DRAINAGE PLAN
For

E 27th Short Plat

CITY OF SPOKANE, WASHINGTON

Prepared for:

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7154 W. State St., #320
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Prepared by:

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February 25, 2025

Drainage Plan
E 27th Short Plat
City of Spokane, WA.

The data, calculations, text and graphic information contained in this document were compiled and published under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice as such in the State of Washington, is affixed below.

______________________________________ Date 2-25-25

(Consultant/Professional Engineer)

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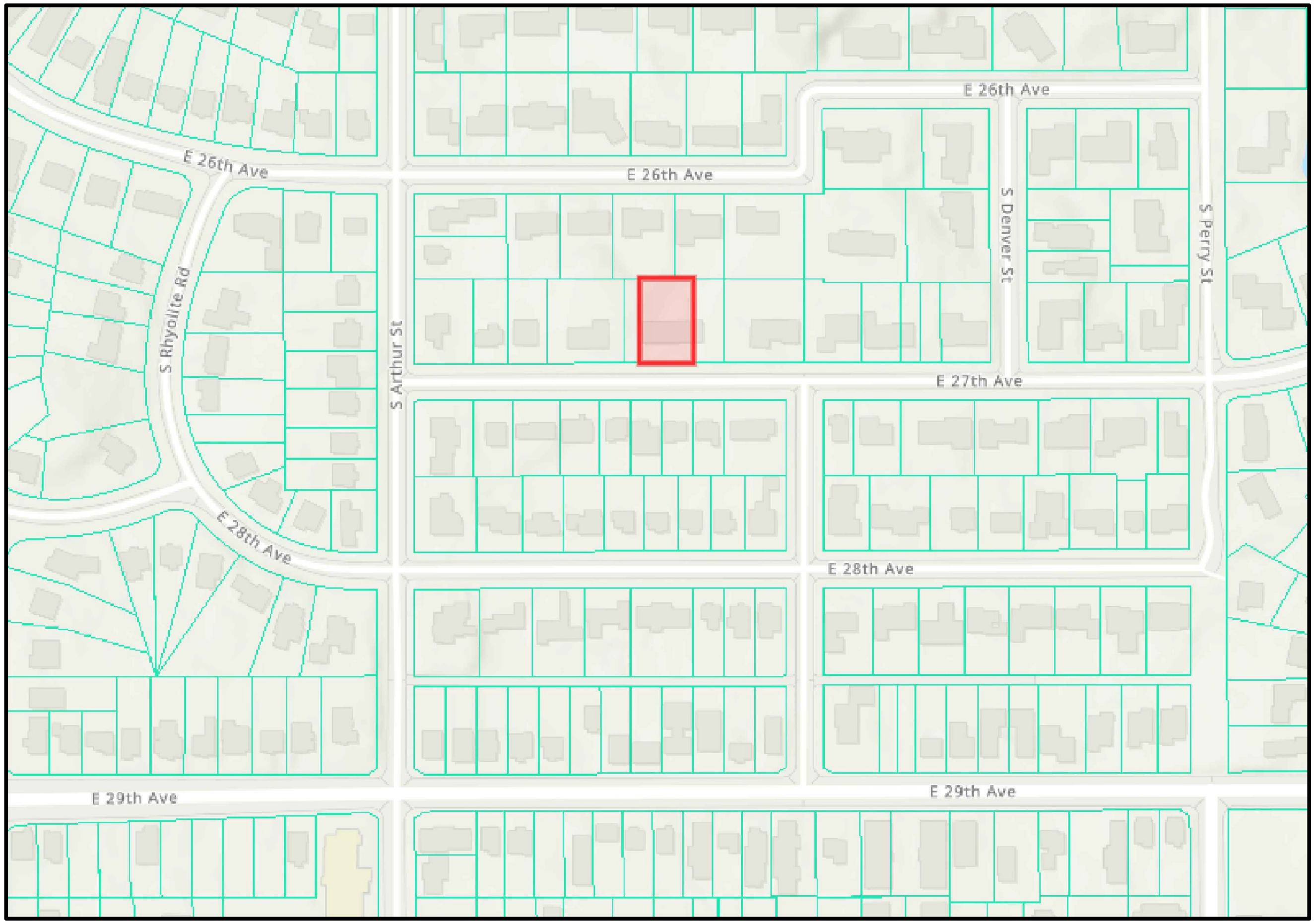
I. Introduction

I.1. Site Description

The project is located at 1121 E 27th Avenue, City of Spokane, Washington. The subject site is identified as Tax Assessor Parcel 35294.2114. The size of the property is 11,927 square feet.

