CITY OF SPRINGDALE
Committee Agendas
Monday, May 17, 2021
City Council Chambers
City Administration Building
Meetings begin at 5:30 P.M.

Ordinance Committee by Chairman Mike Overton

1. ***An Ordinance*** amending Chapter 98, regulation pertaining to specific sign types, of the Code of Ordinances of the City of Springdale, Arkansas, and for other purposes. Ordinance presented by Ernest Cate, City Attorney. Pgs. 2 & 3

2. ***A Ordinance*** amending Chapter 106, Stormwater Drainage Criteria Manual, of the Code of Ordinances of the City of Springdale, Arkansas. Ordinance presented by Ernest Cate, City Attorney. Pgs. 4 - 92

3. ***A Discussion*** of Act 930 of 2021. Discussion led by Mike Overton. Pgs. 93 & 94

Finance Committee by Chairman Jeff Watson

4. ***A Resolution*** authorizing the execution of a construction contract for a traffic signal (located at Ford Avenue and Butterfield Coach Road). Resolution presented by Brad Baldwin, City Engineer. Pgs. 95 & 96

5. ***A Resolution*** expressing the willingness of the City of Springdale to utilize Federal Funding for the following project: Dean's Trail Phase IIIA. Resolution presented by Brad Baldwin, City Engineer. Pg. 97

6. ***A Resolution*** authorizing the execution of a Construction Contract at the Springdale Municipal Airport for regional detention. Resolution presented by Brad Baldwin, City Engineer. Pgs. 98 & 99

Police and Fire Committee by Chairman Brian Powell

7. ***A Resolution*** authorizing the change in staffing of the Police Department to fill the vacant position of Assistant Police Chief and reduce the captains by one. Resolution presented by Mike Peters, Chief of Police. Pgs. 100 & 101

Committee of the Whole

8. ***A Discussion*** regarding a platted street in Mt. Callahan Acres Subdivision. Discussion led by Ernest Cate, City Attorney. Pgs. 102 - 109

That which is underlined is added; that which is stricken through is deleted.

ORDINANCE NO. ________

AN ORDINANCE AMENDING CHAPTER 98 OF THE CODE OF ORDINANCES OF THE CITY OF SPRINGDALE, ARKANSAS, AND FOR OTHER PURPOSES.

WHEREAS, the City Council for the City of Springdale has adopted regulations pertaining to specific sign types;

WHEREAS, the City Council finds that the regulations pertaining to certain vehicle signs needs to be clarified;

WHEREAS, the City Council recognizes that protection of the City's visual environment and beauty will benefit both residential and commercial property owners and will promote a positive image of the City, and the City Council has a compelling interest and desire to promote the reasonable, orderly, and effective display of signs in the City of Springdale;

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS:

Section 1: Section 98-56(a)(1) of the Code of Ordinances of the City of Springdale, Arkansas, is hereby amended to read as follows:

Sec. 98-56. – Nonconforming uses

(a) *Grace period.* Signs in place on the effective date of this chapter which are not in compliance with its terms shall be deemed a nuisance and are required to be removed or brought into full compliance as follows:

1) Signs not in compliance with sections 98-31, 98-60(a)(3) through (a)~~(5)~~(6), 98-60(b) and 98-61 except (a) and (1), within 30 calendar days after the effective date; and

Section 2: Section 98-60(a) of the Code of Ordinances of the City of Springdale, Arkansas, is hereby amended to read as follows:

Sec. 98-60. - General requirements for all signs.

(a) *Prohibited signs.* No sign shall be permitted, erected, used or maintained in the city which:

(1) Is not constructed in full compliance with the current adopted Building Code and the electrical wiring standards of National Electrical Code and with the approved plastic materials specified in the current adopted Building Code, as applicable, and with the requirements of section 98-62, whichever is more restrictive, and with all other applicable provisions of this chapter and the city code except signs exempt from permit requirements of article II of this chapter and except as otherwise herein provided.

(2) Is not permanently attached and anchored in full compliance with the construction requirements of this chapter and the current adopted Building Code, whichever is more restrictive, except for signs exempt from permit requirements of article II of this chapter and except for temporary signs.

(3) Contains or consists of such animation, flashing or focused light, lighting, noise or illumination of such intensity so as to impair the safety of the public, unduly disturb the use of any property or otherwise constitute a nuisance or hazard or is constructed, erected, used and/or maintained so as to be an obstruction of vision near any driveway, parking lot or roadway or interferes with, obstructs the view of or is likely to be confused with any authorized traffic

sign, signal or device by such location as may interfere with, mislead or confuse traffic.

(4) No longer identifies a bona fide business, service, current interest or activity.

(5) Is in a state of structural, mechanical or cosmetic disrepair such that it does not meet the construction standards hereof or such that it is a visual blight or eyesore clearly visible from public rights-of-way.

(6) Is a vehicle sign, which is a sign attached to or painted on vehicles including automobiles, trucks, boats, campers, and trailers, which are parked on or otherwise utilizing a public right-of-way, public property or on private property so as to be intended to be viewed from a vehicular right-of-way for the basic purpose of providing advertisement for products or services or directing people to a business or activity. This definition is not to be construed to include those signs that identify a firm or its principal product as on a vehicle or such advertising devices as may be attached to and within the normal unaltered lines of the vehicle of a licensed transit carrier, when and during that period of time said vehicle is regularly and customarily used to traverse the public highways during the normal course of business.

Section 3: All other provisions of Chapter 98 of the Code of Ordinances of the City of Springdale, Arkansas, not specifically amended by this ordinance shall remain in full force and effect.

PASSED AND APPROVED this ______ day of ________________, 2021.

____

Doug Sprouse, Mayor

ATTEST:

____

Denise Pearce, City Clerk

APPROVED AS TO FORM:

____

Ernest B. Cate, City Attorney

That which is underlined is added; that which is stricken through is deleted.

ORDINANCE NO. ________

AN ORDINANCE AMENDING CHAPTER 106 OF THE CODE OF ORDINANCES OF THE CITY OF SPRINGDALE, ARKANSAS.

WHEREAS, Chapter 106 of the Code of Ordinances of the City of Springdale, Arkansas, contains the Stormwater Drainage Criteria Manual for the City of Springdale, Arkansas;

WHEREAS, it is in the best interest of the City of Springdale, Arkansas, for the City Council of the City of Springdale, Arkansas, to amend Section 5.4.5 of the Stormwater, Drainage Criteria Manual for the City of Springdale, Arkansas, to allow for and to implement the City of Springdale Low Impact Development Design Guide ;

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS:

Section 1: Section 5.4.5 of the Springdale Drainage Criteria Manual is hereby amended to read as follows:

5.4.5 LOW IMPACT DEVELOPMENT AND OTHER METHODS

Low Impact Development (LID) design alternatives for stormwater mitigation are permitted; however, LID proposals must meet the detention requirements of Section 2.1 and 5.1 of this ordinance. Hybrid systems that combine detention ponding areas and LID elements are permitted. Permeable pavement designs should follow the methods outlined in the latest edition of ASCE 68-18 and manufactured product guidance. Manufacturer's product documentation must be provided. LID proposals for greenspace features should follow the methods outlined in the "City of Springdale Low Impact Development Design Guide", which is incorporated herein by reference. ~~Other methods of detention such as seepage pits, French drains, etc, are not permitted.~~ If other methods are proposed, proper documentation of soil data, percolation, geological features, etc., will be needed for review and consideration. Other methods proposed must meet the detention requirements of Section 2.1 and 5.1 of this ordinance.

Section 2: All other provisions of the Springdale Drainage Criteria Manual (Chapter 106 of the Code of Ordinances of the City of Springdale, Arkansas) not specifically modified herein shall remain in full force and effect.

Section 3: There is adopted by reference the amended Stormwater Drainage Criteria Manual, which includes the City of Springdale Low Impact Development Design Guide, three copies of which are on file in the office of the City Clerk of the City of Springdale, being marked and designated as the Stormwater Drainage Criteria Manual for the City of Springdale, Arkansas.

PASSED AND APPROVED this ______ day of ________________, 2021.

____
Doug Sprouse, Mayor

ATTEST:

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Denise Pearce, City Clerk

APPROVED AS TO FORM:

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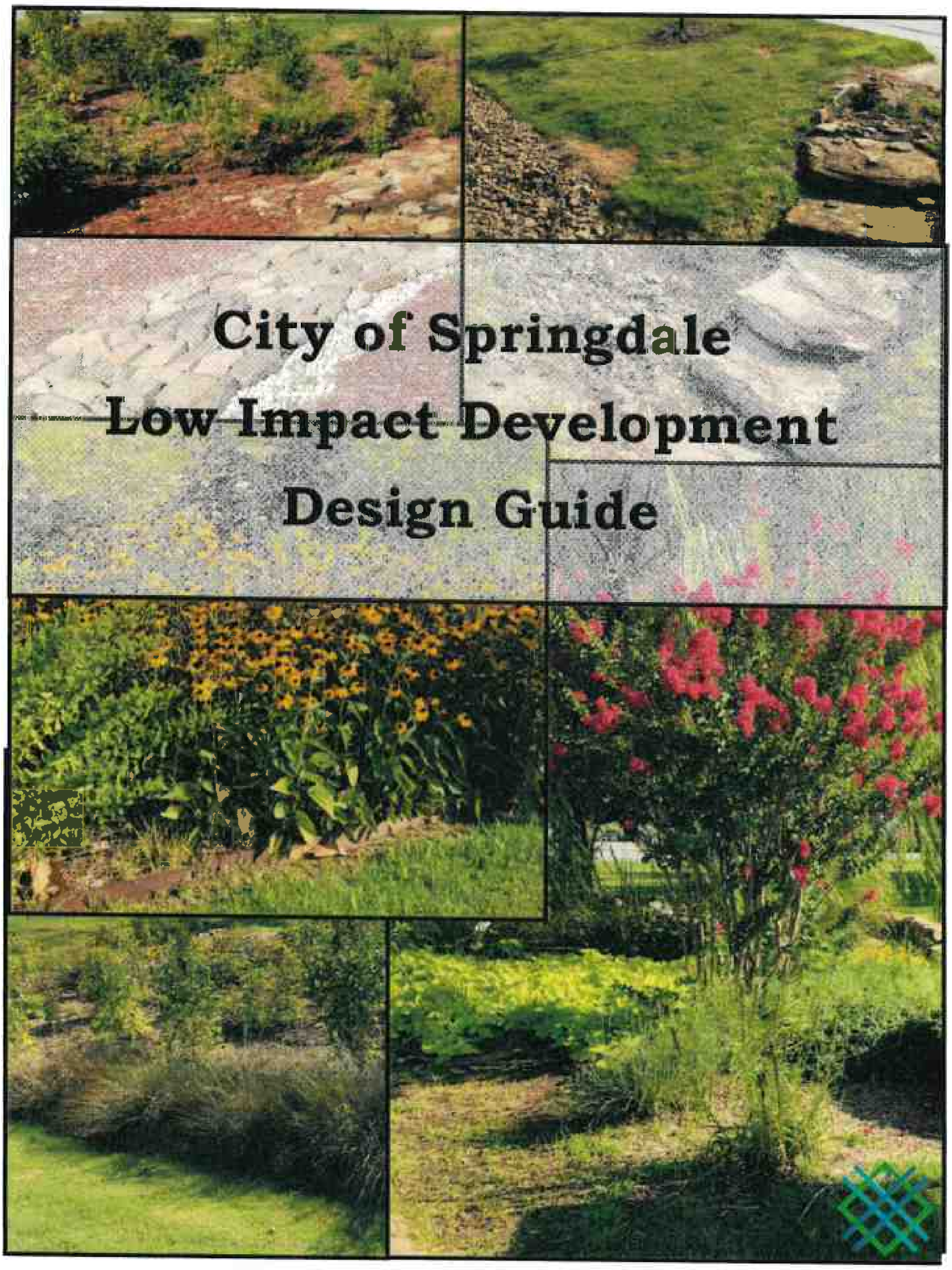
Ernest B. Cate, City Attorney



City of Springdale Low Impact Development Design Guide

P.5

City of Springdale

Low Impact Development Design Guide

SPRINGDALE
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APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ASTM .... American Society for Testing and Materials
BMP .... Best Management Practice
EPA .... United States Environmental Protection Agency
EPDM .... ethylene propylene diene monomer
F .... Fahrenheit
ft. .... Feet
in .... Inches
LID .... Low Impact Development
MCBUR .... Monolithic multi–ply hot asphalt mineral surfaced built–up–roof
PVC .... Polyvinylchloride
SCS .... Soil Conservation Service
TPO .... thermoplastic olefin
TSS .... Total Suspended Solids
US .... United States
WMS .... Watershed Management Services

VARIABLES AND CONSTANTS

A .... Contributing Area (feet^2)
A_a .... Contributing Area (acres)
A_r .... Bioretention cell Footprint (feet^2)
A_i .... Trench Footprint (feet^2)
A_o .... Orifice Opening Area (feet^2)
C .... Runoff Coefficient per Chapter 106
C_d .... Coefficient of Discharge
D_i .... Infiltration Trench Depth (feet)
D_{rs} .... Total Depth of Bioretention cell With Subdrain (feet)
E_d .... Depth of the Engineered Soils (feet)
F_d .... Freeboard (inches)
G .... Grate Reduction Factor
g .... Gravitational Constant (feet/second^2)
H .... Head (feet)
h_b .... Height of the Berm (feet)
I .... Design Infiltration Rate (inches/hour)
I_e .... Infiltration Rate of Engineered Soils (inches/hour)
L_f .... With of Filter Strip Parallel to Flow Path (feet)
L_i .... Length of Infiltration Trench (feet)
L_r .... Approximate Length of Bioretention cell Along the Axis of the Subdrain (feet)
N .... Manning's "n" Roughness Coefficient
N_o .... Number of Orifices
N_s .... Number of Outfall Structures
n_s .... Storage Media Void Ratio
P .... Target Precipitation (inches)
P_d .... Depth of Ponded Water (inches)
P_s .... Perimeter of the Stand Pipe (feet)
Q .... Flow Rate (feet^3/second)
q .... Volumetric Discharge per Foot Width (feet^3/second-foot)
S .... Slope of Filter Strip (ft/ft)
S_d .... Depth Required for Subdrain Diameter and Drain Rock (feet)
t .... Detention Time (hours)
TIV .... Target Infiltration Volume (feet^3)
T_t .... Travel Time through Filter Strip (minutes)
V_w .... Volume of a Wedge (feet^3)
V .... Velocity (feet/second)
W_f .... Width of Filter Strip Parallel to Flow (feet)
W_{fp} .... Width of Filter Strip Perpendicular to Flow Path (feet)
W_i .... Width of Infiltration Trench (feet)
W_{if1} .... Width of Infiltration Trench and One Filter Strip (feet)
W_{if2} .... Width of Infiltration Trench and Two Filter Strips (feet)
W_r .... Width of Bioretention cell (feet)
Y .... Allowable Depth of Flow (inches)

1 Introduction

The *Low Impact Development Design Guide* has been developed by the City of Springdale to provide the engineering and development community with additional guidance for the design of infiltration controls as stormwater mitigation. This manual also introduces other infiltration controls for consideration such as pervious pavements. The application of such mechanisms and strategies is referred to as Low Impact Development (LID).

LID is a storm water management strategy that focuses on maintaining or restoring the natural hydraulic functions of a site for the purpose of water resources protection. LID uses a decentralized approach that disperses flows and manages runoff closer to where it originates, as opposed to collecting storm water in a piped or channelized network and managing it at a large–scale "end of pipe" location. This management practice focuses on mimicking the natural retention, filtration, and infiltration mechanisms that storm water runoff would encounter on an undeveloped site. Therefore, the most important factor to consider in the application of LID to site design is the preservation of native vegetation and natural drainage features.

An essential part of the LID approach is conserving portions of the site in its predeveloped state to preserve the hydrologic functions of the site. To achieve this, site planners should identify and preserve areas that most affect hydrology, such as streams, wetlands, floodplains, steep slopes, and high–permeability soils. The development layout should be adjusted to reduce, minimize, and disconnect the total impervious area. Finally, on– site options for handling runoff from the impervious areas should be employed before conventional off–site storm water practices are used.

In addition to the importance of preserving native vegetation and natural drainage features, gains are made in the effort to mimic natural conditions by reducing and or disconnecting proposed impervious surfaces. Areas of pavement that can be easily broken up into multiple disconnected impervious surfaces include traffic lanes, parking lots, and paved walkways. Traffic lanes can be separated by pervious medians that receive runoff from roadway surfaces. Parking lots can be designed to incorporate vegetated strips of land to collect and convey runoff. Paved walkways can be separated from roadways by vegetated strips of land providing not only opportunities for infiltration but also increase pedestrian safety.

While water quality treatment is not the principle purpose of LID, these practices also provide water quality benefits. Overall reduction in surface runoff reduces the volume of runoff that can potentially transport pollutants. Infiltration as an LID technique reduces the mass of pollutants by filtration of particles and adsorption of chemicals to soil.

This LID policy provides guidance for the design of the following LID elements: filter strips (a type of infiltration surface), bioretention cells (a type of infiltration basin), infiltration trenches and pervious pavements. This manual also includes discussions of other LID elements that are applicable for storm water treatment in Northwest Arkansas.

The design guidance presented in this manual is based in part on the requirements presented in Springdale's Drainage Criteria Manual (Chapter 106). When performing the design of an LID element, guidance presented in both manuals should be followed. This guidance is provided to facilitate and encourage the usage of LID elements in development and redevelopment projects within the City of Springdale. **The guidance provided in this manual is not intended to supplant professional judgment.**

1.1 Costs and Benefits of LID

In 2007, the Environmental Protection Agency (EPA) published a report titled *Reducing Storm Water Costs* through *Low Impact Development: Strategies and Practices* (EPA, 2007). The report compares the projected or known costs of LID practices with those of conventional storm water management approaches. The EPA defines "traditional approaches" to storm water management as those that typically involve hard infrastructure such as curbs, gutters, and piping.

The report indicates that LID techniques can significantly reduce infrastructure costs by eliminating the need for extensive storm water infrastructure such as underground conveyance systems. The report also notes that by infiltrating or evaporating runoff, LID techniques can reduce the size and cost of flood control structures. In some circumstances, LID practices can offset the costs associated with regulatory requirements for storm water control. However, it should be noted that LID techniques may in some cases result in higher costs due to expensive plant materials, additional site preparation, soil amendments, construction of underdrains, and increased project management costs. Other cost considerations include the amount of land required to implement LID practices and potential additional maintenance requirements.

The above–mentioned cost consideration notwithstanding, case studies reviewed in the EPA report demonstrate that LID practices can reduce project costs and improve the overall environmental performance of a development. Though not all the benefits of the LID applications were monetized, with a few exceptions, LID practices were shown to be both fiscally and environmentally beneficial to communities. In a few case studies, initial project costs were higher than those for conventional designs. In most cases, however, significant savings were realized due to reduced costs for site grading and preparation, storm water infrastructure, and site paving. Total capital cost savings ranged from 15 to 80% when LID techniques were used.

The project benefits that were not monetized in the EPA study include improved aesthetics, expanded recreational opportunities, increased property values due to the desirability of the lots and their proximity to open space, increased marketing potential, and faster sales. These are all positive impacts that LID can bring to the surrounding community. On a municipal level, the EPA case studies indicate benefits such as reduced runoff volumes and pollutant loadings to downstream waters, and reduced incidences of combined sewer overflows. These benefits save taxpayer dollars and reduce pollution in downstream waters that support wildlife and recreation. This manual is intended to give the design community some of the design tools necessary to implement LID on residential, commercial, and transportation related projects so that both the monetary and non–monetary benefits discussed here can be realized.

In addition to the benefits discussed above, LID elements such as bioretention cells and filter strips can be used to meet drainage requirements in Chapter 106.

1.1 How to Use this Manual

It is not necessary for designers to read every section of this manual to design a particular LID element. After reading Section 1, designers may turn to the section that addresses the particular LID element of interest. However, being familiar with the design considerations associated with each LID element will greatly assist designers in the proper selection of the element best suited for a particular application.

1.1.1 General Structure of the Design Guidance Sections

This manual contains three major LID design guidance sections.

- Section 2: Biorentention– Shallow depressions planted with vegetation, underlain by local or engineered soils and a subdrain and/or impermeable liner.
- Section 3: Infiltration Trenches – Rectangular excavations lined with geotextile filter fabric and filled with coarse stone aggregate that serve as underground infiltration reservoirs for sheet flow runoff from impervious surfaces such as parking areas.
- Section 4: Permeable Pavements – Permeable interlocking concrete pavers underlain by local or engineered soils and a subdrain and/or permeable liner. Spaces between pavers are filled with washed, small-sized joint aggregate.

The development of a proper LID element design can be accomplished by following the guidance provided in Sections 2, 3, and 4 of this manual. Section 5 is provided to introduce additional LID elements for consideration. While the guidance provided in Section 5 is not as in–depth as that provided in the other sections, the information should be adequate to assist designers in the appropriate application and design for these elements.

A brief description of the LID element is provided at the beginning of each section. The design process is then presented in three major sections: preliminary site evaluation, preliminary design, and final design. In the preliminary site evaluation subsection, the minimum considerations to be evaluated to establish that a site is, or is not, a good candidate for the use of the particular LID element are presented. These considerations are in addition to the basic site evaluation considerations presented in Subsection 1.3. At the end of each preliminary site evaluation subsection, a checklist is introduced to assist designers in conducting a preliminary site evaluation. In the preliminary design subsection, the minimum considerations to be evaluated during the preliminary design of each LID element are presented. Where necessary, these discussions include equations to be used during the preliminary design. At the end of each preliminary design subsection, a calculation table is introduced to assist designers in conducting a preliminary design. In the final design subsection, the minimum considerations to be addressed during the final design are discussed.

Design examples for each of the three LID elements are provided in the appendices of this manual. Each design example starts with a brief description of the theoretical site being considered for the application of the particular LID element. The description is followed by a checklist for an example preliminary site evaluation. The preliminary design example is then presented using a preliminary design calculation table. In the final design example sections, discussions are provided of how the minimum considerations presented in each section are to be addressed in the final design. Conceptual design figures are also presented.

