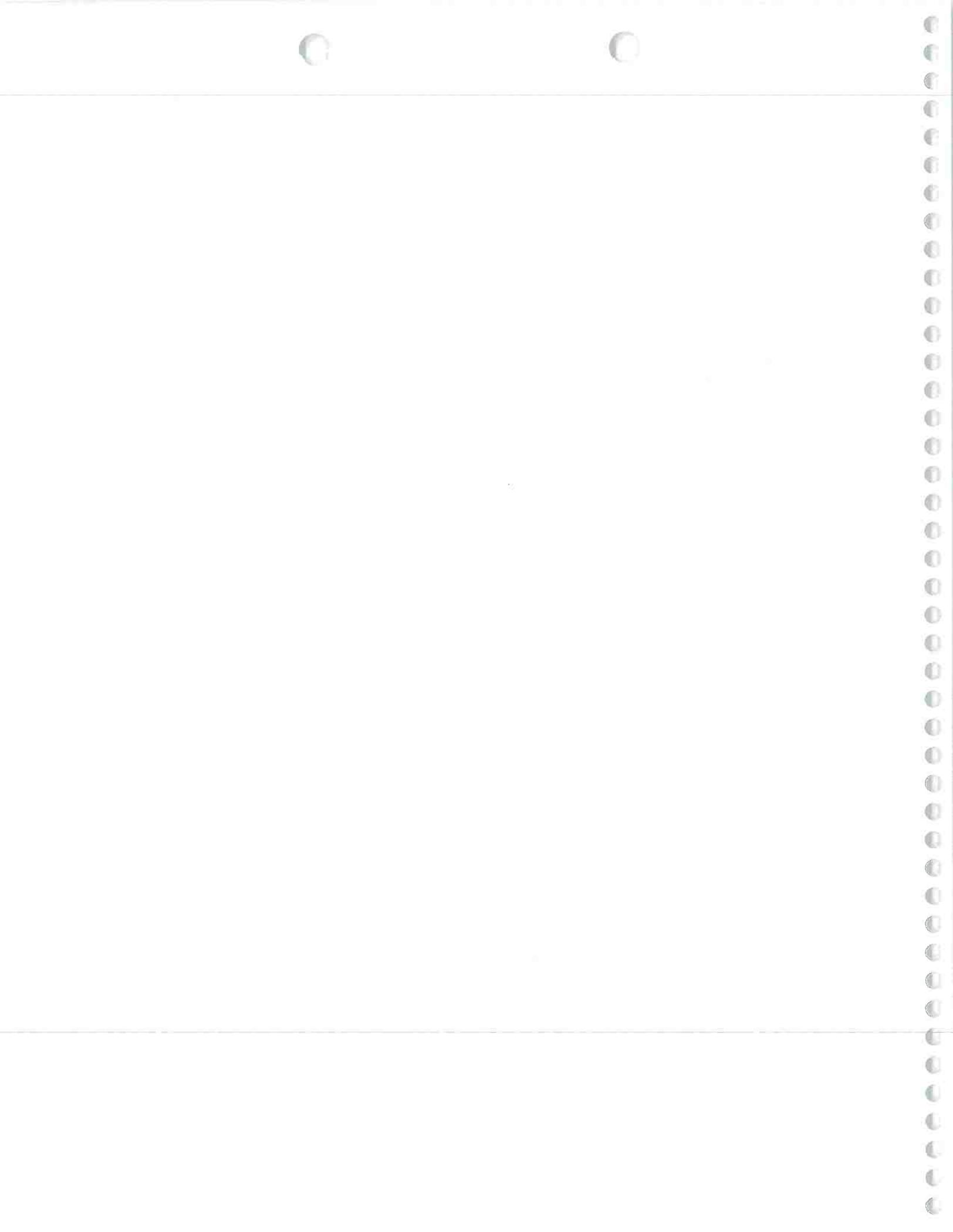
## 3.0 MACRO HYDROLOGY ANALYSIS

This section presents hydrology calculations for pre-development and post-development flow that are used as the basis of design of the recommended drainage improvements in the subdivision.

### 3.1 Calculation Methodology

The County of Humboldt requires that macro hydrology be analyzed for subdivision development. The purpose of this requirement is to reasonably verify that the on-site development does not adversely affect the off-site watershed as a whole. Runoff calculations were performed in conformance with the requirements.

To accomplish this, the Rational Method was used to determine peak flows for pre and post-development conditions for the site. The Rational Method estimates runoff for a given rainfall event using the following formula:

$$Q = C*I*A$$

Where:

$Q$ = Flow (Cubic Feet per Second, cfs)

$C$ = Runoff Coefficient (Unitless), See Appendix B3 for typical coefficients

$I$ = Rainfall Intensity (in/hr), which is dependent of frequency of event, duration, and time of concentration

$A$ = Drainage Area (acres)

For a project of this size, engineering convention typically specifies a minimum time of concentration (Tc) of 10 minutes for use in estimating rainfall intensities. The calculations of time of concentration can vary greatly according to formulae used. See Appendix B5 for summary of time of concentration formulas.

A previous Interim Drainage Study for McKinleyville Community Services District was completed by Edward Schillinger (on file with County Land Use). This report used a time of concentration of 10 minutes and developed rainfall intensities per the Eureka IDF Curves (See Appendix B2). As the previous storm drainage report by Edward Schilinger was preliminary in nature for previous parcel map approval, no other rainfall intensity correlation factors were used. Per the McKinleyville Drainage Study of 1982 by Winzler & Kelly, a correlation factor (R) was developed to correlate rainfall intensity in McKinleyville with the Eureka weather stations rainfall records. This factor is being used in this study and thus, a factor of R = 1.04 is incorporated into calculating the 2-year and 100-year rainfall intensities as follows:

$I_2$ = 2-year storm intensity curve value * R = 1.25 in/hr * 1.04

**$I_2$ = 1.27 in/hr**

$I_{100}$ = 100-year storm intensity curve value * R = 3.20 in/hr * 1.04

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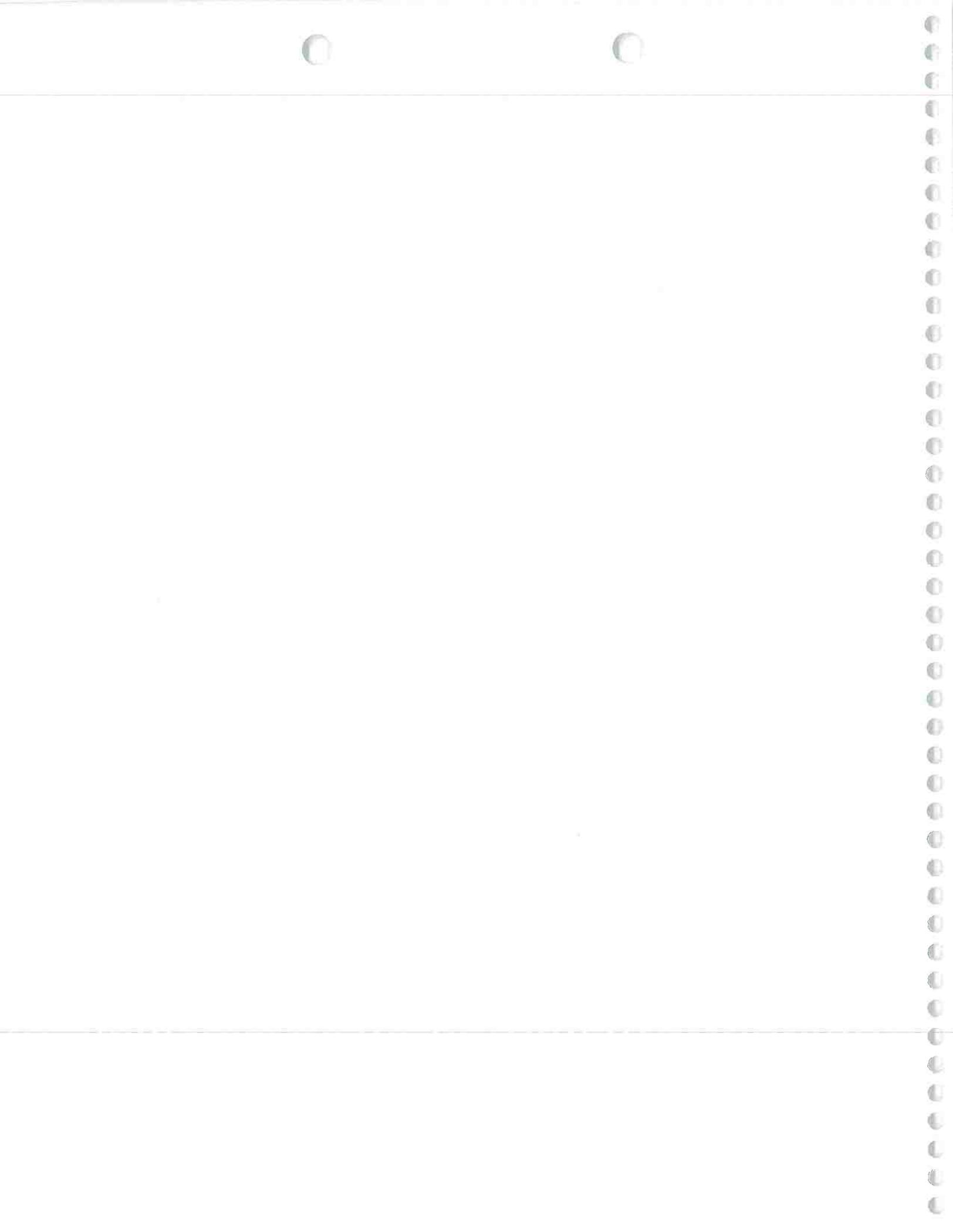
$$I_{100} = 3.33 \text{ in/hr}$$

In compliance with the stormwater drainage design criteria required by the County of Humboldt, Land Use Division, stormwater detention systems recommended herein are designed to curtail stormwater generated by a post- development 100-year rainfall event by releasing stormwater at a runoff at a rate equal to or less than the pre-development 2-year rainfall event. This is in addition to the LID Stormwater Requirements for the MS4 permit. Please refer to Appendix B7 for full calculations summarized below.

## 3.2 PRE-DEVELOPMENT FLOW CALCULATIONS

As shown on the Drainage Basin Map in Appendix B1, the property is being developed into forty (40) separate lots and include an existing roadway via easement (Washington Avenue). As such, the pre-development drainage area selected is the entire lot area of 7.6 Acres, to be conservative.

A weighted run-off coefficient was considered for the drainage basin due to variability in permeable vs. non-permeable surfaces. Typical ranges for rational method runoff coefficients are shown in Appendix B3. In summary:

1) For the current Undisturbed Agricultural Lane, a runoff coefficient of 0.25 was selected.

2) For the existing pavement along Washington Avenue a runoff coefficient of 0.85 was selected

In Summary the composite Runoff Coefficient for the site for pre-development is as follows:

| Total Acreage | Composite C factor |
|---------------|--------------------|
| 7.6 Acres | 0.28 weighted |

Thus, Pre-Development Drainage Flow from a 2-year storm: $Q_2 = 2.9$ cfs

## 3.3 POST-DEVELOPMENT FLOW CALCULATIONS

As with the pre-development calculations, a weighted runoff coefficient was considered for each major area for the post-development 100-year flow analysis. The site will be developed into three major areas: 1) Houses / Driveways / Sidewalks / Curbs, 2) Asphalt Roadway, and 3) vegetated lawns, swales, and basin. Off-site contributions have been excluded from the post development analysis as it is currently assumed that when MCSD develops the adjacent parcel, their proposed site plan will be designed to treat and reduce any off-site runoff. Thus, off-site contributions will likely have insignificant impacts on this residential development and are being excluded from these calculations.

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Please refer to the Drainage Basin Map in Appendix B1 for a map of improved areas utilized in the calculations below. Typical ranges for rational method runoff coefficients are shown in Appendix B3. In summary:

1) For the Future Houses, footprints of 2000 s.f. per lot, (40x40 house with 20x20 concrete driveway slab) and 1300 s.f. (30x30 house with 20x20 concrete driveway slab). In addition, Sidewalks and Curbs are included in this calculation. A runoff coefficient of 0.95 was selected.

2) For the Pavement a runoff coefficient of 0.85 was selected.

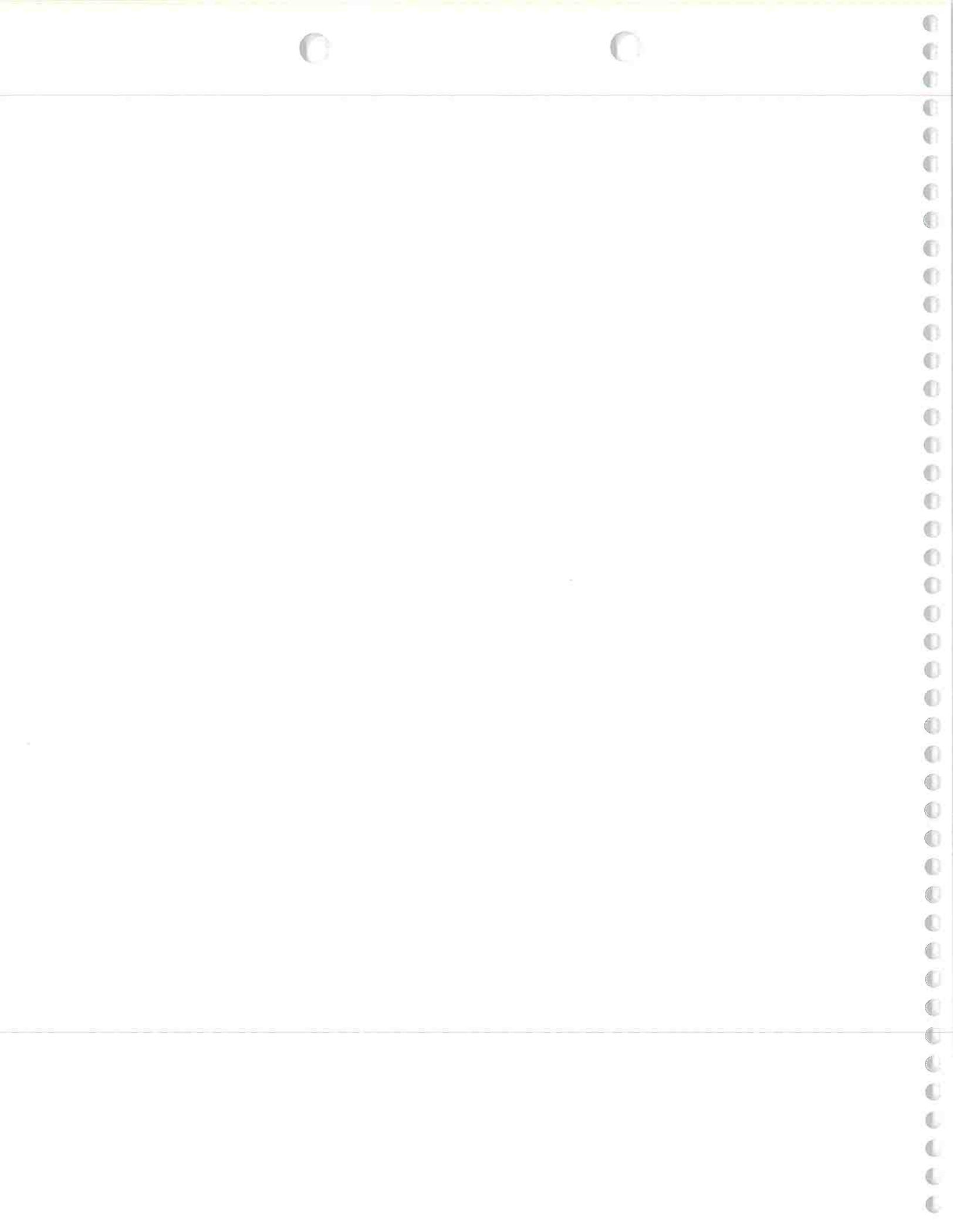3) For the remaining area that will be Vegetated (lawns, swales, basin) a runoff coefficient of 0.25 was selected.

In Summary the composite Runoff Coefficient for the site for post-development is as follows:

| Total Acreage | Composite C factor |
| --- | --- |
| **7.6 Acres** | **0.57 weighted** |

Thus, Post-Development Drainage Flow from a 100-year storm: $\underline{\mathbf{Q_{100} = 15.0\ cfs}}$
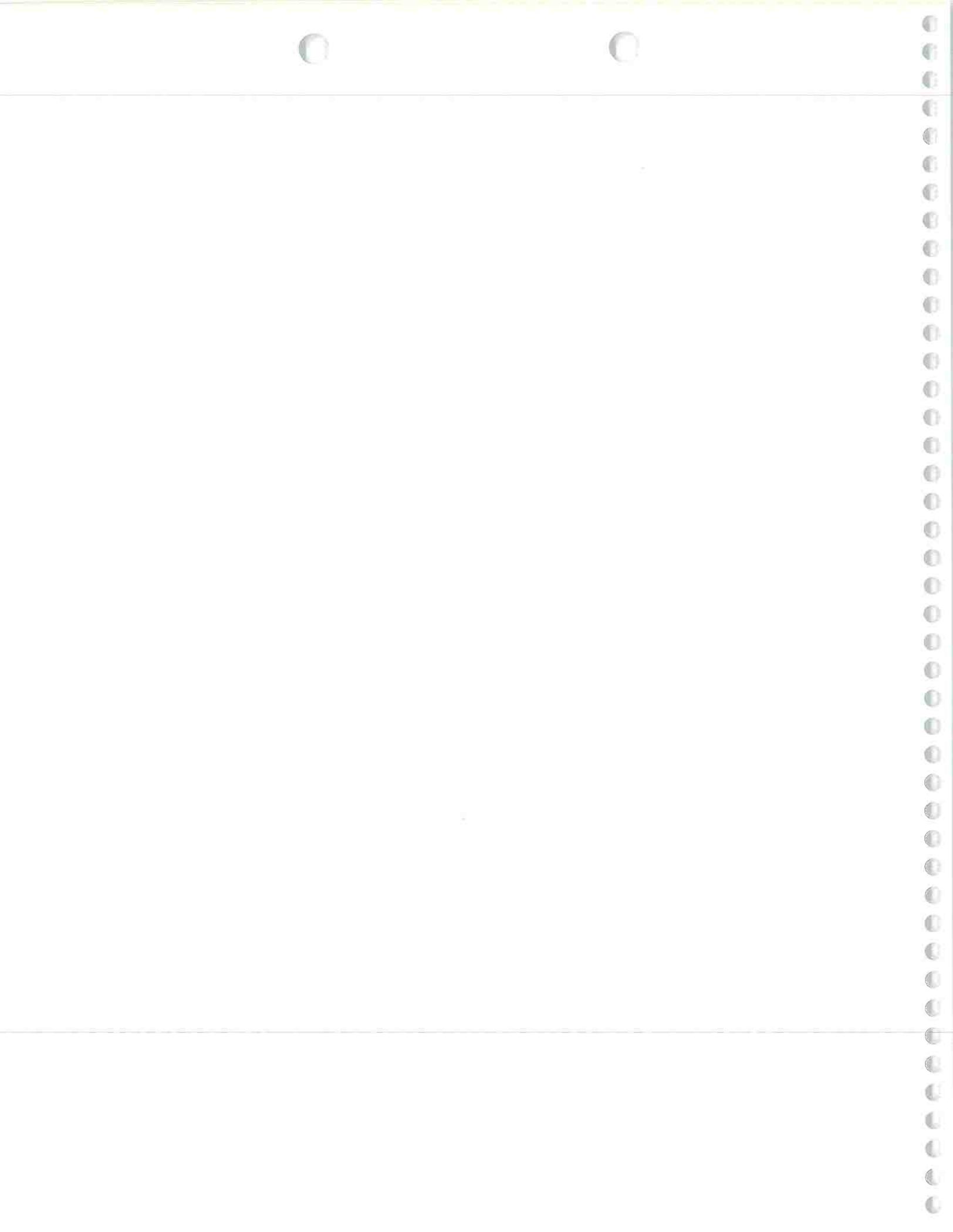
# 4.0 CONVEYANCE SYSTEM ANALYSIS & DESIGN

This section outlines guidelines and designs for the project's drainage improvements. Each new parcel and roads in the subdivision will direct stormwater runoff toward a combination of systems including a vegetated swale with check dams, stormwater planter systems, and a terminal bio-retention / overflow stormwater basin with an associated outlet structure system.

## 4.1 Drainage Basin Descriptions

The project was split into post-development drainage basins as shown on the Drainage Basin Map in Appendix B1 for a micro analysis of the storm drain system. The drainage areas are lettered, drainage inlet the flow is expected to reach identified, and each pipe run is labeled. A time of concentration of 10 minutes was used in the calculations. In summary:

| Drainage Basin | Area (ac) | $C_w$ | $Q_{100}$ (ft³/sec) |
|---|---|---|---|
| A | 0.62 | 0.58 | 1.20 |
| B | 0.61 | 0.54 | 1.10 |
| C | 0.71 | 0.52 | 1.23 |
| D | 0.48 | 0.56 | 0.90 |
| **E | 0.80 | 0.51 | 1.36 |
| **F | 0.07 | 0.71 | 0.17 |
| **G | 0.41 | 0.54 | 0.74 |
| H | 0.24 | 0.67 | 0.54 |
| I | 1.9 | 0.56 | 3.54 |
| **J | 0.57 | 0.42 | 0.80 |
| *K | 0.65 | 0.82 | 1.77 |
| | | Total | 13.3 |

*Ignored as these are offsite Washington Avenue improvements.

**Vegetated swale flow not counted in on-site pipe sizing only basin sizing.

Note: The total Q100 flow shown here is **13.3 cfs,** whereas the macro hydrology calculations in Section 3.3 conservatively were estimated at **15 cfs**. The difference is that the areas east of the Washington Avenue centerline will continue to drain east in existing drainage patterns.

## 4.2 Conveyance System Analysis

On-site stormwater conveyance has been calculated through gravity flow analysis of the piping network. Based on a 100-year storm event, peak runoff was routed through the system and determined to be adequate. Please see Appendix B8 for a detailed analysis including hydraulic grade line calculations. See also Section 4.5 for pipe capacity calculations for various pipe sizes. Generally, the on-site piping design has the following gravity flow capacity:
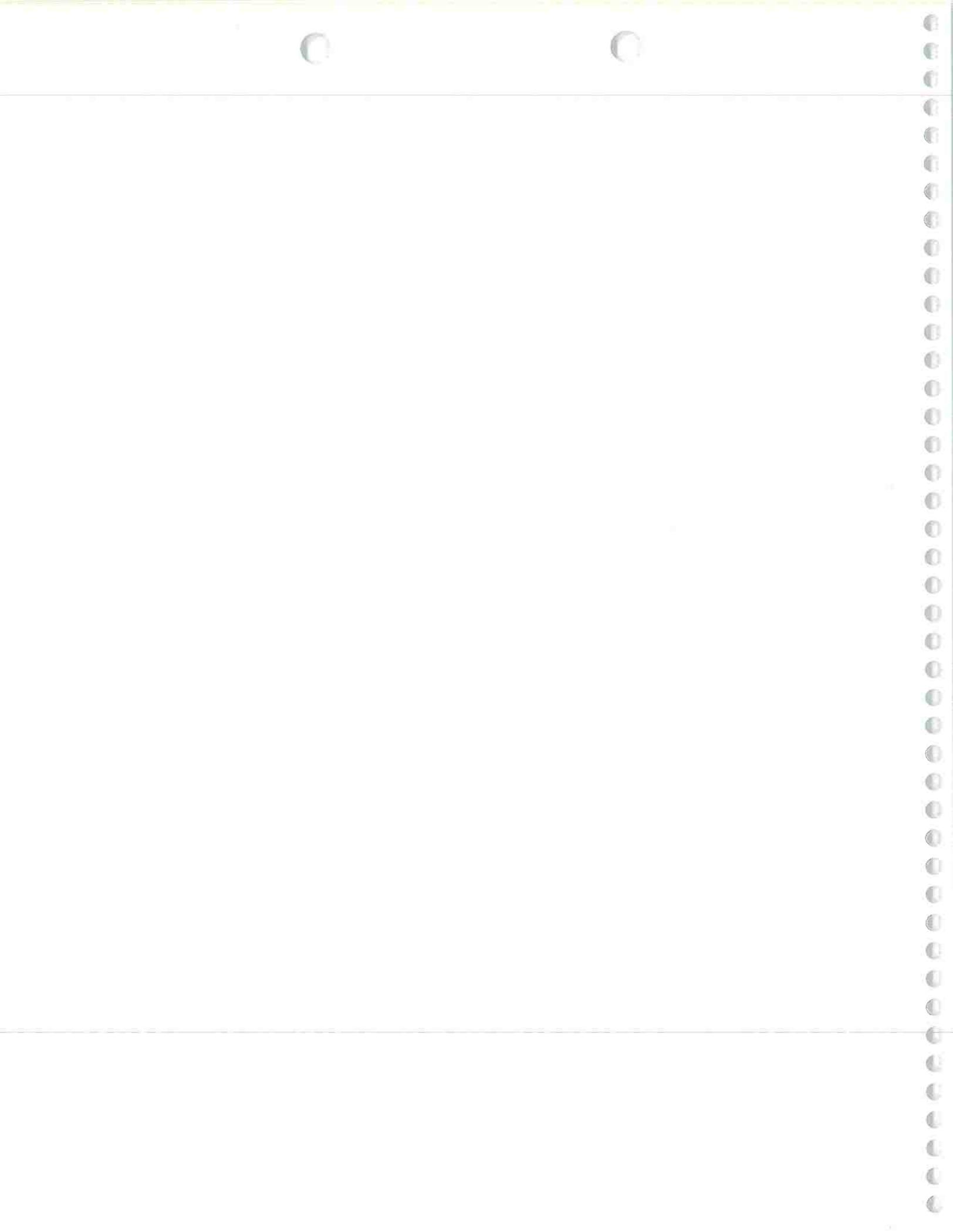
| Pipe Label | Contribution Area | $Q_{100}$ (ft³/sec) | Pipe Size (in) | Pipe Slope (ft/ft) | Pipe Capacity (ft³/sec) | Velocity @ design flow (ft/sec) |
|---|---|---|---|---|---|---|
| SD-1 | A | 1.20 | 18 | 0.005 | 8.1 | 3.3 |
| SD-2 | A+B | 2.29 | 18 | 0.005 | 8.1 | 3.9 |
| SD-3 | A+B | 2.29 | 18 | 0.020 | 16.1 | 6.2 |
| SD-4 | A+B+C | 3.52 | 18 | 0.005 | 8.1 | 3.9 |
| SD-5 | A+B+C+D | 4.42 | 18 | 0.005 | 8.1 | 4.4 |
| SD-6 | A+B+C+D | 4.42 | 18 | 0.005 | 8.1 | 4.6 |
| SD-7 | A+B+C+D | 4.42 | 18 | 0.005 | 8.1 | 4.6 |
| SD-8 | A+B+C+D+H | 4.95 | 24 | 0.005 | 17.3 | 4.7 |
| SD-6 | A+B+C+D+H+I | 8.50 | 24 | 0.005 | 17.3 | 5.5 |

## 4.3    Gutter Flow Calculations

This section analyzes the impacts of stormwater on the proposed Ascent Place and Washington Court with regards to flow in the planned concrete curb and gutter and flooding in the 7 foot wide parking lane and adjacent traveled way. Per the Humboldt County Roadway Design Manual the $Q_{100}$ flow shall not flood the traveled way (at depressed sections) to avoid creating a vehicular safety hazard. In addition, the $Q_{100}$ flow shall not overtop the 6" tall curb.