I.2. Proposed Project

The proposed project will subdivide the existing parcel into (4) lots short plat. Each lot will have a duplex. Construction will include clearing and grading of the site, and installation of underground utilities.



N

NOT TO SCALE

VICINITY MAP

FIGURE 1
SCALE: NTS
DRAWN BY: MHE

E 27TH SHORT PLAT
CITY OF SPOKANE, WASHINGTON
DRAINAGE REPORT

MHE ENGINEERING
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II.Background Information

II.1. Topography

The topography of the site slopes downhill from north to south. The site is currently vacant.

II.2. Soils

The USDA Soil Conservation Service, now known as the National Resources Conservation Service (NRCS), has mapped the soil in the vicinity of the project site. According to the National Soil Survey soils map obtained from the Natural Resources Conversation Service (via Web Soil Survey 1.1), the native soil in the proposed development area can be classified as “Urban land-Northstar, disturbed complex”.

The soils of this series are made up of extremely gravely loam. A conservative infiltration estimate of 0.4 inch/hour was assumed.

See Appendix “A” of this report for additional soil information and soil map.

II.3.Drainage System Determination

The best means to deal with runoff from the new short plat is with new drainage swale areas.

III.Drainage Narrative

III.1.Theory

The storm drainage facilities on this project have been designed to dispose of runoff by using new drainage swales.

III.2. Off Site

Based upon the general geographic tendencies surrounding this site, there will be no offsite flows entering the development.

III.3. Pre-Developed

In the pre-developed condition, the site will be considered as one basin. The basin was determined by the natural topography of the parcel.

III.4. Post-Developed

All runoff from the new duplex will be disposed off using new drainage swale areas. In the developed condition, the project includes one (1) on-site basin. Table 1 provides the basin size, total impervious areas, and runoff coefficients for the post developed condition.

Table No. 1 – Runoff Coefficient Summary

Basin	Total Area (SF)	Total Area (AC)	'208' Impervious Area (SF)	Total Impervious Area (SF)	Runoff Coefficient "C"
A	11927	0.274	4954	4954	0.46

III.5. New Swale Areas

The new swale area was designed to adequately contain the runoff created by the first half-inch of rainfall upon the new roof and impervious areas within the basin it serves. The provided ‘208’ treatment volume shown in Table 2 is based on pond bottom areas and 3:1 side slopes at a maximum six-inch treatment depth of the swale. See Appendix “C” for swale volume calculations.

Table 2 summarizes the requirements and designs of the ponds by sub basin.

Table No. 2 – ‘208’ Volume Summary

Pond	Pond Bottom Area (SF)	‘208’ Volume Required (CF)	Provided Pond ‘208’ Volume (CF)
1N – 4N	48	19	41
1S – 4S	110	33	73

III.6.Total Stormwater Storage Calculations

Since the contributing area is from the on-site area, the minimum storage volumes of the swales are designed for the 10-year storm event. Bowstring calculations have been included for the basin to determine the extent of storm drainage required for the 10-year storm event. The provided storm/storage volume shown in Table 3 is based on pond bottom areas and 3:1 side slopes at a maximum of nine-inch depth. See Appendix “C” for swale volume calculations.

An outflow rate was used based on the infiltration rate of 0.4 inch per hour and the swale bottom area for each of the sub basins.

Table 3 summarizes the total storage volume proposed for each sub basin.

Table No. 3 – Storm/Storage Volume Summary

Basin	10-Year Volume Required (CF)	Storage Volume Provided (CF)
1N – 4N	76	76
1S – 4S	121	126

III.7 Larger Storm Events

An analysis was done to evaluate the affects of larger storm events or failure of proposed facilities. A visual inspection was conducted and the following was concluded:

- The proposed project engineering plans will neither aggravate an existing drainage problem nor create a new drainage problem.
- All storm water runoff from the proposed project will discharge at the natural, pre-developed location and will not adversely affect any private property.