1.1.2 Selecting an LID Element

Bioretention and infiltration trenches are suitable for applications where infiltration of the adjusted 2–year, 24–hour storm event is desired. Thus, by incorporating these LID elements into small and large developments, designers can potentially limit the amount of infrastructure required to meet the requirements listed in Chapter 106.

Filter strips are suitable for applications where treatment of the first flush of runoff is desired. Filter strips are also suitable for use as pretreatment devices upstream of other LID elements such as bioretention cells and infiltration trenches.

Each of the elements presented in Sections 2 through 4 of this manual are suitable to a wide range of applications. Table 1 below provides some suggestions for suitable applications for each element. To perform a detailed evaluation of whether or not a particular LID element is suitable for application to a particular site or portion of a site, performance of a preliminary site evaluation and a preliminary site design is required.

Table 1 – Suggested Suitable Applications for LID Elements

LID Element	Parking Lot Runoff	Roof Top Runoff	Roadway Runoff	Airport Drainage	Residential Development	Pretreatment
Bioretention	Yes	Yes	Yes	No	Yes	No
Infiltration Trenches	Yes	Yes	Yes	Yes	Yes	No
Filter Strips	Yes	No	Yes	Yes	Yes	Yes
Permeable Pavers	Yes	Yes	Yes	No	Yes	No

1.2 Basic Site Evaluation Considerations

The considerations listed below should be included in the site evaluation for each of the LID elements in Section 2 through Section 4. Considerations specific to the particular elements are listed under the preliminary site evaluation discussion within each section.

1.2.1 Infiltration Rate of the Surrounding Soil

The utility of LID elements such as bioretention cells, infiltration trenches, and soak–away pits is dependent on the rate at which the local soil can infiltrate storm water. To operate properly, these LID elements should completely infiltrate storm water runoff from a particular event within 48 hours. Thus, soils with low infiltration rates are not desirable.

Infiltration rates must be estimated based on site investigations. All LID designs must be accompanied by a geotechnical report addressing sections 1.2.1- 1.2.4. Infiltration testing includes soil borings or test pits in the vicinity of the proposed facility as well as physical in-situ infiltration tests. Accepted engineering methods should be used. The acceptable range of measured infiltration rates of soils in an area being considered for use of these LID elements is 0.3 to 8 inches/hour. These infiltration rates must be representative of the soil at the bottom of the proposed facility. The minimum infiltration rate does not apply to bioretention cells with impermeable liners (known as "lined bioretention cells").

For design purposes, the measured infiltration rate of soils is adjusted using a factor of safety to account for soil non-homogeneity and to reflect reduction in infiltration capacity over the life of the facility. Equations in this manual use design rather than measured infiltration rates and 1 inch per hour is specified as the maximum design infiltration rate.

Use of higher design infiltration rates may be allowed, based on site specific investigation.

1.2.2 Depth to Groundwater

To protect groundwater resources, it is important to provide ample separation between LID elements and the surface of the local groundwater table. The minimum separation distance between the seasonal high groundwater table elevation and the bottom of infiltration trenches is 4 feet. The minimum separation distance between the seasonal high groundwater table elevation and the surface of an unlined bioretention cell is 4 feet. Due to difficulties with bioretention cell construction at or near the groundwater surface, the minimum separation distance between the bottom of lined bioretention cells and the seasonal high groundwater table elevation is 2 feet.

1.2.3 Depth to Bedrock or Relatively Impervious Soils

Bedrock or Hydrologic Soil Group Class D soils directly below the bottom of LID elements can have undesirable effects, such as limiting the infiltrative capacity of the element, or in the case of highly fractured bedrock, allowing untreated discharge to reach groundwater. To reduce the possibility of limited infiltration or treatment due to the presence of bedrock or impervious soils, the minimum separation distance between these materials and the bottom of unlined bioretention cells and infiltration trenches is 3 feet.

1.2.4 Separation Distance from Foundations and Road Subgrades

Unlined bioretention cells and infiltration trenches must be either outside of the zone of influence of foundations and road subgrades or separated from these structures by a horizontal distance of 20 feet. The zone of influence refers to the area of the surrounding subgrade that is critical to proper function and support of the overlying and/or adjacent foundation or road subgrade. The zone of influence can be defined as the area bounded within a 3–dimensional surface extending at a 1:1 slope down and away from the outer edge of a foundation or road subgrade. An additional horizontal setback may be required when there is potential for surface seepage due to the vertical elevation difference between the bottom of the infiltration facility and adjacent land or property due to steep slopes or retaining walls.

1.3 Construction Considerations

Construction of the LID elements discussed in Sections 2 through 4 of this manual shall incorporate the considerations discussed below in addition to those provided in the construction considerations discussion presented in the section specific to each LID element.

1.3.1 Excavation

Care must be taken during the excavation of areas for LID elements to assure that the existing infiltrative capacity of the soil is not reduced due to compaction. Excavation should be performed by machinery operating adjacent to the excavated area, if possible. When it is necessary for excavation equipment to operate within the footprint of an LID element, lightweight, low ground contact pressure equipment should be used. Heavy equipment with narrow tracks, narrow tires or large lugged, high pressure tires should not be allowed on the bottom of the excavations. Following excavation, the base of the excavation should be ripped to refracture the soil to a minimum of 12 inches.

1.3.2 Excess Sediment

Care must be taken to assure that LID elements are not overburdened with sediment generated by construction in adjacent areas. LID elements should not be used as sediment control facilities for construction. Runoff from adjacent construction should be directed away from LID elements with temporary diversion swales or other protection. Flow to newly constructed LID elements should not be allowed until all of the contributing area is stabilized according to the satisfaction of the engineer.

1.4 Separation from Underground Utilities

Generally, LID elements should have the following separation distances from underground utilities:

Wastewater – 10 feet
Drinking Water – 10 feet
Electric – 6 feet
Gas – 6 feet

Deviation from these separation distances may be granted at the discretion of the Springdale Engineering Department and in cooperation with the utility company or companies.

1.5 Equations

This document contains a number of design equations that are provided to assist the development community in the proper design of the LID elements presented in this manual. A brief discussion of each equation, including an explanation of constants, is provided in Appendix A.

1.6 LID Design Notes

The following design notes are common to the design of bioretention, infiltration trenches, and filter strips.

- Rainfall Depth: The guidance provided in this manual has been developed in part to assist the development community in the design of LID elements capable of infiltrating the base 2–year, 24–hour event.

- Runoff Coefficient per Chapter 106: The preliminary design process for bioretention, infiltration trenches, and filter strips requires the calculation and input of the Runoff Coefficient. The term "Runoff Coefficient" is used in this document to refer to the "Rational Method Coefficient" as described in Chapter 106. In all cases, the Runoff Coefficient is to be calculated according to guidance contained in Chapter 106.

- Soil Infiltration Rates: The design of bioretention cells, infiltration trenches, and filter strips requires knowledge of the local infiltration rate. In addition, when engineered soil is used in a bioretention cell design, the design process requires knowledge of the infiltration rate of the engineered soil. Measured infiltration rates should be adjusted to design infiltration rates using appropriate factors of safety. For estimation of the infiltration rate for engineered soils, designers are referred to Appendix C of this manual.

- Overflow Structures: In all cases, overflow structures for LID elements should be designed and sized to assure that during a 100–year 24–hour storm water is provided a clear, safe, non–destructive path to an appropriately sized conveyance system without causing any kind of localized flooding.

- Target Infiltration Volume (TIV): The term Target Infiltration Volume is used in this manual to define the target volume for design of LID elements.

2 Bioretention

A bioretention cell or bioswale is a shallow depression planted with vegetation, underlain by local or engineered soils and a subdrain and/or impermeable liner. Both bioretention cells and bioswales are intended to temporarily retain and treat storm water runoff through filtration and other mechanisms. A subdrainage system that discharges to an open channel or storm drain is required.

Bioretention cells are an extremely versatile LID element and several variations exist. In Springdale, all Biorention cells require a subdrain. Impervious liners are sometimes required to protect groundwater or to protect adjacent foundations. Conceptual profile drawings of both types of bioretention cells are presented in Figure 1.

The soil within a bioretention cell serves as the filtration medium and also provides a rooting area for the bioretention cell plants. The bioretention cell plants play an important role in the storm water treatment process, as they encourage infiltration (if the bioretention cell is not lined) and provide treatment for pollutants, such as total petroleum hydrocarbons, through the process of phytoremediation. In addition to their value as storm water treatment devices, bioretention cells can be designed as attractive landscaping features.

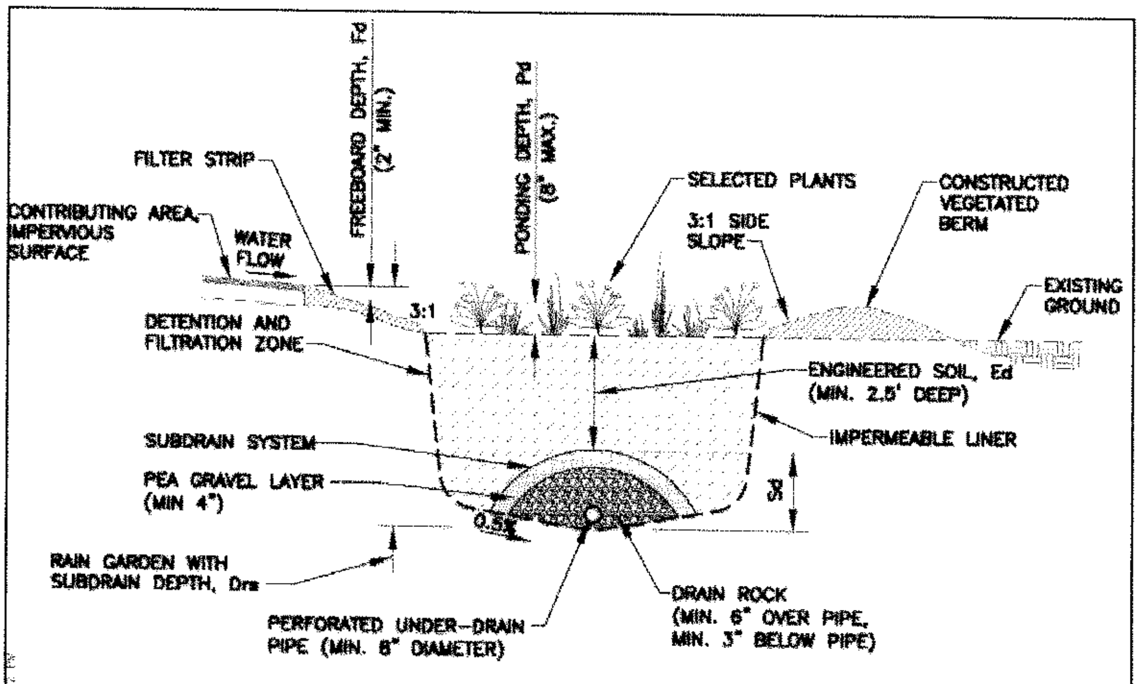
Bioretention cells are a good choice to treat and/or infiltrate runoff from impervious parking lots, both high– and low–density housing developments and recreation areas. They can also be used in high–density urban applications when the proper precautions are taken to protect adjacent foundations. Bioretention cells are capable of removing fine suspended solids as well as other pollutants including copper, lead, zinc, phosphorous, and nitrogen.

In order for rain gardens and bioswales to be effective, they must be designed to meet the geologic, vertical, and horizontal constraints of a site. The process of developing an appropriate bioretention cell design based on local site constraints is presented in the following sections.

2.1 The Bioretention Cell Design Process

The bioretention cell design process involves preliminary site evaluation, preliminary and final design, the basic site evaluation considerations discussed in Subsection 1.3, and the following more specific considerations.

Figure 1 – Conceptual Bioretention Cell Profiles



LINED RAIN GARDEN WITH SUBDRAIN

2.1.1 Preliminary Site Evaluation – Bioretention cells

The following subsections present the minimum site–specific factors, in addition to those discussed in Subsection 1.3, that are to be considered when evaluating a site for the potential use of a bioretention cell to treat storm water runoff. The minimum considerations presented below do not include typical engineering considerations such as utility conflicts and are not a substitute for sound engineering judgment.

2.1.1.a Runoff Source

Bioretention cells are intended to treat runoff from urban and suburban drainage areas where pollutant loads are related primarily to residential, parking, and road surface runoff. Bioretention cells are not appropriate to receive runoff from industrial facilities or areas where runoff is likely to contain industrial pollutants.

2.1.1.b Contributing Area

Because of the difficulty of providing retention and infiltration of runoff from a large area within the relatively small footprint of a bioretention cell, it is necessary to limit the size of the area contributing runoff. Generally, a single bioretention cell should not be designed to receive runoff from areas larger than 5 acres. It is possible to treat runoff from very large areas if multiple bioretention cells or bioretention cells in combination with other LID elements are used.

2.1.1.c Slope of Available Area for Bioretention cell

Bioretention cells are generally difficult to construct on steep sites. This is because the surface of a bioretention cell must be designed to be relatively level to promote infiltration evenly across the surface of the garden. For this reason, the maximum recommended slope of an area where a bioretention cell will be placed is 5%.

2.1.1.d Available Area

A fundamental consideration to make when evaluating a site for use of a bioretention cell is whether or not there will be adequate space available. A general rule of thumb is that a bioretention cell will require an area that is approximately 10% of the total contributing area. While the exact area required for a bioretention cell can only be established through the design process, this generalization is a good starting point to use during the preliminary site evaluation process.

2.1.1.e Down Gradient Slope

It's important to consider the slope of adjacent properties that are down gradient of the site to limit the possibility of seepage from the subgrade to the ground surface at lower elevations. For this reason, unlined bioretention cells should not be used when the average slope of an adjacent down gradient property is 12% or greater. This consideration does not apply to lined bioretention cells.

In order to assist designers in the evaluation of sites for use of a bioretention cell, a checklist of each of the above considerations, as well as those discussed in Subsection 1.3, is provided in Table 2. A site must meet all of the requirements discussed in these subsections to be a candidate for the use of a bioretention cell.

2.1.2 Preliminary Design Considerations – Bioretention cells

If the preliminary site evaluation indicates that the site is a good candidate for the use of a bioretention cell to treat storm water, the preliminary design can be carried out to establish the approximate dimensions of the bioretention cell. Knowing the required dimensions of the bioretention cell will allow for further evaluation of whether or not there is adequate space within the site to accommodate one. There are several important considerations to be made when performing a preliminary design. Descriptions of the minimum preliminary design considerations are provided in the subsections below.

2.1.2.a Target Treatment Volume

The target treatment volume will ultimately determine the surface area for the bioretention cell. The target treatment volume is referred to in this manual as the Target Infiltration volume. This volume is a function of the contributing area, runoff coefficient, and target precipitation. The equation relating the three variables is presented below.

$$TIV = \frac{A*P*C}{12} \qquad \textit{Equation 2.1}$$

TIV = Target Infiltration Volume ($feet^3$)
A = Contributing Area ($feet^2$), generally less than 5 acres
P = Target Precipitation (inches), 1.1 for the 1–Year, 24–Hour Storm
C = Runoff Coefficient

2.1.2.b Ponding Depth and Freeboard

Both the design and function of a bioretention cell rely on the garden's ability to temporarily store a known depth of water at the surface. The maximum allowable ponding depth for bioretention cells is 8 inches. In addition to this ponding depth, a freeboard of 4 inches is also required.

Table 2 – Bioretention cells – Preliminary Site Evaluation Checklist

Site Location:			**Evaluated by:**			
Date:						
Considerations	**Applies to Lined Bioretention cell?**	**Applies to Bioretention cells with Subdrains?**	**Requirement/ Recommendation**	**Site Conditions /Notes**	**Pass /Fail**	**Data Source**
Soil Infiltration	Y	N	Measured soil infiltration rate must be between 0.3 and 8 in/hr.			
Proximity to Surface Waters	N	Y	Bioretention cell should be located at least 100 feet from surface waters.			
Depth to Seasonal High Groundwater Level	Y	Y	4 feet or more below the top of an unlined bioretention cell and 2 feet or more below the top of a lined rain garden..			
Depth To Bedrock	N	Y	Bedrock must be 3 foot or more below the bottom of a bioretention cell.			
Proximity to Building Foundations	N	Y	Bioretention cell must be located outside of the zone of influence or at least 20 feet from building foundations.			
Proximity to Road Subgrades	N	Y	Bioretention cell must be located outside of the zone of influence or at least 20 feet from road subgrades.			
Runoff Source	Y	Y	Bioretention cell is not to receive runoff containing industrial pollutants.			
Contributing Area	Y	Y	The contributing area must be less than 5 acres.			
Available Area Slope	Y	Y	The slope must be less than or equal to 5%.			
Available Area	Y	Y	The area available for treatment must be at least 10% of the total contributing area.			
Down Gradient Slope	N	Y	Average slope of adjacent down gradient property must be less than 12%.			

2.1.2.c Bioretention cell Footprint and Geometry

The bioretention cell footprint is the total area of the bioretention cell in plan view. The bioretention cell footprint is a function of the target treatment volume, ponding depth, and side slopes. The recommended side slope for a bioretention cell is 3:1 (horizontal: vertical). The equation for determining the bioretention cell footprint is provided below.

$$A_r = \left(\frac{12*TIV}{P_d}\right) * (0.26 * I_e^{-0.53})$$ *Equation 2.2*

A_r = Bioretention cell Footprint ($feet^2$)
TIV = Target Infiltration Volume ($feet^3$), Equation 2.1
P_d = Depth of Ponded Water (inches), 8 inches maximum
I_e = Infiltration Rate of Engineered Soils (inches/hour)*, 1.0 inches/hour

Bioretention cells are an extremely versatile LID element in terms of plan view geometry. They can take nearly any shape to fit within the site plan. While there is a great deal of freedom associated with specifying the shape of a bioretention cell, it is important to consider that runoff discharging to the bioretention cell (typically along the long side of the garden) should be spread evenly across the surface of the garden to promote infiltration across the entire garden surface.

2.1.2.d Depth of Engineered Soils

The engineered soils within a bioretention cell provide a medium for infiltration and plant growth. In order for the soil to provide adequate treatment, the minimum depth of engineered soils within a bioretention cell is 2.5 feet.

2.1.2.e Overflow Structure

All bioretention cells must incorporate some kind of emergency overflow structure that will safely transmit any storm water to an appropriately sized storm water conveyance system when ponding depths are exceeded. Overflow structures may include perimeter weirs and/or stand pipes. Depending on the nature of the overflow structure, an underground conveyance system may be necessary, which should be determined at the preliminary design stage.

2.1.2.f Subdrain

All bioretention systems in Springdale require a subdrain system that discharges to an open channel or storm drain. Subdrain systems are needed because local soil infiltration rates are low.

Subdrains may serve as discharge points from overflow structures to limit the amount of buried infrastructure necessary for the bioretention cell construction.

Minimum slope of subdrains is 5%.

2.1.2.g Total Depth

The total depth of a bioretention cell is the depth from the freeboard elevation to the bottom of the excavation.

For bioretention cells with a subdrain or underground overflow structure within the boundary of the bioretention cell, the total depth can be calculated with the following relationship.

$$D_{rs} = \frac{P_d + F_d}{12} + E_d + S_d + (0.0005 * L_r) \qquad \textit{Equation 2.3}$$

D_{rs} = Total Depth of Bioretention cell with Subdrain (feet)
P_d = Depth of Ponded Water (inches), 8 inches maximum
F_d = Freeboard (inches), 2 inches minimum
E_d = Depth of the Engineered Soils (feet), 2.5 feet maximum
S_d = Depth Required for Subdrain Diameter and Drain Rock (feet), can assume 1.75 during the preliminary design
L_r = Approximate Length of Bioretention cell, Along the Axis of the Subdrain (feet)

Note: The equation above is intended to assist designers in the conservative estimation of the depth required for the bioretention cell at its deepest point. The exact depth is determined during final design.

In order to assist designers in the preliminary design of a bioretention cell, a blank sample calculation sheet has been developed and is presented as Table 3. The sample calculation sheet includes the preliminary design considerations and equation discussed above and is presented in three steps.

Table 3 – Bioretention Cell Preliminary Design

Site Location:		**Evaluated by:**	
Date:			
Step 1: Calculate the Target Infiltration Volume, TIV			**Notes**
Contributing Area, A		(ft^2)	
Target Infiltration Rainfall, P	1.1	(in)	Set Value
Runoff Coefficient, C			Per Ch. 106
TIV = A*P*C/12 =		(ft^3)	Using Equation 2.1
***Step 2: Calculate the Required Bioretention cell Footprint Area**			
TIV (from Step 1)		(ft^3)	
Depth of Ponded Water, P_d		(in)	Maximum of 8 inches
Design Infiltration Rate, I_e (or I, see Subsection 2.1.2.c)		(in/hr)	1.0 for engineered soils
$A_r = (TIV*12/P_d)\ (0.26*I_e^{-0.53}) =$		(ft^2)	Using Equation 2.2
Approximate Width, W_r $W_r=A_r/L_r=$		(ft)	
Approximate Length, L_r $L_r=A_r/W_r=$		(ft)	
Step 3: Approximate Bioretention cell Depth, with Subdrain			
P_d (From Step 2)		(in)	
Freeboard Depth, F_d		(in)	Minimum of 4 inches
Depth of Engineered Soils, E_d		(ft)	Minimum of 2.5 feet
Minimum Subdrain Depth, S_d		(ft)	Assume 1.75 feet
L_r (From Step 3)		(ft)	
$D_{rs} = (P_d+F_d)/12+E_d+S_d+(0.005*L_r) =$		(ft)	Using Equation 2.3
Note: *See Appendix C for guidance on selecting a value for I_e.			

Step 1 – Calculate the Target Infiltration Volume
This step is based on Equation 2.1 presented in Subsection 2.1.2.a above, and requires the independent calculation of the runoff coefficient per Chapter 106.

Step 2 – Calculate the Bioretention cell Footprint
This step involves the application of Equation 2.2 presented in Subsection 2.1.2.c. In this step, the designer must also approximate the length and width values to represent the geometry of the bioretention cell. The product of these numbers should be approximately equal to the calculated footprint area.