This project will utilize a Caltrans A2-6 curb and gutter from their standard details, which has a 6-inch tall curb ("H2" in detail) and a 2 foot wide gutter pan, as shown:
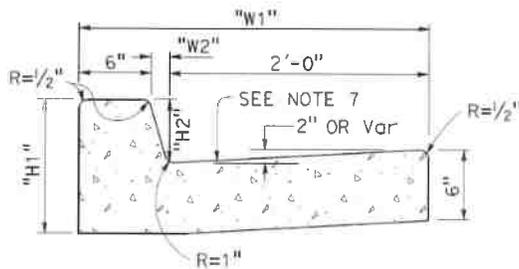


**Caltrans A2-6 Curb & Gutter (Not To Scale)**

From the detail above, a Flow vs. Ponding Depth Table was generated based on the Modified version of Manning's Equation from the Federal Highway Administration's HEC 22 Urban Drainage Design Manual as shown:

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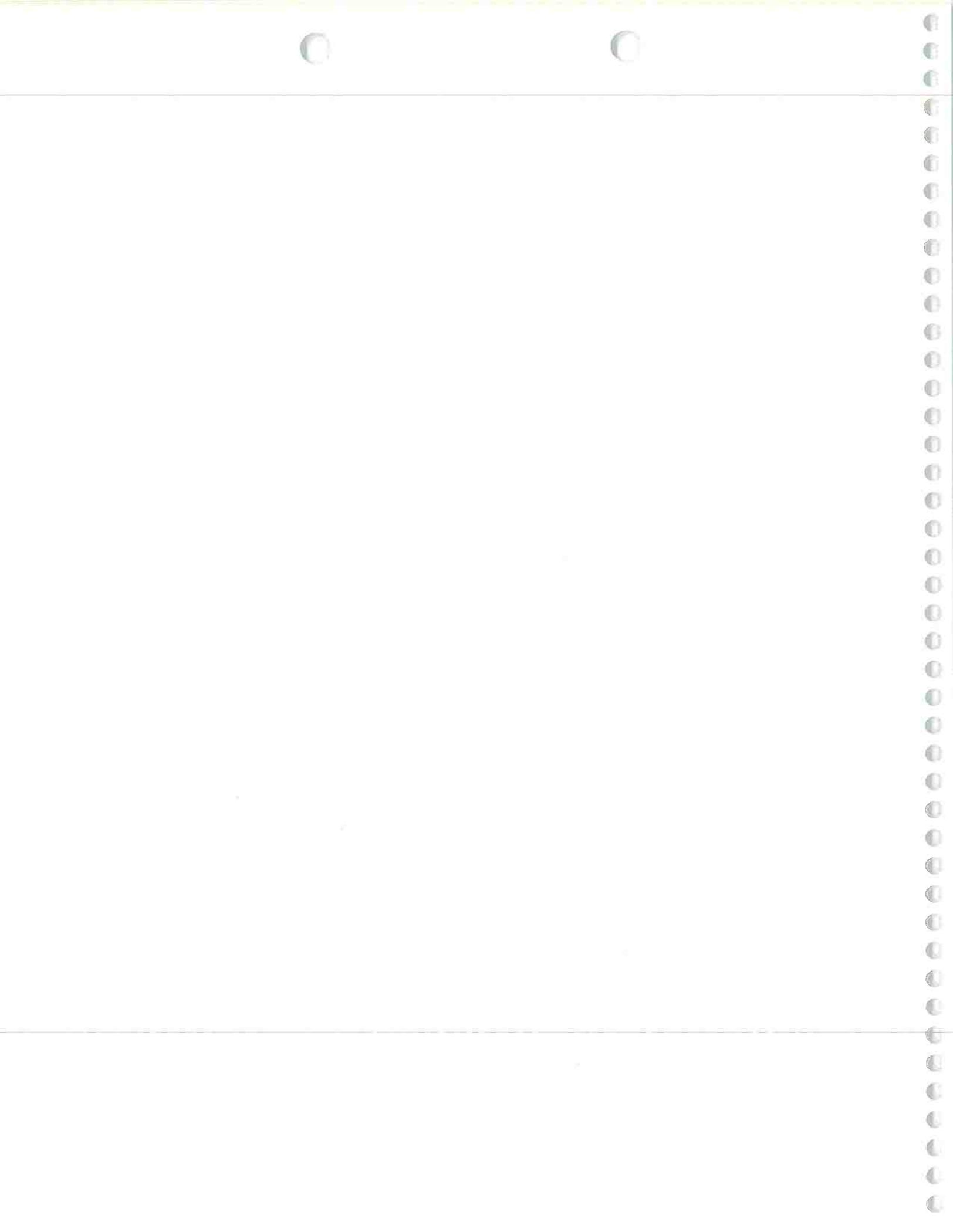
$$Q = \frac{0.56}{n} Sx^{1.67} S^{0.5} T^{2.67}$$

Where:

$Q$ = Flow Rate (ft³/s or cfs)

$n$ = Mannings Coefficient (Assumed as 0.015 for a composite section)

$S$ x = Cross Slope (ft/ft)

$S$ = Longitudinal Cross Slope of Roadway (ft/ft)

$T$ = Width of Flow / Spread (ft)

Do to the complexity and iterative nature of gutter flow calculations on composite sections, Nomographs were utilized to solve the condition of varying roadway and gutter cross slopes. These Nomographs have been included for reference in Appendix B4. In addition, the impacts of parked cars on the reduction of gutter capacity has been ignored. Given this data, a Flow vs. Ponding Depth Table was generated as shown below:

| Depth of Flow (ft) | Width of Flow / Spread, T (ft) | Slope of Roadway / Longitudinal Cross Slope, S (ft/ft) | | |
|---|---|---|---|---|
| | | 0.005 | 0.01 | 0.015 |
| 0.1 | 1.2 | 0.07 | 0.10 | 0.12 |
| 0.2 | 3.1 | 0.44 | 0.62 | 0.76 |
| 0.3 | 6.5 | 1.54 | 2.2 | 2.7 |
| 0.4 | 9.8 | 3.92 | 5.5 | 6.8 |
| 0.5 | 13 | 8.0 | 11.3 | 13.9 |

Flow, Q (cfs) from Flow Depth and Roadway Slopes

**Flow vs. Ponding Depth Table**

From Section 4.1, the following locations are identified where ponding could occur:

| Drainage Inlet # (1) | $Q_{100}$ (ft³/sec) | Slope, S (ft/ft) | $Q_{100}$ Flow Width (Spread) (ft) |
|---|---|---|---|
| DI-1 | 1.20 | 0.015 | 4 |
| DI-2 | 1.10 | 0.015 | 4 |
| DI-3 (2) | 1.23 | 0.010 | 3 |
| DI-4 (2) | 0.90 | 0.010 | 3 |
| DI-5 | 0.54 | 0.015 | 1 |
| DI-6(3) | 3.54 | 0.015 | 7 |
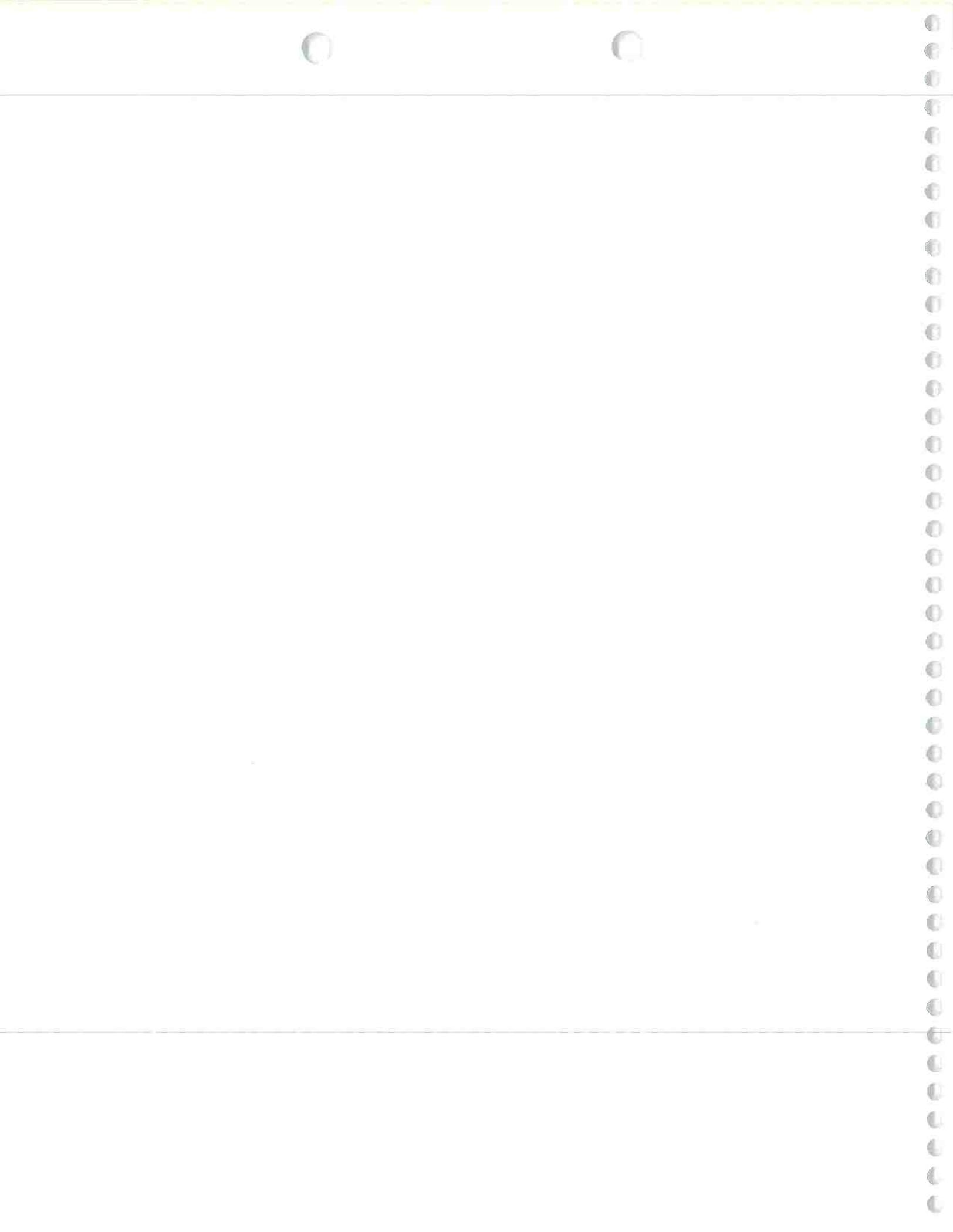
(1) Vegetated Swale piping and interconnecting inlets have been ignored in this draft study due to low flows in the vegetated swales.
(2) Ponding adjacent to these drainage inlets less likely do to their location at the edge of corner stormwater planter systems.
(3) Adding an additional drainage inlet across from DI-5 to reduce flow to DI-6 will be considered during the improvement plan phase to limit roadway ponding.

The above table shows that the extent of $Q_{100}$ ponding at the proposed drainage inlets. Thus, the drainage system is acceptable and has enough capacity in the gutters while enduring a 100-year storm event to not flood the travel lanes in the subdivision.

## 4.4    Drainage Inlet Calculations

Storm drain catch basins are critical for capturing excess stormwater flow in the proposed subdivision that cannot be reasonably routed into stormwater planter / vegetated swale areas to be infiltrated into the ground.

It is anticipated at this time that Caltrans Type GO Drainage Inlets with bicycle safe Type 24-12x grates will be used in the project. Type GO Drainage Inlets are "combination" inlets in the sense that they include both a grate and a curb opening. Inlet placement will generally be in sags in the roadway vertical profile grade as shown on the Stormwater Control Plan in Appendix A1. Type G1 inlets, which do not do not include curb openings, may be incorporated into the design phase on the corner Stormwater Planter Systems. If so, they will be included in the project's Final Drainage Analysis. Final location and sizing of drain inlets will be determined during the improvement plan phase.

Combination drainage inlets operate as weirs when examining inlet capacity per FHWA's HEC 22. Per Appendix B6, inlet capacity is **10.6 cfs** at a depth of 6 inches deep (curb height). Thus, in examining the actual flow into each drainage inlet per the previous section these inlets should not have any issues handling the projected stormwater runoff.

## 4.5    Pipe Capacity Calculations

Drainage Inlets will be connected by required storm drain pipes to covey excess water flow. Per County Standards, 18" diameter Corrugated Plastic Pipes (CPP) are the minimum preferred size as they are able to accommodate sediment build up over time and can be easily cleaned. 24" pipe will be used between DI-5 and basin inlet and between the terminal basin and connection to the existing 30" storm drain system.

A capacity calculation can be done using Manning's Equation as follows:

$$Q = \frac{1.49}{n} A R^{0.67} S^{0.5}$$

Where:

$Q$ = Flow Rate (ft³/s or cfs)

17
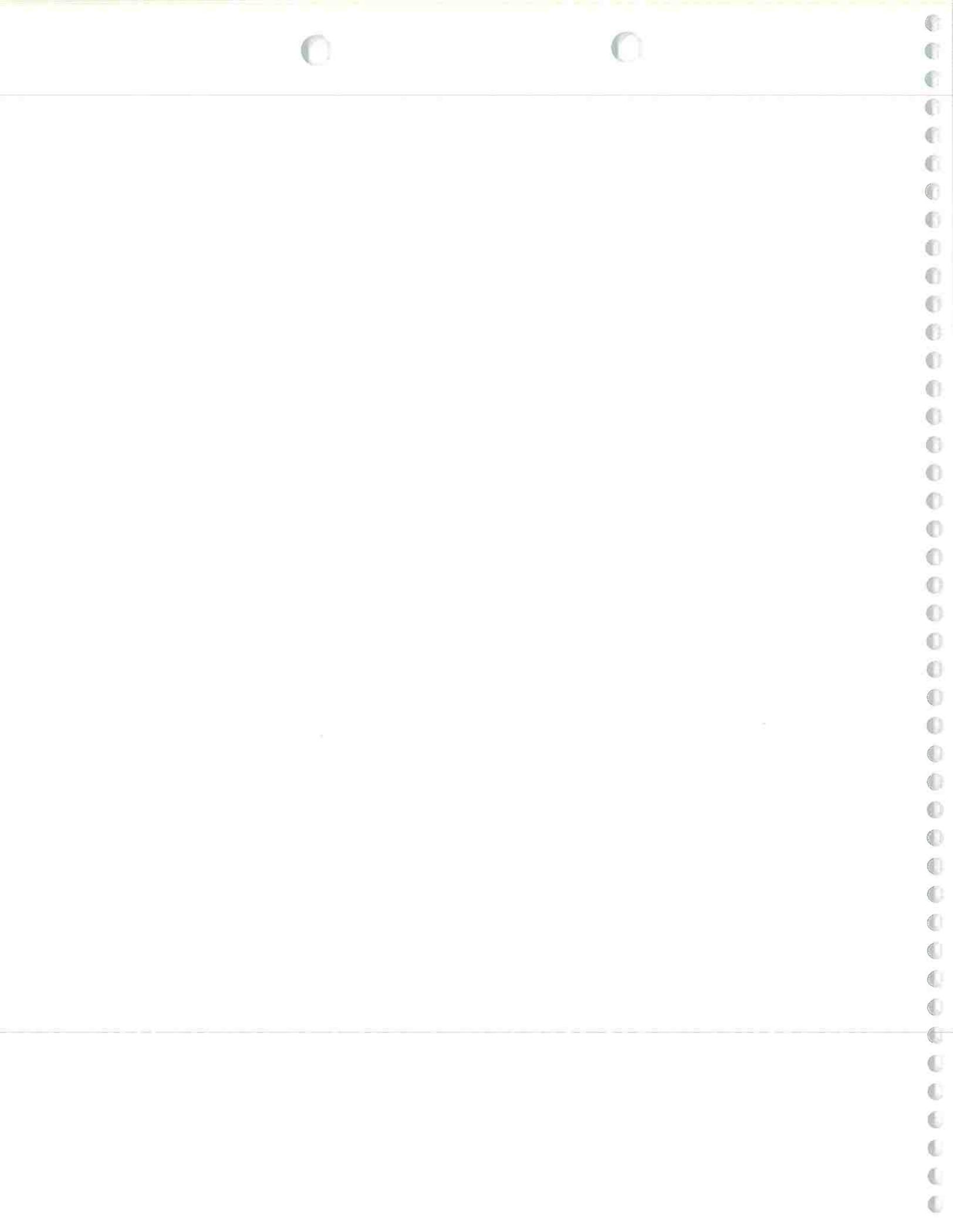
$n$ = Mannings Coefficient (Assumed as 0.012 for smooth wall CPP, 0.010 for smooth wall PVC)

$A$ = Pipe Area (ft)

$R$ = Hydraulic Radius (ft/ft)

$S$ = Pipe Slope (ft/ft) = See Improvement Plans

For 18" CPP Pipe Capacity (0.5% pipe slope, typical):

$$Q = (1.49/.012) * (1.77) * (0.375)^{0.67} * (0.005)^{0.5} = 8.1 \text{ cfs}$$

For 18" CPP Pipe Capacity (2.0% pipe slope on SD-3 See Drainage Basin Map):

$$Q = (1.49/.012) * (1.77) * (0.375)^{0.67} * (0.02)^{0.5} = 16.1 \text{ cfs}$$

For 24" CPP Pipe Capacity (0.5% pipe slope, typical):

$$Q = (1.49/.012) * (3.14) * (0.50)^{0.67} * (0.005)^{0.5} = 17.3 \text{ cfs}$$

For 30" CPP Pipe Capacity (existing on Washington Avenue w/ assumed 0.2% min. slope):

$$Q = (1.49/.012) * (4.90) * (0.625)^{0.67} * (0.002)^{0.5} = 19.9 \text{ cfs}$$

With reference back to Section 4.2, a 24" pipe running at 0.5% slope would have adequate capacity to convey the $Q_{100}$ for this subdivision, if required.

## 4.6    Off-site Analysis & Discussion

A 24" pipe leaves the onsite Bio-retention / Overflow Basin introduced in Section 2.6 via an outlet structure and this pipe extends to an existing drainage inlet that was installed during the Washington Gardens Subdivision development in the 1990's. This drainage inlet is the start of an existing 30" CPP Storm Drain Pipe System that runs north of the Washington Terrace Subdivision in a network of pipes and drainage inlets into an existing drainage channel and large stormwater basin constructed during the Central Estates Subdivision. This stormwater piping and the downstream basins on Central Estates were sized and designed to accommodate future development on the subject parcel and adjacent parcels on Washington Avenue. With reference to the previous section, the existing 30" storm drain pipe running at an assumed 0.2% slope has a capacity of 19.9 cfs. As both detention and retention measures have been implemented the Washington Terrace subdivision development for water quality and to reduce peak flows, it appears as though this pipe has more than enough capacity to handle the additional loading from the Washington Terrace Subdivision project during high flow events.

18
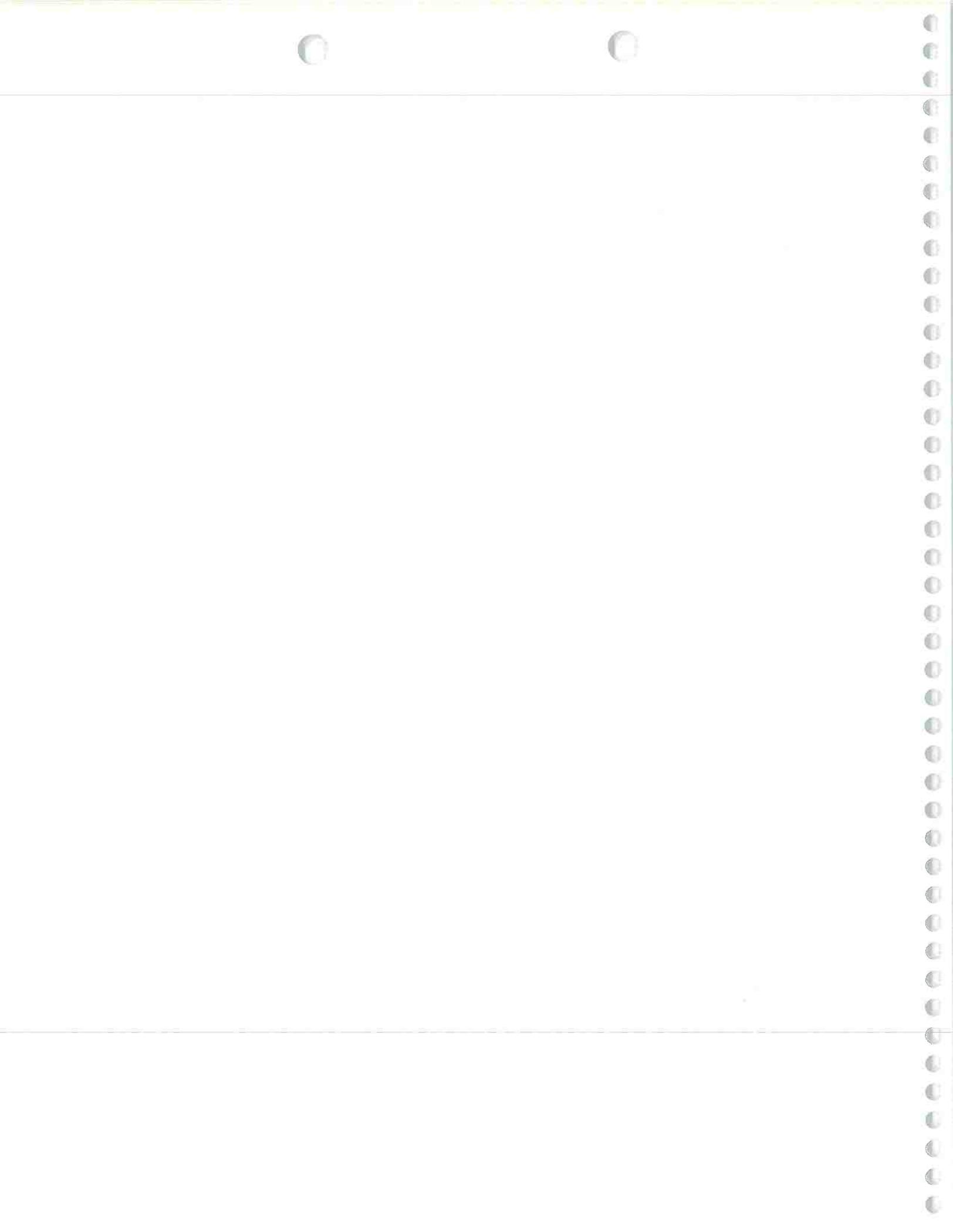
## 5.0   PEAK RUN-OFF CONTROL

As discussed in Section 2.6, a Stormwater Bio-Retention / Overflow Basin System will be designed treat the 85th percentile 24 hour storm and promote infiltration as well as to limit the proposed projects site stormwater discharge to the pre-development flows of a 2-year rainfall event. The following sections describe peak flow run-off control.

### 5.1   Vegetated Swale Capacity

As discussed and shown in a detail in Section 2.4, the Vegetated Swale will consist of a +/- 1 foot deep channel, 2 foot wide bottom, have 6" natural check dams, and run at a 1.5% slope easterly toward an overflow drainage inlet set 6" above flow line. The terminal vegetated swale will overflow into the projects terminal / overflow basin on the far north end of the site. This vegetated swale will provide water quality benefits as discussed in Section 2.4. Assuming a minimum 6-inch water depth, utilizing a runoff coefficient of $n = 0.03$ (for rough grass), and using Manning's Equation for Open Channel Flow as presented in Section 4.5 of this report:

$$Q_{swale} = (1.49/.03) * (1.75) * (0.34)^{0.67} * (0.015)^{0.5} = \mathbf{Q_{swale} = 5.1\ cfs}$$

Per **Section 4.1**, post construction $Q_{100}$ runoff for Drainage Basin E, which addresses runoff from Lots 34-40, is **1.4 cfs = Min Required = $Q_s$.**

→ The proposed swale design meets the required flow.

Per **Section 4.1**, post construction $Q_{100}$ runoff for Drainage Basins F, G, & J, which addresses runoff from a portion of Washington Court, Lots 9-13, excluding overflow from the upstream swale is **1.7 cfs = Min Required = $Q_s$.** Conservatively adding the upstream swale of 1.4 cfs there is more than enough capacity.

→ The proposed swale design meets the required flow.

Since flow velocity will be under 2 feet per second at a 1.5% longitudinal swale slope, and gentle side slopes will be used, a naturally seeded and mulched surface should be sufficient to prevent erosion and turf mat reinforcement is not recommended.

As the interconnecting piping between swales will be 18" minimum in diameter, the flow from the swales will be low and so pipe capacity calculations for this network have been excluded from this draft report. These calculations will be included into the Final Drainage Analysis.

### 5.2   Overflow Basin Design Parameters

#### Basin Design Flow

Per Section 3.0, Macro Hydrology Analysis we have the following:

2-Year Storm Pre-Development Drainage Flow: <u>**$Q_2$ = 2.9 cfs**</u>
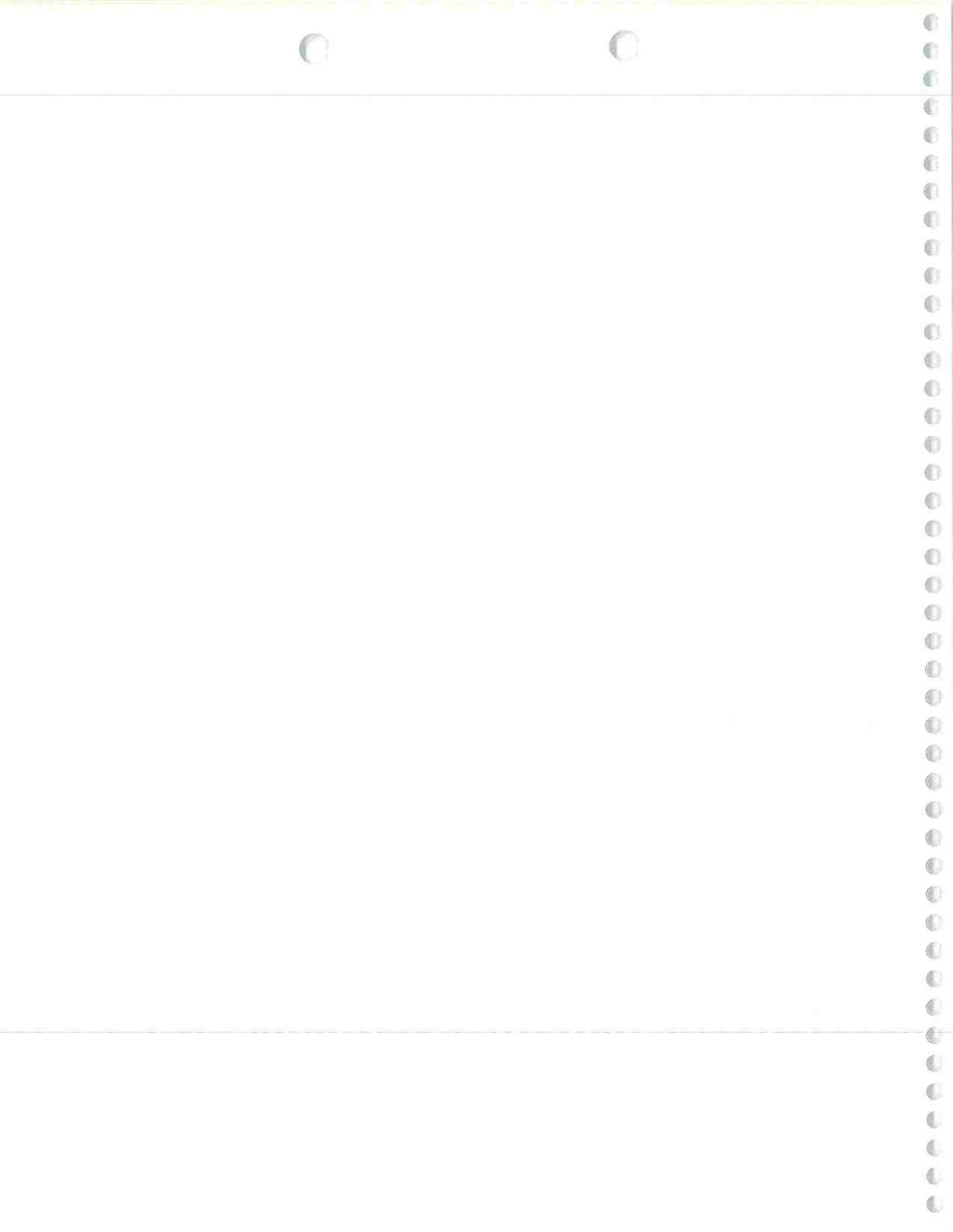
100-Year Storm Post-Development Drainage Flow: **Q$_{100}$ = 15 cfs**

## Required Basin Storage:

Volume for the stormwater detention systems have been sized using the Skupe Method using the following equation:

Volume (V) = [K*(Q$_{100}$-Q$_2$)*(3Tc)]*0.5,

T$_c$ = 10 min. = 600 seconds (units for equation), and the K factor used is 1.5

Volume (V) = [1.5*(15-2.9)*(3*600)]*0.5 = **16335 Cu-Ft = Required Storage.**

Note, per Section 3.0 the entire site area was used in calculating the total Q100 flow. This is conservative as the parcels area includes the areas of Washington Avenue which will continue to drain north and east as it currently does in existing drainage patterns. Basin sizing will be refined during the improvement plan phase and incorporated into the Final Drainage Analysis.