Basin A will overflow into the front yard of the property and possibly into E 27th Avenue.

IV.Conclusion

The proposed project will add a new duplex. All runoff from the new duplex will be disposed off using new drainage swale areas.

As demonstrated by the calculations and body of this report the stormwater can be contained on site utilizing the new swale areas.

APPENDIX A – NRCS SOILS DATA

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Spokane County, Washington

27TH Duplexes

January 10, 2025

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map

Map Scale: 1:371 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 5, 10, 20, 30

Feet: 0, 15, 30, 60, 90

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Spokane County, Washington
Survey Area Data: Version 16, Aug 26, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 9, 2022—Aug 15, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7130	Urban land-Northstar, disturbed complex, 0 to 3 percent slopes	0.6	100.0%
Totals for Area of Interest		**0.6**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Spokane County, Washington

7130—Urban land-Northstar, disturbed complex, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2mdnj
Elevation: 1,800 to 2,360 feet
Mean annual precipitation: 17 to 19 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 60 percent
Northstar, disturbed, and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Description of Northstar, Disturbed

Setting

Landform: Plateaus
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess with an influence of volcanic ash over residuum and/or colluvium derived from basalt

Typical profile

A1 - 0 to 6 inches: extremely cobbly ashy loam
A2 - 6 to 11 inches: extremely cobbly ashy loam
BA - 11 to 17 inches: very gravelly ashy loam
Bw - 17 to 26 inches: extremely gravelly loam
R - 26 to 36 inches: bedrock

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F009XY001WA - Mesic Xeric Loamy Hills and Canyons Ponderosa Pine Moderately Warm Dry Shrub
Other vegetative classification: ponderosa pine/common snowberry (CN170)
Hydric soil rating: No

Minor Components

Rock outcrop
Percent of map unit: 8 percent
Hydric soil rating: No

Rockly, disturbed
Percent of map unit: 3 percent
Landform: Plateaus
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R009XY001WA - Very Shallow
Hydric soil rating: No

Springdale, disturbed
Percent of map unit: 3 percent
Landform: Outwash terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Other vegetative classification: ponderosa pine/common snowberry (CN170)
Hydric soil rating: No

Lakespring, disturbed
Percent of map unit: 1 percent
Landform: Outwash plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Other vegetative classification: ponderosa pine/ninebark (CN190)
Hydric soil rating: No