Step 3 – Approximate Garden Depth
Step 3 involves the application of Equation 2.3, presented in Subsection 2.1.2.g., to determine the approximate depth of the bioretention cell.

Once the site evaluation and preliminary design have been completed, the final design can be conducted.

2.1.3 Final Design – Bioretention cells

In order to develop a final bioretention cell design based on the results of the preliminary design, there are several basic factors that must be addressed. Addressing these factors requires some basic understanding of engineering and hydraulic principles. At a minimum, each of the factors discussed in the subsections below should be considered during final design.

2.1.3.a Specifying the Engineered Soils

The engineered soils mixture is a critical component in a bioretention cell design. The recommended soil mixture for bioretention cell applications is a mixture of 60 to 65% loamy sand mixed with 35 to 40% compost. An alternative recommended soil mixture consists of 20% to 30% topsoil (sandy loam), 50% to 60% coarse sand, and 20% to 30% compost (or peat). The soil mix should be uniform and free of stones, stumps, roots or other similar material greater than 2 inches in diameter.

2.1.3.b Specifying Bioretention cell Plants

Bioretention cell plants will assist in the storm water treatment process and contribute to the aesthetic value of the garden. The rain garden or bioswale should be planted with native, perennial vegetation only. There are a wide variety of plants available for use in a bioretention cell. For large plant orders, coordinate with nurseries early to assure an adequate supply will be available. Generally speaking, the selected plants should be tolerant to a wide variety of moisture and salinity conditions, and should not interfere with utilities in the area. A list of suitable plants recommended by the Arkansas Native Plant Society for the Springdale area is provided in Appendix B. This list is a good starting point for plant materials; see the Additional References for more information.

2.1.3.c Subdrain System Design

Note: Subdrain systems are required in all Bioretention cells in Springdale.

The subdrain in a bioretention cell performs the important task of removing treated water from the garden soils and transporting it to the storm drain system or outfall. The subdrain system consists of three main components: a subdrain pipe, drain rock, and an aggregate filter blanket. Each of these components is discussed separately below.

The subdrain pipe should be constructed out of slotted polyvinyl chloride (PVC) pipe. The slots should be approximately 0.05 inches wide and 0.25 inches apart. The slots should be arranged in four rows spaced on 45–degree centers, and cover 50% of the circumference of the pipe. The minimum diameter of the drainpipe should be 8 inches and the minimum slope should be 0.5%. The number of subdrains within a bioretention cell should be adequate to handle the full ponding depth discharge rate of the bioretention cell according to Manning's equation.

The subdrain pipe is placed on a layer of drain rock that is a minimum of 3 feet wide and 3 inches thick. A 6–inch thick layer of drain rock should be placed above the drainpipe. The recommended gradation for the drain rock is provided below:

Sieve Size	Percent Passing
¾ inch	100
¼ inch	30–60
US No. 8	20–50
US No. 50	3–12
US No. 200	0–1

An aggregate filter blanket diaphragm (pea gravel) will reduce the likelihood of clogging when placed in a 4–inch layer above the drain rock. Pea gravel should be washed and be 0.25 to 0.5 inches in diameter.

2.1.3.d Bottom Grading

In order for the underdrain system to function properly, the bottom of the bioretention cell must be graded to allow the treated water to flow towards the subdrain. The minimum acceptable bottom slope for providing drainage to the subdrain is 0.5%.

2.1.3.e Specifying the Bioretention cell Impermeable Liner

An impermeable liner is not a requirement for all bioretention cells. However, liners are required if minimum separation distances from building foundations, road subgrades, or water sources cannot be achieved.

2.1.3.f Overflow Bypass

Overflow bypass structures are important for the proper design of bioretention cells. An overflow structure can take many forms. Examples include stand pipes discharging to an underground storm drain network, and broad–crested grassed weirs discharging to grassed ditches. All bioretention cells must include some form of overflow bypass sufficient to transmit runoff from a 100–year, 24–hour duration storm event without overtopping the bioretention cell. Overtopping shall be allowed in cases where discharge due to overtopping is provided a clear, safe, non– destructive path to a conveyance system.

2.1.3.g Pretreatment

Pretreatment for bioretention cells can significantly reduce the amount of maintenance associated with sediment deposition. Filter strips, as described in Section 4, are suitable for providing pretreatment. Where site conditions allow, pretreatment devices are recommended for bioretention cells receiving runoff from parking areas and other areas known to have high sediment loads.

2.2 Bioretention Cell Construction and Maintenance

2.2.1 Construction Considerations – Bioretention cells

In addition to the minimum construction considerations discussed in Subsection 1.5, consideration should be given to the placement of engineered soils. Onsite mixing and/or placement of engineered soils should not be performed when the soil or ground is saturated. The engineered soils should be placed and graded by excavators and/or backhoes operating adjacent to the bioretention cell. If machinery must operate in the bioretention cell for excavation, lightweight, low ground contact pressure equipment should be used. The engineered soils should be placed in 12–inch lifts. Compaction of engineered soils should be allowed to occur through natural settlement over time rather than through mechanical means. To speed settling, each lift can be watered to the saturation point.

The minimum considerations presented in this manual do not include some typical engineering considerations such as resolving utility conflicts, and are not a substitute for sound engineering judgment.

2.2.2 Maintenance Considerations – Bioretention cells

In order to function properly over long periods of time, bioretention cells must be maintained properly and regularly. The following are general considerations that should be addressed when developing a maintenance agreement as required by this policy.

2.2.2.a Watering

Because the plants selected for bioretention cell applications are to be suitable for a wide range of soil moisture conditions, watering will generally not be required after the plants are well established. However, during the first 2 to 3 years, watering will be required to nurture the young plants. Watering may also be required during prolonged dry periods after plants are established (PSAT, 2003)

2.2.2.b Plant Material

Depending on the aesthetic requirements of the bioretention cell, occasional pruning and removal of dead plants may be necessary. Periodic weeding will be necessary for the first 2 to 3 years, until the plants are well established (PSAT, 2003). As the garden matures, it may be necessary to prune, thin, or split plants to avoid an overgrown appearance and maintain plant health.

2.2.2.c Mulch

If mulch is used in a bioretention cell, it should be replaced annually if heavy metal deposition or heavy sedimentation is likely (e.g., if runoff comes from parking lots and roads). If heavy metal deposition and/or sedimentation is not a major concern, the mulch should be amended at least once every 2 years to maintain a 2 to 3–inch depth. If mulch is used, allow for additional depth to account for the thickness of the mulch layer.

2.2.2.d Soil

In bioretention cells where heavy metals deposition is likely, it is recommended that the engineered soil be removed and replaced once every 20 years. Replacing soil in bioretention cells will provide a prolonged service life.

2.2.2.e Inspection and Trash Removal

Bioretention cells should be inspected following large rain events. If ponded water persists for more than 24 hours after a rain event, the first six inches of soil may need to be removed and replaced or amended to restore infiltration. This task must be performed carefully to limit damage to established plants. Because of the aesthetic value of bioretention cells, trash should be regularly removed.

2.2.3 Bioretention cell Conceptual Design Example

A conceptual design example for a bioretention cell is provided in Appendix D of this manual.

3 Infiltration Trenches

An infiltration trench is a rectangular excavation lined with a geotextile filter fabric and filled with coarse stone aggregate. These trenches serve as underground infiltration reservoirs. Storm water runoff directed to these trenches infiltrates into the surrounding soils from the bottom and sides of the trench. Infiltration trenches require pretreatment of storm water runoff to remove large sediments. Pretreatment for infiltration trenches is typically accomplished with the use of filter strips. Trench depths generally range between 2.5 and 10 feet. They can be covered with grating, stone, gabions, sand, or a grassed area with surface inlets. A conceptual drawing of an infiltration trench is provided in Figure 2.

An infiltration trench is a good choice to treat and infiltrate runoff from impervious parking lots, high– and low–density housing developments, and recreation areas. Infiltration trenches can be difficult to use in high–density urban applications due to the amount of area they require for pretreatment, and the potential hazard they pose to adjacent foundations. Infiltration trenches are intended to remove fine suspended solids and other pollutants such as copper, lead, zinc, phosphorous, nitrogen, and bacteria.

In order for infiltration trenches to be effective, they must be located in areas where the local soil is appropriate for infiltration and they must be designed accordingly. The process for developing an appropriate infiltration trench design based on local site constraints is presented in the following sections. Infiltration trenches must have a subdrain.

3.1 The Infiltration Trench Design Process

The infiltration trench design process involves preliminary site evaluation, preliminary and final design, and the basic site evaluation considerations discussed in Subsection 1.3.

Figure 2 – Infiltration Trench Conceptual Drawing

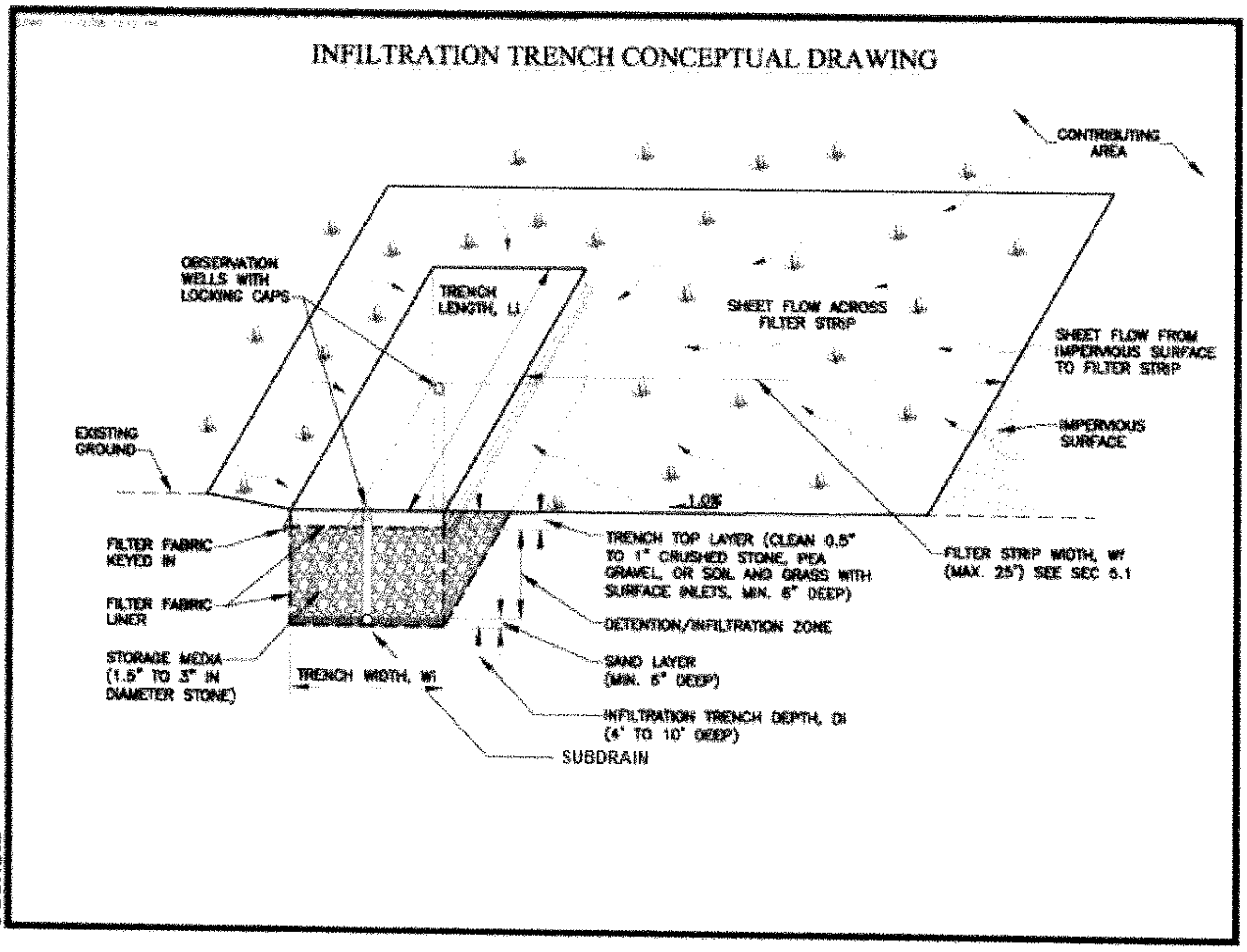


FIGURE 2

3.1.1 Preliminary Site Evaluation – Infiltration Trench

The following subsections present the minimum site–specific factors, in addition to those discussed in Subsection 1.3, that are to be considered when evaluating a site for the potential use of an infiltration trench to treat storm water runoff. The minimum considerations presented below do not include some typical engineering considerations such as resolving utility conflicts, and are not a substitute for sound engineering judgment.

3.1.1.a Runoff Source

Infiltration trenches are intended to treat runoff from urban and suburban drainage areas where pollutant loads are related primarily to parking lot and road surface runoff. Infiltration trenches are not appropriate to receive runoff from industrial facilities where runoff is likely to contain industrial pollutants.

3.1.1.b Contributing Area

In the past, infiltration trenches have been designed to accommodate large drainage areas. However, long term monitoring suggests that large–scale infiltration is not feasible. The main factor being that infiltration of storm water from a large area into a relatively small area does not reflect the natural hydrologic cycle and generally leads to problems such as groundwater mounding, soil clogging, and soil compaction. It is recommended that the contributing area to an infiltration trench be limited to 3 acres or less.

3.1.1.c Slope of Available Area for Infiltration Trench

Infiltration trenches are generally difficult to construct on steep sites because the bottom and top surfaces of the trench must be completely level. The design of filter strips to provide pretreatment to runoff is also more problematic on steep sites. For these reasons, the maximum recommended slope of a site being considered for use of an infiltration trench is 5%.

3.1.1.d Available Area

The area that is required for an infiltration trench can be as much as 15 to 35% of the total contributing area. The most efficient sites are ones in which the contributing area dimensions are nearly square and the infiltration trench can be constructed along one side of the square. Infiltration trenches can be designed to receive runoff from sites with length to width ratios as low as 3:1 with moderate increases in the percentage of the relative area required for the trench. During the site evaluation process, it can be assumed that the area required for the infiltration trench and filter strip(s) is 35% of the total contributing area.

3.1.1.e Down Gradient Slope

The slope of adjacent properties that are down gradient of the site is important to consider the possibility of seepage from the subgrade to the ground surface at lower elevations. For this reason, infiltration trenches should not be used when the average slope of an adjacent down gradient property is 12% or greater.

In order to assist designers in the evaluation of sites for use of an infiltration trench, a checklist of each of the above considerations, as well as those discussed in Subsection 1.3, is provided in Table 4. A site must meet all of the requirements discussed in these subsections to be a candidate for the use of an infiltration trench.

3.1.2 Preliminary Design Considerations – Infiltration Trench

If the preliminary site evaluation indicates that the site is a good candidate for the use of an infiltration trench to treat storm water, the preliminary design can be carried out to establish the approximate dimensions of the trench and pretreatment area. Knowing the required dimensions of the infiltration trench will allow for further evaluation of whether or not there is adequate space within the site to accommodate the trench and pretreatment area. There are several important considerations to be made when performing a preliminary design of an infiltration trench. Descriptions of the recommended preliminary design considerations are provided in the subsections below.

Table 4 – Infiltration Trench – Preliminary Site Evaluation Checklist

Site Location:		Evaluated by:		
Date:				
Considerations	**Requirement/Recommendation**	**Site Conditions/Notes**	**Pass/Fail**	**Data Source**
Soil Infiltration	Measured soil infiltration rate must be between 0.3 and 8 in/hr.			
Proximity to Surface Waters	Trench should be located at least 100 feet from surface waters.			
Depth to Seasonal High Groundwater Level	Must be 4 feet or more below the bottom of the trench.			
Depth To Bedrock	Bedrock must be 3 feet or more below the bottom of the trench.			
Proximity to Building Foundations	Trench must be located outside of the zone of influence or at least 20 feet from building foundations.			
Proximity to Road Subgrades	Trench must be located at least 20 feet from road subgrades.			
Runoff Source	Infiltration trench is not to receive runoff containing industrial pollutants.			
Contributing Area	The contributing area must be less than 3 acres.			
Available Area Slope	Available area slope must be less than or equal to 5%.			
Available Area	The area available for treatment must be at least 15% of the total catchment area.			
Down Gradient Slope	Average slope of adjacent down gradient property must be less than 12%.			

3.1.2.a Target Treatment Volume

The target treatment volume will ultimately determine the area of the infiltration trench. The target treatment volume is referred to in this manual as the Target Infiltration volume. This volume is a function of the contributing area, runoff coefficient, and target precipitation. The equation relating the three variables, presented for the first time in Subsection 2.1.2.a, is presented again below.

$$TIV = \frac{A*P*C}{12} \qquad \textit{Equation 2.1}$$

TIV = Target Infiltration Volume ($feet^3$)
A = Contributing Area ($feet^2$)
P = Target Precipitation (inches), 1.1 for the 1–Year, 24–Hour Storm
C = Runoff Coefficient per Chapter 106

3.1.2.b Void Ratio

The function of an infiltration trench is reliant on not only the infiltration rate of the surrounding soil but also on the trench's ability to temporarily retain water. The storm water is retained within the void spaces of the storage media. The ratio of the volume of the space between individual particles of the storage media over the volume of the storage media particles is known as the void ratio. Infiltration trench storage media should consist of clean aggregate ranging from 1.5 to 3 inches in diameter. For the sake of calculation in this manual, assume a void ratio of 0.4.

3.1.2.c Detention Time

The retention time associated with an infiltration trench is the amount of time it takes for the full trench to discharge to the surrounding soil through the subdrain. In order to provide adequate treatment, the acceptable range for detention time is 24 to 48 hours.

3.1.2.d Trench Depth

The trench depth is the depth of the trench from the top surface to the bottom of the excavated area. Trench depth is a function of the design infiltration rate; the storage media void space, and the retention time. The trench depth should be between 4 and 10 feet. A minimum depth of 4 feet allows for the bottom of the trench to be at or below the frost line. Shallower depths may be permitted in non–frost susceptible soils. The equation for determining trench depth is provided below.

$$D_i = \frac{I*t}{n_s*12} + 1$$ *Equation 3.1*

D_i = Trench Depth (feet), must be 4 to 10 feet
I = Design Infiltration Rate (inches/hour), between 0.3 and 1 inch/hour
t = Retention Time (hours), 24 to 48 hours
n_s = Storage Media Void Ratio, 0.4 typical for 1.5 to 3–inch stones

The additional one foot added to the equation above is to allow for the use of a 6–inch layer of sand in the bottom of the trench and a 6–inch top layer. The sand acts to distribute flow and to reduce localized compaction when placing the storage media during construction.

3.1.2.e Trench Footprint

The trench footprint is the plan view area of the trench and is a function of the design infiltration rate, the retention time, and the target infiltration volume. The equation for determining the trench footprint is provided below.

$$A_i = \frac{TIV*0.66}{n_s*(D_i-1)}$$ *Equation 3.2*

A_i = Trench Footprint (feet^2)
TIV = Target Infiltration Volume (feet^3)
n_s = Storage Media Void Ratio, 0.4 typical for 3–inch stones
D_i = Trench Depth (feet), between 4 and 10 feet

3.1.2.f Trench Width

The width of a trench can be adjusted to meet site constraints as long as the necessary footprint area is maintained. The minimum suggested length to width ratio to be applied to an infiltration trench design is 3:1. The maximum allowable trench width, parallel to flow, is 25 feet.

3.1.3 Pretreatment

Infiltration trenches require pretreatment to remove large particulates. Grass filter strips are generally used to provide pretreatment for runoff entering an infiltration trench although other pretreatment devices may be used including vegetated swales, ponds, etc. At the preliminary design stage, the designer may assume a 20–foot filter strip width. For additional information on sizing filter strips for pretreatment, refer to Subsection 5.1 of this manual.

In order to assist designers in the preliminary design on an infiltration trench, a sample calculation sheet has been developed and is included in Table 5. The calculation sheet covers the above considerations and equations in six steps.

Step 1 – Calculate the Target Infiltration Volume
This step is based on Equation 2.1 presented in Subsection 3.1.2.a above, and requires the independent calculation of the runoff coefficient per Chapter 106.

Step 2 – Calculate the Depth of the Trench
This step is based on Equation 3.1 presented in Subsection 3.1.2.d above. The depth can be adjusted by adjusting the drawdown time. However, it should be noted that reductions in depth will result in increases in area.

Step 3 – Calculate the Footprint of the Trench
This step is based on Equation 3.2 presented in Subsection 3.1.2.e above.

Step 4 – Establish the Trench Length and Width
In this step, the designer may choose to set either the trench length or width to meet particular site requirements. Note that the maximum allowable trench width is 25 feet and the maximum recommended length to width ratio is 3:1.

Step 5 – Account for Pretreatment
This step involves determining the total width of the infiltration trench and associated filter strips. Note that if the site only drains to one side of an infiltration trench, only a single filter strip on that side is necessary.

Step 6 – Required Length and Width for Trench and Filter Strip
This step involves summarizing the preliminary design values for length and width established in Steps 4 and 5.

Table 5 – Infiltration Trench Preliminary Design

Site Location:	**Evaluated by:**		
Date:			
Step 1: Calculate the Target Infiltration Volume			**Notes**
Contributing Area, A		(ft^2)	
Target Infiltration Rainfall, P		(in)	Set Value
Runoff Coefficient, C			Per Ch. 106
TIV = A*P*C/12 =		(ft^3)	Using Equation 2.1
Step 2: Calculate the Depth of the Trench			Must be between 4 and 10 feet
Void Ratio, n_s			0.4 is Typical of 1.5 to 3 in. Stone
Design Infiltration Rate, I		(in/hr)	Based on site investigation (Subsection 1.3.1 and Ch. 106)
Detention Time, t		(hr)	Must be 24 to 48 hours
$D_i = (I*t)/(n_s*12) + 1 =$		(ft)	Using Equation 3.1
Step 3: Calculate the Footprint of the Trench			
TIV (from Step 1)		(ft^3)	
n_s (from Step 2)			
D_i (from Step 2)		(ft)	
$A_i = (TIV *0.66)/(n_s*(D_i - 1)) =$		(ft^2)	Using Equation 3.2
Step 4: Establish the Trench Length and Width			Minimum Recommended Ratio is 3L:1W
Set Trench Length, L_i		(ft)	
Or			
Set Trench Width, W_i		(ft)	Maximum Width is 25 feet
Then Calculate Either			
$W_i=A_i/L_i$		(ft)	Maximum Width is 25 feet
Or			
$L_i=A_i/W_i$		(ft)	
Record Final L_i and W_i Values			
$L_i=$		(ft)	
$W_i=$		(ft)	
Step 5: Account for Pretreatment			
Filter Strip Width, W_f		(ft)	Minimum Recommended Width is 20 feet
If Receiving Flow From Both Sides			
Total Width (W_{if1}), $W_{if1} = W_i + 2*W_f =$		(ft)	
Or, If Receiving Flow From One Side			
Total Width (W_{if2}), $W_{if2}=W_i + W_f =$		(ft)	
Step 6: Required Length and Width for Trench and Filter Strip			
L_i (from Step 4) =		(ft)	
Appropriate Total Width (from Step 5) =		(ft)	

Once the site evaluation and preliminary design have been completed, the final design can be performed.