## 5.3 Outlet Structure Design

As discussed in Section 2.5, a Stormwater Bio-Retention / Overflow Basin System will be designed to limit the proposed projects site stormwater discharge to the pre-development flows of a 2-year rainfall event as well as treat the 85th percentile 24 hour storm and promote infiltration. Outlet structure sizing and design is as follows:

## Outlet Structure Orifice Sizing:

The allowable outflow based on the pre-development **2-year storm is 2.9 cfs.** A metering pipe will ensure that the outlet structure releases water through a small pipe at this flow rate until the basin reaches overflow condition. Orifice control can be sized using the following equation:

Orifice Equation: $$Q = C_a A (2gH)^{0.5}$$

Where: $Q$ = Flow Rate (ft$^3$/s or cfs) = **2.9 cfs from above**

$C_a$ = Discharge Coefficient = 0.67

$A$ = Area of orifice (ft$^2$)

$g$ = gravity = 32.2 ft/s$^2$

$H$ = Head above center orifice (ft) = 2.5 ft average assumed

A = (2.9 cfs) / [(0.67)(2*32.2*2.5)$^{0.5}$] = 0.34 ft$^2$ = 0.65 ft dia = use 6" pipe (conservative)
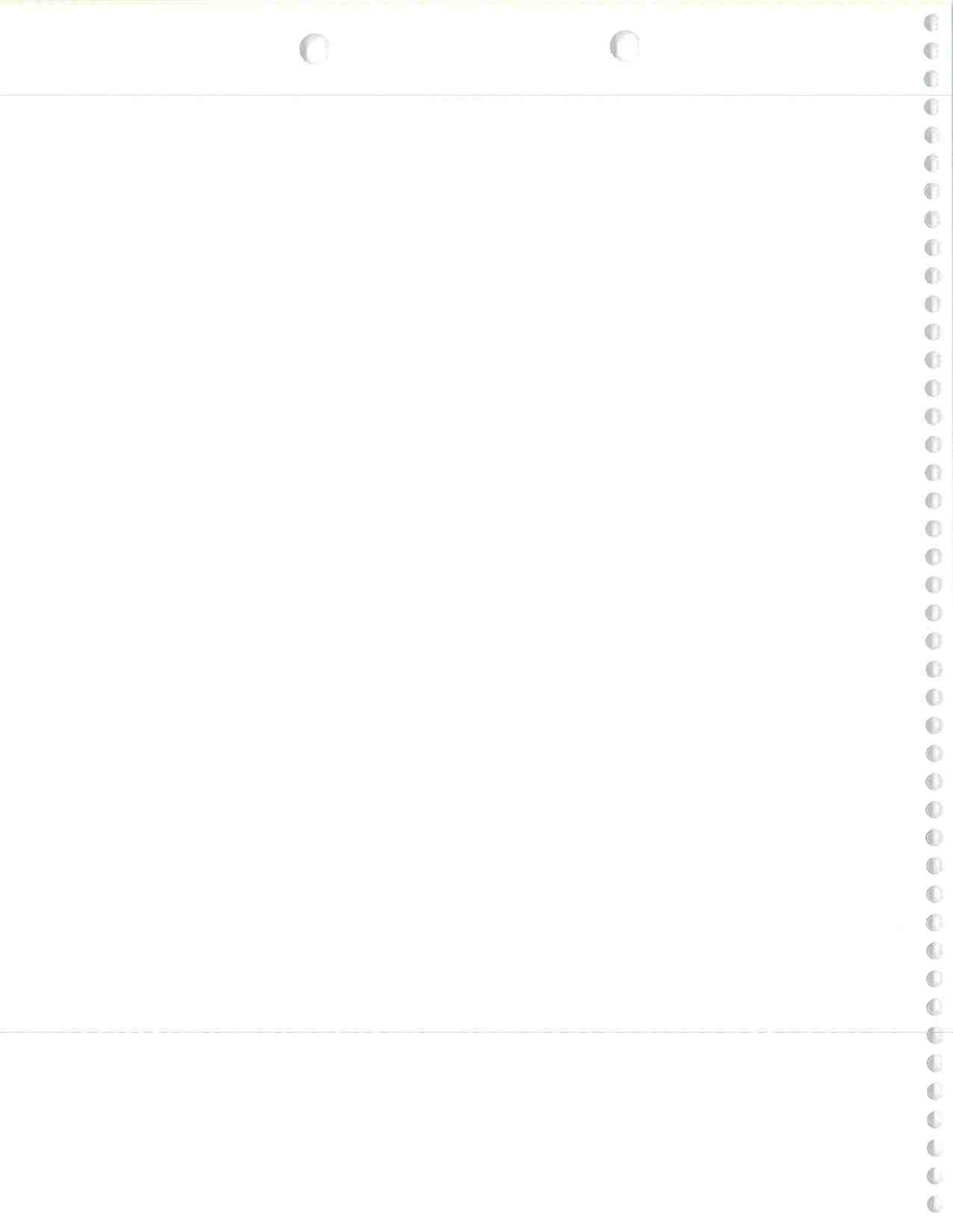
## Stormwater Basin Outlet Structure:

A typical basin outlet structure is shown below. The structure will include inlet and overflow grates, a flow restriction orifice by way of a 6" PVC outlet pipe inside the outlet structure to reduce (meter) the release of flow to the required amount stated in Section 2.2. A 4" perforated drain pipe can reduce oversaturation of the soil media / gravel layer of the pond (Bio-retention infiltration layer & Peak Overflow Storage) while retaining stormwater quality benefits. Specifying this underdrain will be considered during the improvement plan phase as the existing on-site soils are expected to have an acceptable percolation rate and a network of subsurface piping can be maintenance intensive, especially at the bottom of a deep basin. This outlet structure is both meant to infiltrate the "first flush" of contaminants from the road and other impervious areas not addressed by the stormwater planter systems, vegetated swales, and other design measures after a rain event. This is in addition to handling larger storm events, which could push the basin into overflow condition.
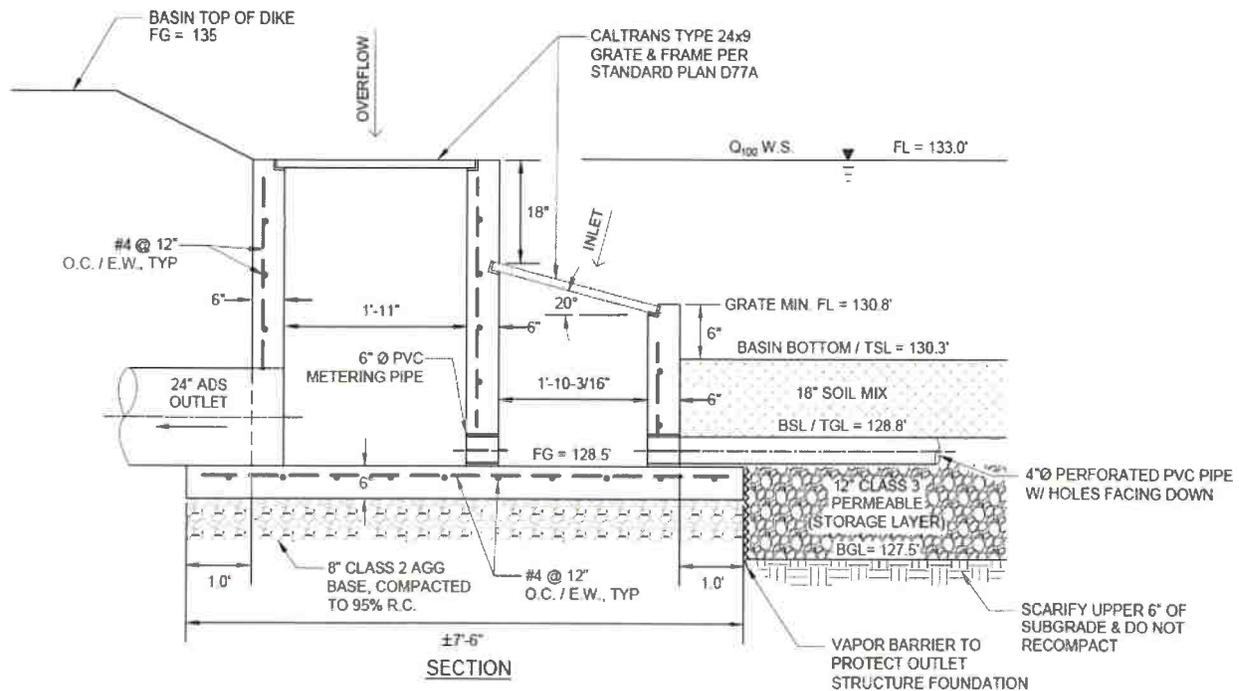


**Typical Bio-Retention / Overflow Basin Outlet Structure & Section Detail**

21
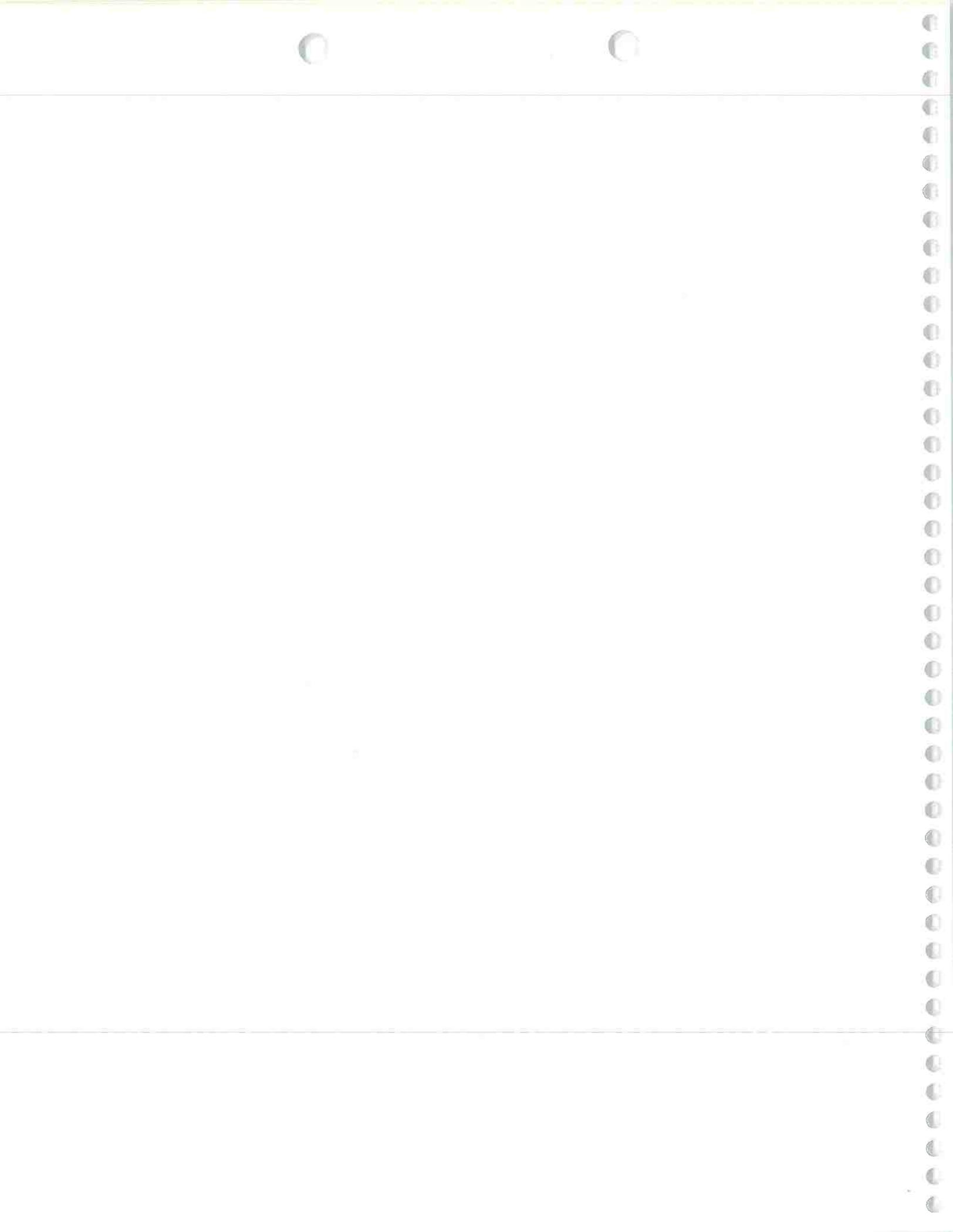
# 6.0  STORMWATER FACILITY MAINTENANCE

## 6.1  Maintenance Overview & Considerations

Low Impact Development strategies require additional maintenance considerations and necessitate a designated responsible party to do periodic maintenance.  Maintenance for the storm drainage mitigation measures discussed in this report may include the following:

1. Removing Trash and sediment from curb and basin inlets grates and inlet sumps.
2. Replacing damaged or stolen drainage structure grates and cleanout caps.
3. Clearing sediment from curb cuts to as not to inhibit storm water inflow.
4. Maintaining / replacing any dead / diseased / dying trees and plantings.
5. Replacing and mulch in Stormwater Planter areas.
6. Mowing and vegetation management of the vegetated swale.

Many "off the shelf" Low Impact Development Systems such as subsurface detention systems, drywells, and the like, can require more extensive measures such as the use of "Vactor" trucks, and other similar equipment to clean and maintain.  Such vehicles are typically only owned by public agencies.  As such, these systems are not being proposed for use on this project.

Examples on how these storm drainage strategies could be maintained and by whom include Road Maintenance Associations, Homeowner Covenants, Codes, and Restrictions (CC&R's) and Assessment Districts.  Another potential option for the McKinleyville area is having facilities such as the proposed Vegetated Swale, and Bio-retention / Overflow Basin included in an Open Space Maintenance Zone (OSMZ) agreement with the McKinleyville Community Services District (MCSD) and district staff will conduct maintenance.

## 6.2  Maintenance Checklists

See Appendix C for sample maintenance check lists from the Humboldt County LID Manual used for Storm Drainage and Low Impact Development systems that is typically used in Operation and Maintenance Manuals (O & M Manuals).
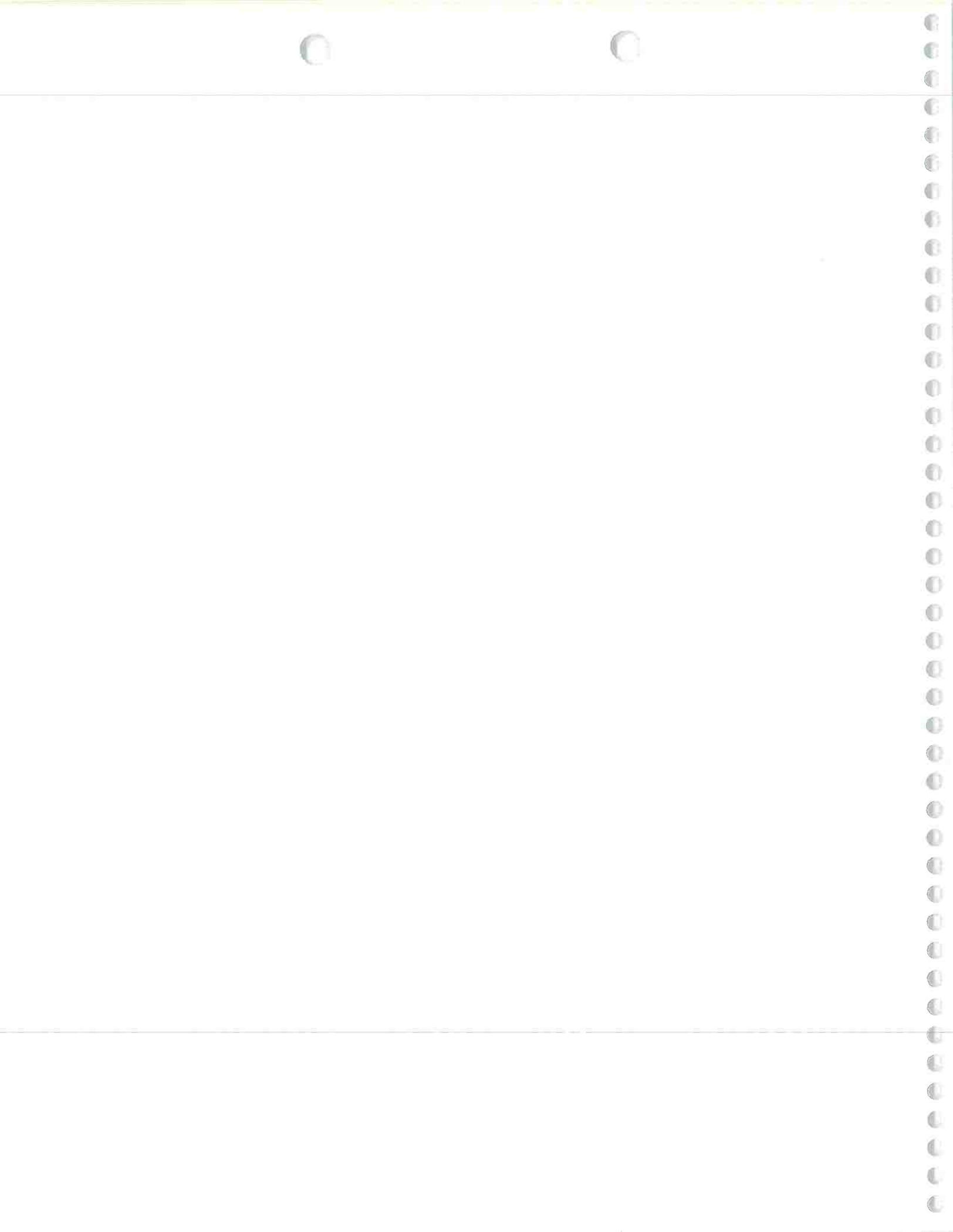
# APPENDIX A

# STORMWATER CONTROL / LID
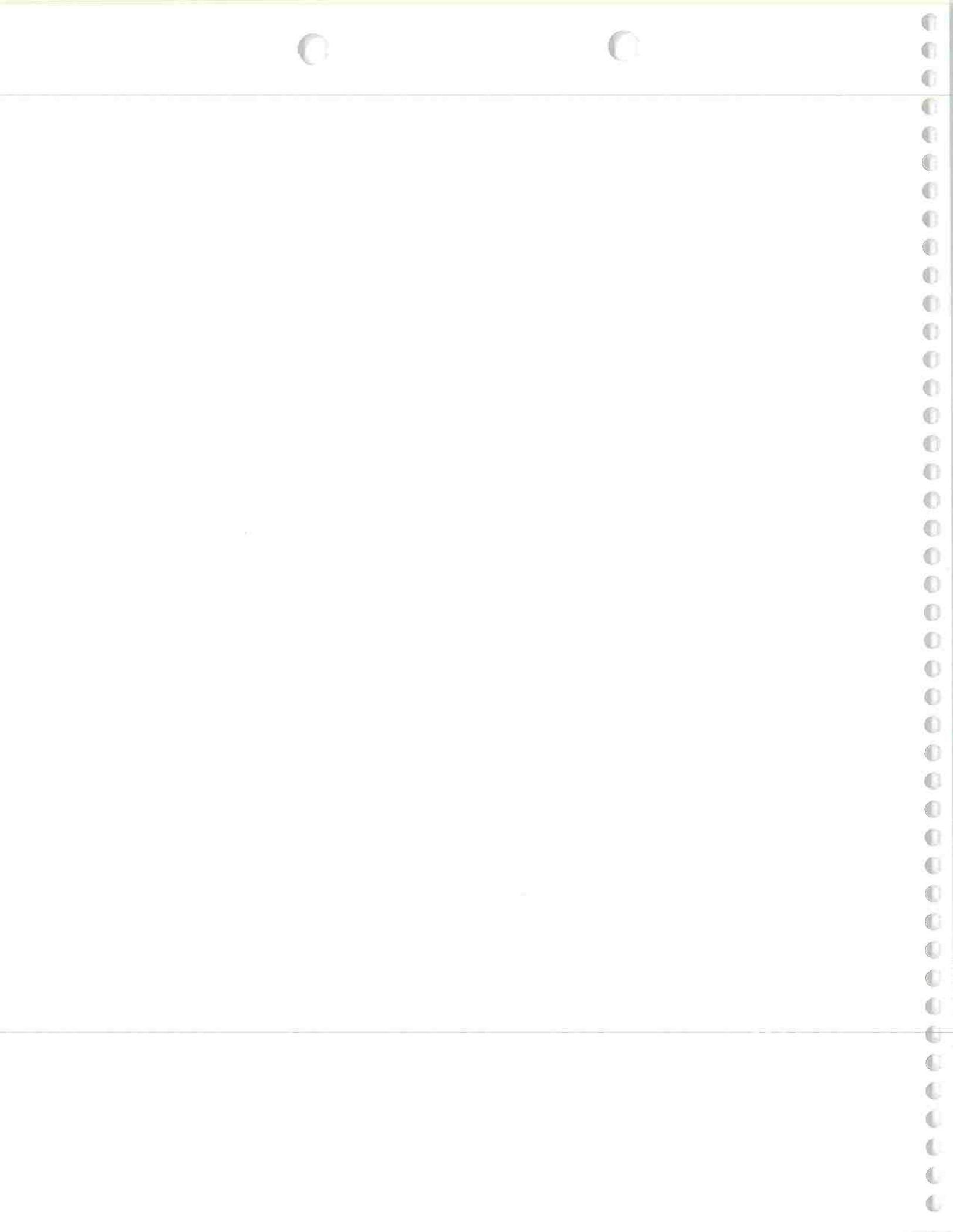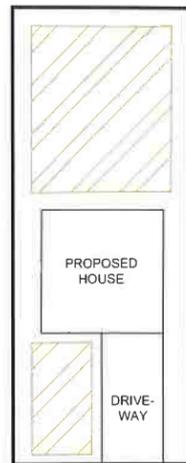
# NOTES (Typical Bio-Retention Area)

1. TOPSOIL IN BIO-RETENTION AREA SHALL MEET THE FOLLOWING CHARACTERISTICS:
   - 60% TO 70% SAND
   - 20% TO 40% COMPOSTED ORGANIC MATTER
   - <5% CLAY
   - HAVE A MIN. INFILTRATION RATE = 5" / HR
2. TSL = TOP SOIL LAYER
   TGL = TOP GRAVEL LAYER
   BGL = BOTTOM OF GRAVEL LAYER / SUBGRADE

PLANTINGS

TSL — 18" MIN. TOPSOIL, SEE NOTE 1.

TGL — 4" PERFORATED SDR 35 PIPE W/ HOLES FACING DOWN, WHERE SPECIFIED ON PLAN, EXTENDED TO DRAINAGE STRUCTURE

BGL — 12" MIN CLASS 3 DRAIN ROCK

SCARIFY UPPER 4" OF <E> NATIVE TOPSOIL / SUBGRADE

### (B) TYPICAL BIO-RETENTION AREA & STORMWATER PLANTER SECTION
SCALE: N.T.S.

# NOTES

1. SOIL QUALITY IMPROVEMENT AREAS WILL BE LOCATED IN THE YARDS OF EACH LOT. MATERIAL TO CONSIST OF 8 INCHES OF TOPSOIL HARVESTED ONSITE, PLACED ON SUBGRADE THAT IS SCARIFIED MIN. 4 INCHES DEEP, FOR A TOTAL DEPTH OF 12 INCHES. COVERAGE AREA VARIES BY LOT DIMENSIONS.
2. YARDS ARE PROPOSED TO HAVE GRASS SOD INSTALLED ON THE TOPSOIL LAYER.

PROPOSED HOUSE

DRIVEWAY

### (A) TYPICAL SOIL-IMPROVEMENT AREA
N.T.S

BASIN OUTLET STRUCTURE w/ METERING ORIFICE

PARCEL B BIO-RETENTION / OVERFLOW BASIN
16,335 c.f. Storage
4000 s.f. treatment
INV 133.0



## STORMWATER CONTROL STRATEGY

- LOTS 2 - 8 AND A PORTION OF WASHINGTON COURT WILL DRAIN TOWARD A VEGETATED SWALE SYSTEM (PARCEL B). OVERFLOW FROM THIS SWALE WILL RUN INTO THE BIO-RETENTION / OVERFLOW BASIN (PARCEL C).
- LOT 1, LOTS 9 - 20, AND A PORTION OF WASHINGTON COURT, WILL DRAIN TO THE STREET AND STORMWATER COLLECTED VIA TWO DRAINAGE INLETS AND PIPING TO THE BIO-RETENTION / OVERFLOW BASIN (PARCEL C). THE BASIN IS SIZED TO PROVIDE BOTH STORMWATER QUALITY AND QUANTITY BENEFITS AND ALSO ALLOW THE HANDLING OF STORMWATER QUALITY RUNOFF NOT ADDRESSED BY UPSTREAM DRAINAGE MANAGEMENT STRATEGIES DUE TO SITE CONSTRAINTS (I.E. SMALLER LOT SIZES, REDUCED STREET WIDTHS).
- LOTS 21 - 22 AND A PORTION OF WASHINGTON COURT AND ASCENT PLACE WILL DRAIN TOWARD A CORNER STORMWATER PLANTER SYSTEM, WITH OVERFLOW INTO THE STORM DRAIN SYSTEM.
- LOTS 23 - 26 AND LOTS 27 - 30 AND PORTIONS OF ASCENT PLACE WILL DRAIN TOWARD MID-BLOCK STORMWATER PLANTER SYSTEMS, WITH OVERFLOW INTO THE STORM DRAIN SYSTEM.
- LOTS 31 - 33, FRONT YARDS OF LOTS 36 - 40, AND A PORTION OF ASCENT PLACE WILL DRAIN TOWARD A CORNER STORMWATER PLANTER SYSTEM, WITH OVERFLOW INTO THE STORM DRAIN SYSTEM.
- LOTS 34 - 40 FROM REAR OF FRONT YARDS TO THE BACK OF LOT WILL DRAIN TOWARD A VEGETATED SWALE SYSTEM (PARCEL A), WHICH HAS A TERMINAL OVERFLOW DRAINAGE INLET AND PIPING CONNECTING TO A SWALE TO THE NORTH (PARCEL B).
- WASHINGTON AVENUE FRONTAGE IMPROVEMENT DRAINAGE WILL BE COLLECTED BY A NEW DRAINAGE INLET AND PIPING EXTENSION AND CONVEY FLOW TO THE EXISTING STORM DRAIN SYSTEM ON THE NORTH END OF THE SITE.