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APPENDIX B – PRE-DEVELOPED MAP & DRAINAGE ANALYSIS

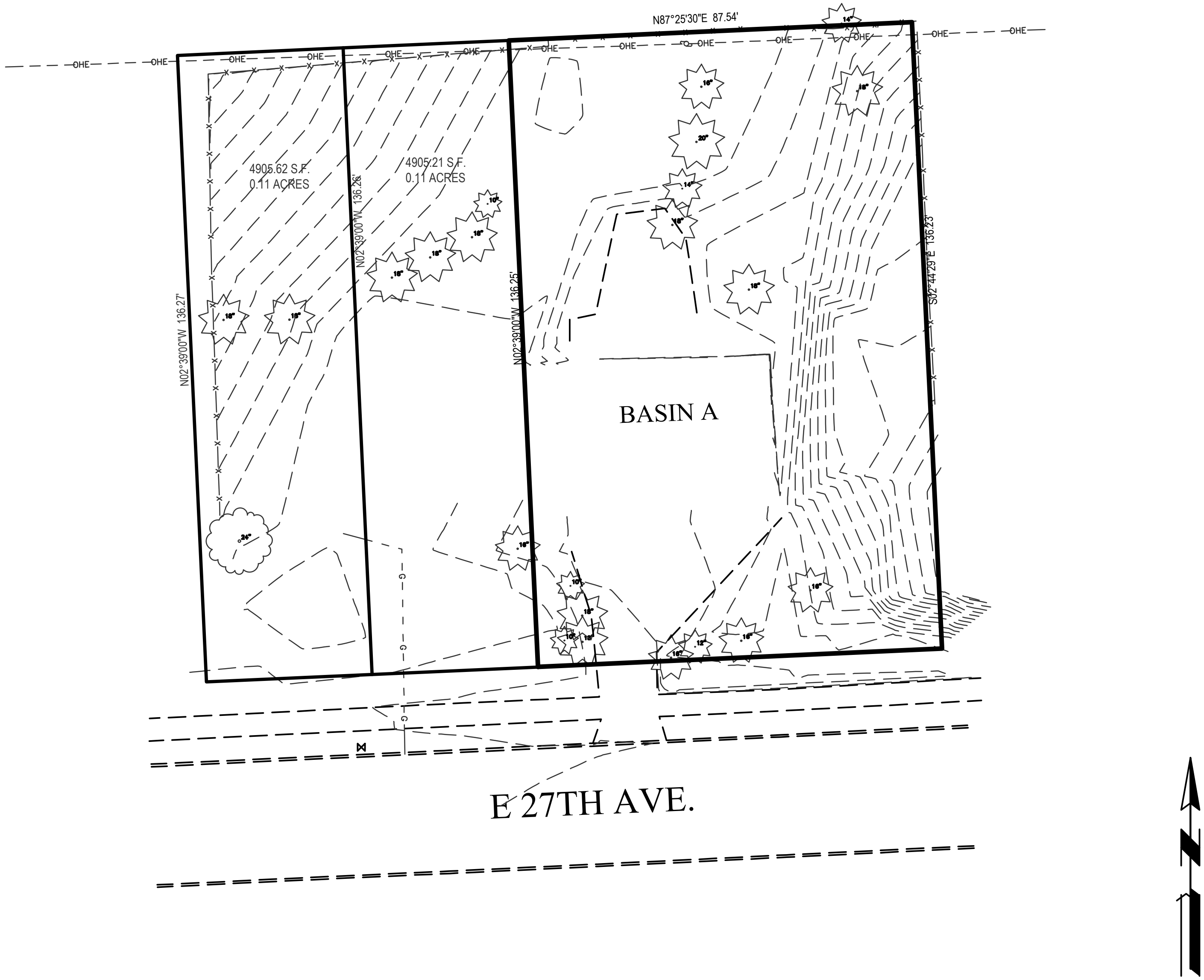

FIGURE 2- PRE-DEVELOPMENT CONDITIONS

NOT TO SCALE

FIGURE 2
SCALE: NTS
DRAWN BY: MHE

E 27TH SHORT PLAT
CITY OF SPOKANE, WASHINGTON
DRAINAGE REPORT

MHE ENGINEERING
9702 W. MASTERS LANE
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PEAK FLOW CALCULATION PROJECT: E 27th Short Plat

10-Year Design Storm

Basin: Pre-A

Tot. Area	11,927 SF	0.274 Acres	
Imp. Area	0 SF	Per. Area	11,927 SF
Weighted C	0.25		

Tc = 5.0 minutes.

I (10 yr) = 2.62 in/hr.

Q10 = CIA = 0.25 x 2.62 in/hr. x 0.274 acres = 0.18 cfs

PEAK FLOW CALCULATION PROJECT: E 27th Short Plat

50-Year Design Storm

Basin: Pre-A

Tot. Area	11,927 SF	0.274 Acres	
Imp. Area	0 SF	Per. Area	11,927 SF
Weighted C	0.25		

Tc = 5.0 minutes.

I (50 yr) = 4.58 in/hr.