3.1.4 Final Design Considerations – Infiltration Trench

In order to develop a final infiltration trench design based on the results of the preliminary design, there are several basic factors that must be addressed. Addressing these factors requires some basic understanding of engineering and hydraulic principles. At a minimum, each of the factors discussed in the subsections below should be considered during final design.

3.1.4.a Filter Fabric

Filter fabric selection and placement are important to both the effectiveness and the service life of an infiltration trench. Filter fabric should be selected that matches the infiltrative capacity of the soil in the trench to prevent clogging and piping. The fabric should be placed so that it lines the bottom and sides of the trench. Overlap between separate pieces of fabric should be a minimum of one foot. Filter fabric should also be placed below the top layer of the infiltration trench to reduce maintenance costs, since the top fabric can be cleaned or replaced much more easily than the fabric lining the bottom and sides when fine particles clog the trench.

3.1.4.b Overflow Structure

Overflow structures are important for the proper design of infiltration trenches. An overflow structure can take many forms. Examples include stand pipes discharging to an underground storm drain network, and broad crested weirs discharging to grassed ditches. No matter what kind of overflow structure is selected, it must be capable of safely transmitting runoff from the 100–year, 24–hour duration storm event so that the infiltration trench does not overtop. Overtopping may be allowed in cases where discharge due to overtopping is provided an unobstructed, safe, and non–destructive path to a conveyance system.

Any portion of an overflow structure that lies within the subgrade of an infiltration trench will reduce the volume of storm water that can be held by the trench. The trench footprint must be adjusted accordingly to account for the lost storage volume.

3.1.4.c Top Layer

Infiltration trenches can be covered with a variety of different materials. The top layer is intended to provide cover for the first layer of filter fabric and to provide a level surface that can be easily traversed. An additional benefit of the top layer is improvement of aesthetics. The top layer of an infiltration trench should consist of a minimum of 6 inches of one of the following: clean 0.5 to 1–inch crushed stone, pea gravel, or other pervious media. Due to the need for periodic maintenance, infiltration trenches should not be covered with concrete or asphalt.

3.1.4.d Bottom Layer

The bottom layer of an infiltration trench consists of 6 inches of clean sand or fine gravel. The purpose of the bottom layer is to evenly distribute flows along the bottom of the trench and to protect the underlying soil from localized compaction during placement of the storage media.

3.1.4.e Grading

Site grading is one of the most critical factors in the final design of an infiltration trench. The site must be graded so that runoff is directed to the infiltration trench evenly across the surface of the filter strips. The site must also be graded so that both the top surface and the bottom of the infiltration trench are completely level.

3.1.4.f Observation Well

An observation well is to be installed in each infiltration trench. An additional observation well shall be installed for every 50 linear feet of infiltration trench. Observation wells allow drawdown times to be monitored within the trench, and will allow maintenance crews to identify when the trench has become clogged and is in need of repair. The wells should be placed to the full depth of the trench and be secured to a footing plate. The observation well should be a minimum of 6 inches in diameter and have a waterproof locking cap at the surface.

The perforated portion of the observation well shall be between the top and bottom layers of filter fabric. Where the observation well passes through the top layer of filter fabric, the filter fabric shall be sealed around the un-perforated section of the well. This will limit the intrusion of sediments collected by the upper filter fabric into the lower portion of the well, where they are more difficult to remove.

The above list does not include every possible final design consideration. However, for most infiltration trench designs, each of the above design considerations will be necessary. Additional engineering considerations, such as the depth and location of utilities within and adjacent to the site, will be required depending on the site specific conditions.

3.2 Infiltration Trench Construction and Maintenance

3.2.1 Construction Considerations – Infiltration Trench

In addition to the minimum general considerations, discussed in Subsection 1.5, the construction of an infiltration trench requires care in the placement of the storage media. Storage media should be placed without causing compaction of the subsoil. This can be accomplished by placing the storage media in 6–inch lifts. The storage media should not be compacted.

The minimum considerations presented in this manual do not include some typical engineering considerations such as resolving utility conflicts, and are not a substitute for sound engineering judgment.

3.2.2 Maintenance Considerations – Infiltration Trench

In order to function properly over long periods of time, infiltration trenches must be maintained properly and regularly. The following are general considerations that should be addressed when developing a maintenance agreement as required by Chapter 106.

3.2.2.a Watering and Weeding

If a top layer of grass (with inlets) is used, periodic watering will be required in the first year to help the grass become established. Watering may also be required during prolonged dry periods. Weeding should be performed as necessary to maintain a healthy grassed top layer.

3.2.2.b Filter Fabric

The top layer of filter fabric in an infiltration trench will require periodic cleaning or replacement. The observation well(s) can be used to establish which portion of the filter fabric is in need of replacement. If standing water persists in the infiltration trench longer than the designed detention time, the observation well(s) should be checked. If the observation wells are empty, then the top layer of filter fabric will need to be cleaned or replaced to remove accumulated sediments. If the observation wells are full of standing water, then the storage media will need to be removed and washed, and the layer of filter fabric along the trench sides and bottom will need to be cleaned or replaced.

3.2.2.c Routine Post–Storm Inspection

Infiltration trenches and filter strips should be inspected after large rain events. The filter strips and the top layer of the infiltration trench should be inspected for evidence of erosion (which is unlikely in properly designed systems). Any visible trash accumulated on top of the infiltration trench or on the filter strip should be removed.

3.2.3 Infiltration Trench Conceptual Design Example

A conceptual design example for an infiltration trench is provided in Appendix E of this manual.

4 *Pervious Pavements*

One approach to lowering the overall imperviousness of an area, while retaining necessary surfaces for fire lanes, shoulders, sidewalks, etc., is the use of porous pavement technologies. Some porous pavement technologies are not applicable in areas where sanding is common. However, other types of porous pavement can be used when adequate underdrainage, such as a sand or gravel bed, is provided. Porous pavement types suitable for application in Springdale are discussed below.

4.1 Types of Pervious Pavements

Open–Jointed Paving Blocks or Interlocking Concrete Pavements – These are modular paving units that allow infiltration between individual units. They are typically built over an open–graded or rapid–draining crushed stone base; with less than 3% fines passing the No. 200 sieve (see Figure 3). Perforated drainage pipes can provide drainage in heavy overflow conditions, or provide secondary drainage if the base loses some of its capacity over time. For installations where slow–draining subgrade soils are present, perforated pipes can drain excess runoff and alleviate potential for frost heaving.

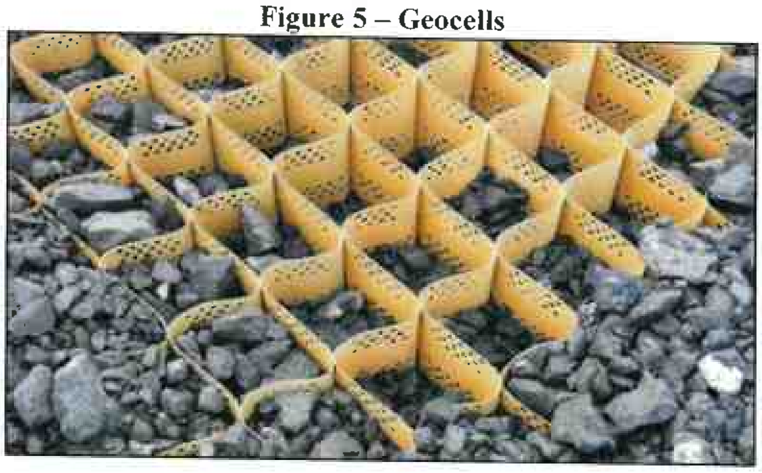
Figure 3 – Open–Jointed Paving Block

Concrete Grids – These are perforated concrete units installed over a compacted soil subgrade, which overlies a dense–graded base of compacted crushed stone, which in turn overlies 1 to 1–1/2 inch thick bedding sand (see Figure 4). The openings in the grids are filled with either topsoil and grass or aggregate.

Figure 4 – Concrete Grid

Plastic Lattices (Geocells) – These are interlocking, high–strength blocks made from plastic materials. They provide vehicular and pedestrian load support over grass areas while protecting the grass from the harmful effects of traffic. The system is comprised of base support soil beneath the lattice unit, which is then filled with selected topsoil, and seeded with selected vegetation.

Figure 5 – Geocells



4.2 Benefits and Disadvantages

The benefits of porous pavement technologies include the following:

- Porous pavements provide a pervious, load–bearing surface with minimal increases in imperviousness.
- Application of pervious pavement technologies can reduce site runoff and limit the degree of complexity required for storm drain design and analysis

under Chapter 106.

- In some cases, construction costs of porous pavements can be less than conventional pavements.
- Soil–enhanced turf systems are advantageous for sports and recreation fields because they resist compaction, promote infiltration, and provide a soft playing surface.

Though porous pavement technologies have a number of potential applications and benefits, there are some limitations that bear consideration. These limitations include the following:

- Sand and salt in snowmelt runoff can cause clogging of porous pavements. However, studies suggest that permeable surfaces can be used successfully, especially if they are installed properly (backfilled with clean gravel), and maintained through semi–annual vacuum cleaning.
- Construction costs of porous pavements can be higher in some cases than conventional pavement, depending on the application, and maintenance costs are usually higher.
- Most porous pavements limit wheelchair access and do not meet Americans with Disabilities Act standards, thus limiting their applicability in foot traffic areas.

Some design considerations for porous pavement are listed below.

- Assessment of site soil infiltration capacity is required to assure proper functioning of the porous pavement, which should not be installed on clayey soils or in areas of high groundwater.
- Subdrains are required for adequate drainage.
- Plant with drought tolerant turf grass (such as fescue) rather than less drought tolerant strains such as bluegrass.

4.3 Design Methods for Permeable Interlocking Concrete Pavements

For design examples, equations, and additional guidance, use the following resources:

- *Permeable Interlocking Concrete Pavements* – David R. Smith
  Fifth Edition, Published by the Interlocking Concrete Pavement Institute
- *Permeable Interlocking Concrete Pavement* – ASCE Standard 68-18
  Published by the American Society of Civil Engineers

5 Additional LID Elements for Consideration

5.1 Filter Strips

Filter strips are gently sloped, vegetated areas designed to decelerate and filter sheet flow runoff. Existing areas of dense, healthy vegetation that are capable of dispersing runoff and have experienced relatively little site disturbance or soil compaction often provide the most desirable areas for use as filter strips. These LID elements also treat total suspended solids (TSS), but they can also reduce concentrations of hydrocarbons, heavy metals, and nutrients. Filter strips remove pollutants via sedimentation, filtration, absorption, infiltration, biological uptake, and microbial activity. Depending on site characteristics such as soil type, vegetative cover, slope, and available area, filter strips can provide a modest reduction in runoff volume due to infiltration. In addition to their value as storm water treatment devices, filter strips can serve as attractive landscaping features that may incorporate a variety of trees, shrubs, and native vegetation. The simplest and often most effective filter strips are those that incorporate undisturbed existing vegetation.

The size and character of contributing drainage areas largely dictate the size and location of filter strips, since filter strips perform effectively only under sheet flow conditions, and flows tend to concentrate and have higher velocities over large or impervious drainage areas. A conceptual drawing of a filter strip is presented in Figure 6.

The advantages of filter strips include removal of sediment and insoluble contaminants from runoff, and increased infiltration of soluble nutrients and pesticides. The tall, dense vegetation of filter strips can provide a visual barrier between roads and recreation sites. Filter strips work particularly well in residential areas, providing open spaces for recreation and maintaining riparian zones along streams, which can reduce erosion and enhance animal habitats and aquatic life. In general, filter strips are simple and inexpensive to install, and have relatively few maintenance requirements. In order for filter strips to be effective, they must be properly graded to limit erosive velocities.

Figure 6 – Filter Strip Conceptual Plan and Profile

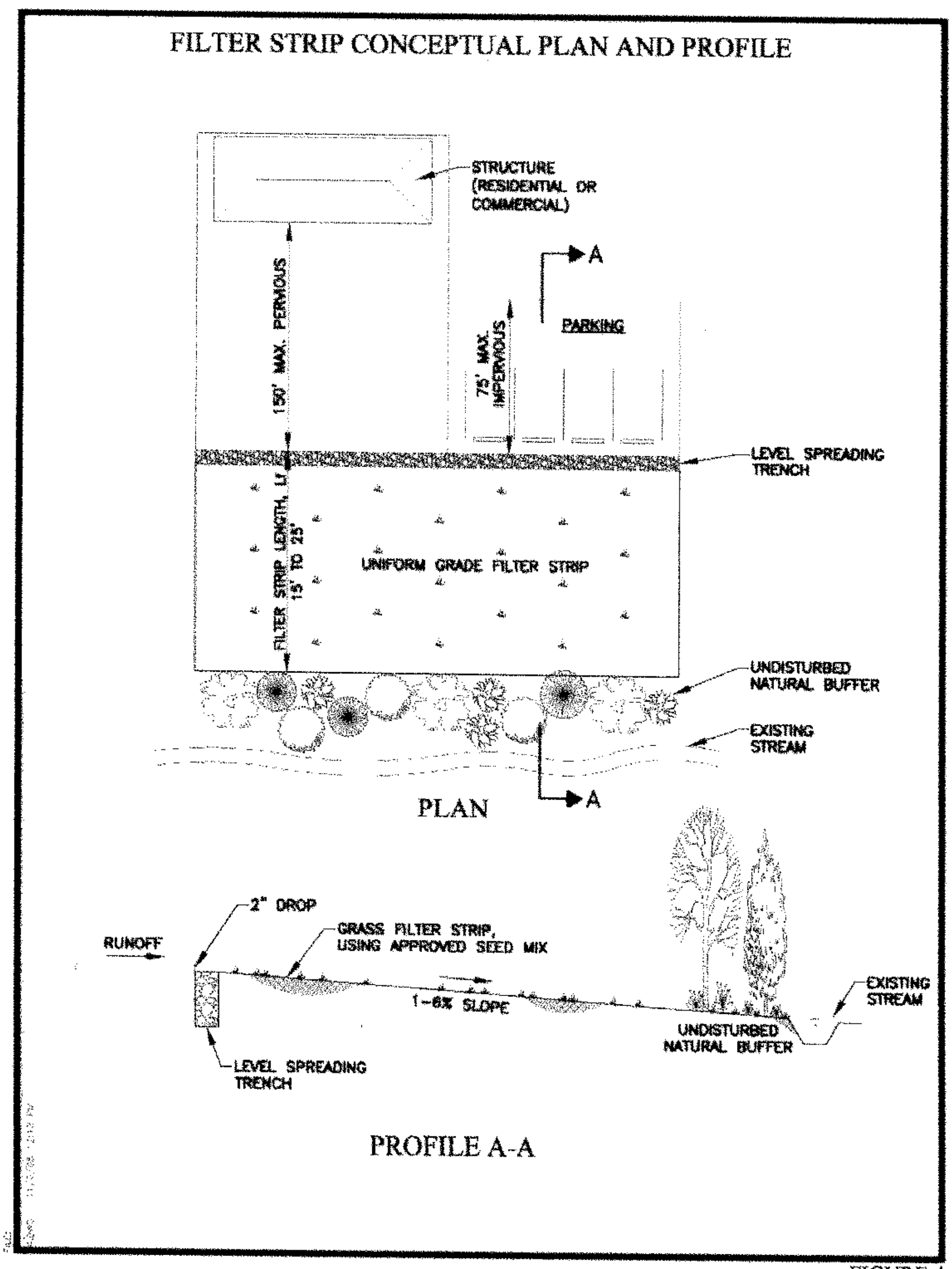


FIGURE 4

5.2 Filter Strips for Pretreatment

Filter strips are commonly used for pretreatment in association with other LID elements such as bioretention cells and infiltration trenches. Table 6 presents design guidance for slopes and lengths (parallel to flow) of pretreatment filter strips based on the slopes, dimensions, and surface characteristics of the contributing drainage areas.

Table 6 – Pretreatment Filter Strip Design Guidance

Parameter	**Land Cover in Contributing Areas**							
	Impervious Areas				**Pervious Areas**			
Maximum Inflow Approach Length (ft)	35		75		75		100	
Filter Strip Slope (Maximum = 6%)	≤ 2%	> 2%	≤ 2%	> 2%	≤ 2%	> 2%	≤ 2%	> 2%
Minimum Filter Strip Length (ft)	10	15	20	25	10	12	15	18

5.3 The Filter Strip Design Process

The filter strip design process involves preliminary site evaluation, preliminary and final design. The following subsections present the minimum site–specific factors that are to be considered when evaluating a site for the potential use of a filter strip as primary LID elements discharging to storm water conveyance systems, natural areas, or receiving waters. These sections include a site evaluation checklist and preliminary design calculation table to guide readers through design processes for filter strips.

5.3.1 Preliminary Site Evaluation – Filter Strips

The minimum preliminary site evaluation considerations presented below do not include some typical engineering considerations such as resolving utility conflicts and are not a substitute for sound engineering judgment.

Runoff Source

Filter strips are intended to treat runoff from urban and suburban drainage areas where pollutant loads come from residential, parking, and road surface runoff. Filter strips are not appropriate to receive runoff from industrial facilities or from areas where runoff is likely to contain industrial pollutants.

Contributing Area

Filter strips are suitable to treat small drainage areas, generally one acre or less in size. It is possible to treat runoff from large areas if multiple filter strips are used. For effective performance, runoff must enter the filter strip as sheet flow. Runoff tends to concentrate within 75 feet along impervious surfaces and within 150 feet along pervious surfaces. Longer flow paths upstream of filter strips are acceptable, but require special consideration to ensure design flows are spread evenly across the surface of the filter strips.

Slope of the Contributing Area and Filter Strip

The contributing drainage area slopes should be less than 10% for effective performance. Steeper slopes require additional energy dissipation to promote the dispersion of storm water evenly across the length of the filter strips and to prevent erosion. Slopes parallel to the flow path across filter strips should be between 1 and 6%.

Available Area

For a given site, filter strip length, parallel to the direction of flow, is dependent on slope, vegetative cover, and soil type. Generally, filter strips should extend a minimum of 15 feet in the direction of flow, with 25 feet preferred if space is available. Filter strip width, perpendicular to the direction of flow, should be equal to the width of the contributing drainage area. When filter strips are the primary LID element providing storm water treatment, the ratio of contributing area to filter strip area should not exceed 6:1.

To assist designers in the evaluation of sites for use of a filter strip, a checklist of each of the above considerations is provided in Table 9. A site must meet all of the requirements discussed in the subsections above to be a candidate for the use of a filter strip.

5.3.2 Preliminary Design – Filter Strips

If the preliminary site evaluation indicates that a site is a good candidate for the use of filter strips to treat storm water, the preliminary design can proceed to establish approximate filter strip dimensions. Determining the dimensions of filter strips during preliminary design is an iterative process. There are several important considerations to be made when performing the preliminary design of a filter strip. Descriptions of the recommended preliminary design considerations are provided in the subsections below.

5.3.2.1 Filter Strip Slope

Filter strip slopes should generally range from 1% to 6% for effective performance. Slopes at the top and toe of filter strips should be as flat as possible to encourage sheet flow and prevent erosion. The maximum allowable lateral slope (perpendicular to the direction of flow) for filter strips should not exceed 1%.

Table 7 – Filter Strips – Preliminary Site Evaluation Checklist

Site Location:		**Evaluated by:**		
Date:				
Considerations	**Requirement/Recommendation**	**Site Conditions/Notes**	**Pass/Fail**	**Data Source**
Runoff Source	The filter strip is not to receive runoff containing industrial pollutants.			
Contributing Area	The contributing area must be less than 1 acre.			
Slope of the Contributing Area	Slope of the contributing area must be less than 10%.			
Available Area	The available area for the filter strip shall generally extend the full width of the contributing area and allow for a length (parallel to flow) of 15 to 25 feet. The ratio of total contributing area to the total available area must not exceed 6:1.			

5.3.2.2 Filter Strip Flow Depths

Flow depths on filter strip surfaces should not exceed 0.5 inches. At depths greater than 0.5 inches, treatment through infiltration is reduced as deeper flows tend to push filter strip grasses parallel to the ground.