## LEGEND

| | |
|---|---|
| | BOUNDARY LINE OF SUBJECT PROPERTY |
| | LOT LINES OF ADJACENT LOTS |
| | PROPOSED LOT LINES |
| | PROPOSED EASEMENT LINES |
| | EXISTING EASEMENT LINES |
| | PROPOSED BUILDING SETBACKS |
| | EXISTING STORM DRAIN INLET & LINE |
| | PROPOSED STORM DRAIN SYSTEM |
| | PROPOSED STORM DRAIN MANHOLE |
| | VEGETATED SWALE AREA (SEE DETAIL E THIS SHEET) |
| | BIO-RETENTION CELLS (SEE DETAILS C & D THIS SHEET) |
| | BIO-RETENTION / OVERFLOW BASIN AREA (SEE DETAIL ON SHEET 2 ON TENTATIVE MAP) |
| | SOIL IMPROVEMENT AREA - ALL LOTS (SEE DETAIL A THIS SHEET) |
| | STREET TREES |
| DM-1 | DRAINAGE MANAGEMENT AREA SEE LID WORKSHEETS FOR CALCULATIONS |

## DRAINAGE MANAGEMENT AREA (SQUARE-FEET)

| | |
|---|---|
| DM-1 = | 0.62 ACRES |
| DM-2 = | 0.61 ACRES |
| DM-3 = | 0.47 ACRES |
| DM-4 = | 0.71 ACRES |
| DM-5 = | 0.87 ACRES |
| DM-6 = | 0.41 ACRES |
| DM-7 = | 2.15 ACRES |
| DM-8 = | 0.57 ACRES |

## HYDROLOGIC SOIL GROUP

THE PROJECT SITE FALLS UNDER HYDROLOGIC SOIL GROUP B.
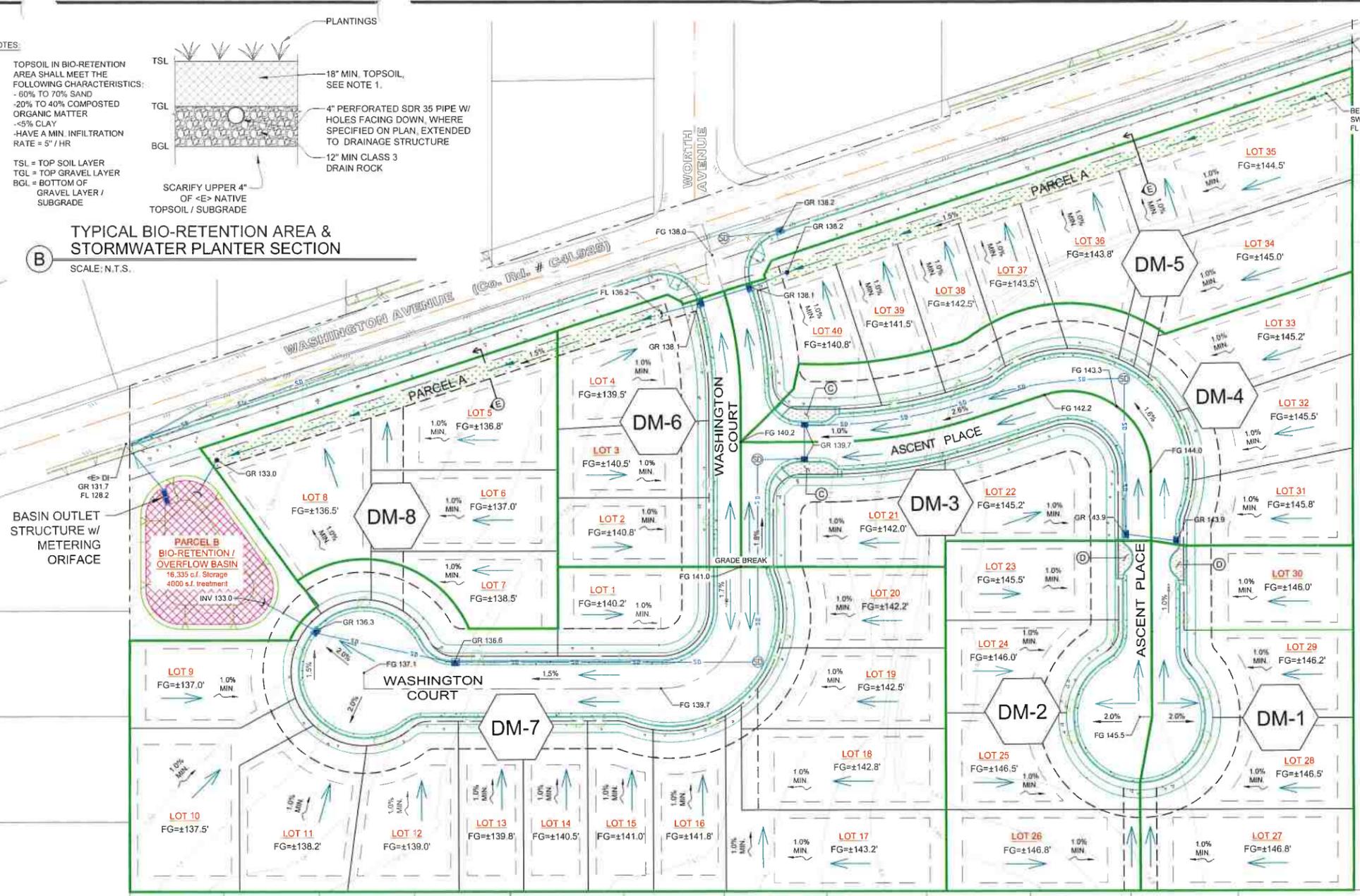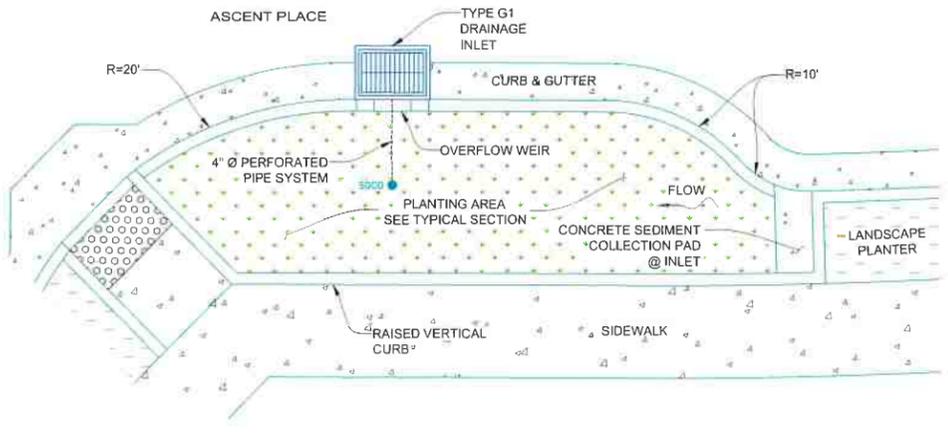
### (C) TYPICAL STORMWATER PLANTER (CORNER)
SCALE: N.T.S.

ASCENT PLACE · TYPE G1 DRAINAGE INLET · CURB & GUTTER · R=20' · R=10' · 4" Ø PERFORATED PIPE SYSTEM · OVERFLOW WEIR · FLOW · PLANTING AREA SEE TYPICAL SECTION · CONCRETE SEDIMENT COLLECTION PAD @ INLET · LANDSCAPE PLANTER · RAISED VERTICAL CURB · SIDEWALK

### (D) TYPICAL STORMWATER PLANTER (MID-BLOCK)
SCALE: N.T.S

RAISED VERTICAL CURB · SIDEWALK · LANDSCAPE PLANTER · CONCRETE SEDIMENT COLLECTION PAD @ INLET · PLANTING AREA SEE TYPICAL SECTION · LANDSCAPE PLANTER · CURB & GUTTER · FLOW · TYPE GO CURB INLET · CURB & GUTTER · TYPE A1-6 VERTICAL CURB · ASCENT PLACE · R=10' · OVERFLOW WEIR · 4" Ø PERFORATED PIPE SYSTEM

### (E) TYPICAL VEGETATED SWALE DETAIL
N.T.S.

10' · <P> P/L · SEEDED & MULCHED SURFACE · 6" NATURAL CHECK DAM · 2 MAX · 2 MAX · SIDEWALK & PUE EASEMENT · PROPOSED LOTS SLOPE · 2'-0" MAX · 4" MIN. TOPSOIL · OVERFLOW DRAINAGE STRUCTURE WHERE SHOWN ON PLAN W/ BEEHIVE GRATE

0 40' 80' GRAPHIC SCALE

N

Plan area labels: WORTH AVENUE · WASHINGTON AVENUE (Co. Rd. # CAL686) · PARCEL A · WASHINGTON COURT · ASCENT PLACE

LOT 35 FG=±144.5' · LOT 34 FG=±145.0' · LOT 33 FG=±145.2' · LOT 32 FG=±145.5' · LOT 31 FG=±145.8' · LOT 30 FG=±146.0' · LOT 29 FG=±146.2' · LOT 28 FG=±146.8' · LOT 27 FG=±146.8' · LOT 26 FG=±146.8' · LOT 25 FG=±146.5' · LOT 24 FG=±146.0' · LOT 23 FG=±145.5' · LOT 22 FG=±145.2' · LOT 21 FG=±142.0' · LOT 20 FG=±142.2' · LOT 19 FG=±142.5' · LOT 18 FG=±142.8' · LOT 17 FG=±143.2' · LOT 16 FG=±141.8' · LOT 15 FG=±141.0' · LOT 14 FG=±140.5' · LOT 13 FG=±139.8' · LOT 12 FG=±139.0' · LOT 11 FG=±138.2' · LOT 10 FG=±137.5' · LOT 9 FG=±137.0' · LOT 8 FG=±136.5' · LOT 7 FG=±138.5' · LOT 6 FG=±137.0' · LOT 5 FG=±136.8' · LOT 4 FG=±139.5' · LOT 3 FG=±140.5' · LOT 2 FG=±140.8' · LOT 1 FG=±140.2' · LOT 36 FG=±143.8' · LOT 37 FG=±143.5' · LOT 38 FG=±142.5' · LOT 39 FG=±141.5' · LOT 40 FG=±140.8'

DM-1 · DM-2 · DM-3 · DM-4 · DM-5 · DM-6 · DM-7 · DM-8

**Regulated Projects Worksheet 1 - Humboldt Low Impact Development Stormwater Manual**

| DMA Name | Total Post Project Impervious Surface Area (square feet) | Pervious Self-Retaining Area[1] (square feet) | Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area | Does Ratio Achieve 3.5 : 1 ratio or better of Impervious Surface Area to Self-Retaining Pervious Surface Area (Yes or No)[2] |
|---|---|---|---|---|
| Example A | 500 | 150 | 3.3 : 1 | YES |
| Example B | 500 | 100 | 5.0 : 1 | NO |
| DM-1 | 13157 | 1 | 13157.0 : 1 | NO |
| DM-2 | 11422 | 1 | 11422.0 : 1 | NO |
| DM-3 | 11064 | 1 | 11064.0 : 1 | NO |
| DM-4 | 15814 | 1 | 15814.0 : 1 | NO |
| DM-5 | 13158 | 1 | 13158.0 : 1 | NO |
| DM-6 | 7922 | 1 | 7922.0 : 1 | NO |
| DM-7 | 44672 | 1 | 44672.0 : 1 | NO |
| DM-8 | 7042 | 1 | 7042.0 : 1 | NO |
| | | | : | |
| | | | : | |
| | | | : | |
| | | | : | |
| | | | : | |
| | | | : | |

1: Self-Retaining Areas where impervious surface runoff is directed to the Pervious Self-Retaining Area in accordance with Humboldt LID Manual - Part C, Section 6.0

2: If "Yes", Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area is equal to 3.5:1 or better (1.3:1 or better in the Shelter Cove MS4 area), then compliance with runoff reduction measures have been met for DMA.

If "No", Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area does not achieve 3.5:1 or better (1.3:1 in Shelter Cove), then compliance with runoff reduction measures have not been met for DMA (Complete Worksheet 2).

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | Formulas/Notes |
|---|---|---|---|---|---|

| DMA Name: | DM-1 | | | | |
|---|---|---|---|---|---|
| Total Post-Project Impervious Surface Area (square feet) | | A | 13157 | square feet | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 5309 | Gallons per 24 hours | C = A x B x 0.083 x 7.48 |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | | # of trees | | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | D | 4 | E | 400 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | F | 0 | G | 0 | square feet | G = F x 200 |

**Existing Trees (Credit for 50% of existing canopy area)**

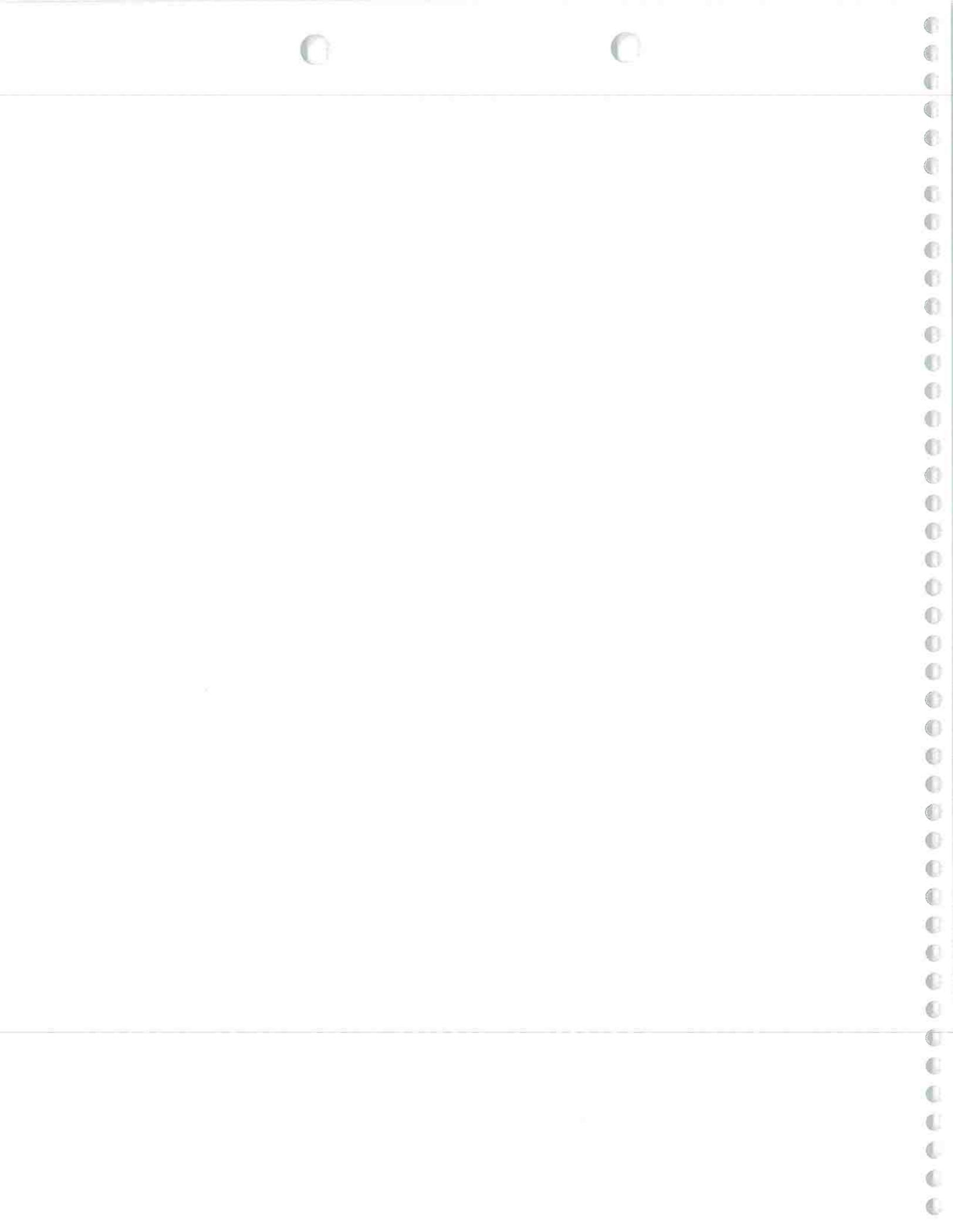| | | Canopy diameter (feet) | | | | |
|---|---|---|---|---|---|---|
| Tree #1 | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | K | 2.48 | | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | Gallons | | | | |
|---|---|---|---|---|---|---|
| Rain Barrels | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³** )

| | | cubic feet | | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | V | 7560 | square feet | V = Enter square foot value |
|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | Y | 0 | square feet | Y = Enter square foot value |
|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|

| Credits Total | AA | 7960 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|

| Post-Project Impervious Surface Area minus Site Design Measure Credits | BB | 5197 | square feet | BB = A - AA |
|---|---|---|---|---|

*[handwritten] X 0.04 = 208 SF Bio-Retention*

| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | CC | 2097 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
|---|---|---|---|---|

| Percent reduction in Impervious Surface Runoff Value* | DD | 60.5 | % | DD = ((C - CC ) / C) x 100% |
|---|---|---|---|---|

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by valueBB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill in [Enter Value] | Conversions Used: |
|---|---|---|
| Red | Calculated Value | 1 inch = 0.083 feet |
| Black | Fixed Value/Selectable Value | 1 cubic foot = 7.48 gallons |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

# check with agency with project area jurisdiction for requirements

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | | Formulas/Notes |
|---|---|---|---|---|---|---|
| DMA Name: | DM-2 | | | | | |
| Total Post-Project Impervious Surface Area (square feet) | | A | 11422 | square feet | | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 4609 | Gallons per 24 hours | | C = A x B x 0.083 x 7.48 |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier  Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | | | # of trees | | | | |
|---|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | | D | 4 | E | 400 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | | F | 0 | G | 0 | square feet | G = F x 200 |

Existing Trees (Credit for 50% of existing canopy area)

| | | | Canopy diameter (feet) | | | | |
|---|---|---|---|---|---|---|---|
| Tree #1 | | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | | K | 2.48 | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | | Gallons | | | | |
|---|---|---|---|---|---|---|---|
| Rain Barrels | | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**)**

| | | | cubic feet | | | | |
|---|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|---|

**Soil Quality improvement**

| Credit per square foot of soil quality improvement | | V | 7321 | square feet | V = Enter square foot value |
|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | Y | 0 | square feet | Y = Enter square foot value |
|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer# | | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|---|

| Credits Total | | AA | 7721 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|---|

| Post-Project Impervious Surface Area minus Site Design Measure Credits | | BB | 3701 | square feet | BB = A - AA |
|---|---|---|---|---|---|

*[handwritten: X 0.04 = 148 SF  Bio-Retention]*

| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | | CC | 1494 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
|---|---|---|---|---|---|

| Percent reduction in Impervious Surface Runoff Value* | | DD | 67.6 | % | DD = ((C - CC) / C) x 100% |
|---|---|---|---|---|---|

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill In (Enter Value) | Conversions Used: |
|---|---|---|
| Red | Calculated Value | 1 inch = 0.083 feet |
| Black | Fixed Value/Selectable Value | 1 cubic foot = 7.48 gallons |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016     # check with agency with project area jurisdiction for requirements

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | Formulas/Notes |
|---|---|---|---|---|---|
| DMA Name: | DM-3 | | | | |
| Total Post-Project Impervious Surface Area (square feet) | | A | 11064 | square feet | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 4465 | Gallons per 24 hours | C = A x B x 0.083 x 7.48 |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | | | # of trees | | | | |
|---|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | | D | 4 | E | 400 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | | F | 0 | G | 0 | square feet | G = F x 200 |

**Existing Trees (Credit for 50% of existing canopy area)**

| | | | Canopy diameter (feet) | | | | |
|---|---|---|---|---|---|---|---|
| Tree #1 | | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | | K | 2.48 | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | | Gallons | | | | |
|---|---|---|---|---|---|---|---|
| Rain Barrels | | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**)**

| | | | cubic feet | | | | |
|---|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | | | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | | | | V | 3936 | square feet | V = Enter square foot value |
|---|---|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | | | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | | | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | | | Y | 0 | square feet | Y = Enter square foot value |
|---|---|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer[8] | | | | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|---|---|---|

| Credits Total | | | AA | 4336 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|---|---|
| Post-Project Impervious Surface Area minus Site Design Measure Credits | | | BB | 6728 | square feet | BB = A - AA |
| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | | | CC | 2715 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
| Percent reduction in Impervious Surface Runoff Value* | | | DD | 39.2 | % | DD = ((C - CC) / C) x 100% |

*handwritten annotation near BB row:* X 0.04 = 269 SF Bio-Retention

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill In (Enter Value) |
|---|---|
| Red | Calculated Value |
| Black | Fixed Value/Selectable Value |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

Conversions Used:

1 inch = 0.083 feet

1 cubic foot = 7.48 gallons

# check with agency with project area jurisdiction for requirements

## Regulated Projects Worksheet 2
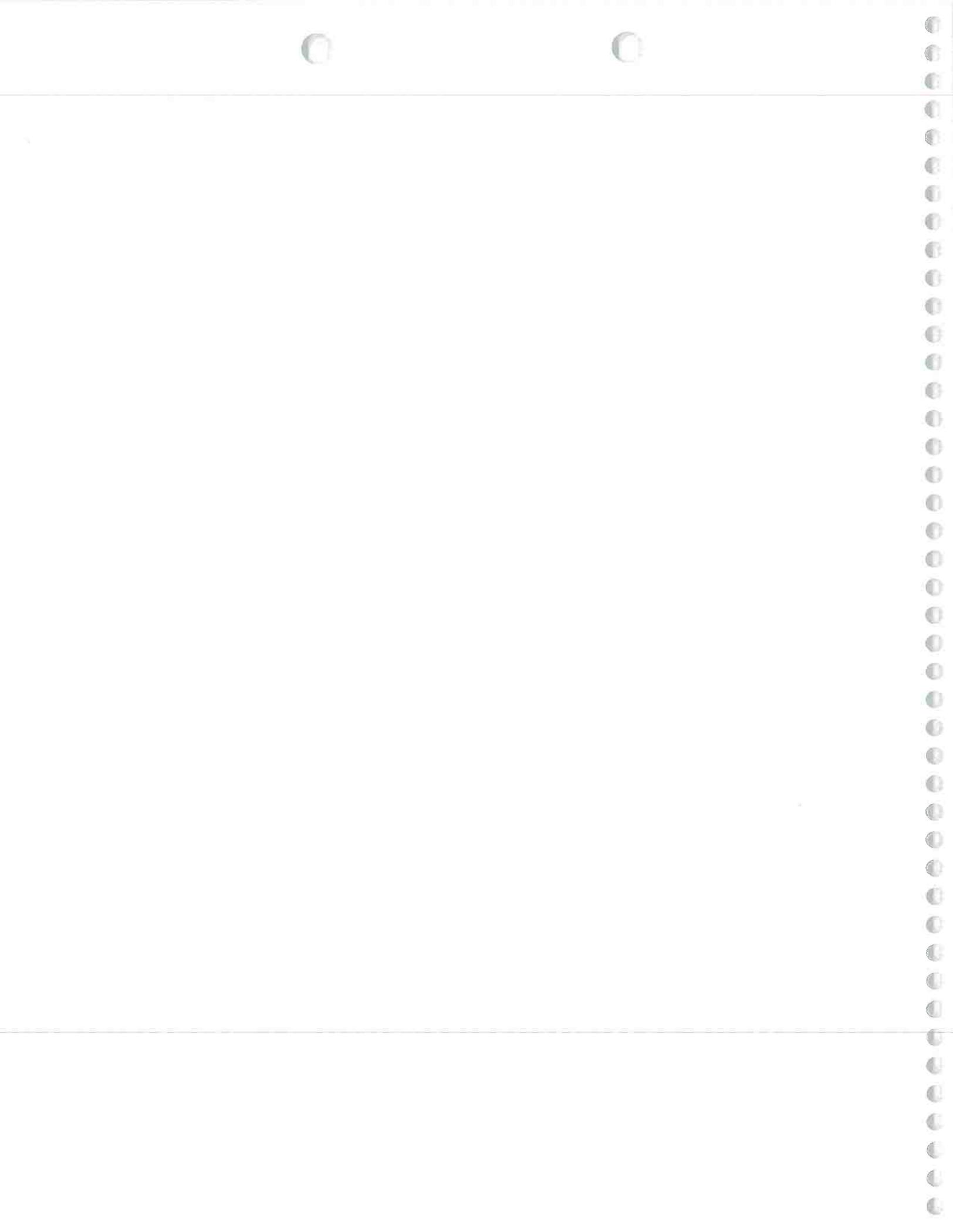### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | | Formulas/Notes |
|---|---|---|---|---|---|---|
| DMA Name: | DM-4 | | | | | |
| Total Post-Project Impervious Surface Area (square feet) | | A | 15814 | square feet | | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 6382 | Gallons per 24 hours | | C = A x B x 0.083 x 7.48 |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | # of trees | | | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | D | 7 | E | 700 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | F | 0 | G | 0 | square feet | G = F x 200 |

| Existing Trees (Credit for 50% of existing canopy area) | Canopy diameter (feet) | | | | | |
|---|---|---|---|---|---|---|
| Tree #1 | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | K | 2.48 | | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|
| | | Gallons | | | | |
| Rain Barrels | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**\*\***)**

| | cubic feet | | | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | V | 7990 | square feet | V = Enter square foot value |
|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | Y | 0 | square feet | Y = Enter square foot value |
|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer# | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|

| Credits Total | AA | 8690 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|
| Post-Project Impervious Surface Area minus Site Design Measure Credits | BB | 7124 | square feet | BB = A - AA  *X 0.04 = 285 SF   Bio-Retention* |
| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | CC | 2875 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
| Percent reduction in Impervious Surface Runoff Value* | DD | 55.0 | % | DD = ((C - CC) / C) x 100% |

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill in [Enter Value] | Conversions Used: |
|---|---|---|
| Red | Calculated Value | 1 inch = 0.083 feet |
| Black | Fixed Value/Selectable Value | 1 cubic foot = 7.48 gallons |
| Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016 | | # check with agency with project area jurisdiction for requirements |

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | Formulas/Notes |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| DMA Name: | DM-5 | | | | |

| Total Post-Project Impervious Surface Area (square feet) | | A | 13158 | square feet | |
|---|---|---|---|---|---|

| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
|---|---|---|---|---|---|

| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 5310 | Gallons per 24 hours | C = A x B x 0.083 x 7.48 |
|---|---|---|---|---|---|

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | | # of trees | | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | D | 0 | E | 0 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | F | 0 | G | 0 | square feet | G = F x 200 |

**Existing Trees (Credit for 50% of existing canopy area)**

| | | Canopy diameter (feet) | | | | |
|---|---|---|---|---|---|---|
| Tree #1 | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | K | 2.48 | | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | Gallons | | | | |
|---|---|---|---|---|---|---|
| Rain Barrels | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**)**

| | | cubic feet | | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | | V | 13157 | square feet | V = Enter square foot value |
|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | Y | 3755 | square feet | Y = Enter square foot value |
|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer[#] | | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|---|

| Credits Total | | AA | 16912 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|---|

| Post-Project Impervious Surface Area minus Site Design Measure Credits | | BB | -3754 | square feet | BB = A - AA       *No Bio-Retention* |
|---|---|---|---|---|---|

| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | | CC | -1515 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
|---|---|---|---|---|---|