Q50 = CIA = 0.25 x 4.58 in/hr. x 0.274 acres = 0.31 cfs

APPENDIX C – POST-DEVELOPED MAP & DRAINAGE ANALYSIS

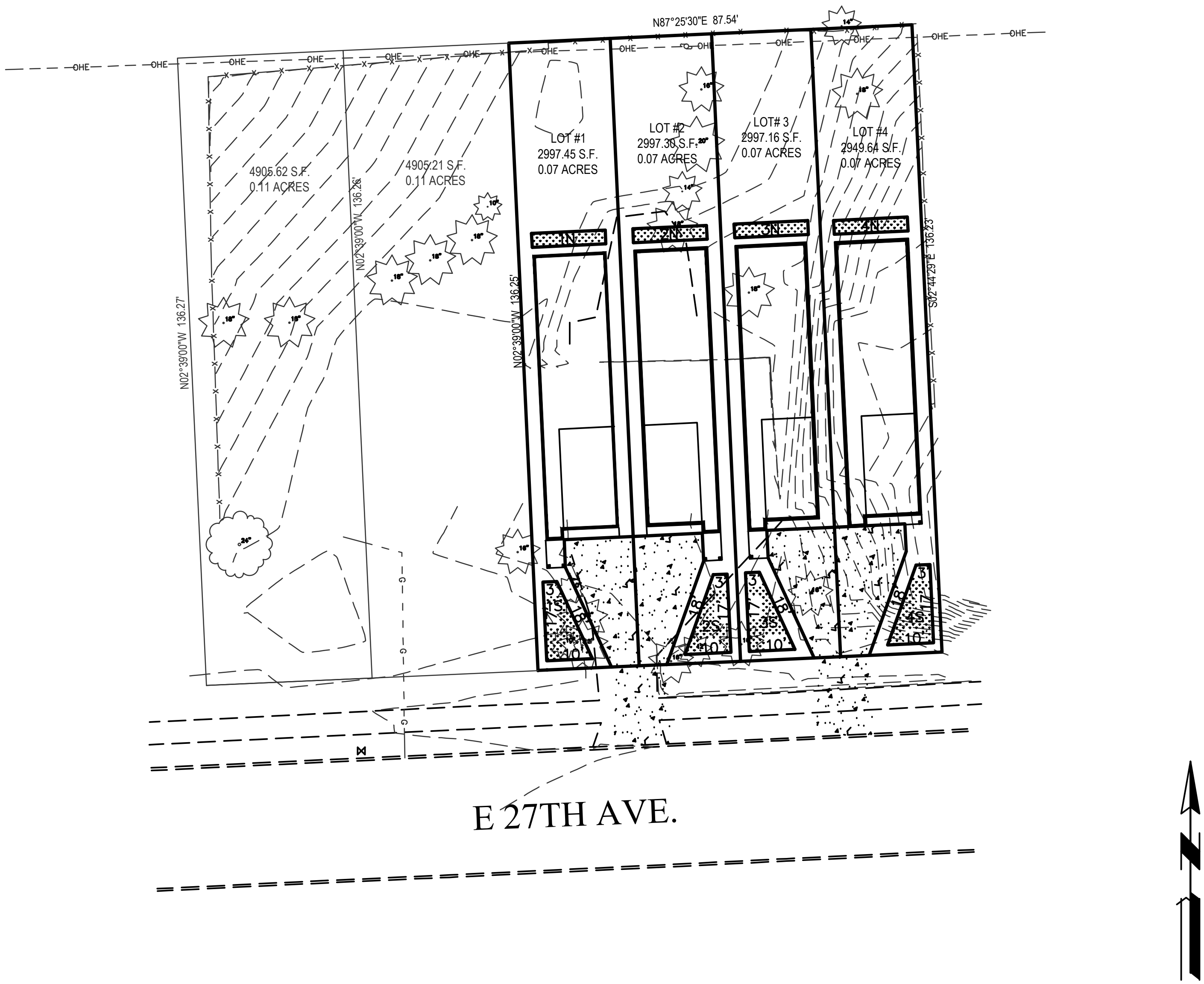

FIGURE 3- POST-DEVELOPMENT CONDITIONS

NOT TO SCALE

FIGURE 3
SCALE: NTS
DRAWN BY: MHE

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CITY OF SPOKANE, WASHINGTON
DRAINAGE REPORT

MHE ENGINEERING
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BASIN "A"

Total Area = 11,927 sf = 0.274 acres.