5.3.2.3 Maximum Discharge Loading

The maximum discharge load represents the maximum flow rate that can cross the threshold of a filter strip without compromising the filter strip performance. The maximum discharge loading refers to the flow entering the filter strip. The calculation of maximum discharge loading per foot width along the filter strip is based on Manning's equation, as shown below.

$$q = \frac{1.49}{n} * \left(\frac{Y}{12}\right)^{\frac{5}{3}} * S^{\frac{1}{2}}$$ *Equation 5.1*

q = Volumetric Discharge per Foot Width (feet^3/second–foot)
Y = Maximum Allowable Depth of Flow (inches), 0.5
S = Slope of Filter Strip (feet/foot), between 1% and 6%
n = Manning's "n" Roughness Coefficient, Equal to 0.2 for mowed grass and 0.25 for unmowed grass

5.3.2.4 Maximum Allowable Design Velocity

The maximum allowable design velocity is the minimum allowable velocity along the filter strip under normal design conditions. The maximum allowable velocity for filter strips is 0.9 feet per second. This is based on the calculated volumetric discharge per foot width and the design flow depth. The maximum allowable design flow depth is 0.5 inches. The design velocity can be calculated using the following formula.

$$V = \frac{q}{Y/12} \qquad \textit{Equation 5.2}$$

V = Velocity (feet/second), 0.9 feet^3/second maximum
q = Volumetric Discharge per Foot Width (feet^3/second–foot)
Y = Maximum Allowable Depth of Flow (inches), 0.5 inches maximum

5.3.2.5 Minimum Allowable Filter Strip Width

The minimum width (W_{fp}) of a filter strip, which is the dimension perpendicular to flow, is a function of flow rate entering and exiting the filter strip, according to equation shown below.

$$W_{fp} = \frac{A_a * C * 0.5}{q} \qquad \textit{Equation 5.3}$$

W_{fp} = Width of Filter Strip Perpendicular to Flow Path (feet)
A_a = Area (acres)
C = Runoff Coefficient per Chapter 106
q = Volumetric Discharge per Foot Width (feet^3/second-foot)

5.3.2.6 Filter Strip Length

Filter strip length is the dimension parallel to flow. Filter strip length should be calculated for a travel time of 5 to 9 minutes according to the Soil Conservation Service (SCS) Technical Release 55 (TR–55) travel time equation (SCS, 1986) shown below.

$$L_f = \frac{T_t^{1.25} * P^{0.625} * (S * 100)^{0.5}}{3.34 * n} \qquad \textit{Equation 5.4}$$

L_f = Length of Filter Strip Parallel to Flow Path (feet), 15 to 25 feet
T_t = Travel Time through Filter Strip (minutes), 5 minutes minimum
P = Precipitation (inches) (SCS parameter used to calibrate this equation); 3.9" for the 2–Year, 24–Hour Storm
S = Slope of Filter Strip (ft/ft), 0.01 to 0.06 ft/ft

n = Manning's "n" Roughness Coefficient, Equal to 0.2 for mowed grass and 0.25 unmowed grass

To assist designers in the preliminary design of a filter strip, a sample calculation sheet has been developed and is presented as Table 10. The calculation sheet covers the above considerations and equations in 4 steps.

Step 1 – Calculate the Maximum Discharge Loading
This step is based on guidance provided in Subsection 5.2.2.a and Equation 5.1 presented in Subsection 5.2.2.c above.

Step 2 – Check Velocity
This step is based on Equation 5.2 and guidance provided in Subsection 5.2.2.d.

Step 3 – Calculate the Minimum Allowable Filter Strip Width
This step is based on Equation 5.3 and guidance provided in Subsection 5.2.2.e above.

Step 4 – Calculate the Minimum Allowable Filter Strip Length
This step is based on Equation 5.4 and guidance provided in Subsection 5.2.2.f above.

Once the site evaluation and preliminary design have been completed the final design can be conducted.

5.3.3 Final Design – Filter Strips

To develop a final filter strip design based on the results of the preliminary design, there are several basic factors that must be addressed. Addressing these factors requires some basic understanding of engineering and hydraulic principles. At a minimum, each of the factors discussed in the subsections below should be considered during final design.

Table 8 – Filter Strip Preliminary Design

Site Location:			**Evaluated by:**
Date:			
Step 1: Calculate the Maximum Discharge Loading, q			**Notes**
Maximum Allowable Depth of flow, Y		(in)	Maximum is 0.5 inches
Slope of Filter Strip, S		(ft/ft)	Between 0.01 and 0.06
Manning's "n"			
$q=(1.49/n)*(Y/12)^{(5/3)}*S^{(1/2)}$		(ft^3/sec–ft)	Using Equation 5.1
Step 2: Check Velocity, V			Maximum Allowable is 0.9 ft/sec
q (from Step 1)		(ft^3/sec–ft)	
Y (from Step 1)		(in)	
$V=q/(Y/12)$		(ft/sec)	Using Equation 5.2
Step 3: Calculate the Minimum Allowable Filter Strip Width, W_{fp}			
q (from Step 1)		(ft^3/sec–ft)	
Contributing Area, A_a		(acres)	
Runoff Coefficient, C			Per Ch. 106
$W_{fp} = (A_a*C*0.5)/q$		(ft)	Using Equation 5.3
Step 4: Calculate the Minimum Allowable Filter Strip Length, L_f			
Travel Time Through Filter Strip, T_t		(min)	Between 5 and 9
Calibration Precipitation, P		(in)	1.3 inches
S (from Step 1)		(ft/ft)	
n (from Step 1)			
$L_f=(T_t^{1.25}*P^{0.625}*S*100)^{0.5})/3.34*n$		(ft)	Using Equation 5.4

5.3.3.1 Overall Site Integration

Site designs should incorporate filter strips as elements in the overall site plan. Filter strips can outfall to a variety of features, such as natural buffer areas, vegetated swales, curb and gutter systems, or natural drainage features.

5.3.3.2 Filter Strip Cover

Filter strip cover may consist of existing vegetation, hearty native vegetation, planted turf grasses, or a mixture of grasses and shrub vegetation. Optimal vegetation arrangements incorporate plants with dense growth patterns, fibrous root systems for stability, and adaptability to local soil and climatic conditions. Filter strips can also incorporate vegetation including sedges and flowers.

5.3.3.3 Level Spreading Devices

Level spreading devices installed upstream of filter strips produce uniform sheet flow conditions along the entire leading edge of the filter strip, and help prevent concentration of flows that create erosive conditions. Level spreaders have a number of different configurations with one common function – to spread concentrated flow into sheet flow upstream of filter strips. The following examples describe common features and applications of two types of level spreading devices.

Level Spreading Trench

This device consists of a gravel–filled trench installed along the entire leading edge of a filter strip. Gravel can range in size from pea gravel, as specified by ASTM D 448, to shoulder ballast for roadways. Level spreading trenches typically have widths of 12 inches and depths of 24 to 36 inches, and they typically use nonwoven geotextile linings. A 1–inch to 2–inch drop between the adjacent impervious surface and the edge of the trench inhibits the formation of an initial deposition barrier. In addition to acting as a level spreader, these trenches also act as pretreatment devices, allowing sediment to settle out before reaching the filter strip.

Natural Berms

Shaping and grading of the area immediately upslope of a filter strip into a berm can also promote uniform sheet flow conditions. This method has a more natural appearance, though the berms can fail more readily than other devices due to irregularities in berm elevation and density of vegetation that may grow over time.

5.4 Filter Strip Construction and Maintenance

5.4.1 Construction Considerations – Filter Strips

The following subsections summarize the minimum considerations to be made during construction to enhance the effectiveness and function of filter strips. These construction considerations are not all necessarily applicable when using existing undisturbed areas as filter strips.

5.4.1.1 Filter Strip Installation

Before beginning construction, install temporary erosion and sediment control measures and ensure that upgradient sites have stabilized slopes. Install the filter strips during a time of year when successful establishment of vegetation can occur with little or no irrigation, and use temporary irrigation during dry periods. Clear and grub the site as necessary for filter strips that incorporate planted rather than native vegetation. During installation, disturb as little existing vegetation as possible and avoid soil compaction.

5.4.1.2 Grading and Level Spreader Installation

Accurate grading must occur during the construction of filter strips, because even small departures from design slopes can affect sheet flow conditions and decrease filter strip effectiveness. Use the lightest, least disruptive equipment when rough grading slopes to avoid excessive compaction and land disturbance. Following the rough grading, install level spreading devices at the upgradient edges of filter strips. If using a gravel trench, do not compact the subgrade and follow the construction sequence for infiltration trenches.

5.4.1.3 Vegetation Establishment

Seeding should be performed immediately after grading. Simultaneously stabilize seeded filter strips with temporary techniques such as erosion control matting or blankets. Maintain erosion control for seeded filter strips for at least 75 days following the first storm event of the season.

5.4.2 Maintenance Considerations – Filter Strips

The application of regular maintenance procedures enables filter strips to function properly over long periods of time. The following subsections outline suggestions for consideration when developing a maintenance plan and schedule as required by this policy.

5.4.2.1 Soil

In areas where heavy metals deposition is likely, it is recommended that soils should be removed and replaced once every 20 years. Replacing soil in filter strips is likely to provide a prolonged service life. When replacing soil in filter strips, refer to recommendations for engineered soils in bioretention cells provided in Appendix C of this manual.

5.4.2.2 Watering and Weeding

Periodic watering is required in the first year to help grass become established. Watering may also be required during prolonged dry periods. Weeding should be performed as necessary to maintain a healthy grassed top layer.

5.4.2.3 Routine Post–Storm Inspection

Filter strips should be inspected after large rain events and should be inspected for evidence of erosion, which is not likely in properly designed systems. Any visible trash accumulated on the filter strips should be removed.

5.4.2.4 Vegetation Maintenance

Basic maintenance of filter strips involves normal landscaping maintenance activities such as mowing, trimming, removal of invasive species, and replanting when necessary. Filter strips receiving large amounts of sediment may require periodic regrading and reseeding of their upslope edges. If a high volume of sediment builds up, creating concentrated flows and channels, filter strips may require reworking or replanting. Grass should be maintained at a length of 3 to 8 inches. Allowing grass to grow taller can cause thinning, which compromises the effectiveness of the vegetative cover. The removal of clippings and regular maintenance promotes vegetation growth and pollutant uptake.

5.4.3 Filter Strip Conceptual Design Example

A conceptual design example for a filter strip is provided in Appendix E of this manual.

6 Glossary of Selected Terms

Freeboard – The vertical distance between the level water surface and the lowest point along the top of a structure, such as a berm, that impounds or restrains the water.

Zone of Influence – The zone of influence refers to the area of the surrounding subgrade that is critical to proper function and support of the overlying and/or adjacent foundation or road subgrade. Generally, the zone of influence can be defined as the area bounded within a 3–dimensional surface extending at a 1:1 slope down and away from the outer edge of a foundation or road subgrade.

Catchment Area – In this document, catchment area refers to the total area contributing storm water runoff to a particular LID element.

Cleanout – A cleanout is an access point in a buried storm drain conveyance to allow periodic removal of any collected sediment or debris.

Keyed In – The phrase "keyed in" refers to the condition in which the top edge of a geotextile (impervious or pervious) is folded into the surrounding soil to keep the material from slipping downward over time.

Foot Plate – A foot plate is a plate that can be round or rectangular, and is fixed to the bottom of an observation well. The intent of the foot plate is to provide a foundation for the observation well and prevent any vertical movement. Generally, foot plates should be either plastic or metal with the shortest dimension being twice the length of the diameter of the observation well.

Hydrologic Soil Group D – Soils with a very low rate of water transmission (less than 0.06 in/hr) (NRCS, 2007).

Runoff Coefficient – Rational Method Runoff Coefficient calculated according to guidance contained in Chapter 106.

Subdrain –A system of underground perforated pipes which are used to collect water that has infiltrated through the soil in a bioretention cell and transmit it to an underground conveyance.

Underground Conveyance – This term refers to a system of underground storm drain pipes which convey storm water, such as pipes within the existing municipal separate storm sewer system.

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Appendix A
Equations

Equation 2.1: Target Treatment Volumes for Bioretention cells

$$TIV = \frac{A*P*C}{12} \qquad \textit{Equation 2.1}$$

TIV = Target Infiltration Volume ($feet^3$)
A = Contributing Area ($feet^2$)
P = Target Precipitation (inches)
C = Runoff Coefficient per Chapter 106

Equation 2.2: Bioretention cell Footprint

$$A_r = \left(\frac{12*TIV}{P_d}\right) * (0.26 * I_e^{-0.53}) \qquad \textit{Equation 2.2}$$

A_r = Bioretention cell Footprint ($feet^2$)
TIV = Target Infiltration Volume ($feet^3$)
P_d = Depth of Ponded Water (inches)
I_e = Infiltration Rate of Engineered Soils (inches/hour)

Equation 2.3: Total Depth for Bioretention cells

$$\boldsymbol{D_{rs} = \frac{P_d + F_d}{12} + E_d + S_d + 0.005 * L_r} \qquad \textit{Equation 2.3}$$

D_{rs} = Total Depth of Bioretention cell with Subdrain (feet)
P_d = Depth of Ponded Water (inches)
F_d = Freeboard (inches)
E_d = Depth of the Engineered Soils (feet)
S_d = Depth Required for Subdrain Diameter and Drain Rock (feet)
L_r = Approximate Length of Bioretention cell Along the Axis of the Subdrain (feet)

Equation 3.1: Trench Depth

$$D_i = \frac{I*t}{n_s*12} + 1 \qquad \textit{Equation 3.1}$$

D_i = Trench Depth (feet)
I = Design Infiltration Rate (inches/hour)
t = Retention Time (hours)
n_s = Storage Media Void Ratio

Equation 3.2: Trench Footprint

$$A_i = \frac{TIV*0.66}{n_s*(D_i-1)} \qquad \textit{Equation 3.2}$$

A_i = Trench Footprint (feet^2)
TIV = Target Infiltration Volume (feet^3)
n_s = Storage Media Void Ratio
D_i = Trench Depth (feet)

Equation 5.1: Filter Strip Maximum Discharge Loading

$$q = \frac{1.49}{n} * \left(\frac{Y}{12}\right)^{\frac{5}{3}} * S^{\frac{1}{2}} \qquad \textit{Equation 5.1}$$

q = Volumetric Discharge per Foot Width (feet^3/second–foot)
Y = Allowable Depth of Flow (inches)
S = Slope of Filter Strip (feet/foot)
n = Manning's "n" Roughness Coefficient

Equation 5.2: Maximum Allowable Design Velocity

$$V = \frac{q}{\frac{Y/12}{12}} \qquad \textit{Equation 5.2}$$

V = Velocity (feet/second)
q = Volumetric Discharge per Foot Width (feet^3/second–foot)
Y = Maximum Allowable Depth of Flow (inches)

Equation 5.3: Minimum Allowable Filter Strip Width

$$W_{fp} = \frac{A_a * C * 0.5}{q}$$ *Equation 5.3*

W_{fp} = Width of Filter Strip Perpendicular to Flow Path (feet)
A_a = Area (acres)
C = Runoff Coefficient per Chapter 106
q = Volumetric Discharge per Foot Width ($feet^3$/second–foot)

Equation 5.4: Filter Strip Length

$$L_f = \frac{T_t^{1.25} * P^{0.625} * (S * 100)^{0.5}}{3.34 * n}$$ *Equation 5.4*

L_f = Length of Filter Strip Parallel to Flow Path (feet)
T_t = Travel Time through Filter Strip (minutes)
P = Target Precipitation (inches)
S = Slope of Filter Strip (ft/ft)
n = Manning's "n" Roughness Coefficient

Equation D.1: Weir Equation for Flow into Standpipe or Riser

$$Q = N_s * G * C_w * P_s * H^{3/2}$$ *Equation D.1*

Q = Flow Rate, ($feet^3$/second)
N_s = Number of Outfall Structures G = Grate Reduction Factor
C_w = Weir Coefficient
P_s = Perimeter of the Stand Pipe (feet) H = Head (feet)

For the design of LID elements in this manual, the weir coefficient can be assumed as 3.3. Grate reduction factors are available from various grate manufacturers. For preliminary planning purposes, a value of 0.5 may be used.

Appendix B
Additional Specifications for Bioretention Cells

Table B.1 – Vegetation Suitable for Bioretention cells in Springdale

Native perennial flowers, grasses, and shrubs that prefer or tolerate moist soils should thrive in a rain garden or bioswale. They'll also entice butterflies, hummingbirds, and other nectar and berry feeders to visit. These local plants tend to be well-adapted to a range of regional temperature and moisture conditions and will flourish without chemical fertilizers and pesticides.

Perrenials and Herbaceous Plants

Amsonia, *Amsonia sp.*
Bushy Aster, *Aster dumosus*
Heath Aster, *Aster ericoides*
New England Aster, *Aster novae-anglia*
Beardtongue, *Penstemon digitalis 'Huskers Red'*
Black-eyed Susan, *Rudbeckia fulgida 'Goldstrum'*
Blazing Star, *Liatris spicata 'Kobod'*
Narrowleaf Blue Star, *Amsonia hubrictii*
Cardinal Flower, *Lobelia peciose*
Carolina Lovegrass, *Eragrostis pectinacea*
Catmint, *Nepeta cataria 'Walker's Low'*
Wild Columbine, *Aquilegia canadensis*
Christmas Fern, *Polystichum acrostichoides*
Northern Maidenhair Fern, *Adiantum Pedatum*
Sensitive Fern, *Onoclea sensibilis*
Rough Goldenrod, *Solidago rugosa*
Hypericum, *Hypericum profificum*
Hyssop, *Agastache rupestris*
Blue Flag Iris, *Iris veriscolor*
Jack-in-the-pulpit, *Arisaema triphyllum*
Sweet Joe-Pye Weed, *Euptorium Purpureum*
Milkweed, *Asclepias*
Torrey's Mountain Mint, *Pycanthemum Virginianum*
Obedient Plant, *Physotegia virgniana*
Ornamental Grass, *Miscanthus sinensis 'Adagio' and 'Little Kittens'*
Ponytail Grass, *Stipa tenuissima*
Striped Rush, *Baumea rebiginos 'Variegata'*
Russian Sage, *Perovskia atriplicifolia*
Golden Tickseed, *'Coreopsis tinctoria*

Shrubs and Vines

American Arborvitae, *Thuja occidentalis*
Rosebud Azalea, *Rhododendron periclymenoides*
Northern Bayberry, *Myrica pensylvanica*
Highbush Blueberry, *Vaccinium corymbosum*

Late Lowbush Blueberry, *Vaccinium angustifolium*
Butterfly Bush, *Buddleia davidii*
Red Chokeberry, *Aronia arbutifolia*
Black Chokeberry, *Aronia melanocarpa*
Red Twig Dogwood, *Cornus sericea*
Elderberry, *Sambucus Canadensis*
American Holly, *Ilex opaca*
Winterberry Holly, *Ilex verticillata*
Trumpet Honeysuckle, *Lonicera sempervirens*
Black Huckleberry, *Gaylussacia baccata*
Inkberry, Ilex glabra
Mountain Laurel, *Kalmia latifolia*
Nannyberry, *Viburnum lentago*
Sweet Pepperbush, *Clethra alnifolia*
Northern Spicebush, *Lindera benzoin*
Bluebeard Spirea, *Caryopteria x Clandonensis*
Shining Sumac, *Rhus copllinum*
Virginia Creeper, *Parthenocissus quinquefolia*
Prairie Willow, *Salix humilis*

Trees

Green Ash, *Fraxinus pennsylvanica*
White Ash, *Fraxinus Americana*
Gray Birch, *Betula populifolia*
River Birch, *Betula nigra*
Blackgum, *Nyssa sylvatica*
Red Cedar, *Juniperus virginiana*
Red-Panicled Dogwood, *Cornus racemose*
Elm, *Ulmus glabra 'Camperdownii'*
American Hop Hornbeam, *Ostrya virginiana*
Sweet Bay Magnolia, *Magnolia virginiana*
Red Maple, *Hacer rubrum*
Pawpaw, *Asimina spp.*
Pin Oak, *Quercus palustris*
Red Oak, *Quercus rubra*
Redbud, *Cercis canadensis 'Oklahoma'*
Sassafras, *Sassafras albidium*
Serviceberry, *Amelanchier arbórea*
American Sweetgum, *Liquidambar styraciflua*
Tupelo, *Nyssa sylvatica*
Witch Hazel, *Hammamelis virginiana*
Swamp White Oak, *Quercus bicolor*
Dwarf Yaupon Holly, *Ilex vomitoria 'Nana'*

Additional Guidance for the Specification of Engineered Soils for Bioretention cells

The following bulleted list is intended to assist designers in specifying an engineered soil mix for use in a bioretention cell. Soil specifications may vary slightly depending on site characteristics and related design considerations.

- The final soil mix (including compost and soil) should have a long–term hydraulic conductivity of approximately 1.0 inch/hour according to ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 80% compaction per ASTM Designation D 1557 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Note that infiltration rate and hydraulic conductivity are assumed to be approximately the same in a uniform mix soil.

- The final soil mixture should have a minimum organic content of 10% by dry weight per ASTM Designation D 2974 (Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils).

- The final soil mixture should be tested by an independent laboratory prior to installation for fertility, micronutrient analysis, and organic material content. Soil amendments per laboratory recommendations (if any) should be uniformly incorporated for optimum plant establishment and early growth.

- The clay content of the final soil mix should be less than 5%.

- The pH for the soil mix should be between 5.5 and 7.0. If the pH falls outside of the acceptable range, it may be modified with lime to increase the pH or iron sulfate plus sulfur to lower the pH. The lime or iron sulfate must be mixed uniformly into the soil prior to use in the bioretention cell.

- Soil mix should be uniform and free of stones, stumps, roots, or other similar material greater than 2 inches in diameter.

Unless laboratory analysis indicates otherwise, engineered soils are to be assigned a design infiltration rate of 1.0 inches/hour during design efforts. This value is consistent with a moderately high saturated hydraulic conductivity.

Appendix C
Bioretention Cell Design Example

C. Design Example – Bioretention cell

This section presents the design process for a bioretention cell to treat runoff from the parking area of the site described below.

Site Description – *A 1.8–acre lot in midtown Anchorage is to be redeveloped. The existing lot contains an old warehouse and a large parking area. The redeveloped lot will include a three–story office building a landscaped garden and a parking area. The new parking lot will contain approximately 0.75 acres of paved surface. Bioretention cells have been identified as a good alternative for treating runoff from the parking area, since a bioretention cell can be designed to serve as the required site landscaping as well. The preliminary site design has included an area within the center of the parking facility to place the bioretention cell.*

In the following subsections a preliminary site evaluation and a preliminary design are presented for the design of a bioretention cell for this site. Following these sections, a final design is discussed and a conceptual drawing of the final design is presented.

C.1 Example Preliminary Site Evaluation – Bioretention cell

To conduct the preliminary site evaluation, the preliminary site evaluation checklist (Table 2) provided in Section 2 has been used. To fill out the preliminary site evaluation checklist, the following reference materials were required:

- The draft preliminary site plans,
- Springdale stormwater network maps
- Local topographic maps, and
- The site geotechnical report.