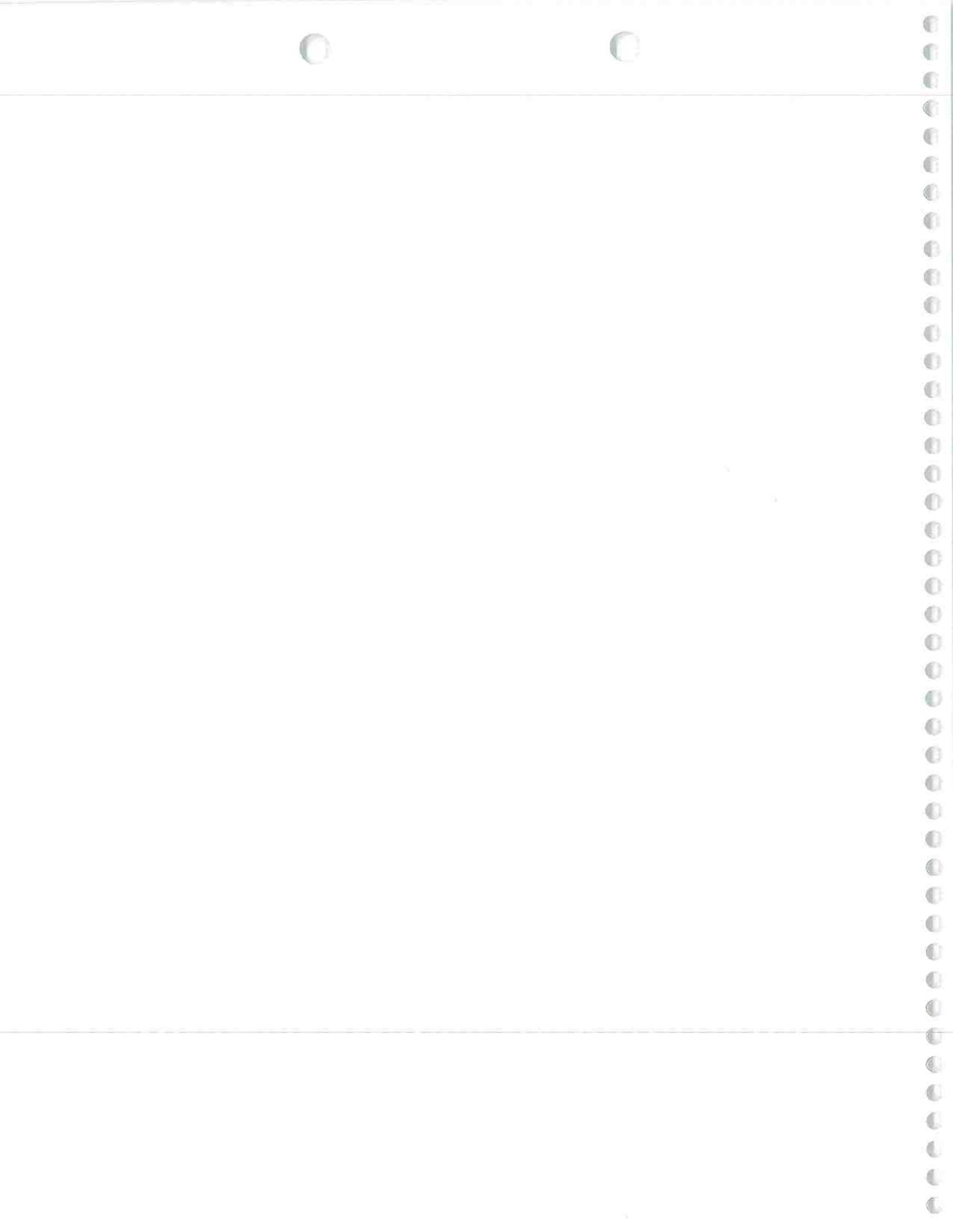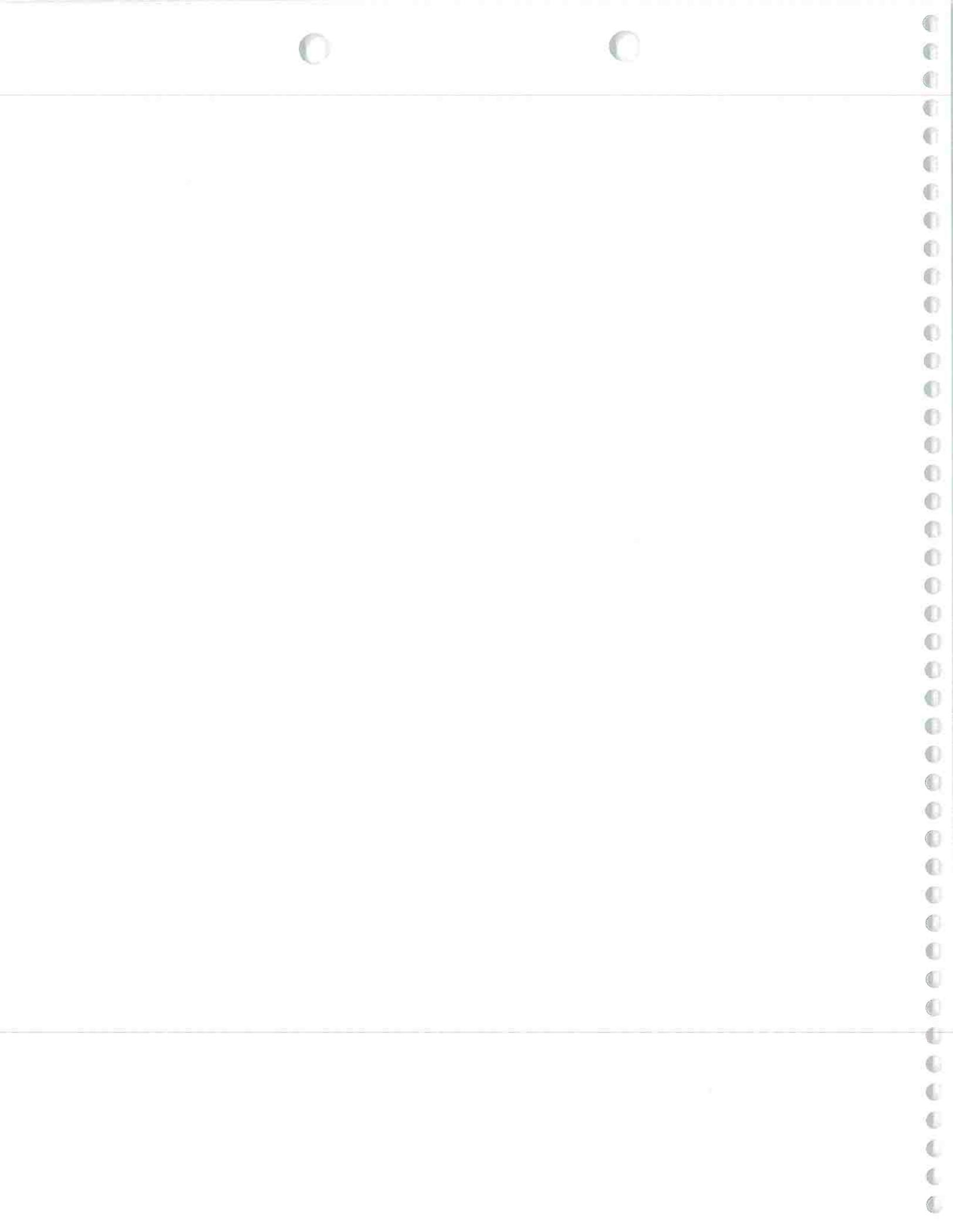| Percent reduction in Impervious Surface Runoff Value* | | DD | 128.5 | % | DD = ((C - CC) / C) x 100% |
|---|---|---|---|---|---|

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by valueBB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill In [Enter Value] | Conversions Used: |
|---|---|---|
| Red | Calculated Value | 1 inch = 0.083 feet |
| Black | Fixed Value/Selectable Value | 1 cubic foot = 7.48 gallons |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016     # check with agency with project area jurisdiction for requirements

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | Formulas/Notes |
|---|---|---|---|---|---|
| DMA Name: | DM-6 | | | | |
| Total Post-Project impervious Surface Area (square feet) | | A | 7922 | square feet | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 | inch | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 3197 | Gallons per 24 hours | C = A x B x 0.083 x 7.48 |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

New Trees

| | | # of trees | | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | D | 4 | E | 400 | square feet | E = D x 100 |
| 200 square feet per evergreen tree | F | 0 | G | 0 | square feet | G = F x 200 |

Existing Trees (Credit for 50% of existing canopy area)

| | | Canopy diameter (feet) | | | | |
|---|---|---|---|---|---|---|
| Tree #1 | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | K | 2.48 | | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | Gallons | | | | |
|---|---|---|---|---|---|---|
| Rain Barrels | L | 0 | M | 0 | square feet | M = L x K |
| Cisterns | N | 0 | O | 0 | square feet | O = N x K |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³)**

| | | cubic feet | | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | P | 0 | Q | 0 | square feet | Q = P x R x K x 7.48 |
| porosity (approximate %) | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | S | 0 | T | 0 | square feet | T = S x 7.48 |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | | V | 4812 | square feet | V = Enter square foot value |
|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | Y | 747 | square feet | Y = Enter square foot value |
|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer# | | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|---|

| Credits Total | AA | 5959 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|

| Post-Project Impervious Surface Area minus Site Design Measure Credits | BB | 1963 | square feet | BB = A - AA |
|---|---|---|---|---|

*handwritten:* × 0.04 = 79 SF → Bio-Retention

| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | CC | 792 | Gallons per 24 hours | CC = BB x B x 0.083 x 7.48 |
|---|---|---|---|---|

| Percent reduction in Impervious Surface Runoff Value* | DD | 75.2 | % | DD = ((C - CC) / C) x 100% |
|---|---|---|---|---|

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill in [Enter Value] |
|---|---|
| Red | Calculated Value |
| Black | Fixed Value/Selectable Value |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

Conversions Used:

1 inch = 0.083 feet

1 cubic foot = 7.48 gallons

# check with agency with project area jurisdiction for requirements

*handwritten right margin:* Bio-Retention ↓ DM8 includes Swale & Exceeds requirements so no Bio-Retention necessary for this DMA.

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | Formulas/Notes |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| DMA Name: | DM-7 | | | |
| Total Post-Project Impervious Surface Area (square feet) | | A | 44672 square feet | |
| 24 hour - 85th Percentile Design Storm | | B | 0.65 inch | B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | C | 18027 Gallons per 24 hours | $C = A \times B \times 0.083 \times 7.48$ |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area × Multiplier Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | | | # of trees | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | | D | 13 | E | 1300 square feet | $E = D \times 100$ |
| 200 square feet per evergreen tree | | F | 0 | G | 0 square feet | $G = F \times 200$ |

**Existing Trees (Credit for 50% of existing canopy area)**

| | | | Canopy diameter (feet) | | | |
|---|---|---|---|---|---|---|
| Tree #1 | | $H_1$ | 0 | $J_1$ | 0 square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | | $H_2$ | 0 | $J_2$ | 0 square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | | $H_3$ | 0 | $J_3$ | 0 square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | | K | 2.48 | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|

| | | | Gallons | | | |
|---|---|---|---|---|---|---|
| Rain Barrels | | L | 0 | M | 0 square feet | $M = L \times K$ |
| Cisterns | | N | 0 | O | 0 square feet | $O = N \times K$ |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**)**

| | | | cubic feet | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | | P | 0 | Q | 0 square feet | $Q = P \times R \times K \times 7.48$ |
| porosity (approximate %) | | R | 35% | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | | S | 0 | T | 0 square feet | $T = S \times 7.48$ |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | | U | 0 square feet | U = Enter square foot value |
|---|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | | | V | 25709 square feet | V = Enter square foot value |
|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | | W | 0 square feet | W = Enter square foot value |
|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | | X | 0 square feet | X = Enter square foot value |
|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | | Y | 0 square feet | Y = Enter square foot value |
|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer# | | | Z | 0 square feet | Z = Enter square foot value |
|---|---|---|---|---|---|

| Credits Total | | AA | 27009 square feet | $AA = SRA\ Credit + E + G + J_1 + J_2 + J_3 + M + O + Q + T + U + V + W + X + Y + Z$ |
|---|---|---|---|---|

| Post-Project Impervious Surface Area minus Site Design Measure Credits | | BB | 17663 square feet | $BB = A - AA$ |
|---|---|---|---|---|

*(handwritten annotation: × 0.04 = 707 SF Bio-Retention)*

| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | | CC | 7128 Gallons per 24 hours | $CC = BB \times B \times 0.083 \times 7.48$ |
|---|---|---|---|---|

| Percent reduction in Impervious Surface Runoff Value* | | DD | 60.5 % | $DD = ((C - CC) / C) \times 100\%$ |
|---|---|---|---|---|

*If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill in [Enter Value] |
|---|---|
| Red | Calculated Value |
| Black | Fixed Value/Selectable Value |

Conversions Used:

1 inch = 0.083 feet

1 cubic foot = 7.48 gallons

# check with agency with project area jurisdiction for requirements

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

## Regulated Projects Worksheet 2
### Humboldt Low Impact Development Stormwater Manual

| Project Information | Washington Terrace Subdivision | | | | | Formulas/Notes |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **DMA Name:** | **DM-8** | | | | | |
| Total Post-Project Impervious Surface Area (square feet) | | | A | 7042 | square feet | |
| 24 hour - 85th Percentile Design Storm | | | B | 0.65 | Inch | B = Select Design Storm Value (0.65-Inch Humboldt Bay Area, 1.3-inch Shelter Cove) |
| Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value) | | | C | 2842 | Gallons per 24 hours | $C = A \times B \times 0.083 \times 7.48$ |

**Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)**

| Self-Retaining Area (square feet) | 0 | 3.5 | SRA Credit | 0 | square feet | SRA Credit = Self-Retaining Area x Multiplier  Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove) |
|---|---|---|---|---|---|---|

**Site Design Measure Credits**

**Tree Planting and Preservation**

**New Trees**

| | # of trees | | | | | |
|---|---|---|---|---|---|---|
| 100 square feet per deciduous tree | 0 | D | E | 0 | square feet | $E = D \times 100$ |
| 200 square feet per evergreen tree | 0 | F | G | 0 | square feet | $G = F \times 200$ |

**Existing Trees (Credit for 50% of existing canopy area)**

| | Canopy diameter (feet) | | | | | |
|---|---|---|---|---|---|---|
| Tree #1 | $H_1$ | 0 | $J_1$ | 0 | square feet | $J_1 = 3.14 \times (H_1/2)^2 \times 0.50$ |
| Tree #2 | $H_2$ | 0 | $J_2$ | 0 | square feet | $J_2 = 3.14 \times (H_2/2)^2 \times 0.50$ |
| Tree #3 | $H_3$ | 0 | $J_3$ | 0 | square feet | $J_3 = 3.14 \times (H_3/2)^2 \times 0.50$ |

**Rain Barrel or Cisterns (55 gallon minimum)**

| Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm | K | 2.48 | | | | K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove) |
|---|---|---|---|---|---|---|
| | Gallons | | | | | |
| Rain Barrels | L | 0 | M | 0 | square feet | $M = L \times K$ |
| Cisterns | N | 0 | O | 0 | square feet | $O = N \times K$ |

**Infiltration Trench/Basin (55 gallon minimum ~ 21 ft³**)**

| | cubic feet | | | | | |
|---|---|---|---|---|---|---|
| volume(ft³) = length x width x depth | P | 0 | Q | 0 | square feet | $Q = P \times R \times K \times 7.48$ |
| porosity (approximate %) | R | 35% | | | | |

**Subsurface Infiltrators (55 gallon minimum)**

| Proprietary units vary, insert estimated storage in ft³ | S | 0 | T | 0 | square feet | $T = S \times 7.48$ |
|---|---|---|---|---|---|---|

**Impervious Area Disconnection**

| Credit per square foot of pervious receiving area | | | U | 0 | square feet | U = Enter square foot value |
|---|---|---|---|---|---|---|

**Soil Quality Improvement**

| Credit per square foot of soil quality improvement | | | V | 8694 | square feet | V = Enter square foot value |
|---|---|---|---|---|---|---|

**Green Roof**

| Credit per square foot of green roof installation | | | W | 0 | square feet | W = Enter square foot value |
|---|---|---|---|---|---|---|

**PPPP (Alternative engineered hardscaping surfaces )**

| Credit per square foot of PPPP | | | X | 0 | square feet | X = Enter square foot value |
|---|---|---|---|---|---|---|

**Vegetated Swales**

| Credit per square foot of vegetated swale | | | Y | 2259 | square feet | Y = Enter square foot value |
|---|---|---|---|---|---|---|

**Stream Setbacks and Buffers**

| Credit per square foot of stream setback and buffer# | | | Z | 0 | square feet | Z = Enter square foot value |
|---|---|---|---|---|---|---|

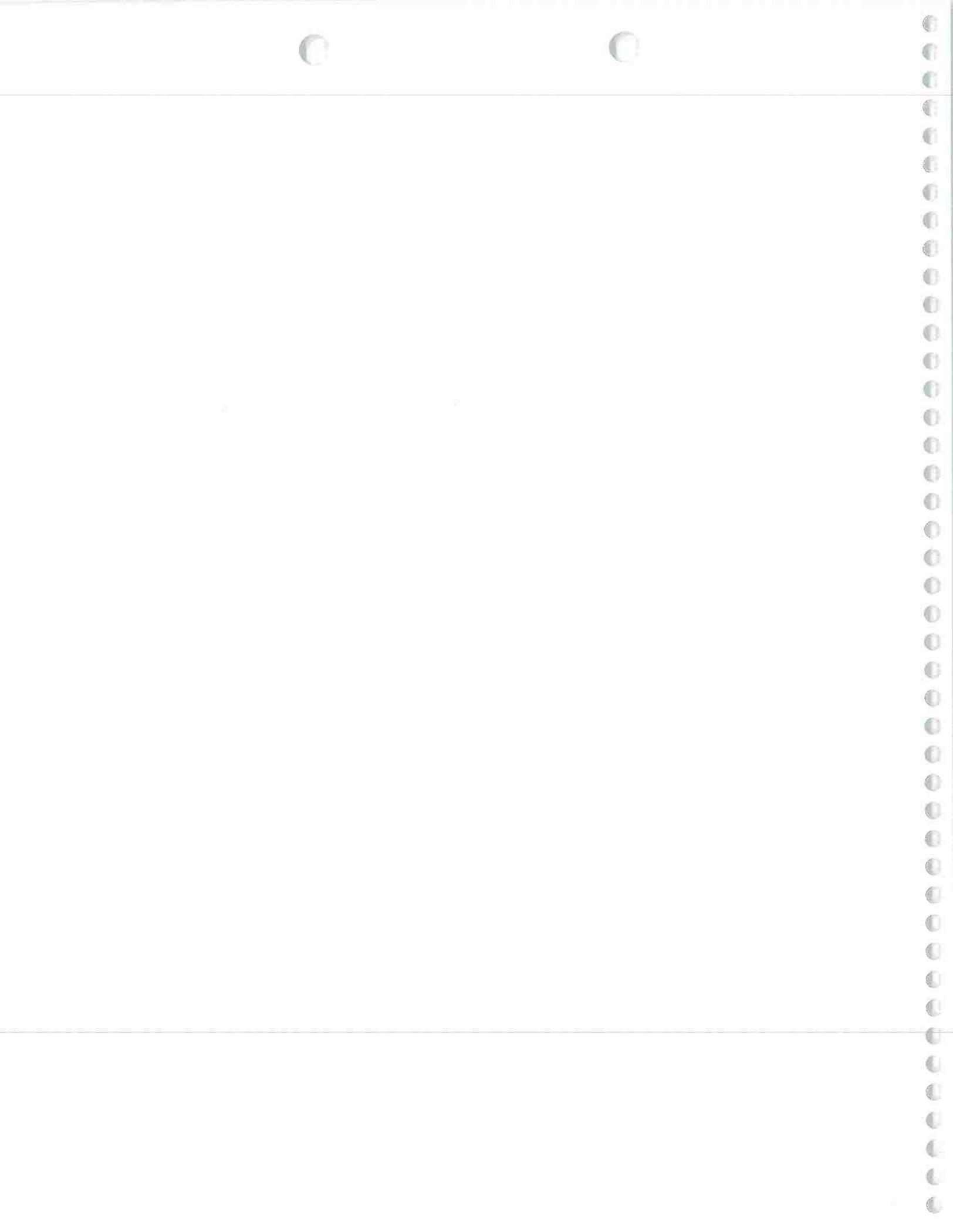| Credits Total | | | AA | 10953 | square feet | AA = SRA Credit + E + G + $J_1$ + $J_2$ + $J_3$ + M + O + Q + T + U + V + W + X + Y + Z |
|---|---|---|---|---|---|---|
| Post-Project Impervious Surface Area minus Site Design Measure Credits | | | BB | -3911 | square feet | BB = A - AA    *No Bio-Retention* |
| NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures) | | | CC | -1578 | Gallons per 24 hours | $CC = BB \times B \times 0.083 \times 7.48$ |
| Percent reduction in Impervious Surface Runoff Value* | | | DD | 155.5 | % | $DD = ((C - CC) / C) \times 100\%$ |

*If value for **DD** is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value**BB**. Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.
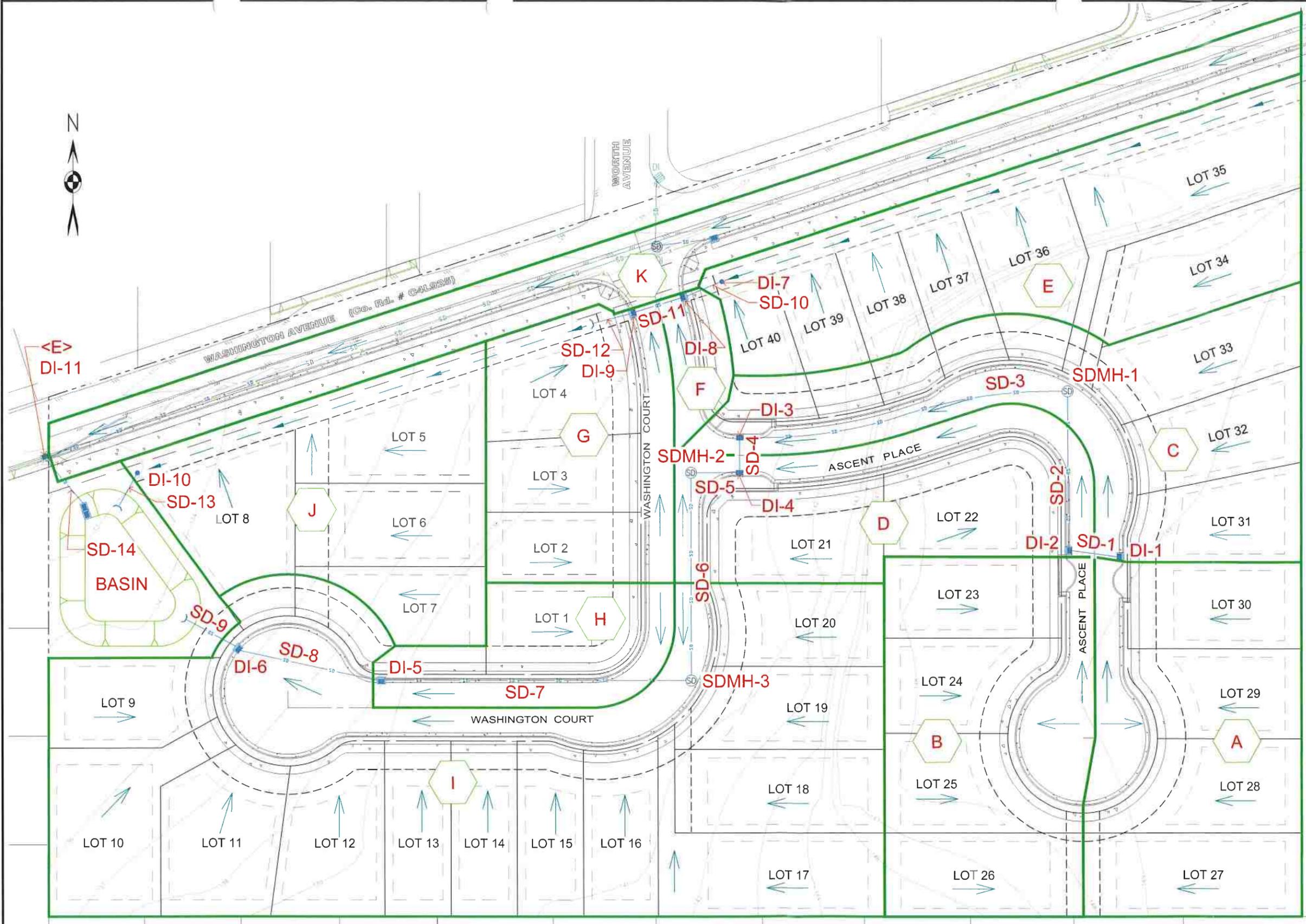
**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.

| Green | Fill In [Enter Value] | Conversions Used: |
|---|---|---|
| Red | Calculated Value | 1 inch = 0.083 feet |
| Black | Fixed Value/Selectable Value | 1 cubic foot = 7.48 gallons |

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

# check with agency with project area jurisdiction for requirements

# APPENDIX B

# HYDROLOGY & CONVEYANCE

**DRAINAGE BASIN DATA**

| LOCATION | AREA | $C_W$ |
|---|---|---|
| A | 0.62 ACRES | 0.58 |
| B | 0.61 ACRES | 0.54 |
| C | 0.71 ACRES | 0.52 |
| D | 0.48 ACRES | 0.56 |
| E | 0.80 ACRES | 0.51 |
| F | 0.07 ACRES | 0.71 |
| G | 0.41 ACRES | 0.54 |
| H | 0.24 ACRES | 0.67 |
| I | 1.90 ACRES | 0.56 |
| J | 0.57 ACRES | 0.42 |
| K | 0.65 ACRES | 0.82 |

**TYPICAL RUNOFF COEFFICIENTS USED IN COMPOSITE, CW**

| DESCRIPTION | $C$ |
|---|---|
| HOUSES, CONCRETE | 0.95 |
| PAVEMENT | 0.85 |
| LAWNS, ETC. | 0.25 |

GRAPHIC SCALE

0   30'   60'

SCHILLINGER ENGINEERING
CIVIL ENGINEERING SOLUTIONS
P.O. BOX 1183
ARCATA, CA 95518
PH (707) 834-6169

JLF CONSTRUCTION INC.