Roof Area

New (4) townhomes x 916 sf each = 3664 sf

Total = 3664 sf C=0.90

Concrete Driveway

645 sf x (2) = 1290 sf C=0.90

Lawns

11927 – 4954 = 6973 sf C=0.15

Weighted “C” Factor

(0.9 x 4954) + (0.15 x 6973) divided by 11927

= 0.46

Required Swale Volume

V = 1815 A, where
V= Volume of swale (cubic feet)
A= Pollution generating impervious surface (acres)

V = 1815 x 0.114 acres

= 206 CF

Basin A was subdivided into (8) sub basins based on the (8) drainage swales provided:

BOWSTRING METHOD PROJECT: E 27th Short Plat
DETENTION BASIN DESIGN Sub Basin: 1N – 4N

Time Increment (min.)	5
Time of Conc. (min.)	5.0
Outflow (cfs)	0.0
Design Year Flow	10
Area (acres)	0.034
Impervious Area (sf)	458
‘C’ Factor	0.46
Area x C	0.01564

Time (min)	Time (sec)	I (in/hr)	Qdev (cfs)	Vin (cu. ft.)	Vout (cu. Ft.)	Storage (cu. Ft.)
5	300	2.62	0.0410	16	0	16
10	600	1.72	0.0269	19	0	19
15	900	1.34	0.0210	21	0	21
20	1200	1.13	0.0177	23	0	23
25	1500	0.98	0.0153	25	0	25
30	1800	0.88	0.0138	26	0	26
35	2100	0.8	0.0125	28	0	28
40	2400	0.74	0.0116	29	0	29
45	2700	0.69	0.0108	30	0	30
50	3000	0.64	0.0100	31	0	31
55	3300	0.61	0.0095	32	0	32
60	3600	0.58	0.0091	34	0	34
65	3900	0.55	0.0086	34	0	34
70	4200	0.53	0.0083	36	0	36
75	4500	0.5	0.0078	36	0	36
80	4800	0.48	0.0075	37	0	37
85	5100	0.47	0.0074	38	0	38
90	5400	0.45	0.0070	39	0	39
95	5700	0.44	0.0069	40	0	40
100	6000	0.42	0.0066	40	0	40
105	6300	0.41	0.0064	41	0	41
120	7200	0.38	0.0059	43	0	43
140	8400	0.34	0.0053	45	0	45
250	15000	0.32	0.0050	76	0	76

“208” TREATMENT REQUIREMENTS

Minimum “208” Volume Required	19 cu. Ft.
Provided Treatment Volume	41 cu.ft.

DRYWELL REQUIREMENTS – 10 YEAR DESIGN STORM

Maximum Storage Required by Bowstring	76 cu. Ft.@250 min
Provided Storage Volume at 9” depth	76 cu. Ft.

The required treatment and storage volume is provided by swales 1N – 4N which are 16’x3’x9” deep each:

Swales 1N – 4N		
Pond Side Slope	3	:1
Bottom Length (ft)	16	
Bottom Width (ft)	3	
Bottom Area (SF)	48	
Treatment Depth (ft)	0.5	
Treatment Area (SF)	114	
Treatment Volume (CF)	41	
Storage Depth (ft)	0.75	
Storage Area (SF)	153.75	
Storage Volume (CF)	75.65625	

BOWSTRING METHOD
DETENTION BASIN DESIGN

PROJECT: E 27th Short Plat
Sub Basins: 1S – 4S

Time Increment (min.)	5
Time of Conc. (min.)	5.0
Outflow (cfs)	0.001 (110 sf x 0.4 in/hr)
Design Year Flow	10
Area (acres)	0.034
Impervious Area (sf)	781
‘C’ Factor	0.46
Area x C	0.01564

Time (min)	**Time (sec)**	**I (in/hr)**	**Qdev (cfs)**	**Vin (cu. ft.)**	**Vout (cu. Ft.)**	**Storage (cu. Ft.)**
5	300	2.62	0.0410	16	0.3	16
10	600	1.72	0.0269	19	0.6	18
15	900	1.34	0.0210	21	0.9	20
20	1200	1.13	0.0177	23	1.2	22
25	1500	0.98	0.0153	25	1.5	23
30	1800	0.88	0.0138	26	1.8	24
35	2100	0.8	0.0125	28	2.1	25
40	2400	0.74	0.0116	29	2.4	27
45	2700	0.69	0.0108	30	2.7	28
50	3000	0.64	0.0100	31	3	28
55	3300	0.61	0.0095	32	3.3	29
60	3600	0.58	0.0091	34	3.6	30
65	3900	0.55	0.0086	34	3.9	31
70	4200	0.53	0.0083	36	4.2	31
75	4500	0.5	0.0078	36	4.5	31
80	4800	0.48	0.0075	37	4.8	32
85	5100	0.47	0.0074	38	5.1	33
90	5400	0.45	0.0070	39	5.4	33
95	5700	0.44	0.0069	40	5.7	34
100	6000	0.42	0.0066	40	6	34
105	6300	0.41	0.0064	41	6.3	35
120	7200	0.38	0.0059	43	7.2	36
140	8400	0.34	0.0053	45	8.4	37
500	30000	0.32	0.0050	151	30	121