Prior to conducting the preliminary site evaluation, it was noted that due to the close proximity of the bioretention cell to the parking lot subgrade, the use of a 30–mil polyethylene liner is required. This information was incorporated into the preliminary site evaluation.

The completed preliminary site evaluation checklist is presented as Table C.1. The information presented in Table C.1 indicates that the site is likely suitable for the use of a bioretention cell to treat parking lot runoff. However, review of the geotechnical report indicates that the groundwater table is located at a depth of 9 feet below grade. Based on the site evaluation, it was not certain that it would be possible to maintain the minimum separation distance between the bottom of the lined bioretention cell and the groundwater table (2 feet for lined bioretention cells). The groundwater table would limit the total depth of the bioretention cell to no more than 7 feet. This has been noted and is to be addressed during the preliminary design.

Table C.1 – Bioretention cell – Preliminary Site Evaluation Checklist

Site Location: 1112 W 100th Street			Evaluated by: William H.Seward			
Date: 8/24/2012						
Consid-erations	**Applies to Lined Bioretention cell?**	**Applies to Bioretention cells with Subdrains?**	**Requirement/ Recommendation**	**Site Conditions /Notes**	**Pass /Fail**	**Data Source**
Soil Infiltration	Y	N	Measured soil infiltration rate must be between 0.3 and 8 in/hr.	The lowest soil infiltration rate in the area being considered for the rain garden is 1.0 in/hr.	Pass	Geotechnical Report
Proximity to Surface Waters	N	Y	Bioretention cell should be located at least 100 feet from surface waters.	There are no surface waters within 100 feet of the site.	Pass	Topo Map
Depth to Seasonal High Groundwater Level	Y	Y	4 feet or more below the top of an unlined bioretention cell and 2 feet or more below the top of a lined bioretention cell.	Groundwater is 9 feet below the proposed grade near the bioretention cell.	Investigate Further	Geotechnical Report
Depth To Bedrock	N	Y	Bedrock must be 3 foot or more below the bottom of a bioretention cell.	Bedrock was not encountered; drilling went to a depth of 15 feet below grade.	Pass	Geotechnical Report
Proximity to Building Foundations	N	Y	Bioretention cell must be located outside of the zone of influence or at least 20 feet from building foundations.	The garden will be located approximately 60 feet from the nearest foundation.	Pass	Preliminary Site Plans
Proximity to Road Subgrades	N	Y	Bioretention cell must be located outside of the zone of influence or at least 20 feet from road subgrades.	Bioretention cell will be located within parking lot. A liner will need to be used.	Pass	Preliminary Site Plans
Runoff Source	Y	Y	Bioretention cell is not to receive runoff containing industrial pollutants.	Runoff is from a parking lot.	Pass	Preliminary Site Plans
Contributing Area	Y	Y	The contributing area must be less than 5 acres.	Area contributing to the garden is 0.75 acres.	Pass	Preliminary Site Plans
Available Area Slope	Y	Y	The slope must be less than or equal to 5%.	Proposed site slopes are 0.5%.	Pass	Preliminary Site Plans
Available Area	Y	Y	The area available for treatment must be at least 10% of the total contributing area.	Adequate space is available.	Pass	Preliminary Site Plans
Down Gradient Slope	N	Y	Average slope of adjacent down gradient property must be less than 12%.	The grade of the adjacent downgradient lot is less than 2%.	Pass	Topo Map

C.2 Example Preliminary Design – Bioretention cell

During the preliminary design process the minimum design considerations presented in Subsection 2.1.2 must be addressed. In order to conduct the preliminary bioretention cell design, the preliminary design calculation table (Table 3) presented in Section 2 has been used. The completed preliminary design calculations are presented in Table C.2.

In Step 1 of the preliminary design calculations, the runoff coefficient has been obtained from Chapter 106. The slope of the parking lot is less than 2% resulting in a runoff coefficient of 0.85. The calculation in Step 1 indicates that the bioretention cell will need to accommodate a volume of approximately 2,546 $feet^3$ of runoff.

In Step 2 of the preliminary design calculations the maximum ponding depth is selected to limit the amount of required area for the bioretention cell. Also the minimum horizontal to vertical side slope is used to minimize the area required for the bioretention cell. The resulting area required to contain the bioretention cell is 993 $feet^2$. It was determined by the design team that a square garden placed in the center of the parking lot would be preferable. Thus, in Step 2 the dimensions of the bioretention cell were calculated to be approximately 32 feet by 32 feet.

In Step 3, use Equation 2.3 to estimate the depth of the bioretention cell. The minimum ponded depth and minimum soil depth were both assumed to limit the total depth of the bioretention cell. The depth required for the subdrain was assumed to be 1.75 feet. This accounts for a 3– inch layer of drain rock under the subdrain, an 8–inch diameter subdrain, a 6–inch layer of drain rock above the subdrain, and a 4–inch layer of pea gravel above the drain rock. The resulting estimated total depth of the bioretention cell is 5.2 feet.

Table C.2 – Bioretention cell Preliminary Design

Site Location: 1112 W 10[th] Street			**Evaluated by:** Don Sheldon
Date: 8/24/2012			
Step 1: Calculate the Target infiltration Volume, TIV			**Notes**
Contributing Area, A	32670	(ft^2)	Approximate Parking Lot Area
Target infiltration Rainfall, P	1.1	(in)	Set Value
Runoff Coefficient, C	0.85		Per Ch. 106
$TIV = A*P*C/12 =$	2546	(ft^3)	Using Equation 2.1
***Step 2: Calculate the Required Bioretention cell Footprint Area**			
TIV (from Step 1)	2546	(ft^3)	
Depth of Ponded Water, P_d	8.0	(in)	Maximum of 8 inches
Design Infiltration Rate, I_e (or I, see Subsection 2.1.2.c)	1.0	(in/hr)	1.0 for engineered soils
$A_r = (TIV*12/P_d)(0.26*I_e)^{-0.53} =$	993	(ft^2)	Using Equation 2.2
Approximate Width, W_r $W_r=A_r/L_r=$	32	(ft)	Assume a Square Garden
Approximate Length, L_r $L_r=A_r/W_r=$	32	(ft)	
Step 3: Approximate Bioretention cell Depth			
P_d (From Step 2)	8.0	(in)	
Freeboard Depth, F_d	2	(in)	Minimum of 4 inches
Depth of Engineered Soils, E_d	2.5	(ft)	Minimum of 2.5 feet
Minimum Subdrain Depth, S_d	1.75	(ft)	
L_r (From Step 3)	32	(ft)	
$D_{rs} = (P_d+F_d)/12+E_d+S_d+(0.005*L_r) =$	5.2	(ft)	Using Equation 2.3
Note: *See Appendix C for guidance on selecting a value for I_e			

The results of the preliminary site evaluation and the preliminary design indicate that the site is a suitable candidate for the use of a bioretention cell to treat storm water runoff from the parking lot. Thus, final design efforts are warranted.

C.3 Example Final Design – Bioretention cell

To develop the final design based on the dimensions calculated in the preliminary design, the minimum factors presented in Subsection 2.1.3 were addressed. In real world applications, the final design of a bioretention cell is likely to include slight adjustments in geometry and will likely include site related engineering considerations specific to the particular project. For the sake of this example, the dimensions calculated in the preliminary design have been directly applied to the final design.

Engineered Soils – The specifications for the engineered soils are based on the requirements presented in Subsection 2.1.3.a, the guidance provided in Appendix C, and the geotechnical investigation for the site. The geotechnical investigation for the site indicates that the native soils are primarily loamy sand. Thus, approximately 60% of the excavated native soil will be set aside and mixed with compost to provide engineered soil for the bioretention cell.

Bioretention cell Plants – The specification for the bioretention cell plants is based on the guidance provided in Subsection 2.1.3.b and the listing of suggested bioretention cell plants provided in Appendix C. The interior of the garden is to be planted with Red Twig Dogwood and Willow. The interior of the garden will also be planted with Native Sedge grass.

Subdrain System – The subdrain system has been designed according to the guidance provided in Subsection 2.1.3.c. The subdrain system includes a branched network of 8–inch slotted PVC pipes. The PVC drainpipe sits atop a 3– foot wide bed of drain rock that is 3 inches thick. The drainpipe is overlaid with drain rock to a depth of 6 inches above the pipe. The drain rock is covered with 4 inches of pea gravel to reduce the likelihood of clogging. Note that backflow preventers have been included to keep the bioretention cell subsoil from becoming saturated when the storm drains become surcharged.

Bioretention cell Liner – The bioretention cell is lined with 30–mil polyethylene plastic with welded joints. The liner is keyed into the sides of the bioretention cell to prevent it from slipping downward over the course of time.

Overflow Structure – The overflow structure selected for the bioretention cell consists of two standpipes located along the center axis of the bioretention cell. The standpipes are connected to an underground storm drain that has been sized for the 100–year, 24–hour storm according to the Rational Method and guidance in Chapter 106. In this case, a 100–year peak flow rate of 0.7 feet^3/second was estimated based on a time of concentration of 15 minutes, an intensity of 1.1 inches per hour, and a weighted C value of 0.85 inch. The standpipes were initially sized to meet the diameter of the underground conveyance system for the sake of convenience. The standpipe sizes were then checked for the maximum overtopping depth of 2 inches using the following inlet weir equation below.

$$Q = N_s * G * C_w * P_s * H^{3/2}$$ *Equation C.1*

Q = Flow Rate, (feet^3/second)
N_s = Number of Structures, 2
G = Grate Reduction Factor, 0.5
C_W = Weir Coefficient, 3.3
P_s = Perimeter of the Stand Pipe (feet), 7.85
H = Head (feet), 0.167

Thus, when the ponded depth of the bioretention cell is 2 inches above the top of the standpipes, the standpipes will be conveying 1.8 feet^3/second of runoff. This exceeds the peak runoff from the 100–year 24–hour storm. The 30–inch diameter standpipes are adequately sized for flood control according to Chapter 106.

A conceptual drawing of the bioretention cell resulting from this design effort is presented in Figure C.1.

This bioretention cell will significantly reduce the runoff peak that exits the site during large rain events. It also provides treatment for the full TIV.

Figure C.1 – Bioretention cell Design Example
Page 1

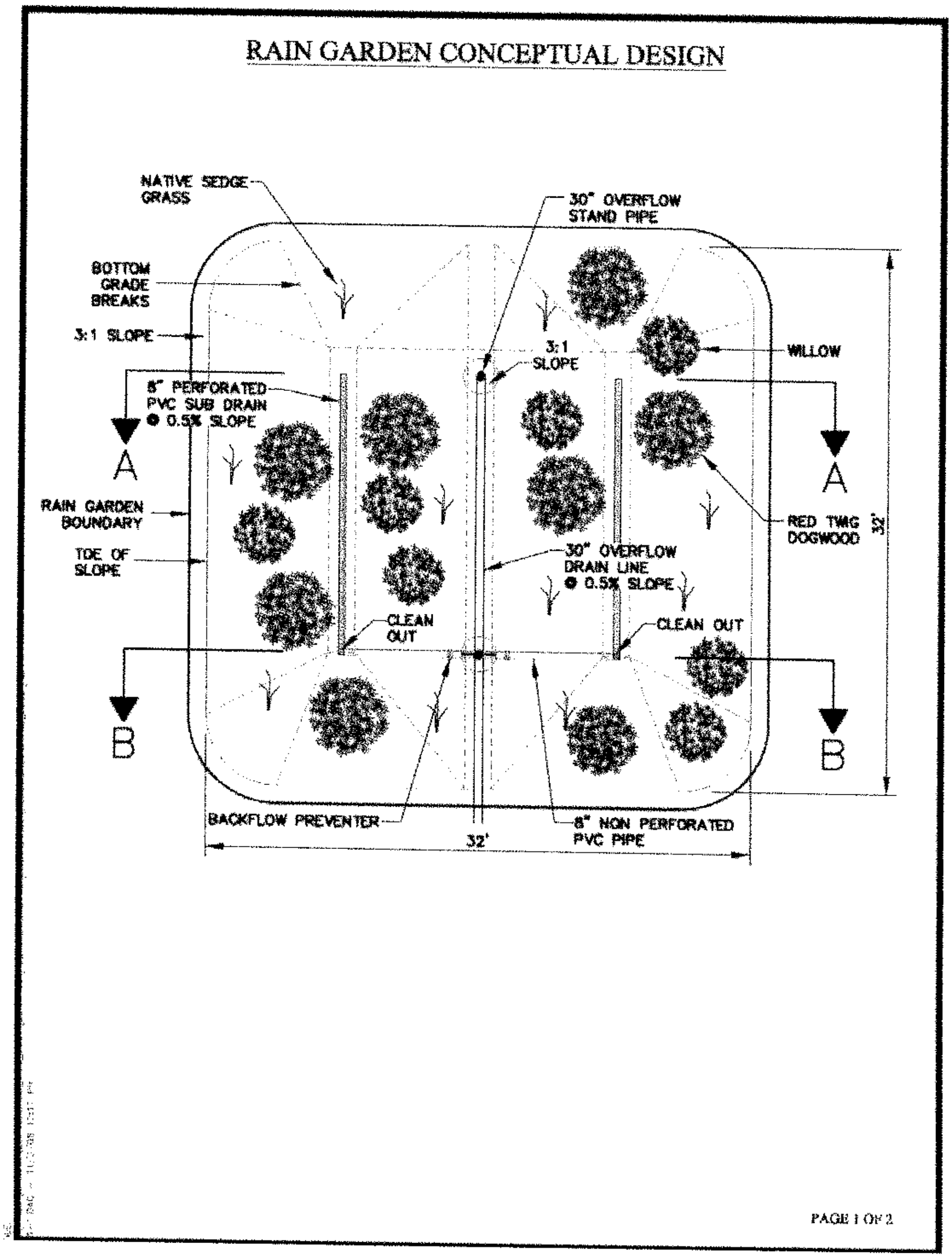

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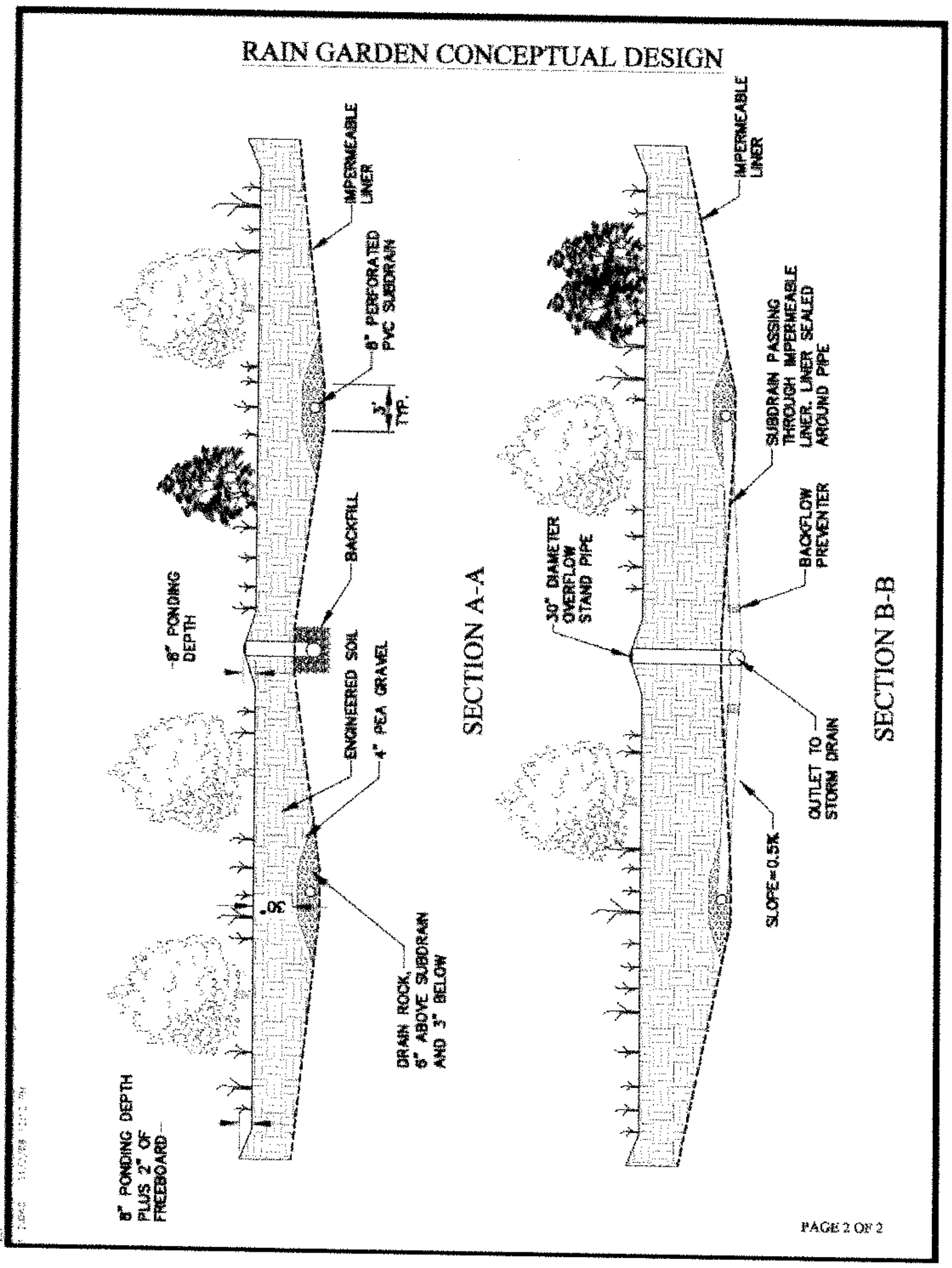
Figure C.1 – Bioretention cell Design Example
Page 2



Appendix D
Infiltration Trench Design Example

D Design Example – Infiltration Trench

This section presents the design process for an infiltration trench to infiltrate parking lot runoff from a portion of the site described below.

Site Description: *An 8–acre tract of relatively flat land is to be developed into an apartment complex. The complex will include four separate three–story apartment buildings each containing 12 two–bedroom apartments. The development will include a 32 space parking lot for each building as well as open green space to be used for landscaping and recreation. The developer would like to incorporate LID elements to infiltrate runoff from the base 2–year, 24–hour storm event. Infiltration trenches have been identified as a potential option to infiltrate runoff from the parking areas. Each parking lot is approximately 65 feet by 140 feet. The available space for an infiltration trench at each parking lot is approximately 40 by 65 feet.*

In the following subsections, a preliminary site evaluation and a preliminary design are presented for an infiltration trench for a single parking lot. Following these sections, a final design is discussed and a conceptual drawing of the final design is presented.

D.1 Example Site Evaluation – Infiltration Trench

In order to conduct the preliminary site evaluation, the preliminary site evaluation checklist (Table 4) provided in Section 3 has been used. To fill out the preliminary site evaluation checklist, the following reference materials were required:

- The draft preliminary site plans,
- Water and Wastewater Utility Maps,
- Local topographic maps, and
- The site geotechnical report.

The completed preliminary site evaluation checklist is presented as Table D.1. The information presented in Table D.1 indicates that that the site is likely suitable for the use of an infiltration trench to treat parking lot runoff. However, review of the preliminary site plan indicates that the infiltration trenches will be limited to a length of no more than 65 feet due to the parking lot layout. The preliminary site evaluation also indicates that groundwater is at a depth of 8 feet, thus limiting the allowable depth of an infiltration trench to no more than 4 feet.

Other than these considerations, the site is a good candidate for the use of an infiltration trench to treat runoff from the parking lot. The limitations in the possible trench dimensions have been noted and are addressed during the preliminary design.

Table D.1 – Infiltration Trench – Preliminary Site Evaluation Checklist

Site Location: 1112 W 100th Street		Evaluated by: Leonhard Seppala		
Date: 8/24/2010				
Considerations	**Requirement/Recommendation**	**Site Conditions/Notes**	**Pass/Fail**	**Data Source**
Soil Infiltration Rate	Measured soil infiltration rate must be between 0.3 and 8 in/hr.	The lowest soil percolation rate in the area being considered for the trench is 0.3 in/hr.	Pass	Geotechnical Report
Proximity to Surface Waters	Trench should be located at least 100 feet from surface waters.	There are no open surface waters within 200 feet of the site.	Pass	Topo Map
Depth to Seasonal High Groundwater Level	Groundwater must be 4 feet or more below the bottom of the trench.	Groundwater is 8 feet below the surface. Need to know how deep trench will be.	Investigate Further	Geotechnical Report
Depth To Bedrock	Bedrock must be 3 feet or more below the bottom of the trench.	Bedrock is at a depth of 10 ft. Need to know how deep the trench will be.	Investigate Further	Geotechnical Report
Proximity to Building Foundations	Trench must be located outside of the zone of influence or at least 20 feet from building foundations.	Trenches will be located more than 20 feet from building foundations	Pass	Draft Preliminary Site Plans
Proximity to Road Subgrades	Trench must be located at least 20 feet from road subgrades.	It is anticipated that there will be adequate room to place the trenches a minimum of 20 feet from road subgrades.	Pass	Draft Preliminary Site Plans
Runoff Source	Infiltration trench is not to receive runoff containing industrial pollutants.	Parking Area	Pass	Draft Preliminary Site Plans
Contributing Area	The contributing area must be less than 3 acres.	The approximate contributing area is 0.2 acres.	Pass	Draft Preliminary Site Plans
Available Area Slope	Available area slope must be less than or equal to 5%.	The average slope of the contributing area is 0.5%.	Pass	Draft Preliminary Site Plans
Available Area	The area available for treatment must be at least 20% of the total catchment area.	Approximately 40% of the total site area will consist of open space for lawns and landscaping.	Pass	Draft Preliminary Site Plans
Down Gradient Slope	Down gradient slope must be less than 12%.	The adjacent properties are also gently sloping.	Pass	Site Visit/Topo Map

D.2 Example Preliminary Design – Infiltration Trench

In order to conduct the preliminary infiltration trench design, the table (Table 5) presented in Section 3 has been used. The completed preliminary design calculations are presented in Table E.2.

In Step 1 of the preliminary design calculations, the runoff coefficient, 0.85, has been obtained from Chapter 106. The calculation in Step 1 indicates that the infiltration trench will need to accommodate a volume of approximately 709 feet^3 of runoff.