WASHINGTON TERRACE SUBDIVISION

DRAINAGE BASIN MAP

JOB NUMBER 0319-JLF

SHEET 1 OF 1

APP B1
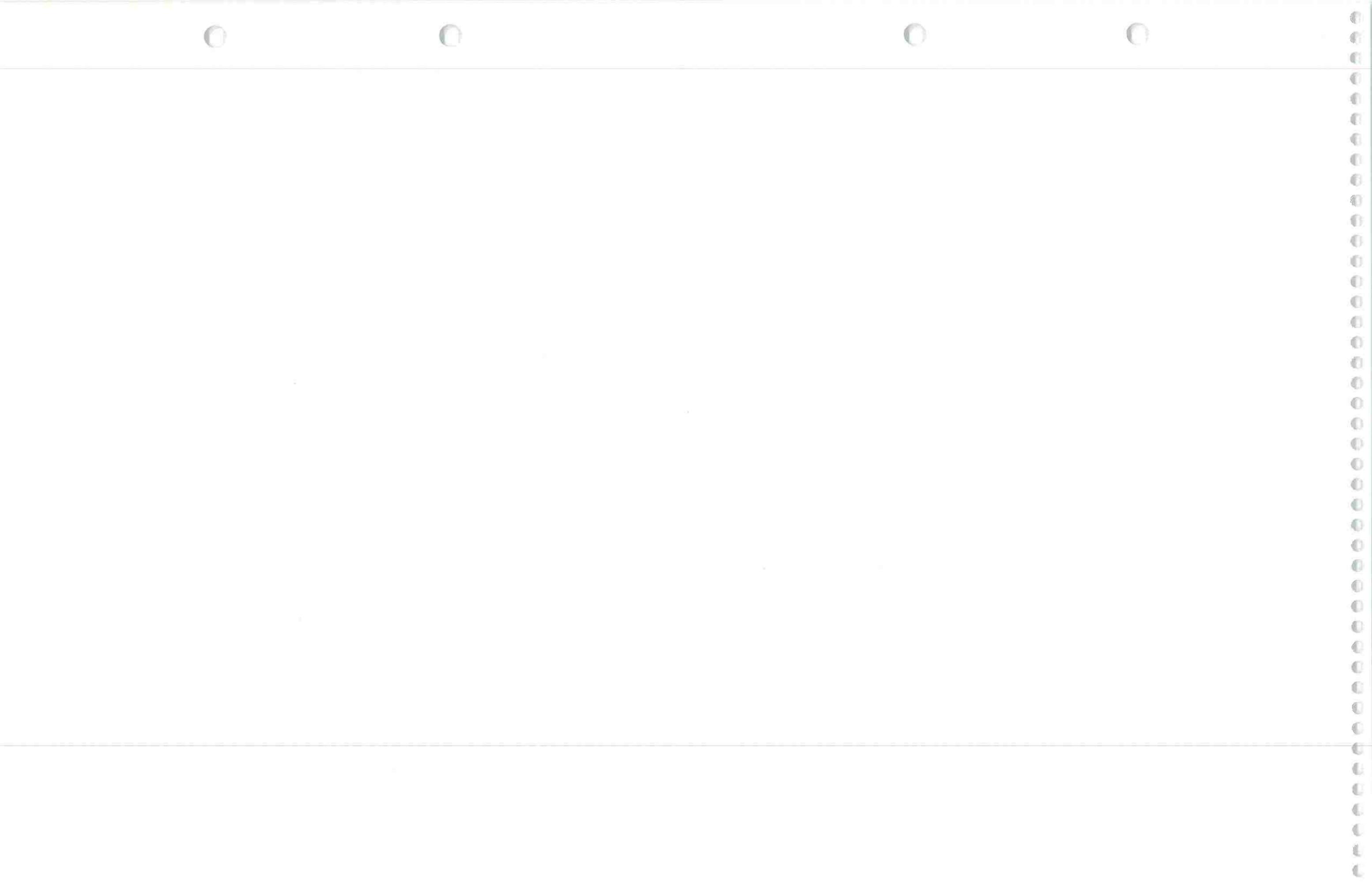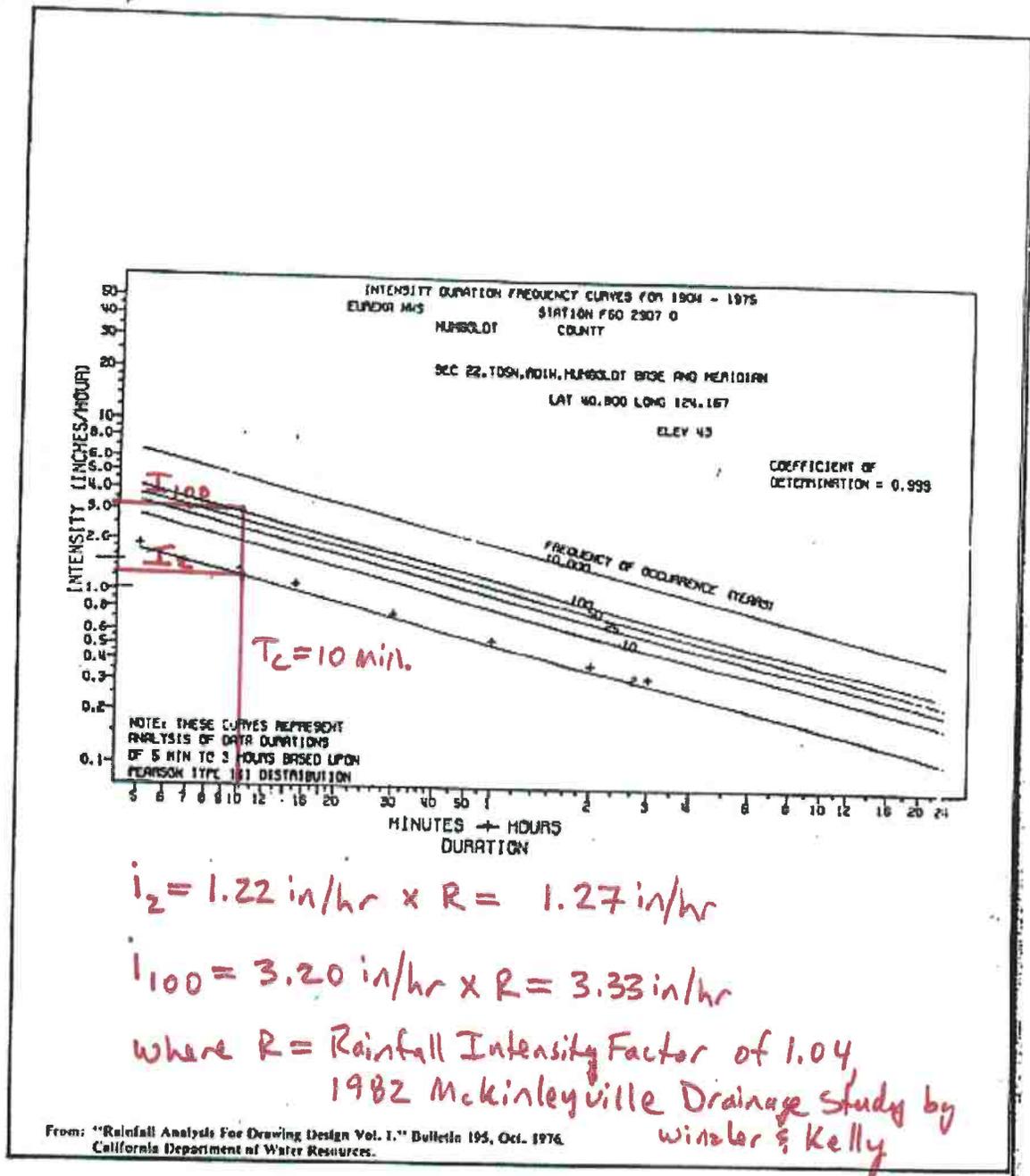
INTENSITY DURATION FREQUENCY CURVES · 1904 · 1975

FIGURE IV - 2

IDF Curves Eureka, CA

APPENDIX B2
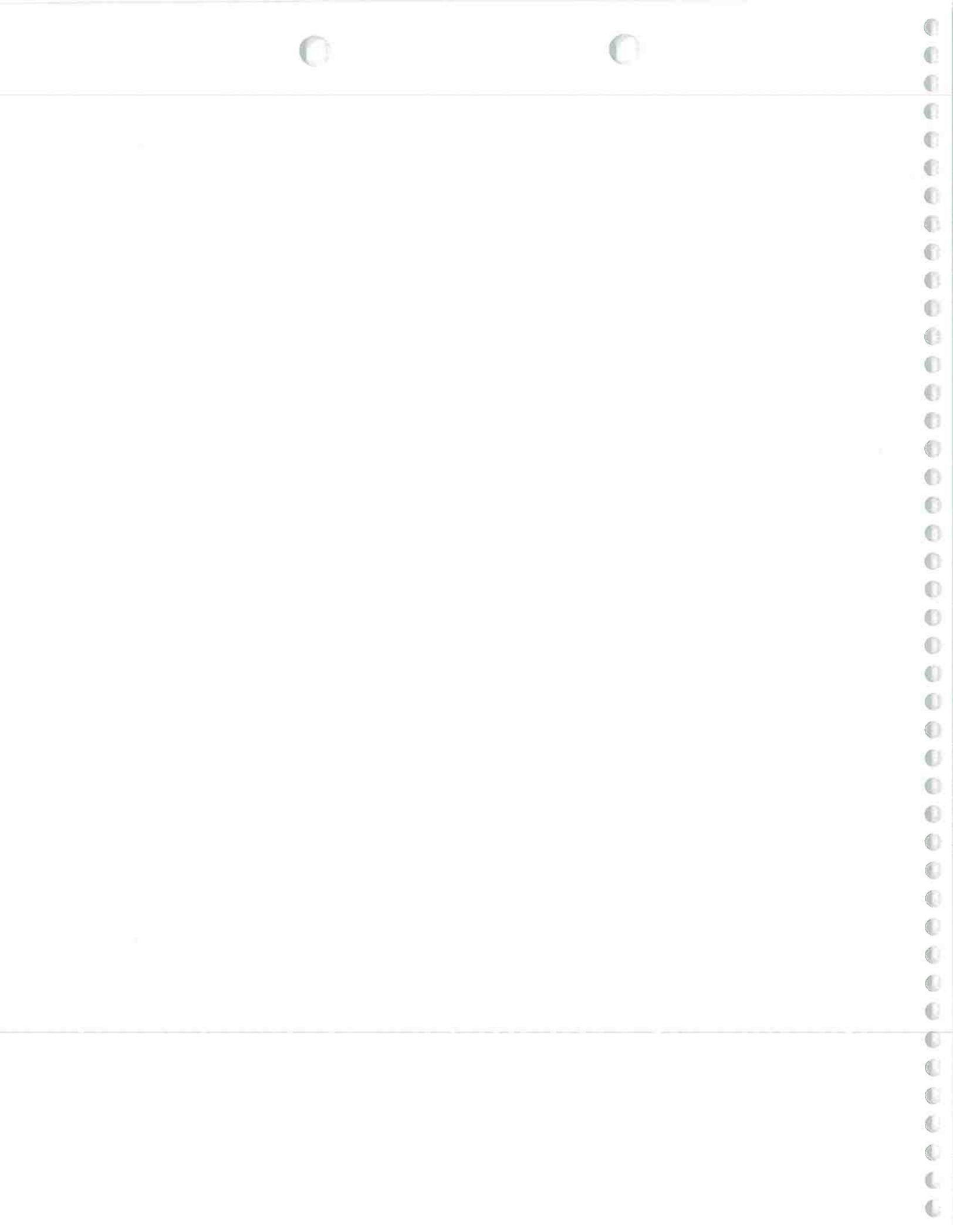
*categorized by surface*

| | |
|---|---|
| forested | 0.059–0.2 |
| asphalt | 0.7–0.95 |
| brick | 0.7–0.85 |
| concrete | 0.8–0.95 |
| shingle roof | 0.75–0.95 |
| lawns, well-drained (sandy soil) | |
|   up to 2% slope | 0.05–0.1 |
|   2% to 7% slope | 0.10–0.15 |
|   over 7% slope | 0.15–0.2 |
| lawns, poor drainage (clay soil) | |
|   up to 2% slope | 0.13–0.17 |
|   2% to 7% slope | 0.18–0.22 |
|   over 7% slope | 0.25–0.35 |
| driveways, walkways | 0.75–0.85 |

*categorized by use*

| | |
|---|---|
| farmland | 0.05–0.3 |
| pasture | 0.05–0.3 |
| unimproved | 0.1–0.3 |
| parks | 0.1–0.25 |
| cemeteries | 0.1–0.25 |
| railroad yards | 0.2–0.35 |
| playgrounds (except asphalt or concrete) | 0.2–0.35 |
| business districts | |
|   neighborhood | 0.5–0.7 |
|   city (downtown) | 0.7–0.95 |
| residential | |
|   single family | 0.3–0.5 |
|   multiplexes, detached | 0.4–0.6 |
|   multiplexes, attached | 0.6–0.75 |
|   suburban | 0.25–0.4 |
|   apartments, condominiums | 0.5–0.7 |
| industrial | |
|   light | 0.5–0.8 |
|   heavy | 0.6–0.9 |

**Runoff Coefficients - Rational Method**

**APPENDIX B3**
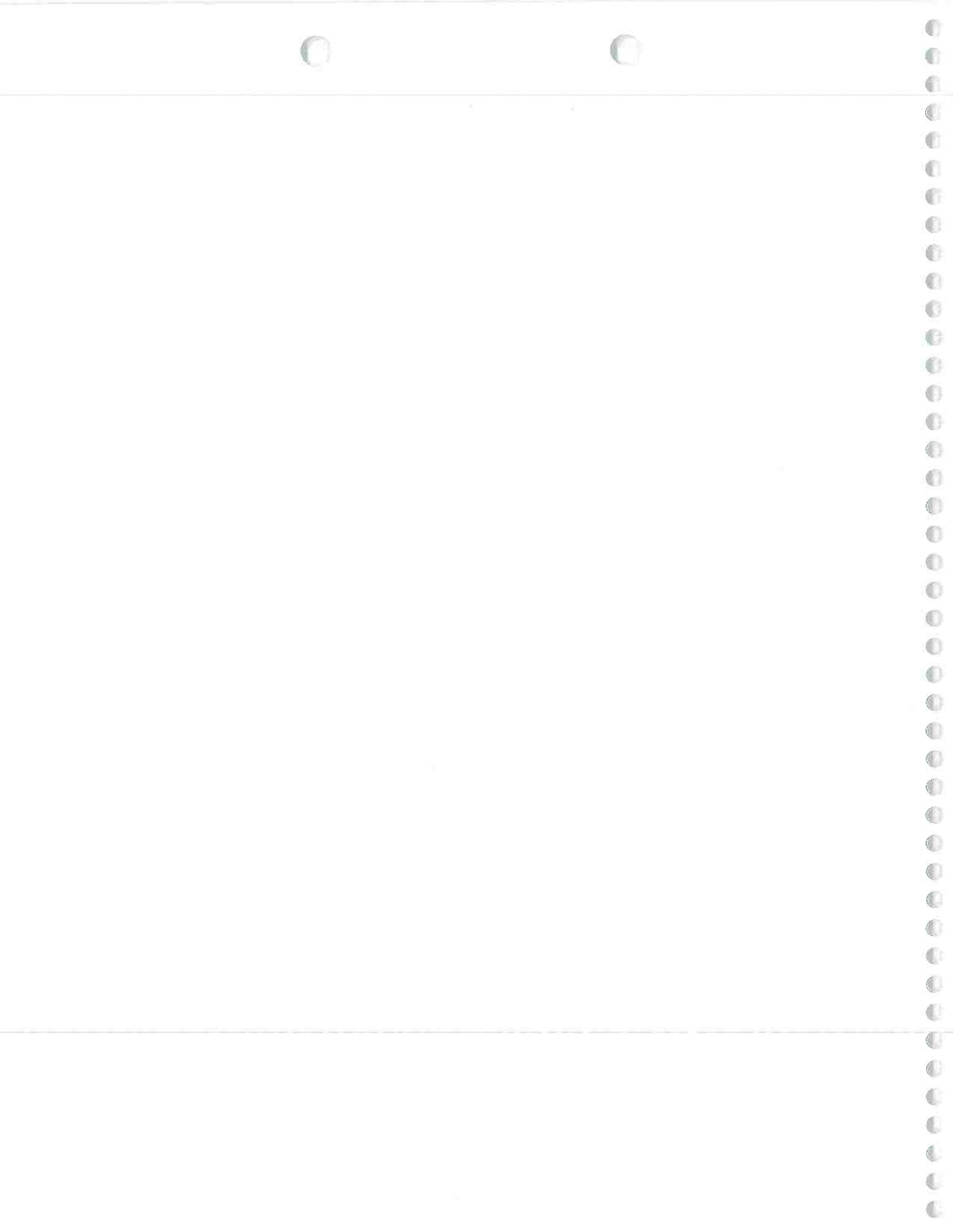
## APPENDIX B4

## FHWA HEC 22 Gutter Flow Nomographs
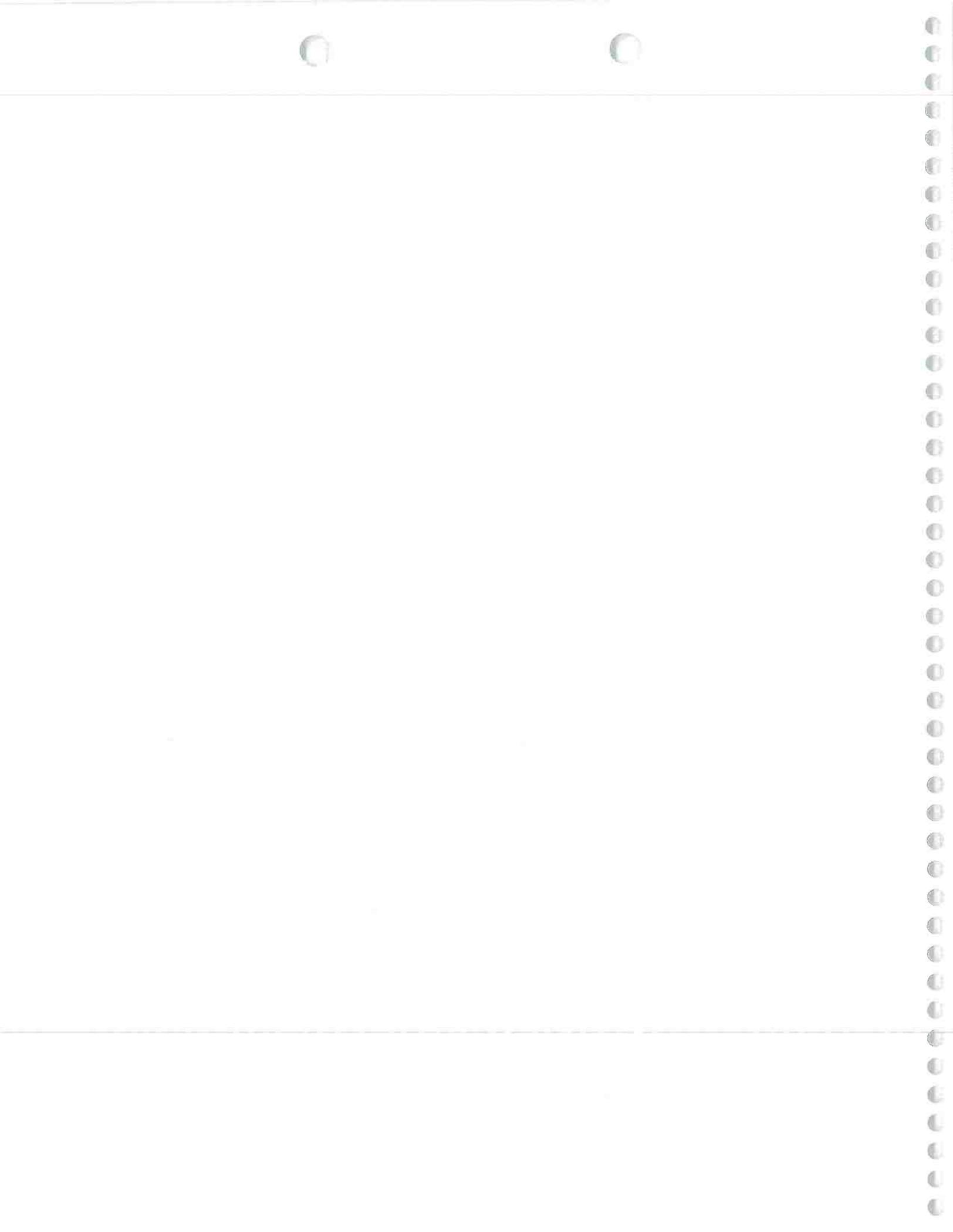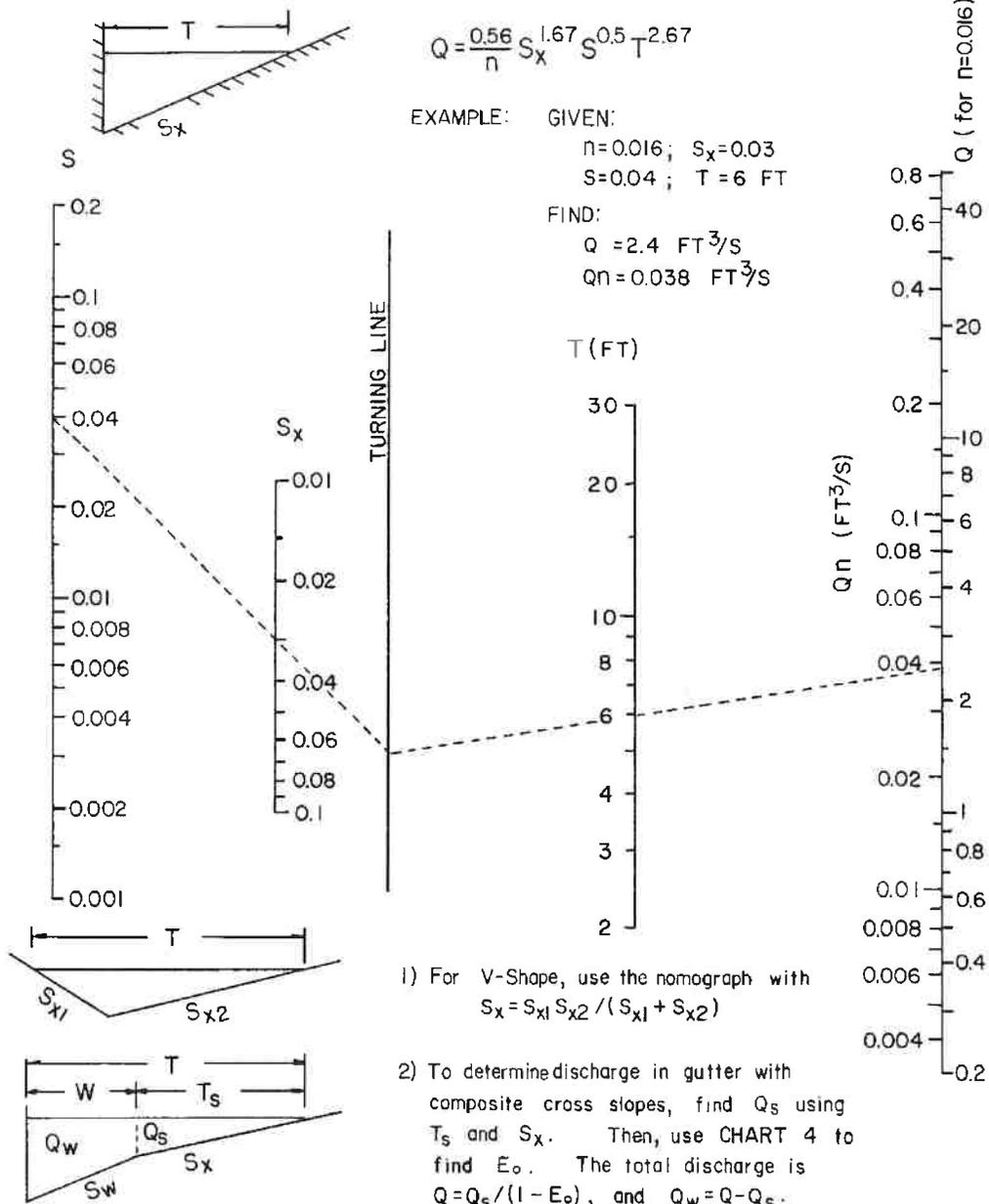
# CHART 1B

$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

EXAMPLE:    GIVEN:
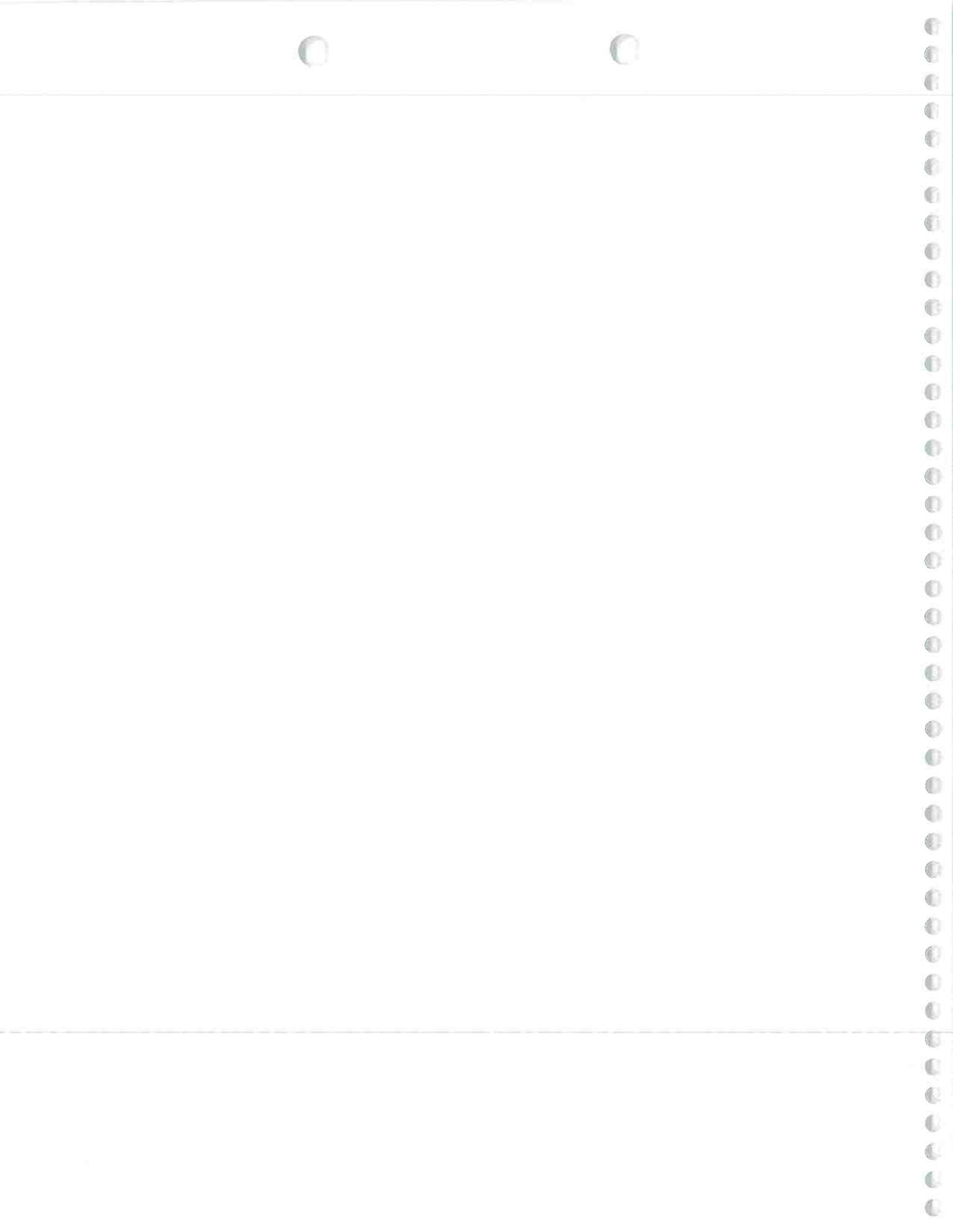 $n = 0.016$;  $S_x = 0.03$
 $S = 0.04$ ;   $T = 6$ FT