“208” TREATMENT REQUIREMENTS

Minimum “208” Volume Required	33 cu. Ft.
Provided Treatment Volume	73 cu.ft.

DRYWELL REQUIREMENTS – 10 YEAR DESIGN STORM

Maximum Storage Required by Bowstring	121 cu. Ft.@500 min
Provided Storage Volume at 9” depth	126 cu. Ft.

The required treatment and storage volume is provided by swales 1S – 4S which have a bottom area of 110 sf each:

Swales 1S – 4S		
Pond Side Slope	3	:1
Bottom Length (ft)	10	
Bottom Width (ft)	11	
Bottom Area (SF)	110	
Treatment Depth (ft)	0.5	
Treatment Area (SF)	182	
Treatment Volume (CF)	73	
Storage Depth (ft)	0.75	
Storage Area (SF)	224.75	
Storage Volume (CF)	125.5313	

APPENDIX D – OPERATION AND MAINTENACE

Owner / Responsible Entity:

Urban Empire Homes, LLC
7154 W. State St., #320
Boise, ID 83714

Parent Parcel Number: 35294.2114

The proposed project will subdivide the existing parcel into (4) lots short plat. Each lot will have a duplex. Construction will include clearing and grading of the site, and installation of underground utilities.

This project contains the following facilities, which require regular maintenance:

- ☐ Drainage Swales.

The owner are responsible for (details described later):

- The continued operation and maintenance, including repair and replacement as needed, of these facilities,
- Providing funds to finance the continued operation and maintenance of these facilities,
- Establishing a maintenance committee and designating a member to be responsible for the administration of this agreement.

The City of Spokane assumes no responsibility at all for any operation or maintenance of the facilities mentioned herein or the administration of this agreement.

1.00 PURPOSE

This maintenance agreement is to provide:

1. General operations and maintenance responsibilities for the facilities described herein.

2.00 GENERAL OPERATIONAL CHARACTERISTICS

Drainage Facilities

The private drainage system in this project is intended to collect, treat and discharge stormwater runoff generated by onsite improvements and, possibly, also stormwater from adjacent properties that has historically flowed onto this site. The drainage facilities consist primarily of drainage swales. Stormwater runoff from the driveway and buildings is routed into the drainage swales where the grass and underlying soil provide treatment and infiltration. It is important to provide adequate maintenance activities to ensure that the drainage facilities remain silt and dirt free, as this silt and dirt will affect their performance. Maintenance details are discussed below in Section 3.0.

3.00 MAINTENANCE REQUIREMENTS AND SCHEDULES

Drainage Facilities

The drainage facilities consist of drainage swales and are located as shown in the approved plans. The following describes these facilities and the recommended maintenance.

A visual inspection of the drainage facilities should be conducted each season (spring, summer, fall and winter) and after significant rainfall and snowmelt events. For long duration storms, greater than 24 hours, the drainage facilities should be inspected during the storm event to identify any developing problems and safely correct them before they become major problems.

In general, it is important to provide adequate maintenance activities to ensure that the vegetated areas and structures remain silt, dirt and debris free because accumulation of these will affect the swale's function for stormwater treatment and storage volume as well as the ability of the drywell to discharge stormwater. Should these facilities fill up or become clogged, the only remedy would be to remove the material. Therefore, periodic maintenance is a must.