In Step 2, the typical void ratio was assumed. A retention time of 48 hours was assumed. The resulting trench depth is 4 feet. This depth will still accommodate the minimum separation distance between the bottom of the infiltration trench and the groundwater table.

In Step 3, the bottom area of the trench is calculated based on values collected and calculated in Steps 1 and 2. The required bottom area of the trench is 390 feet^2.

In Step 4, the length and width of the trench is established. The infiltration trench will receive sheet flow from the parking lot along the side that is 35 feet long. Thus, the length of the infiltration trench has been set in Step 4 to be 35 feet. The resulting required width of the infiltration trench (not counting the pretreatment area) is 11.1 feet.

In Step 5, the width required for an infiltration trench receiving runoff from a single side and from both sides is calculated. Note that the infiltration trench will only receive runoff from one side. The resulting width is 31.1 feet.

In Step 6, the length selected in Step 4 is recorded with the width calculated in Step 5 for infiltration trench receiving runoff from one side. These values represent the required area for the infiltration trench.

The results of the preliminary site evaluation and the preliminary design indicate that the site is a suitable candidate for the use of an infiltration trench to treat storm water runoff. Thus, final design efforts are warranted.

Table D.2 – Infiltration Trench Preliminary Design

Site Location: 1112 W 100th Street			**Evaluated by:** Don Sheldon
Date: 8/24/2012			
Step 1: Calculate the Target Infiltration Volume, TIV			**Notes**
Contributing Area, A	9100	(ft^2)	Total Contributing Area
Target Infiltration Rainfall, P	1.1	(in)	Set Value
Runoff Coefficient, C	0.85		Per Ch. 106
TIV = A*P*C/12 =	709	(ft^3)	Using Equation 2.1
Step 2: Calculate the Depth of the Trench, D_i			Must be between 4 and 10 feet
Void Ratio, n_s	0.4		0.4 is Typical of 1.5 to 3 in. Stone
Design Infiltration Rate, I	0.3	(in/hr)	Based on site investigation (Subsection 1.3.1 and Ch. 106)
Detention Time, t	48	(hr)	Must be 24 to 48 hours
$D_i = (I*t)/(n_s*12) + 1 =$	4	(ft)	Using Equation 3.1
Step 3: Calculate the Bottom Footprint of the Trench			
TIV (from Step 1)	709	(ft^3)	
n_s (from Step 2)	0.4		
D_i (from Step 2)	4	(ft)	
$A_i = (TIV*0.66)/(n_s*(D_i - 1)) =$	390	(ft^2)	Using Equation 3.2
Step 4: Establish the Trench Length and Width			Minimum Recommended Ratio is 3L:1W
Set Trench Length, L_i	35.0	(ft)	
Or			
Set Trench Width, W_i		(ft)	Maximum Width is 25 feet
Then Calculate Either			
$W_i=A_i/L_i$	11.1	(ft)	Maximum Width is 25 feet
Or			
$L_i=A_i/W_i$		(ft)	
Record Final L_i and W_i Values			
$L_i=$	35.0	(ft)	
$W_i=$	11.1	(ft)	
Step 5: Account for Pretreatment			
Filter Strip Width, W_f	20.0	(ft)	Minimum Recommended Width is 20 feet
If Receiving Flow From Both Sides			
Total Width (W_{if1}), $W_{if1} = W_i + 2*W_f =$		(ft)	
Or, If Receiving Flow From One Side			
Total Width (W_{if2}), $W_{if2}=W_i + W_f =$	31.1	(ft)	Receiving flow from a single side
Step 6: Required Length and Width for Trench and Filter Strip			
L_i (from Step 4) =	35.0	(ft)	
Appropriate Total Width (from Step 5) =	31.1	(ft)	Receiving flow from a single side

D.3 Example of Final Design – Infiltration Trench

In order to develop the final design based on the dimensions calculated in the preliminary design, the minimum factors presented in Subsection 3.1.4 were addressed. In real world applications, the final design of an infiltration trench is likely to included slight adjustments in geometry as well as site related engineering considerations specific to the particular project.

Filter Fabric – To reduce the likelihood of clogging and piping, a filter fabric has been specified with a flow rate to closely match the surrounding soils' infiltration rate of 0.3 feet/sec. The fabric is placed between the storage media and the trench walls and overlaps by 1–foot long seams. It is placed as a barrier beneath the 6 inches of top material. Filter fabric is placed between the top layer and the storage media. The fabric will be keyed into the sides of the trench walls.

Design of the Overflow Structure – The overflow structure of choice for this particular example is the use of standpipes at the trench boundaries. These structures are connected to a storm drain trunk line that runs down the adjacent road. The standpipes were initially sized to meet the diameter of the underground conveyance system (12 inches) for the sake of convenience. The standpipe sizes were then checked for an overtopping depth of 3 inches as depths greater than 3 inches would result in stormwater spilling beyond the limits of the trench and overflow structures.

$$Q = N_s * G * C_w * P_s * H^{\frac{3}{2}}$$ *Equation D.1*

Q = Flow Rate, ($feet^3$/second)
N_s = Number of Structures, 2
G = Grate Reduction Factor, 0.5
C_W = Weir Coefficient, 3.3
P_s = Perimeter of the Stand Pipe (feet), 3.14
H = Head (feet), 0.25

When the ponded depth of the infiltration trench is 3 inches above the top of the standpipes, the standpipes will be conveying 1.3 $feet^3$/second of runoff. This exceeds the peak runoff from the 100–year 24–hour storm according to a rational calculation. The 12–inch diameter standpipes are therefore adequately sized for flood control according to Chapter 106.

Top Layer – The material selected for this application is washed pea gravel. The pea gravel will be laid in a 6–inch layer on top of the filter fabric that overlies the storage media.

Bottom Layer – The bottom layer consists of washed filter sand.

Grading – The site grading plan has been completed so that the parking lot will sheet drain across the filter strip to the infiltration trench. The trench has been graded to be completely level along the top and bottom.

Observation Well – The infiltration trench includes two 6 inch observation wells that can be seen in Figure D.1.

A drawing of the infiltration trench is presented as Figure D.1. Note that in this design, the area required for the structure is slightly larger than the area estimated using the preliminary design calculations. This is due to the use of overflow inlets on either end of the infiltration trench and the 3:1 (horizontal: vertical) side slope.

Figure D.1 – Infiltration Trench Design Example

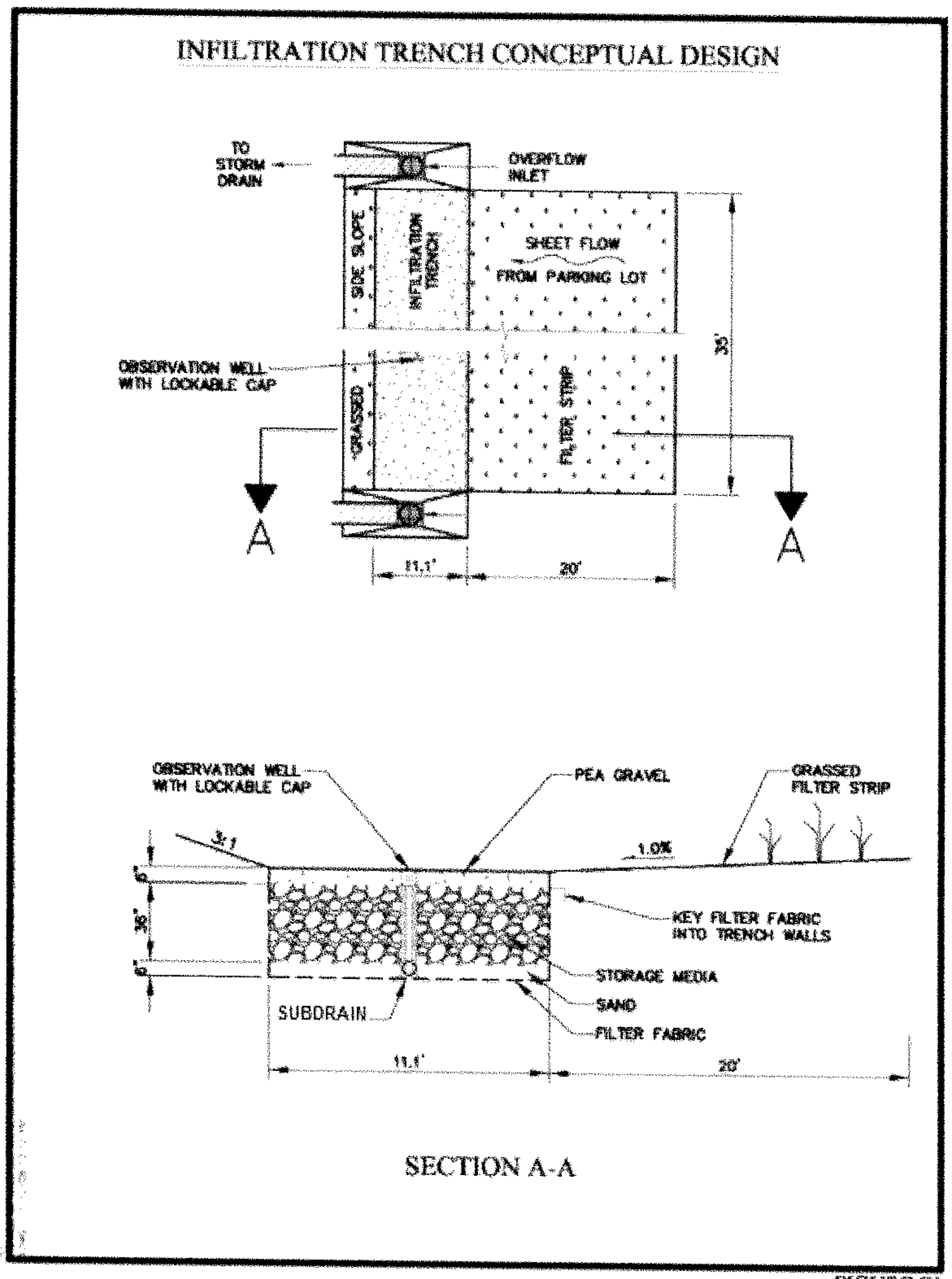


FIGURE E1

Appendix E
Filter Strip Design Examples

E. Filter Strip Design Example

This section presents the design process for a filter strip to infiltrate parking lot runoff from a portion of the site described below.

<u>Site Description:</u> *A small commercial strip development will include a parking area to accommodate 20 vehicles. The site presently drains towards a frontage street into a curb and gutter storm drain system. The area available for the parking lot is 200 feet long by 65 feet wide. A filter strip is proposed to treat runoff from the parking area prior to discharge to the curb and gutter system along the frontage street. Making the assumption that the filter strip will be approximately 25 feet long (dimension parallel to flow) the parking area will be approximately 200 feet by 40 feet.*

In the following subsection, the preliminary site evaluation and a preliminary design are presented for a filter strip for the parking lot. Following these sections, a final design is discussed and a conceptual drawing of the final design is presented.

E.1 Example Preliminary Site Evaluation – Filter Strips

In order to conduct the preliminary site evaluation, the preliminary site evaluation checklist (Table 8) provided in Section 5 has been used. To fill out the preliminary site evaluation checklist, the draft preliminary site plans were required.

The completed preliminary site evaluation checklist is presented as Table E.1. The information presented in Table E.1 indicates that the site is suitable for the use of a filter strip to treat parking lot runoff.

Table E.1 – Filter Strip – Preliminary Site Evaluation Checklist

Site Location: 1115 W 100th Street **Evaluated by:** Aldo Leopold

Date: 8/24/2010

Considerations	Requirement/Recommendation	Site Conditions / Notes	Pass/Fail	Data Source
Runoff Source	Filer strip is not to receive runoff containing industrial pollutants.	Runoff is from a parking lot.	Pass	Draft Preliminary Site Plans
Contributing Area	The contributing area must be less than 1 acre.	Contributing area is approximately 0.18 acres.	Pass	Draft Preliminary Site Plans
Slope of the Contributing Area	Slope of the contributing area must be less than 10%.	The parking lot will have a slope much less than 10%	Pass	Draft Preliminary Site Plans
Available Area	The available area for the filter strip shall generally extend the full width of the contributing area and allow for a length (parallel to flow) of 15 to 25 feet. The ratio of total contributing area to the total available area must not exceed 6:1.	Site provides adequate space for a filter strip. The available area for the filter strip (200 feet by 25 feet) is more than 1/6th the size of the contributing parking lot (200 feet by 40 feet).	Pass	Draft Preliminary Site Plans

E.2 Example Preliminary Design – Filter Strips

In order to conduct the preliminary filter strip design, the preliminary design calculation table (Table 8) presented in Section 5 has been used. The completed preliminary design calculations are presented in Table E.2.

In Step 1, of the preliminary design calculations, the maximum allowable depth of flow is assumed, the design slope is set to 3%, and a Manning's "n" of 0.25 is selected for dense grass. The calculation in Step 1 indicates that the filter strip will be able to accommodate 0.005 $feet^3/sec$ runoff for every linear foot of width (the dimension perpendicular to flow).

In Step 2, the velocity along the filter strip is checked by dividing the maximum discharge loading by the design depth. According to the calculations is Step 2, the design velocity is 0.12 feet/second, which is equal to the maximum allowable velocity.

In Step 3, the minimum allowable filter strip width is calculated. The rational coefficient in this computation is selected based on guidance provided in Chapter 106. The results of the computation in Step 3 indicate that the minimum allowable width for the filter strip is 15.3 feet. This is much less than the available width of 200 feet. Therefore, the preliminary design proceeds to Step 4.

In Step 4, the minimum allowable filter strip length (dimension parallel to flow) is calculated. In this step, a travel time of 5.5 minutes was selected. According to the computations in Step 3, the minimum allowable filter strip length is 21.0 feet. This is approximately equal to the assumed length of 25 feet. Thus, final design efforts are warranted.

Table E.2 – Filter Strip Preliminary Design

Site Location: 1112 W 100th Street			**Evaluated by:** Don Sheldon
Date: 8/24/2012			
Step 1: Calculate the Maximum Discharge Loading, q			**Notes**
Maximum Allowable Depth of flow, Y	0.5	(in)	Maximum is 0.5 inches
Slope of Filter Strip, S	0.03	(ft/ft)	Between 0.01 and 0.06
Manning's "n"	0.25		
$q=(1.49/n)*(Y/12)^{(5/3)}*S^{(1/2)}$	0.005	(ft^3/sec–ft)	Using Equation 5.1
Step 2: Check Velocity, V			Maximum Allowable is 0.9 ft/sec
q (from Step 1)	0.005	(ft^3/sec–ft)	
Y (from Step 1)	0.5	(in)	
$V=q/(Y/12)$	0.12	(ft/sec)	Using Equation 5.2
Step 3: Calculate the Minimum Allowable Filter Strip Width, W_{fp}			
q (from Step 1)	0.005	(ft^3/sec–ft)	
Contributing Area, A_a	0.18	(acres)	
Runoff Coefficient, C	0.85		Per Ch. 106
$W_{fp}=(A_a*C*0.5)/q$	15.3	(ft)	Using Equation 5.3
Step 4: Calculate the Minimum Allowable Filter Strip Length, L_f			
Travel Time Through Filter Strip, T_t	5.5	(min)	Between 5 and 9 Minutes
Target Precipitation, P	1.3	(in)	1.3 inches
S (from Step 1)	0.03	(ft/ft)	
n (from Step 1)	0.25		
$L_f=(T_t^{1.25}*P^{0.625}*(S*100)^{0.5})/3.34*n$	21.0	(ft)	Using Equation 5.4

E.3 Example Final Design – Filter Strips

In order to develop the final design based on the dimensions calculated in the preliminary design, the minimum factors presented in Subsection 5.2.3 were addressed. In real world applications, the final design of a filter strip is likely to include slight adjustments in geometry and will likely include site related engineering considerations specific to the particular project. For the sake of the example, the dimensions calculated in the preliminary design have been directly applied to the final design discussed below.

Overall Site Integration – The existing site did not offer the opportunity to use areas of existing vegetation as filter strips. The existing site offers enough space to meet the desired parking area with additional room for a well designed and constructed filter strip that can sheet drain to an existing curb and gutter system. The filter strip has been placed lengthwise between the frontage road and the new parking area. The parking area has been graded to sheet drain to the filter strip. However, because the parking spaces require parking stops, which will concentrate flows upstream of the filter strip, the design has incorporated a level spreading device.

Filter Strip Cover – The selected filter strip cover in this design is Schedule C seed mix. This grass will require little maintenance and will provide a natural appearance to the site. The application rate is 5 lbs/1,000 square feet.

Level Spreading Devices – As mentioned previously, a level spreading device is required in this design. The device selected is a gravel–filled trench. The trench is 12 inches wide by 24 inches deep. It is lined with a non–woven geotextile material and has a 1 inch drop along its leading edge.

A conceptual plan and profile drawing of the filter strip resulting from this design effort is presented in Figure E.1. This design will provide treatment for the first flush from rainfall events.

Stricken language would be deleted from and underlined language would be added to present law.
Act 930 of the Regular Session

State of Arkansas
93rd General Assembly
Regular Session, 2021

As Engrossed: H3/10/21

A Bill

HOUSE BILL 1

By: Representative Bentley
By: Senator G. Stubblefield

For An Act To Be Entitled

AN ACT TO AMEND THE LAW TO CLARIFY THAT DECISIONS OF A MUNICIPAL BOARD OF ADJUSTMENT ARE APPEALED TO CIRCUIT COURT UNLESS THE GOVERNING BODY OF A MUNICIPALITY PROVIDES BY ORDINANCE THAT THE GOVERNING BODY SHALL HEAR APPEALS FIRST; AND FOR OTHER PURPOSES.

Subtitle

TO CLARIFY THAT DECISIONS OF A MUNICIPAL BOARD OF ADJUSTMENT ARE APPEALED TO CIRCUIT COURT UNLESS THE GOVERNING BODY OF A MUNICIPALITY PROVIDES BY ORDINANCE THAT THE GOVERNING BODY SHALL HEAR APPEALS FIRST.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF ARKANSAS:

SECTION 1. Arkansas Code § 14-56-416(b)(2)(B)(ii), concerning municipal zoning, is amended to read as follows:

(ii)<u>(a)</u> ~~Decisions of the board in respect to the above shall be subject to appeal only to a court of record having jurisdiction~~ <u>Except as provided in subdivision (b)(2)(B)(ii)(b) of this section, decisions of the board under this section shall be appealed to a circuit court of competent jurisdiction.</u>

<u>(b) A governing body of a municipality may provide by ordinance that the governing body of the municipality shall firs</u>

hear appeals under this section.

/s/Bentley

APPROVED: 4/26/21

RESOLUTION NO.________

A RESOLUTION AUTHORIZING THE EXECUTION OF A CONSTRUCTION CONTRACT FOR A TRAFFIC SIGNAL

WHEREAS, sealed bids were received on May 11, 2021 at 2:00 p.m. for the construction of a traffic signal at the intersection of Ford Avenue and Butterfield Coach Road; and

WHEREAS, All Service Electric, Inc. was the low bidder for this project at $269,010.00;

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS, that

Section 1. The Mayor and City Clerk are hereby authorized to execute a contract with All Service Electric, Inc. Inc. for construction of a traffic signal for $269,010.00.

Section 2. The Mayor is authorized to approve construction change orders as long as the cumulative total of the change orders does not exceed 10% of the original contract price.

PASSED AND APPROVED this 25th day of May, 2021.

____
Doug Sprouse, Mayor

ATTEST:

____
Denise Pearce, City Clerk

APPROVED AS TO FORM:

____
Ernest B. Cate, City Attorney

TEC

May 11, 2021

Ryan Carr
City of Springdale
269 E Randall Wobbe Ln
Springdale, AR 72764
rcarr@springdalear.gov

RE: Recommendation of Award - Ford Avenue and Butterfield Coach Road Signal – Springdale, Arkansas

Dear Ryan:

Bids were received for Butterfield Coach Road and Ford Avenue Traffic Signal at the City of Springdale, Arkansas, in the 2nd Floor Multi-Purpose Room at the City Administration Building, 201 Spring Street, Springdale, Arkansas, 72764, at 2:00 p.m. on May 11, 2021 and publicly read aloud.

A total of two bids were received with All Service Electric, Inc. the low bidder at $269,010.00. The bid has been checked for accuracy and for compliance with the contract documents. A tabulation of the bids received is enclosed with this letter. The engineer's opinion of probably construction cost was $248,000.00. The difference in cost is attributed to recent fluctuations in material costs.

We believe that the bid submitted by All Service Electric, Inc. in the amount of $269,010.00 represents a good value for the City of Springdale. We recommend that the construction contract for Butterfield Coach Road and Ford Avenue Traffic Signal be awarded to All Service Electric, Inc.

Please contact me if you have any questions.

Sincerely,

Nathan Becknell, P.E., PTOE, PTP
Fayetteville Office Manager

NLB/nb
Enclosure
F-123

Traffic Engineering Consultants, Inc.
6000 S. Western Avenue, Suite 300 | Oklahoma City, Oklahoma 73139 | Ph. 405-720-7721
6931 S. 66th E. Avenue, Suite 100 | Tulsa, Oklahoma 74133 | Ph. 918-481-8484
217 E. Dickson Street, Suite 106 | Fayetteville, Arkansas 72701 | Ph. 479-335-5636
Website: www.tecusa.com

RESOLUTION NO. ______

A RESOLUTION EXPRESSING THE WILLINGESS OF THE CITY OF SPRINGDALE TO UTILIZE FEDERAL FUNDING FOR THE FOLLOWING PROJECT: DEAN'S TRAIL PHASE IIIA.

WHEREAS, the Arkansas Department of Transportation is accepting applications for Transportation Alternatives Program (TAP) funds for projects at the following Federal and City participating ratios, up to the maximum Federal-aid available:

TYPE WORK	WORK PHASE	FEDERAL %	CITY %
Construction of City Project	Project Design	0	0
	Right-of-Way	0	0
	Utilities	0	0
	Construction	80	20
	Construction Engineering	0	0

WHEREAS, the currently approved funds are to be used for project construction, and

WHEREAS, a maximum $125,000 city match is required with a maximum $500,000 ArDOT reimbursement, is currently budgeted in the Public Works 2021 budget.