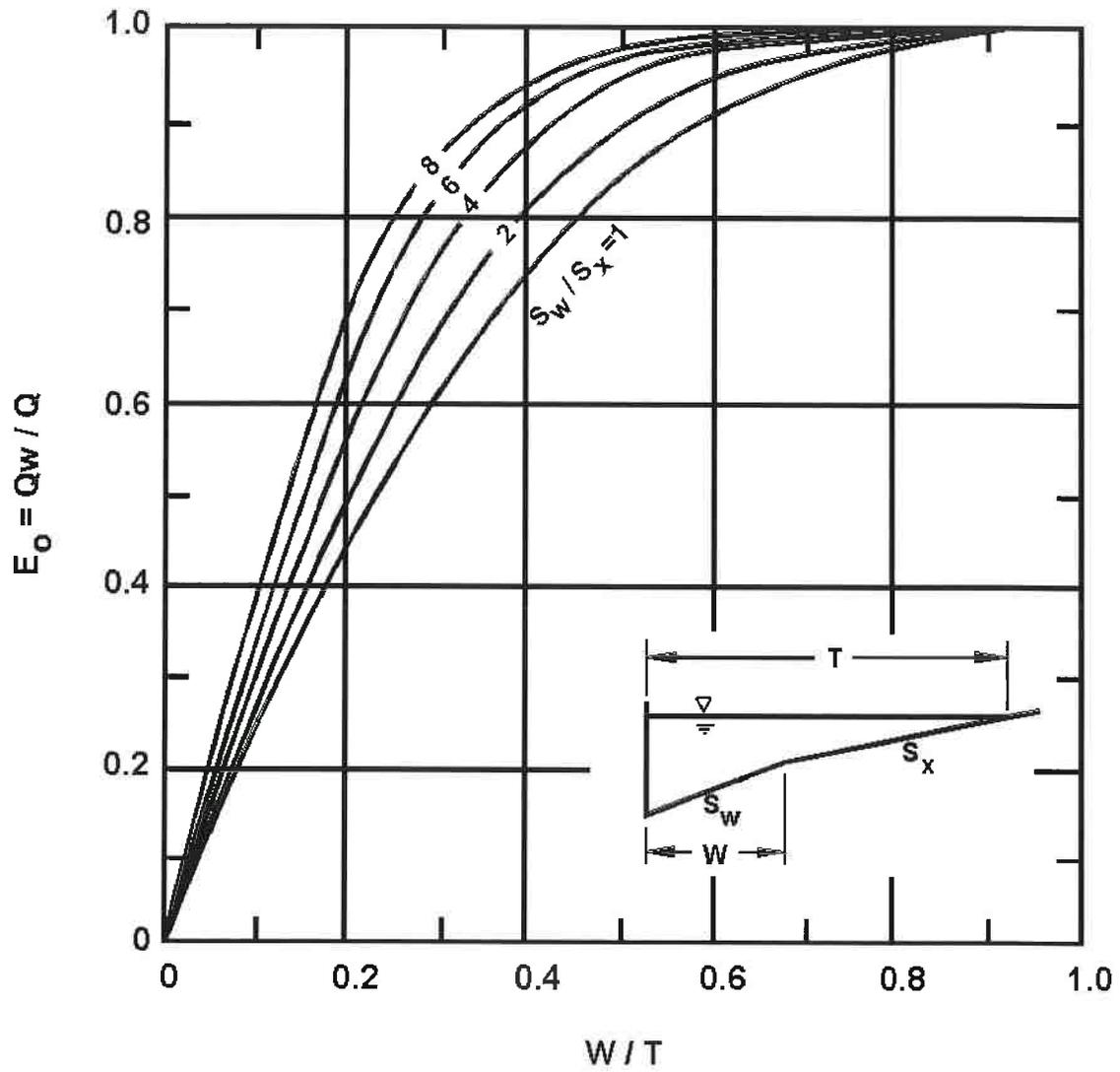FIND:
 $Q = 2.4$ FT$^3$/S
 $Qn = 0.038$ FT$^3$/S

1) For V-Shape, use the nomograph with
 $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$

2) To determine discharge in gutter with
 composite cross slopes, find $Q_S$ using
 $T_s$ and $S_x$.    Then, use CHART 4 to
 find $E_o$.    The total discharge is
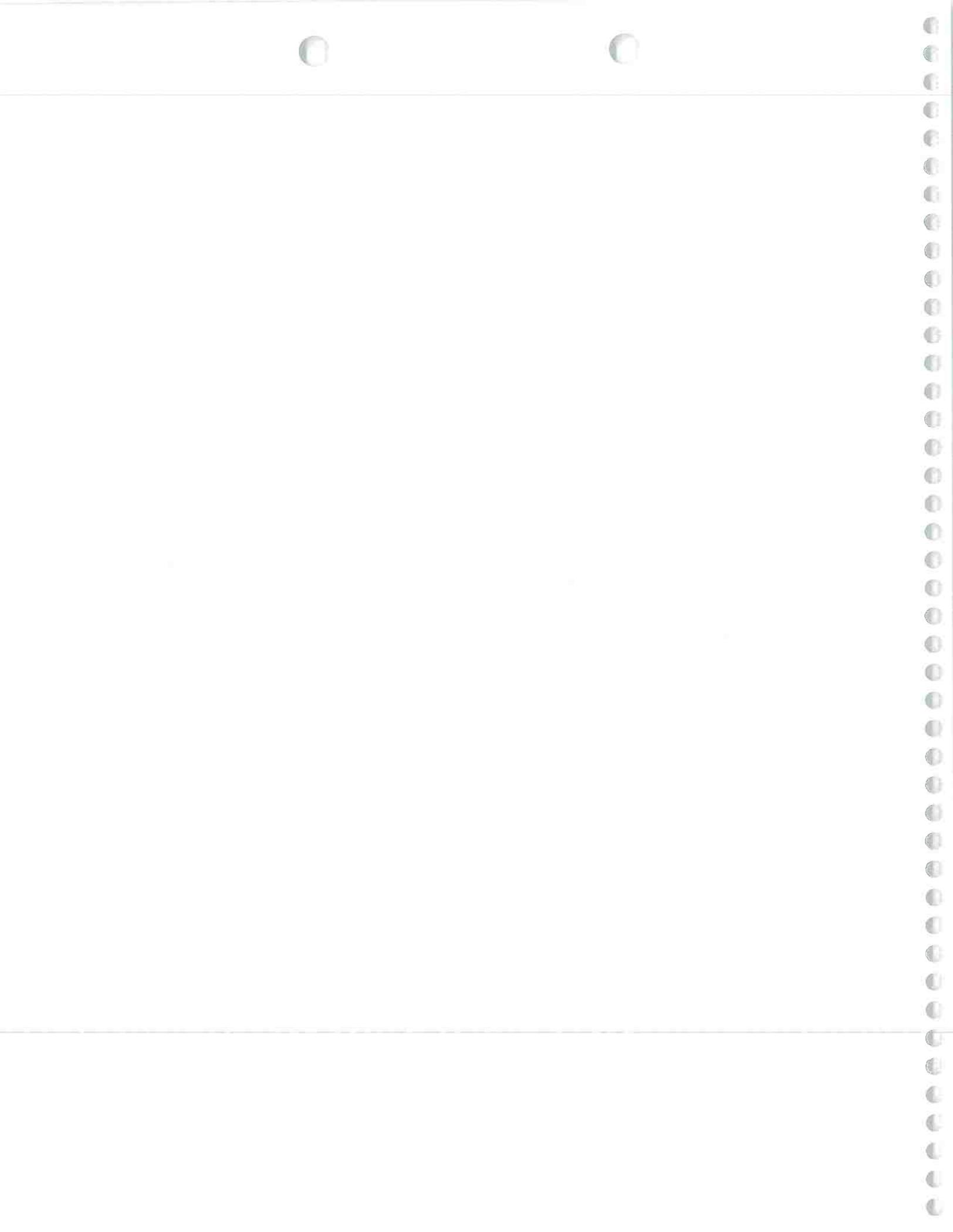 $Q = Q_S / (1 - E_o)$, and  $Q_w = Q - Q_S$.

Flow in Triangular Gutter Sections - English Units

A-3

# CHART 2B



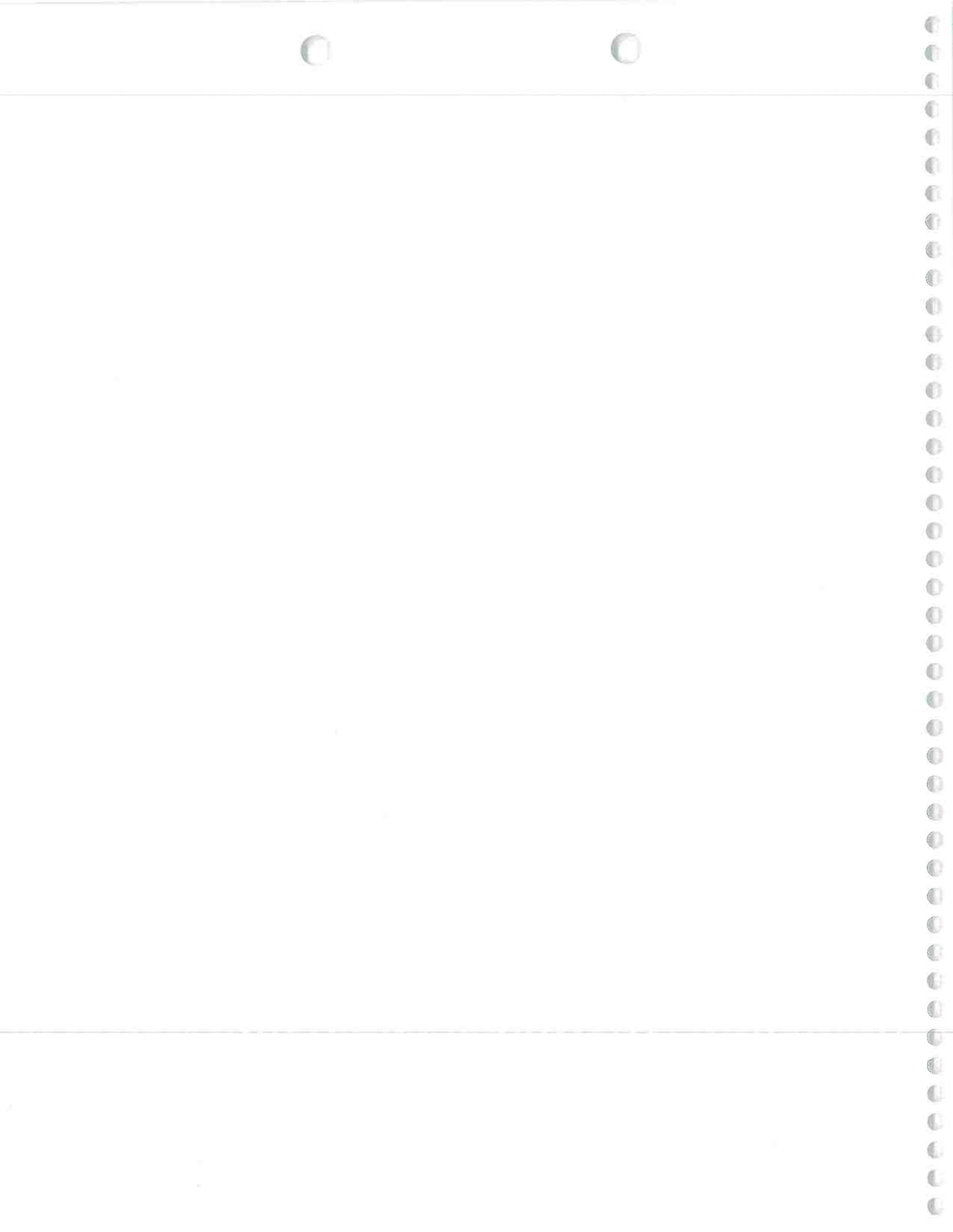Ratio of Frontal Flow to Total Gutter Flow

# APPENDIX B5

TABLE 1   Summary of Time of Concentration Models

| Publication and Year | Equation for Time of Concentration (min) | Remarks |
|---|---|---|
| Williams (1922) (6) | $t_c = 60LA^{0.4} D^{-1}S^{-0.2}$<br>$L$ = basin length, mi<br>$A$ = basin area, mi$^2$<br>$D$ = diameter (mi) of a circular basin of area<br>$S$ = basin slope, % | The basin area should be smaller than 50 mi$^2$ (129.5 km$^2$). |
| Kirpich (1940) (7) | $t_c = KL^{0.77}S^{-y}$<br>$L$ = length of channel/ditch from headwater to outlet, ft<br>$S$ = average watershed slope, ft/ft<br>For Tennessee, $K = 0.0078$ and $y = -0.385$<br>For Pennsylvania, $K = 0.0013$ and $y = -0.5$ | Developed for small drainage basins in Tennessee and Pennsylvania, with basin areas from 1 to 112 acres (0.40 to 45.3 ha). |
| Hathaway (1945) (8), Kerby (1959) (9) | $t_c = 0.8275 (LN)^{0.467}S^{-0.233}$<br>$L$ = overland flow length, ft<br>$S$ = overland flow path slope, ft/ft<br>$N$ = flow retardance factor | Drainage basins with areas of less than 10 acres (4.05 ha) and slopes of less than 0.01. |
| Izzard (1946) (10) | $t_c = 41.025(0.0007i + c)L^{0.33}S^{-0.333} i^{-0.667}$<br>$i$ = rainfall intensity, in./h<br>$c$ = retardance coefficient<br>$L$ = length of flow path, ft<br>$S$ = slope of flow path, ft/ft | Hydraulically derived formula; values of $c$ range from 0.007 for very smooth pavement to 0.012 for concrete pavement to 0.06 for dense turf. |
| Johnstone and Cross (1949) (11) | $t_c = 300L^{0.5}S^{-0.5}$<br>$L$ = basin length, mi<br>$S$ = basin slope, ft/mi | Developed for basins with areas between 25 and 1624 mi$^2$ (64.7 and 4206.1 km$^2$). |
| California Culvert Practice (1955) (12) | $t_c = 60(11.9L^3/H)^{0.385}$<br>$L$ = length of longest watercourse, mi<br>$H$ = elevation difference between divide and outlet, ft<br>If expressed as $T_c = kL^a n^b S^{-s} i^{-t}$ format: $t_c = KL^{0.77}S^{-0.385}$<br>$K$ = conversion constant | Essentially the Kirpich (7) formula; developed for small mountainous basins in California. |
| Henderson and Wooding (1964) (13) | $t_c = 0.94(Ln)^{0.6}S^{-0.3}i^{-0.4}$<br>$L$ = length of overland flow, ft<br>$n$ = Manning's roughness coefficient<br>$S$ = overland flow plane slope, ft/ft<br>$i$ = rainfall intensity, in./h | Based on kinematic wave theory for flow on an overland area. |
| Morgali and Linsley (1965) (14), Aron and Erborge (1973) (15) | $t_c = 0.94L^{0.6} n^{0.6}S^{-0.3}i^{-0.4}$<br>$L$ = length of overland flow, ft<br>$n$ = Manning roughness coefficient<br>$S$ = average overland slope, ft/ft<br>$i$ = rainfall intensity, in./h | Overland flow equation from kinematic wave analysis of runoff from developed areas. |
| FAA (1970) (16)<br>_AKA RATIONAL METHOD_ | $t_c = 1.8(1.1 - C)L^{0.5}S^{-0.333}$<br>$C$ = rational method runoff coefficient<br>$L$ = length of overland flow, ft<br>$S$ = surface slope, ft/ft | Developed from airfield drainage data assembled by U.S. Corps of Engineers. |
| U.S. Soil Conservation Service (1975, 1986) (17, 18) | $t_c = (1/60)\Sigma(L/V)$<br>$L$ = length of flow path, ft<br>$V$ = average velocity in ft/s for various surfaces<br>(The exponent of $S$, if converted from Manning's equation, will be $-0.5$) | Developed as a sum of individual travel times. $V$ can be calculated using Manning's equation. |
| Papadakis and Kazan (1986) (2) | $t_c = 0.66L^{0.5}n^{0.52}S^{-0.31}i^{-0.38}$<br>$L$ = length of flow path, ft<br>$n$ = roughness coefficient<br>$S$ = average slope of flow path, ft/ft<br>$i$ = rainfall intensity, in./h | Developed from USDA Agricultural Research Service data of 84 small rural watersheds from 22 states. |
| Chen and Wong (1993) (19), Wong (2005) (20) | $t_c = 0.595(3.15)^{0.33k}C^{0.33}L^{0.33(2-k)}S^{-0.33}i^{-0.33(1+k)}$<br>For water at 26°C<br>$C, k$ = constants (for smooth paved surfaces, $C = 3$, $k = 0.5$. For grass, $C = 1$, $k = 0$)<br>$L$ = length of overland plane, m<br>$S$ = slope of overland plane, m/m<br>$i$ = net rainfall intensity, mm/h | Overland flow on test plots of 1 m wide by 25 m long. Slopes of 2% and 5%. |
| TxDOT (1994) (21) | $t_c = 0.702(1.1 - C)L^{0.5}S^{-0.333}$<br>$C$ = rational method runoff coefficient<br>$L$ = length of overland flow, m<br>$S$ = surface slope, m/m | Modified from FAA (16). |
| Natural Resources Conservation Service (1997) (22) | $t_c = 0.0526[(1000/CN) - 9]L^{0.8}S^{-0.5}$<br>$CN$ = curve number<br>$L$ = flow length, ft<br>$S$ = average watershed slope, % | For small rural watersheds. |

NOTE: 1 mi = 1.61 km; 1 ft = 0.3048 m; 1 in. = 25.4 mm.

| DEPTH, d (ft) | CW | P (ft) | $d^{1.5}$ | Qf (cfs) |
|---|---|---|---|---|
| 0.1 | 3.0 | 10 | 0.032 | 0.95 |
| 0.2 | 3.0 | 10 | 0.089 | 2.68 |
| 0.3 | 3.0 | 10 | 0.164 | 4.93 |
| 0.4 | 3.0 | 10 | 0.253 | 7.59 |
| 0.5 | 3.0 | 10 | 0.354 | 10.61 |
| 0.6 | 3.0 | 10 | 0.465 | 13.94 |
| 0.7 | 3.0 | 10 | 0.586 | 17.57 |
| 0.8 | 3.0 | 10 | 0.716 | 21.47 |
| 0.9 | 3.0 | 10 | 0.854 | 25.61 |
| 1 | 3.0 | 10 | 1.000 | 30.00 |
| 1.1 | 3.0 | 10 | 1.154 | 34.61 |
| 1.2 | 3.0 | 10 | 1.315 | 39.44 |
| 1.3 | 3.0 | 10 | 1.482 | 44.47 |
| 1.4 | 3.0 | 10 | 1.657 | 49.70 |
| 1.5 | 3.0 | 10 | 1.837 | 55.11 |

*Combination Inlet Flow - Grate Inlet in Sag Locations*

4.4.5.1. Grate Inlets in Sags

A grate inlet in a sag location operates as a weir to depths dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.

$$Q_i = C_w P d^{1.5}$$

where:

P = Perimeter of the grate in m (ft) disregarding the side against the curb
$C_w$ = 1.66 (3.0 in English units)
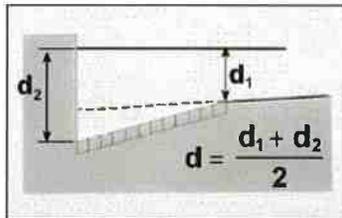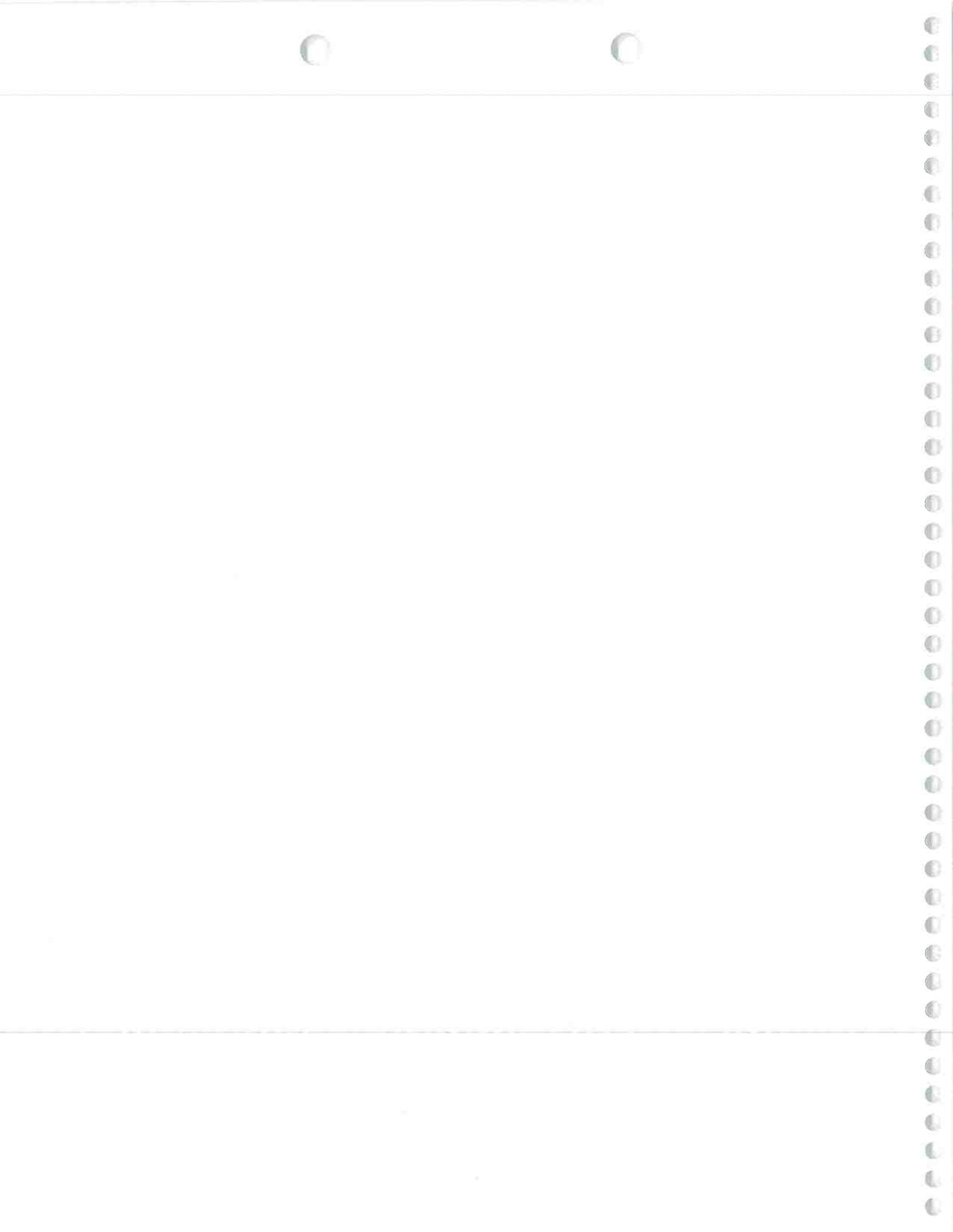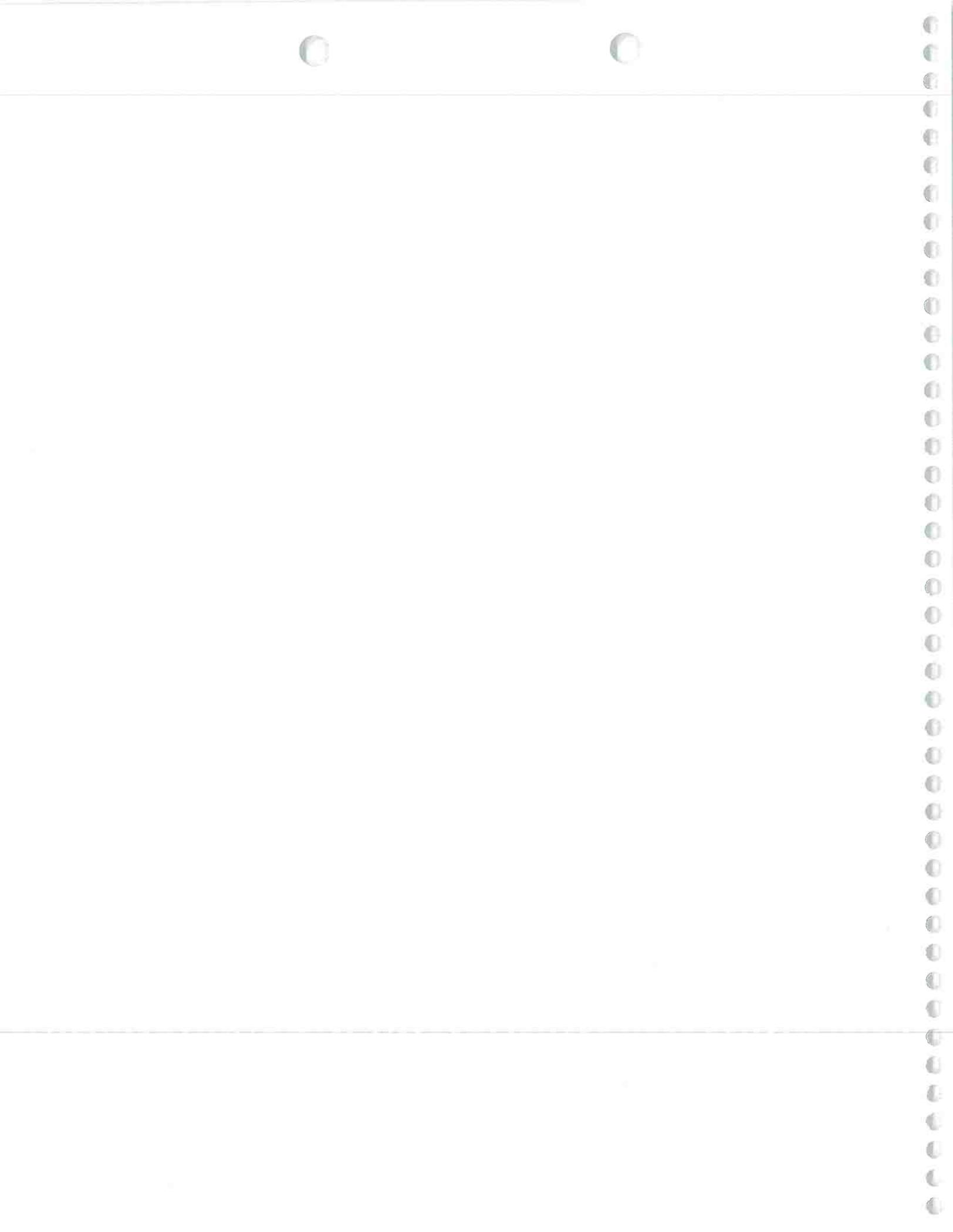d = Average depth across the grate; 0.5 ($d_1 + d_2$), m (ft)



Figure 4-17. Definition of depth.

