ORDINANCE 2022-36

AN ORDINANCE AMENDING AND ADOPTING THE WASHINGTON CITY GRADING, EROSION, AND SEDIMENT CONTROL (GESC) MANUAL

WHEREAS, Washington City has a need update the Grading Manual for construction projects undertaken within Washington City; and

WHEREAS, Washington City desires to continue providing uniform and safe standards and guidelines for such construction projects; and

WHEREAS, an amended Grading, Erosion, and Sediment Control (GESC) Manual has been prepared, which standards promote the health, safety and general welfare of the residents of the municipality as well as the efficient and orderly growth of the municipality; and

WHEREAS, the City Council of Washington City finds that it is in the best interest of the City, residents of the City and those persons involved with construction projects to adhere to this manual, identified as the Washington City Grading, Erosion, and Sediment Control (GESC) Manual;

BE IT ORDAINED BY THE CITY COUNCIL OF WASHINGTON CITY, UTAH

I. The Washington City Grading, Erosion, and Sediment Control (GESC) Manual, as promulgated in March of 2022 is hereby approved and adopted by Washington City.

II. Miscellaneous.

A. If any provision or clause of this Ordinance or the application thereof to any person or entity or circumstance is held to be unconstitutional or otherwise invalid by any court of competent jurisdiction, such invalidity shall not affect any other section, provision, clause or application hereof, and to this end the provisions and clauses of this Ordinance are to be severable.
B. This Ordinance supersedes or repeals the provision(s) of any ordinance(s) or resolution(s); that is (are) inconsistent with the provisions of this Ordinance.
C. This Ordinance shall take effect immediately upon publication or posting, as required by law.

PASSED AND ORDERED POSTED on this 22nd day of June, 2022.

Washington City

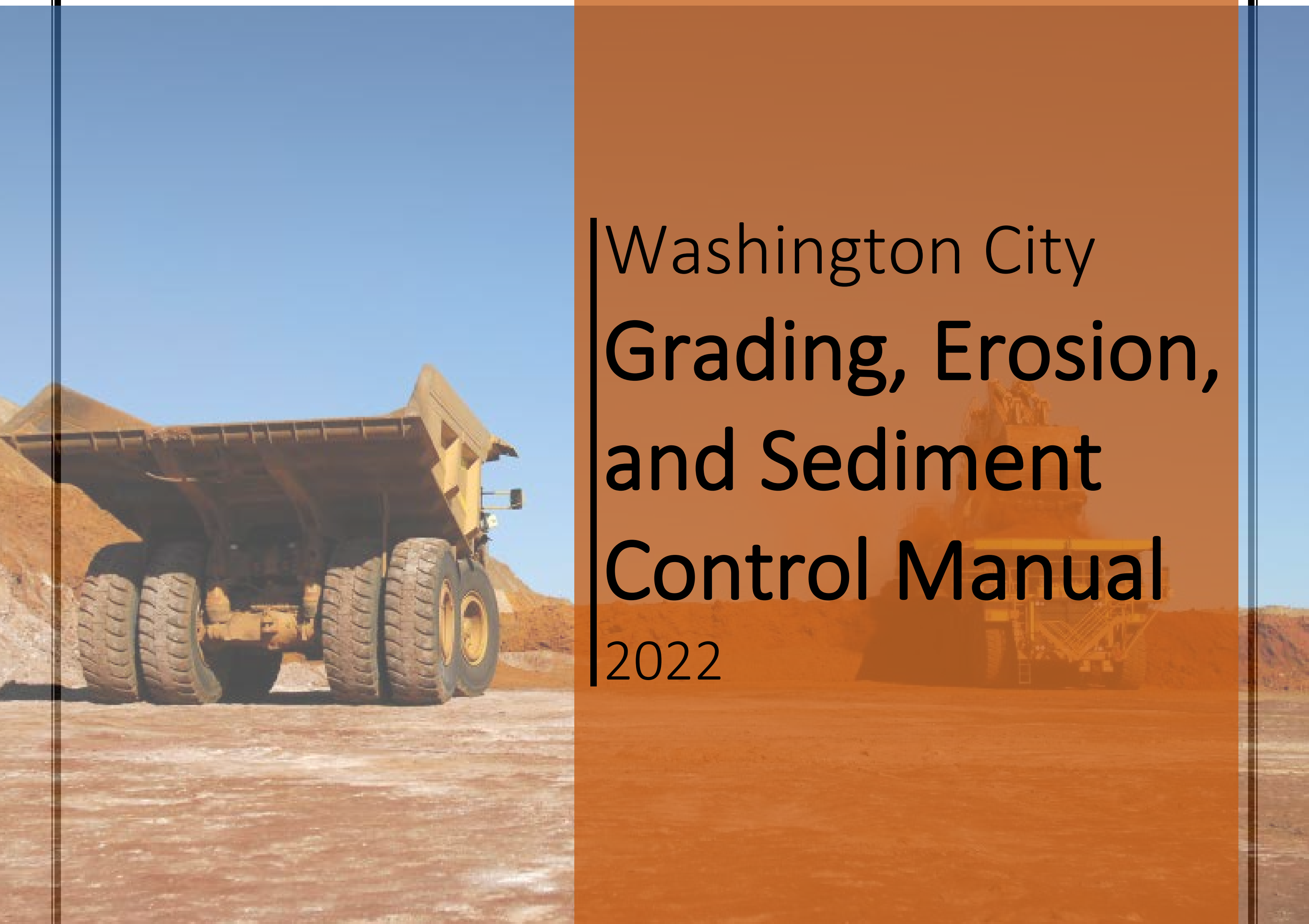
The Great Seal of Washington City ★ Utah ★