Grassed Area:

The roadside grassed area need to be maintained to ensure a strong, healthy, dense vegetative cover and that they are free of debris. Maintenance of ditches and swales located on or adjacent to a lot shall be the responsibility of that lot's owner unless it is agreed upon by the maintenance committee to have these facilities professionally maintained. Maintenance items include:

- Regular watering and mowing, grass should be kept at about 2-4 inches in height,
- Removing trash, debris, noxious weeds and items that reduce the amount of vegetative cover,
- Inspecting the side slopes and bottom making sure there are no breaches or breaks or erosion. Immediately repair with a sandy loess soil, compacted in place and follow up after the storm event with seeding or sodding the repair and more substantial maintenance activities if needed,

- Repairing mowing damage,
- Removal and replacement of the grass and underlying soil if it becomes contaminated to the extent that the grass is not healthy.

The drainage swales should completely drain in 72 hours or less after rainfall. Water ponding over 72 hours after rainfall may be an indication of over compaction or siltation. If failure is deemed to be due to over compaction, replacement of compacted soils with free draining soils that meet the treatment requirements may be necessary.

4.00 SINKING FUNDS

A sinking fund is an account that is set up to receive regular deposits which are to be used for paying off future costs and debts. The sinking fund monies will be used to pay for planned and unplanned operation and maintenance costs along with certain future replacement costs for the private street and associated facilities. The sinking fund calculation should be revised as necessary to account for actual expenses and changes in rates.

In setting up the fund, first the future replacement costs are estimated and then they are converted to annual costs (or deposits) by the following calculations. These calculations assume that the inflation rate is 3% (for estimating the future replacement costs), the typical interest rate is 2% (for estimating the annual costs) and the number of years before replacement is 20. Equations and guidance for using other rates and years can be found in Appendix A.

1) Estimate the value that the item will have in the future when it is time to replace it using the following equation:

   FV=PV*1.8061, where: FV = future value
   PV = present value

2) Estimate how much money will need to be deposited each year in a bank account in order to have enough money accumulated in time to pay for the replacement using the following equation.

   A=FV*0.0412, where: A = annual payment (or deposit)
   FV = future value (from step 1, above)

Sinking Fund Calculation Results:

- The following values are the results of the calculations which are shown immediately following

Annual cost for regular operation and maintenance	$500
Annual cost for replacements	$242
Total annual costs	**$742**
Annual cost per lot	**$186**

Sinking Fund Calculations

REGULAR OPERATION AND MAINTENANCE COSTS

Description	Units	Annual Quantity x	Unit Price =	Annual Cost
Mowing	EA	4	$100	$400
Weed Removal	EA	1	$100	$100
			Total	$500

REPLACEMENT COSTS (for more information on calculations in this table see Appendix A)

	Units	Quantity x	Unit Price =	Present Value, PV	n	Inflation Rate, i_1	Future Value, FV	Interest Rate, i_2	Annual Payment, A
Drainage Swales	SF	650	$5	$3250	20	0.03	$5870	0.02	$242
								Total	$242

Notes:
n = number of years to replacement
LS means Lump Sum, EA means Each, SY means square yard

Appendix A

The future replacement costs can be estimated and then converted to annual costs (or deposits) by the following calculations.

1) Estimate the value that the item will have in the future when it is time to replace it using an assumed (best estimate) inflation rate and the following equation:

   $FV=PV*(1+i_1)^n$, where:

   FV = future value — i_1 = inflation rate

   PV = present value — n = number of years to replacement

   Example values for the factor: $(1+i)^n$

		n, years			
		5	**10**	**15**	**20**
i_1	**0.02**	1.1041	1.2190	1.3459	1.4859
	0.03	1.1593	1.3439	1.5580	1.8061
	0.04	1.2167	1.4802	1.8009	2.1911
	0.05	1.2763	1.6289	2.0789	2.6533

2) Estimate how much money will need to be deposited each year in a bank account in order to have enough money accumulated in time to pay for the replacement using an assumed (best estimate) interest rate and the following equation:

   $A=FV* i_2 / [(1+i_2)^n-1]$, where:

   A = annual payment — i_2 = interest rate

   FV = future value — n = number of years to replacement

   Example values for the factor: $i_2/[(1+i_2)^n-1]$

		n, years			
		5	**10**	**15**	**20**
i_2	**0.02**	0.1922	0.0913	0.0578	0.0412
	0.03	0.1884	0.0872	0.0538	0.0372
	0.04	0.1846	0.0833	0.0499	0.0336
	0.05	0.1810	0.0795	0.0463	0.0302