Source FHWA HEC 22 (Revised August 2013)

# APPENDIX B7

## Macro Hydrology Calculations

Pre-Development: Site consists of an approximate 7.6 acres

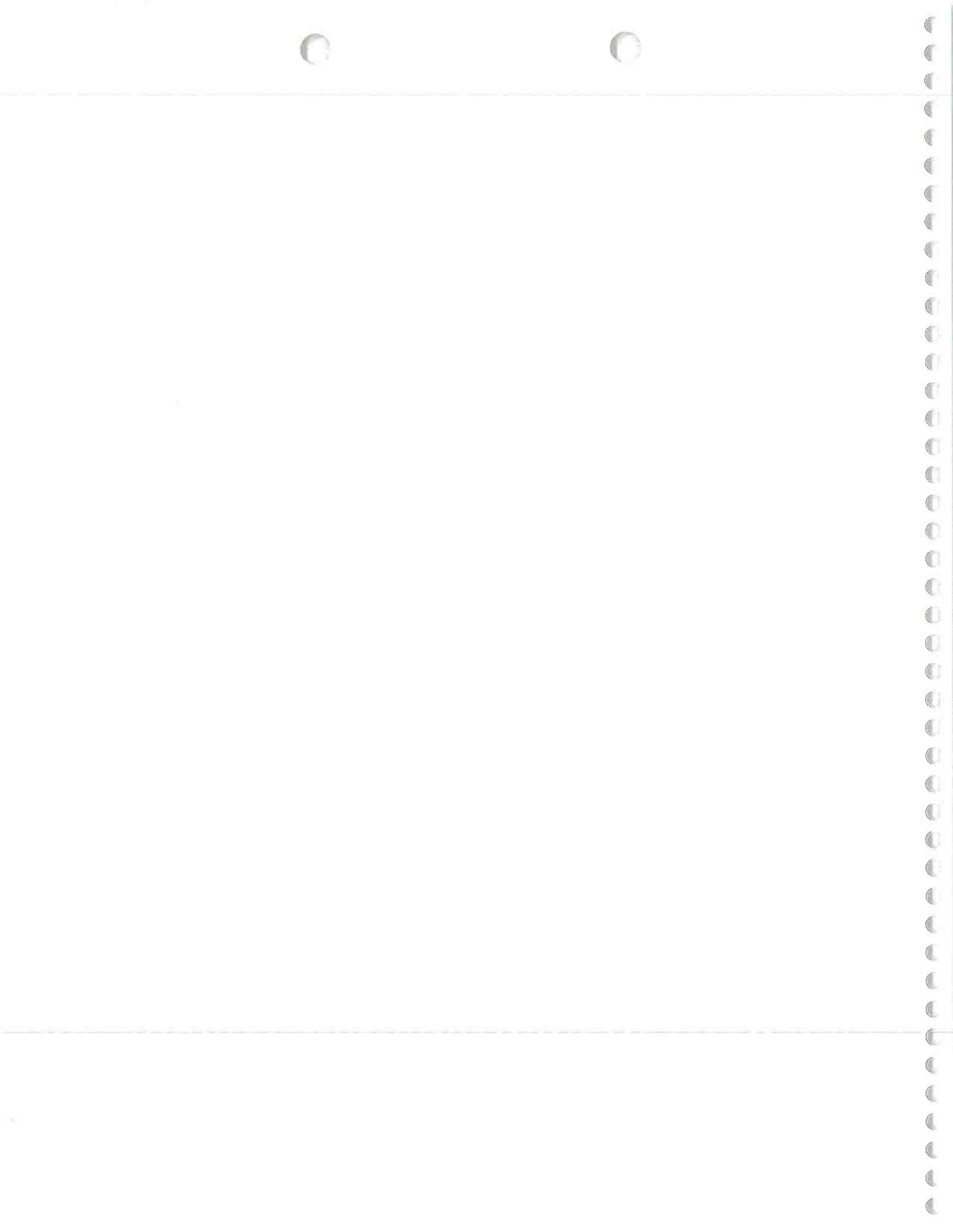Calculate Existing Runoff from 2-YR event

$$Q_2 = c \, i_2 \, A$$

$$i_2 = 1.25 \, {}^{in}/hr \; @ \; T_c = 10 \, min \; (\text{See Appendix B})$$

| Subarea | Acreage | C Factor | C*A |
|---------|---------|----------|-----|
| Agg Land | 7.18 | 0.25 | 1.795 |
| Existing Pavement | 0.42 | 0.95 | 0.357 |
| | 7.6 | | 2.15 |

$$c_w = \frac{2.15}{7.6} = 0.28$$

⟶ correlation factor

$$Q_2 = (0.29)(1.27)(7.6) * 1.04 = \boxed{2.91 \; cfs}$$

∴ Allowable outflow
From development

<u>Post-Development</u>    Site Area = 7.6 acres (Pg 1)

Calculate Future runoff after development for 100 YR event

$$Q_{100} = C i A_{100}$$

$$i_{100} = 3.2 \text{ in/hr} \quad (\text{See Appendix B})$$

| Subarea | Acreage | C Factor | C*A |
|---|---|---|---|
| Houses /Driveways/ Sidewalks /curbs | 2.02 | 0.95 | 1.92 |
| Paved Road | 1.66 | 0.85 | 1.41 |
| Vegetated (lawns, etc) | 3.92 | 0.25 | 0.98 |
| | 7.6 | | 4.31 |

* House = 40' × 40'
  or   30' × 30'
Driveway = 20' × 20'

$$C_w = \frac{4.31}{7.6} = 0.57$$

correlation Factor

$$Q_{100} = (0.57)(3.33)(7.6) * 1.04 = \boxed{15 \text{ cfs}}$$

Note: Increase in impervious area is as follows:

- Pre-development impervious = 0.42 AC (Pg 1)
- Post-development impervious = 3.68 AC

=> Difference = 3.26 acres increase in impervious.
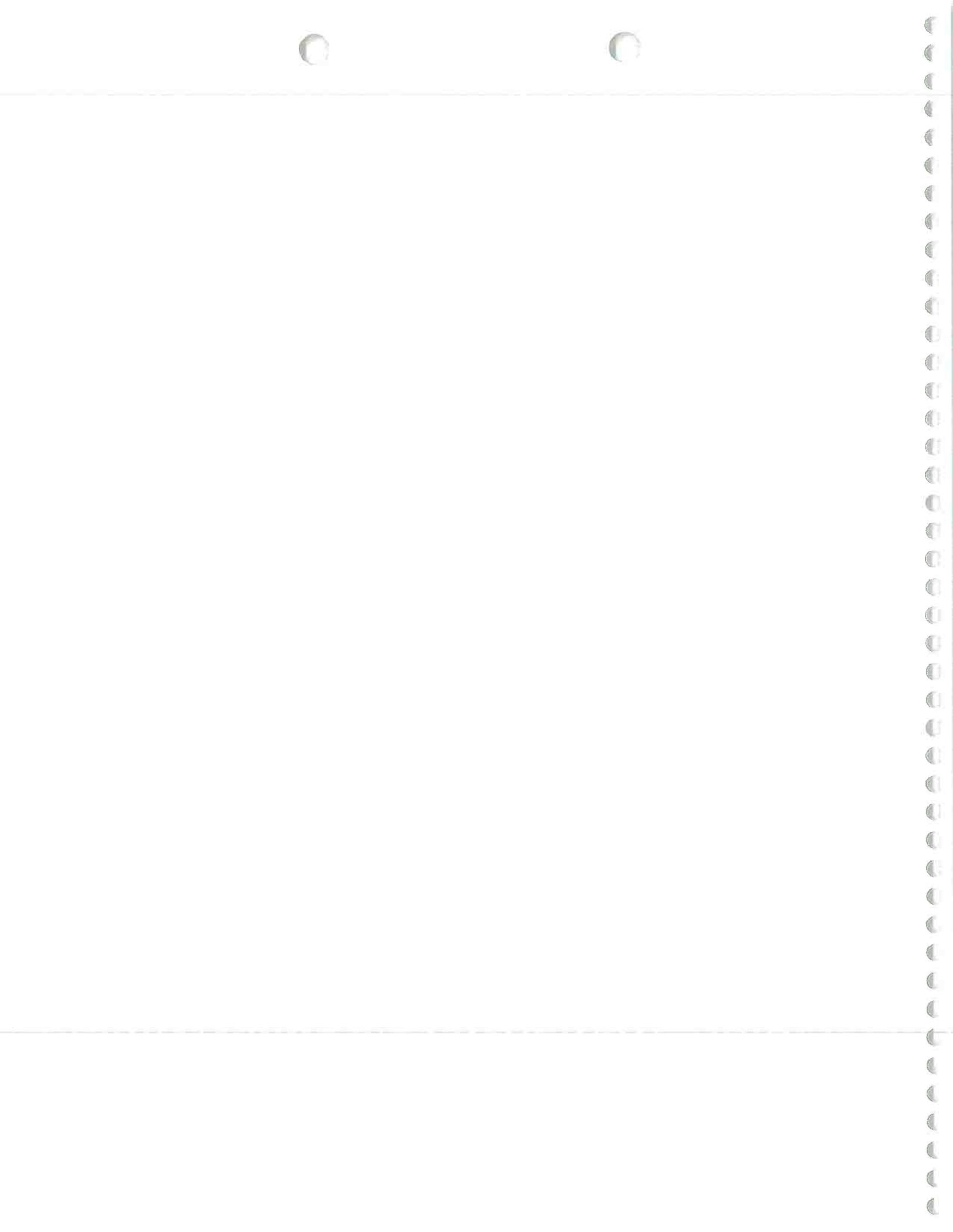
## STORM DRAIN FLOW CALCULATIONS

| Drainage Basin | Area (acres) | $C_W$ | AC | 10-YEAR I (in/hr) | 10-YEAR Q (ft³/sec) | 100-YEAR I (in/hr) | 100-YEAR Q (ft³/sec) |
|---|---|---|---|---|---|---|---|
| A | 0.62 | 0.58 | 0.36 | 1.97 | 0.71 | 3.33 | 1.20 |
| B | 0.61 | 0.54 | 0.33 | 1.97 | 0.65 | 3.33 | 1.10 |
| C | 0.71 | 0.52 | 0.37 | 1.97 | 0.73 | 3.33 | 1.23 |
| D | 0.48 | 0.56 | 0.27 | 1.97 | 0.53 | 3.33 | 0.90 |
| **E | 0.80 | 0.51 | 0.41 | 1.97 | 0.80 | 3.33 | 1.36 |
| **F | 0.07 | 0.71 | 0.05 | 1.97 | 0.10 | 3.33 | 0.17 |
| **G | 0.41 | 0.54 | 0.22 | 1.97 | 0.44 | 3.33 | 0.74 |
| H | 0.24 | 0.67 | 0.16 | 1.97 | 0.32 | 3.33 | 0.54 |
| I | 1.9 | 0.56 | 1.06 | 1.97 | 2.10 | 3.33 | 3.54 |
| **J | 0.57 | 0.42 | 0.24 | 1.97 | 0.47 | 3.33 | 0.80 |
| *K | 0.65 | 0.82 | 0.53 | 1.97 | 1.05 | 3.33 | 1.77 |
| | | | | Total | 7.89 | | 13.33 |

*OFFISTE WASHINGTON AVENUE IMPROVEMENTS
**VEGETATED SWALE FLOW NOT COUNTED IN ONSITE PIPE SIZING ONLY BASIN SIZING

## STORM DRAIN PIPE CAPACITY CALCULATIONS

| Pipe Label | Area | 10-YEAR Q (ft³/sec) | 100-YEAR Q (ft³/sec) | Pipe Length (ft) | Pipe Size (in) | S (ft/ft) | Pipe Capacity (ft3/sec) | 100-YEAR *V (ft/sec) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| SD-1 | A | 0.71 | 1.20 | 30 | 18 | 0.005 | 8.1 | 3.3 | >2 ft /s so self clean ok |
| SD-2 | A+B | 1.36 | 2.29 | 96 | 18 | 0.005 | 8.1 | 3.9 | >2 ft /s so self clean ok |
| SD-3 | A+B | 1.36 | 2.29 | 201 | 18 | 0.02 | 16.1 | 6.2 | >2 ft /s so self clean ok |
| SD-4 | A+B+C | 2.08 | 3.52 | 21 | 18 | 0.005 | 8.1 | 3.9 | >2 ft /s so self clean ok |
| SD-5 | A+B+C+D | 2.61 | 4.42 | 29 | 18 | 0.005 | 8.1 | 4.4 | >2 ft /s so self clean ok |
| SD-6 | A+B+C+D | 2.61 | 4.42 | 125 | 18 | 0.005 | 8.1 | 4.6 | >2 ft /s so self clean ok |
| SD-7 | A+B+C+D | 2.61 | 4.42 | 190 | 18 | 0.005 | 8.1 | 4.6 | >2 ft /s so self clean ok |
| SD-8 | A+B+C+D+H | 2.93 | 4.95 | 85 | 24 | 0.005 | 17.3 | 4.7 | >2 ft /s so self clean ok |
| SD-9 | A+B+C+D+H+I | 5.03 | 8.50 | 37 | 24 | 0.005 | 17.3 | 5.5 | To Basin |

*Design flow Velocity Calculated using Autodesk Hydroflow Express Extension

## HYDRAULIC GRADE LINE CALCULATIONS

| Location | 100-YEAR Q (ft³/sec) | Pipe Length (ft) | Pipe Size (in) | V (ft/sec) | V2/2g (ft) | EGL (ft) | HGL (ft) | Design Grate/Rim Elevation (ft) | Pipe FL Elevation (ft) | *Pipe Crown Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| Basin w.s. | | | | | | 133.00 | 133.00 | | | |
| SD-9 Outlet | | | | | | | | - | 133.00 | 135.00 |
| | 8.50 | 37 | 24 | 5.5 | 0.47 | | | | | |
| DI-6 | | | | | | 134.65 | 134.18 | 136.30 | 133.20 | 135.20 |
| | 4.95 | 85 | 24 | 4.7 | 0.34 | | | | | |
| DI-5 | | | | | | 134.81 | 134.47 | 136.50 | 133.60 | 135.60 |
| | 4.42 | 190 | 18 | 4.6 | 0.33 | | | | | |
| SDMH-3 | | | | | | 137.93 | 137.60 | 140.20 | 136.80 | 138.30 |
| | 4.42 | 125 | 18 | 4.6 | 0.33 | | | | | |
| SDMH-2 | | | | | | 138.30 | 137.97 | 140.10 | 137.50 | 139.00 |
| | 4.42 | 29 | 18 | 4.4 | 0.30 | | | | | |
| DI-4 | | | | | | 138.59 | 138.26 | 139.70 | 137.60 | 139.10 |
| | 3.52 | 21 | 18 | 3.9 | 0.24 | | | | | |
| DI-3 | | | | | | 138.48 | 138.18 | 139.70 | 137.70 | 139.20 |
| | 2.29 | 201 | 18 | 6.2 | 0.60 | | | | | |
| SDMH-1 | | | | | | 142.29 | 141.69 | 142.90 | 141.30 | 142.80 |
| | 2.29 | 96 | 18 | 3.9 | 0.24 | | | | | |
| DI-2 | | | | | | 142.53 | 142.29 | 143.90 | 141.25 | 142.75 |
| | 1.20 | 30 | 18 | 3.3 | 0.17 | | | | | |
| DI-1 | | | | | | 142.45 | 142.28 | 143.90 | 141.40 | 142.90 |
| | | | | | | | | | | |
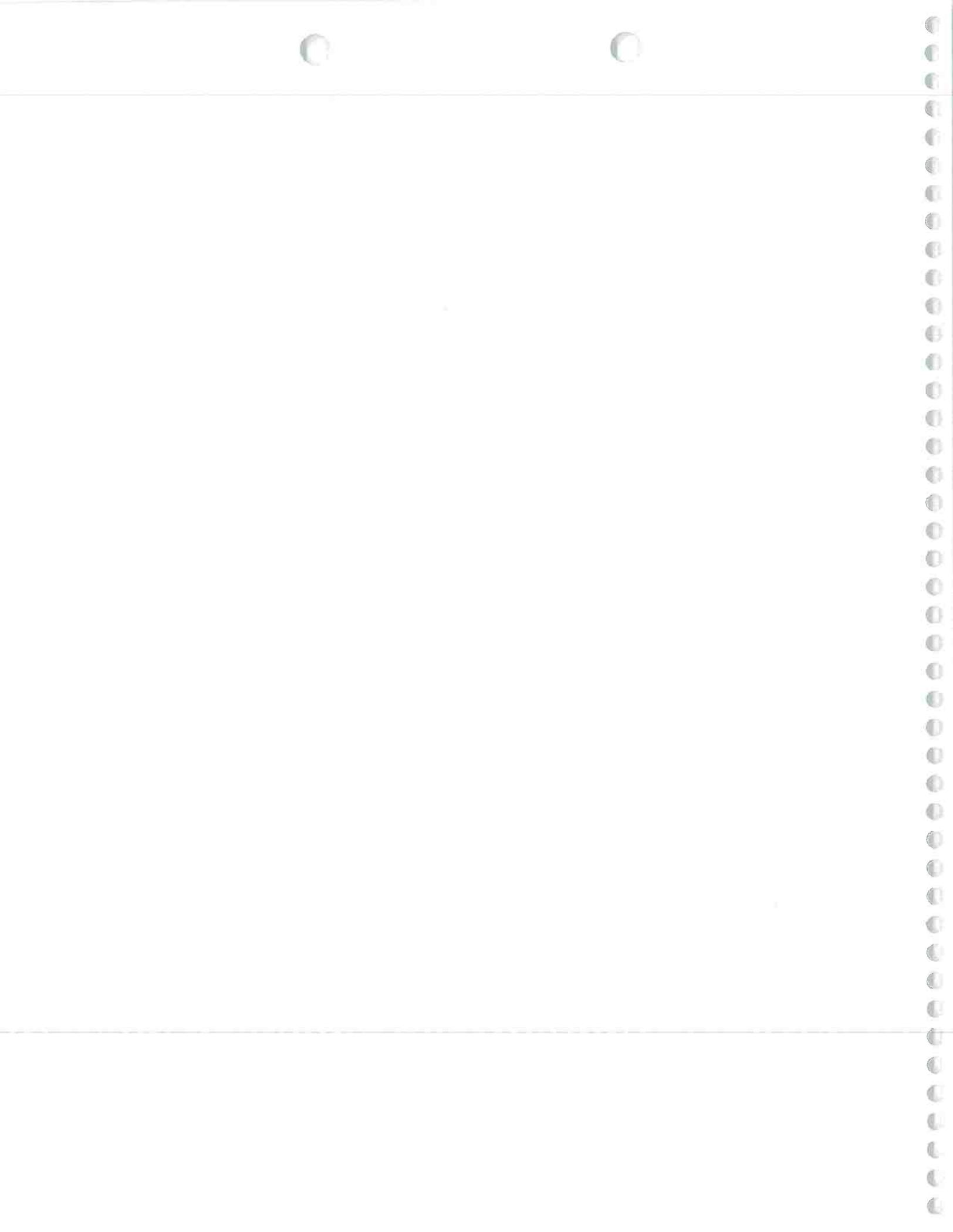
# APPENDIX C

# OPERATIONS & MAINTENANCE
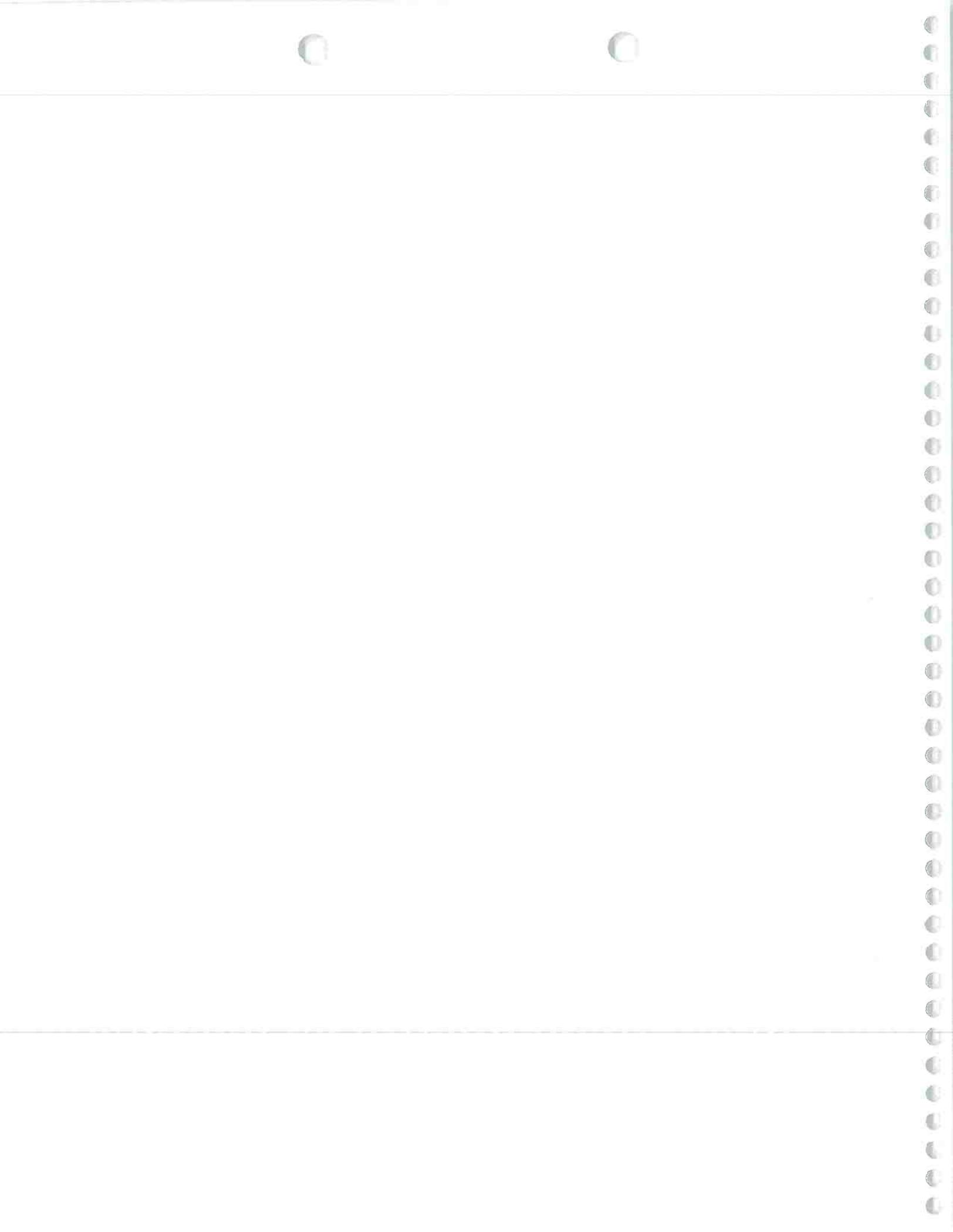
# O and M: Inspection and Maintenance Checklist: Bioretention Facility
## Example of Inspection Maintenance Document

Responsible Individual: _____

Facility Name: _____

Date of Inspection: _____

| Item | Conditions When Maintenance Is Needed | Maintenance Needed? (Y/N) | Comments (Describe maintenance completed; and if any needed maintenance was not conducted, note what is needed and when it will be done) | Results Expected When Maintenance Is Performed |
|---|---|---|---|---|
| General | | | | |
| Trash and Debris | Trash and debris accumulated in basin Visual evidence of dumping | | | Trash and debris cleared from site. |
| Contaminants and Pollution | Any evidence of oil, gasoline, contaminants or other pollutants | | | No contaminants or pollutants present. |
| Vegetation | When the planted vegetation becomes excessively tall. When nuisance weeds and other vegetation start to take over. | | | Vegetation mowed per specifications or maintenance plan, or nuisance vegetation removed so that flow is not impeded. Vegetation should never be mowed lower than the design flow depth. Remove clippings from the area and dispose appropriately. |

This or a similar document should remain with the facility. Inspection and maintenance records should be available upon request from the PBS departments with project location jurisdiction.
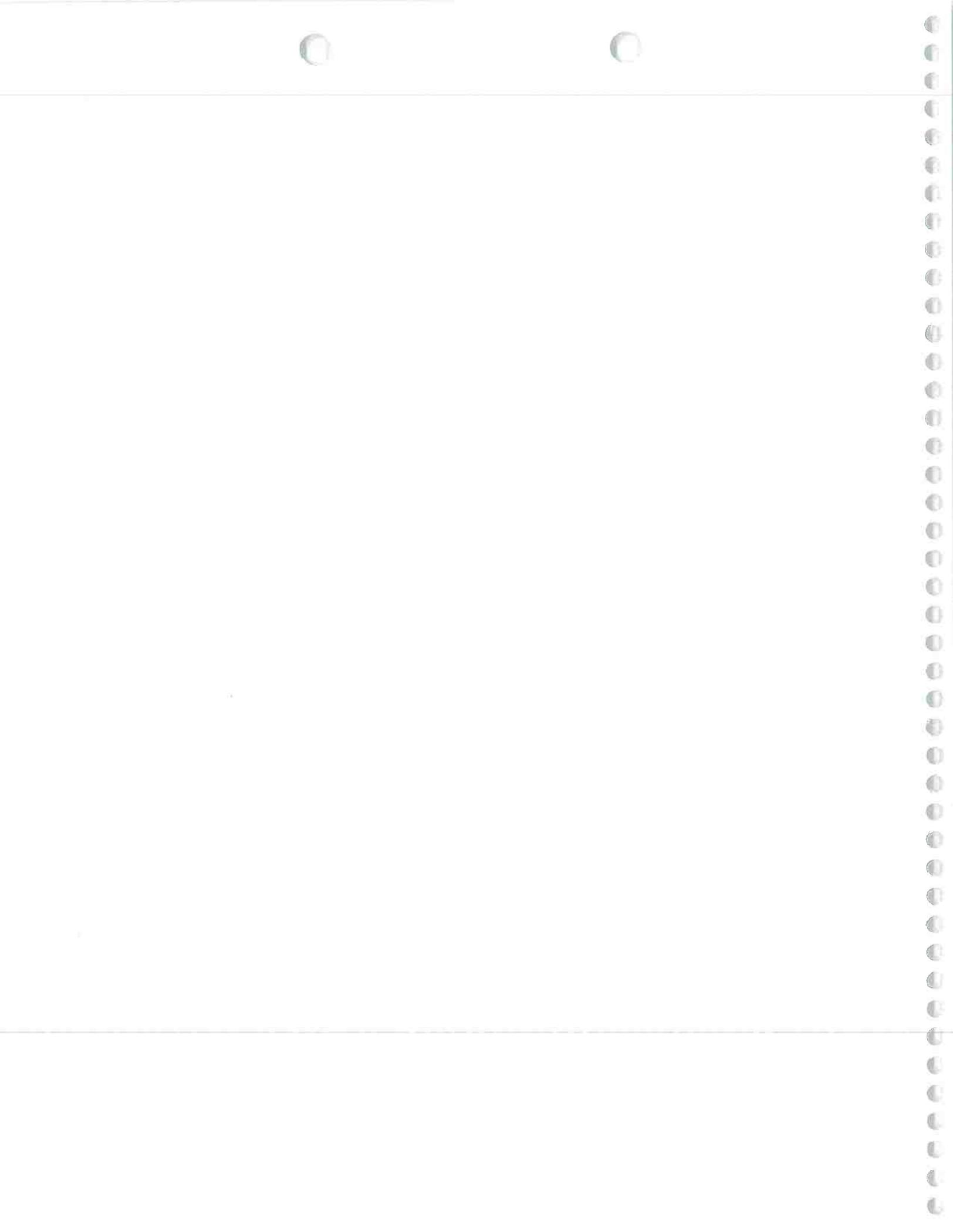
# O and M: Inspection and Maintenance Checklist: Bioretention Facility

| Item | Conditions When Maintenance Is Needed | Maintenance Needed? (Y/N) | Comments (Describe maintenance completed; and if any needed maintenance was not conducted, note what is needed and when it will be done) | Results Expected When Maintenance Is Performed |
|---|---|---|---|---|
| Tree/Brush Growth and Hazard Trees | Growth does not allow maintenance access or interferes with maintenance activity<br><br>Dead, diseased, or dying trees | | | |
| Erosion | Eroded over 2 in. deep where cause of damage is still present or where there is potential for continued erosion. | | | Cause of erosion is managed appropriately. Areas remulched to fill in void areas. |
| Sediment | Accumulated sediment affects inletting or outletting condition of the facility. | | | Sediment removed and area reseeded if necessary to control erosion. |
| Damaged Pipes | Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping. | | | Pipe repaired or replaced. |
| Rodent Holes | If facility acts as a dam or berm, any evidence of rodent holes, or any evidence of water piping through dam or berm via rodent holes. | | | The design specifications are not compromised by holes. Any rodent control activities are in accordance with applicable laws and do not affect any protected species |

This or a similar document should remain with the facility. Inspection and maintenance records should be available upon request from the PBS departments with project location jurisdiction.