Kressi Staheli, Mayor

Attest:

Tara Pentz, City Recorder

Washington City
Where Dixie Begins



Washington City
Grading, Erosion, and Sediment Control Manual
2022

Prepared by:

ALLIANCE CONSULTING
A Planning and Engineering Firm

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APPENDICES

SECTION 1: INTRODUCTION

Section 1 introduces the Grading Permit types and discusses the reasons and legislative mandate for the grading permit program. It also summarizes the 20 permit steps and describes the Grading, Erosion, and Sediment Control (GESC) Manual authorization.

1.1 Overview of the GESC Manual

Washington City issues permits for grading on public and private construction projects within the City. This Manual describes the permitting program that has been adopted to promote environmentally-sound construction practices, water resources and ensuring that future development continues in an environmentally sound manner.

This Manual provides guidance suitable for use by a wide range of individuals involved in construction.

- Developers, including their planners and engineers;
- Contractors, including their engineers, estimators, superintendents, foremen, tradesmen, and subcontractors;
- Municipal inspectors, building inspectors, code enforcement officers, and public works staff.
- The general public with an interest in grading, drainage, and stormwater pollution.

1.2 Reasons for the Grading Program

The goal of the Grading Permit program is to implement effective grading, drainage, and erosion and sediment control Best Management Practices (BMPs) as a standard for all land disturbance activities.

Stormwater is runoff from natural precipitation, such as rain and snow and other surface drainage. This water recharges not only the Virgin River and other tributaries, but the underground aquifers as well. Stormwater is not treated. Any pollutants that are introduced as it flows over the natural landscape are discharged directly to drinking water sources.

As a growing city, grading is a primary source of water pollutants in the form of increased erosion and sedimentation. Soil erosion is the process by which soil particles are removed from the land surface by wind, water, or gravity. Most natural erosion occurs at slow rates. However, the rate of erosion increases when land is cleared or altered and left unprotected. Construction sites, if unprotected, can erode at rates in excess of one hundred times the natural background rate of erosion.

Eroded sediment can clog downstream receiving waters and cause algae blooms. Sedimentation occurs when the velocity of the water transporting eroded particles decreases to the point that the suspended soil particles settle.

1.3 Construction Site Erosion

1.3.1 Erosion from Rainfall Impact

The impact of raindrops on bare soil can cause erosion. On undisturbed soil protected by vegetation or other cover, the erosion is minimal. Construction activities increase the amount of exposed and disturbed soil, which increases erosion potential from rainfall.

1.3.2 Sheet Erosion

After rainfall strikes the ground, it flows in a thin layer for a short distance. The distance of sheet flow depends on slope, soil roughness, type of vegetative cover, and rainfall intensity. Sheet flow erosion on undisturbed soils is minimal. Construction disturbed soils are far more susceptible. Sheet flows are capable of transporting soil particles dislodged by the impact of raindrops onto bare soil.

1.3.3 Rill and Gully Erosion

As runoff accumulates, it concentrates in rivulets that cut grooves (rills) into the soil surface. Rills generally run parallel to one another and to the slope of the soil surface. If left unchecked, several rills may join together to form a gully. Rills are small enough to be stepped across, whereas a gully requires added effort to be traversed. The rate of rill erosion can easily be one hundred times greater than that of sheet flow, and the rate of gully erosion can easily be one hundred times greater than rill erosion. Due to the significant amount of sediment generated by rill and gully erosion, these types of erosion must be given top priority for elimination, reduction, and control.