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS, THAT:

SECTION I: The City will participate in accordance with its designated responsibilities in this project.

SECTION II: The City pledges its full support and hereby authorizes the Arkansas State Highway and Transportation Department to initiate action to implement this project.

PASSED AND APPROVED THIS 25TH DAY OF MAY, 2021

____
Doug Sprouse, Mayor

ATTEST:

____
Denise Pearce, City Clerk

APPROVED AS TO FORM:

____
Ernest Cate, City Attorney

RESOLUTION NO.________

A RESOLUTION AUTHORIZING THE EXECUTION OF A CONSTRUCTION CONTRACT AT THE SPRINGDALE MUNICIPAL AIRPORT FOR REGIONAL DETENTION

WHEREAS, sealed bids were received on May 4, 2021 at 2:30 p.m. for the construction of the Regional Detention at the Springdale Municipal Airport: and

WHEREAS, eight bids were received with Emery Sapp & Sons, Inc., being the low bidder for this project at $793,820.00;

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS, that

Section 1. The Mayor and City Clerk are hereby authorized to execute a contract with Emery Sapp & Sons, Inc for construction of the regional detention at the Springdale Municipal Airport for $793,820.00.

Section 2. The Mayor is authorized to approve construction change orders as long as the cumulative total of the change orders does not exceed 10% of the original contract price.

PASSED AND APPROVED this 25th day of May, 2021.

____
Doug Sprouse, Mayor

ATTEST:

____
Denise Pearce, City Clerk

APPROVED AS TO FORM:

____
Ernest B. Cate, City Attorney

WMresairport052521

Engineering Department www.SpringdaleAR.gov

SPRINGDALE
WE'RE MAKING IT HAPPEN

May 13, 2021

Brad Baldwin
Director of Engineering
269 E. Randall Wobbe Ln.
Springdale, AR 72764

RE: Recommendation of Award – Springdale Municipal Airport Regional Detention

Dear Brad:

Bids were received for Springdale Municipal Airport Regional Detention at the City of Springdale, Arkansas, in the 2nd Floor Multi-Purpose Room at the City Administration Building, 201 Spring Street, Springdale, Arkansas, 72764 at 2:30 p.m. on May 4, 2021 and publicly read aloud.

A total of eight bids were received with Emery Sapp & Sons, Inc. being the low bidder at $793,820.00. The Engineer's Opinion of probable cost was $1,086,050.00.

We believe that the bid submitted by Emery Sapp & Sons, Inc. in the amount of $793,820.00 represents a good value for the City of Springdale. We recommend that the construction contract for Springdale Municipal Airport Regional Detention be awarded to Emery Sapp & Sons, Inc.

Please contact me if you have any questions.

Sincerely,

Ryan Carr, Deputy Director of Engineering Operations

RESOLUTION NO.________

A RESOLUTION AUTHORIZING THE CHANGE IN STAFFING OF THE POLICE DEPARTMENT

WHEREAS, the Police Chief would like to fill the vacant position of Assistant Police Chief and reduce the number of captains by one; and

WHEREAS, Police Department budget has sufficient funds to cover the additional cost of $3,500;

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL FOR THE CITY OF SPRINGDALE, ARKANSAS, that the City Council supports the filling of the position of Assistant Police Chief and hereby authorizes this change.

PASSED AND APPROVED this 25th day of May, 2021.

____
Doug Sprouse, Mayor

ATTEST:

____
Denise Pearce, City Clerk

APPROVED AS TO FORM:

____
Ernest B. Cate, City Attorney

CITY of SPRINGDALE

POLICE DEPARTMENT
OFFICE OF THE CHIEF OF POLICE

To:	Mayor Doug Sprouse
CC:	Wyman Morgan, Colby Fulfer
From:	Chief Mike Peters
Date:	5/13/2021
Re:	Assistant Chief of Police

Mayor Sprouse,

The Police Department has had the position of Assistant Chief of Police in our structure for as long as I can remember. The job description, pay grade, and civil service requirements are all in place.

The position was vacated with the retirement of our last Assistant Police Chief in 2007 and has not been filled since. In lieu of filling the Assistant Chief position we have overstaffed our Captain position.

I am requesting to reduce the number of Captains from four to three and to fill the Assistant Chief position. I have spoken with our Human Resources Director, our City Attorney and the Civil Service Commission, and none of them feel there are any issues with making this change.

Our salary account is well under budget, and I estimate the cost for the remainder of 2021 to be approximately $3,500.

I request that this item be put on the next committee agenda, and if you have any questions or concerns please let me know.

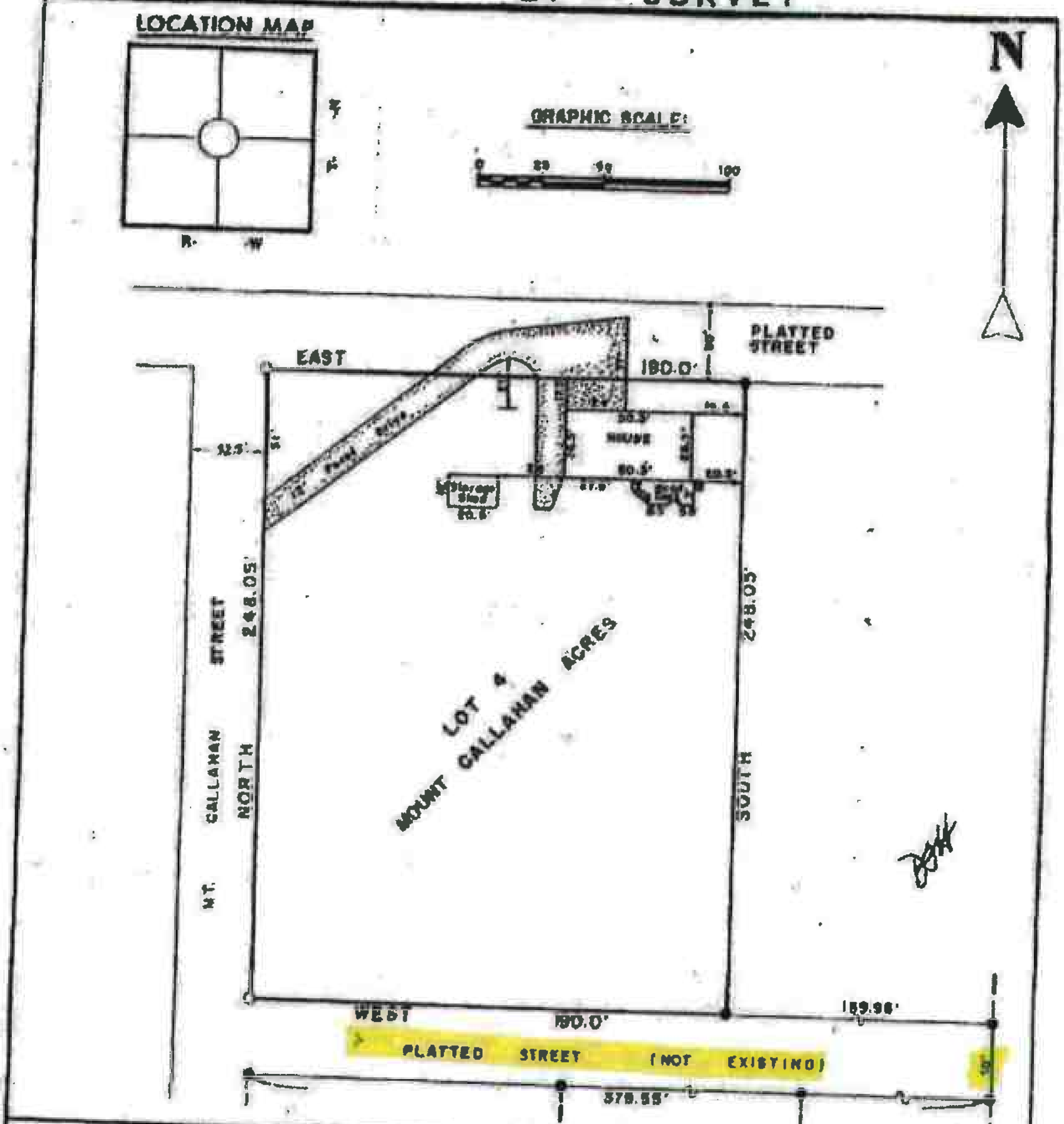
Sincerely,

Mike Peters

Mike Peters
Chief of Police

ADMINISTRATION BUILDING, 201 NORTH SPRING STREET, SPRINGDALE, ARKANSAS 72764
(479) 756-8200
CHIEF MIKE PETERS

PLAT — OF — SURVEY



SURVEY DESCRIPTION

LOT NUMBERED 4 IN MOUNT CALLAHAN ACRES, A SUBDIVISION OF A PART OF THE W 1/2 OF THE SW 1/4 OF SECTION 14, TOWNSHIP 18 NORTH, RANGE 30 WEST, BENTON COUNTY, ARKANSAS.

THIS PROPERTY IS NOT IN THE 100 YEAR FLOOD PLAIN ACCORDING TO THE FIRM MAP OF BENTON COUNTY, ARKANSAS AND INCORPORATED AREAS DATED SEPT. 18, 1991.

CERTIFICATION

This is to certify that I have this day completed a survey of the above described property. All easements and or encroachments revealed by the survey are shown on the plat of survey.

DOUGLAS G. HEMINGWAY
P.L.S. #852

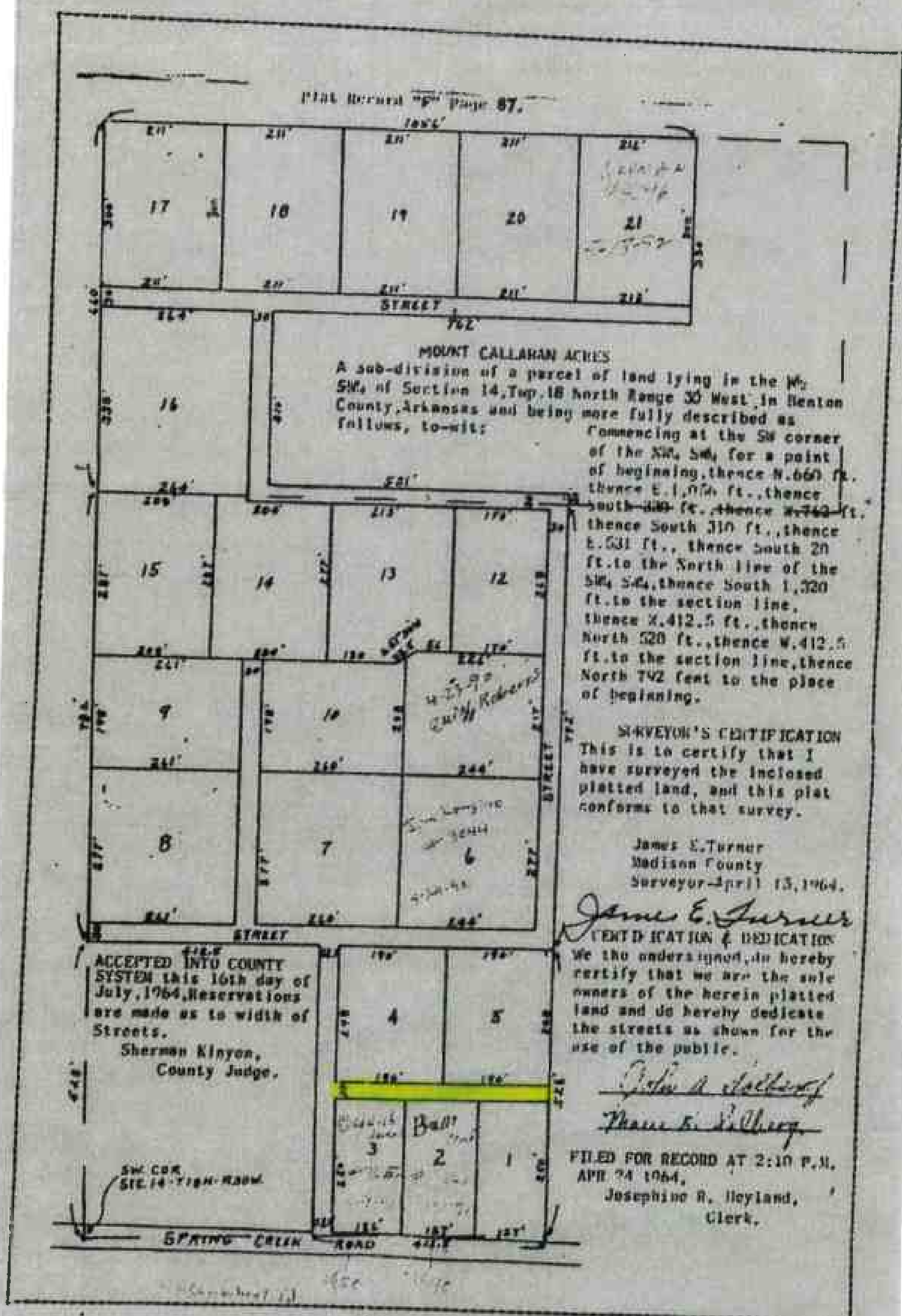
MILHOLLAND COMPANY
ENGINEERING & SURVEYING
FAYETTEVILLE, ARKANSAS

LEGEND

- ● – FOUND IRON PIN
- ○ – SET IRON PIN
- ◯ – MONUMENT
- △ – STONE MARKER
- XX – EXISTING FENCE

WILLIE TAYLOR AND JOY BETH TAYLOR

OWNERS: WILLIE TAYLOR AND JOY BETH TAYLOR	
CITY: SPRINGDALE	COUNTY: BENTON
STATE: ARKANSAS	DATE: MARCH 9, 1992
SCALE: 1" = 50'	JOB NO: S-1745



Sheet

BENTON COUNTY ABSTRACT COMPANY
BENTONVILLE, ARKANSAS

City of Springdale Zoning Map

April 21, 2021

- Form-Based Code District Overlay
- S.E.E.D. Overlay District - Outline
- Washington Co. Parcels
- Benton Co. Parcels
- SCHOOLS
- STREAMS
  - MAIN CHANNEL
  - TRIBUTARY
- LAKES
- Buildings
- RAILROAD

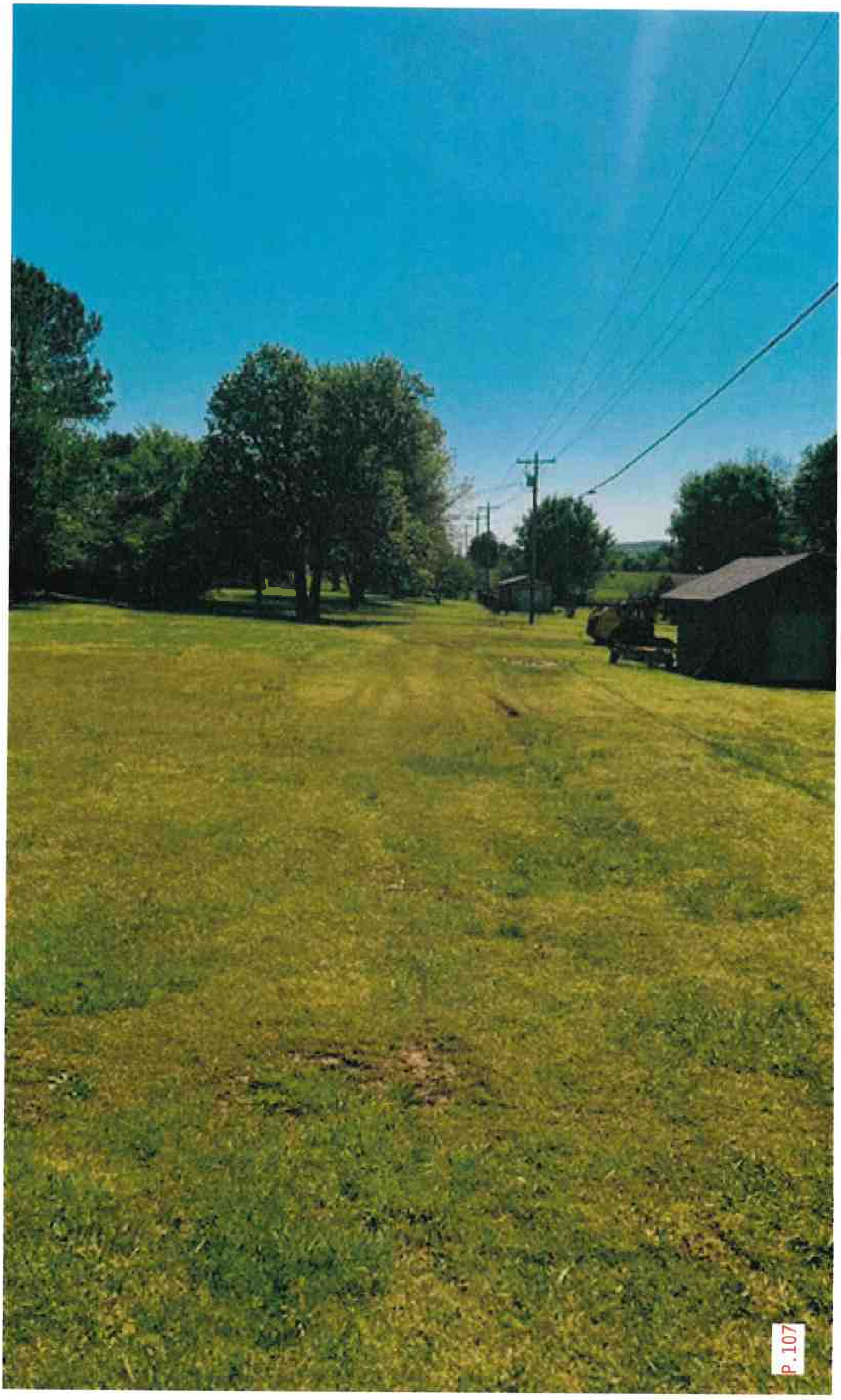
1:1,000

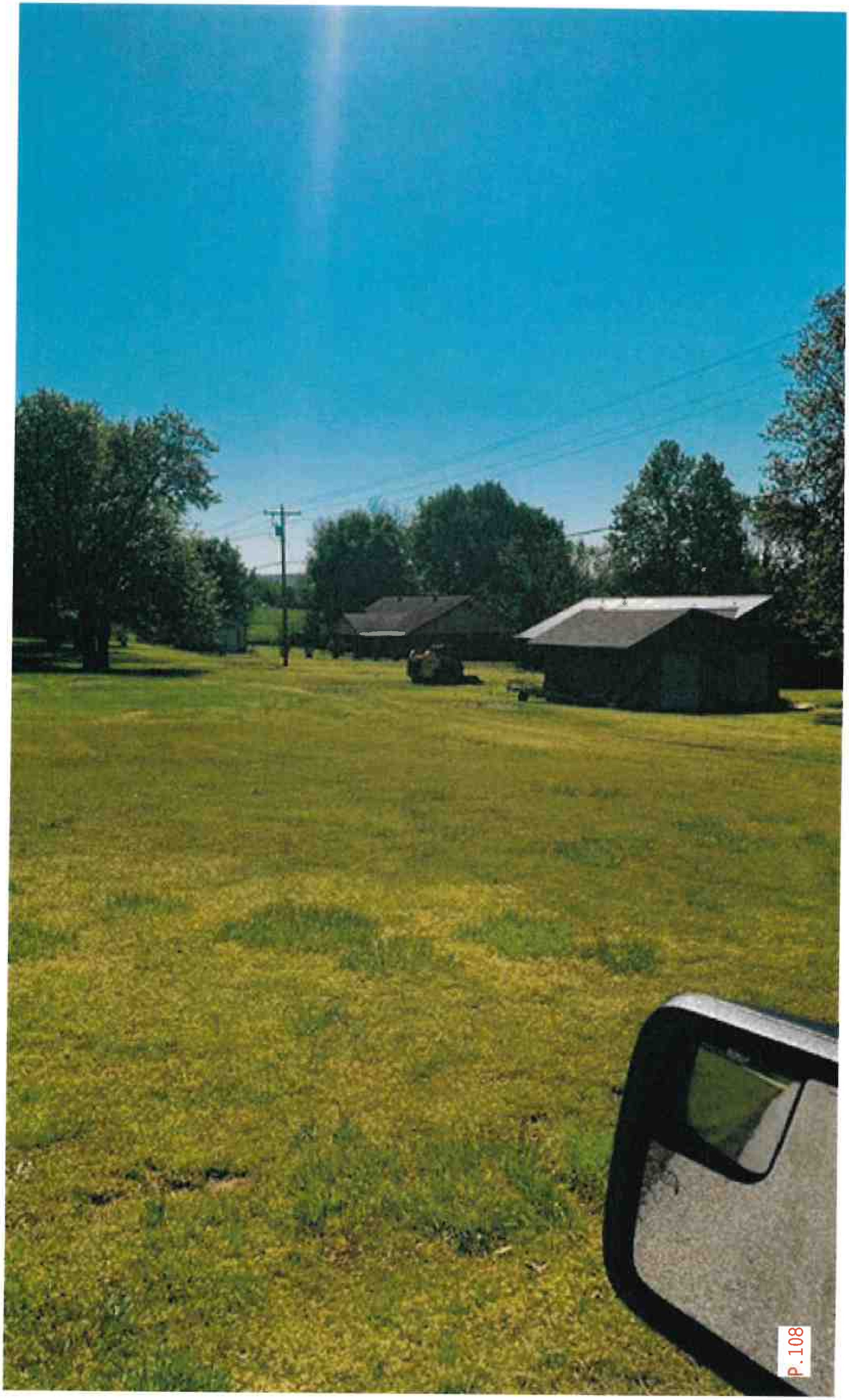
0 0.01 0.01 0.03 mi

0 0.01 0.03 0.05 km

City of Springdale, Clayton Sedberry

Clayton Sedberry | City of Springdale |






N
1 inch = 100 feet
EASEMENT
Book 413 Page 77
EASEMENT
Book 413 Page 79
Retain Easement
for this Location
30'
CALLAHAN MOUNTAIN RD
WAGON WHEEL RD
24"
10"
1
2
3
4
5
Springdale
WATER UTILITIES
Mount Callahan Acres