1.3.4 Wind Erosion

Dust is defined as solid particles or particulate matter which are predominantly large enough to eventually settle out from the air but small enough to remain temporarily suspended in the air for an extended period of time. Construction site dust originates from rock and soil surfaces, material storage piles and construction materials. It is generated by earth work, demolition, traffic on unpaved surfaces, and strong winds.

1.3.5 Stream and Channel Erosion

In general, one or more of the following factors that may occur during construction can change the hydrology of the area to affect erosion of the banks and bottoms of natural drainage channels:

- Soil clearing and re-contouring may increase the volume and rate of runoff leaving the site.
- Replacing pervious natural ground with impervious cover increases runoff.
- Detention basins used to capture sediment extend the duration of flows leaving the site.
- Construction activity erosion control in streams and channels downstream is a complex issue and is usually best addressed through a comprehensive drainage master plan.

1.3.6 Examples of Dust Sources at Construction Sites

The following table lists examples of dust sources on construction sites from various sources.

Table 1.1: Examples of Dust Sources at Construction Sites

Vehicle and Equipment Use	Exposed Areas	Contractor Activities
• Vehicles and equipment entering and leaving the site • Vehicle and equipment movement and use within the project site • Sediment tracking off-site • Temporary parking lots and staging areas • On-site construction traffic	• Exposed soil that has been cleared and grubbed • Construction staging areas • Vehicle and equipment storage and service areas • Material processing areas and transfer points • Construction roads • Spilled materials • Construction stockpiles • Soil and debris piles	• Land clearing and grubbing • Earthwork including soil excavation, filling, soil compaction, rough grading, and final grading • Drilling and blasting • Materials handling, including material stockpiling, transfer, and processing • Batch dropping and dumping • Conveyor transfer and stacking • Material transfer • Crushing, milling, and screening operation • Demolition and debris disposal • Tilling

1.4 Federal and State Legislative Mandates

The need to protect our environment has resulted in a number of laws and subsequent regulation and programs. On this page, various federal, state, and local programs are discussed. The development, implementation, and enforcement of the Washington City Grading Permit program is mandated by both the Federal Government and the State of Utah.

1.4.1 Federal National Pollutant Discharge Elimination System (NPDES) Regulations

The federal Clean Water Act's National Pollutant Discharge Elimination System (NPDES) regulations require that stormwater discharges from certain types of facilities be authorized under discharge permits (40 C.F.R., 122.26) The goal of the NPDES stormwater permits program is to reduce the amount of pollutants entering streams, lakes, and rivers as a result of stormwater runoff from residential, commercial, and industrial areas. The original 1990 regulation (Phase I) covered municipal (i.e. publicly owned) stormwater systems for municipalities with a population greater than 100,000. The regulation was expanded in 1999 to include smaller municipalities, including Washington City. The expansion of the program is referred to as Phase II.

1.4.2 The Utah Department of Environmental Quality (DEQ)

Utah DEQ is responsible for administering the state stormwater management program. The Utah stormwater program is closely modeled after the federal National Pollution Discharge Elimination System (NPDES) program, which requires stormwater be treated to the maximum extent practicable (MEP).

Specific regulatory language governing the UPDES program is provided by Utah Administrative Code as R317-8. This code may be obtained at the following web address: Utah Office of Administrative Rules. Construction activities that disturb one or more acres of land must be authorized under the UPDES program Construction General Permit (CGP). Storm water pollution prevention plans (SWPPP)s are required by this permit to utilize Best Management Practices (BMP)s to minimize pollutants being transported off site by stormwater runoff.

1.4.3 Local Ordinances

Washington City is a municipality with UPDES stormwater permits for its own municipal separate storm sewer system (MS4s). As such, the City is responsible for developing a management program for public and private construction activities in their jurisdiction.

The program addresses appropriate planning and construction procedures; and ensures the implementation, inspection and monitoring of construction sites which discharge stormwater into their systems.

1.5 Grading Permit Project Requirements

1.5.1 Projects Requiring a Grading Permit

Washington City requires that a Grading Permit be obtained prior to the start of the following all land disturbing activities.

- The current updated Small MS4 UPDES Permit UTR 90000 4.2.4 Construction Site Stormwater Runoff Control must be used.
- New development and redevelopment on all sites.
- Installation of utility lines outside the City road right-of-way in excess of 50 linear feet
- Installation of utility lines inside the City road right-of-way in excess of 200 linear feet
- Any clearing, grubbing, grading or filling operations located or adjacent to a drainageway
- Fill or excavation of 50 or more cubic yards of material, not related to building of a detached single family residential unit
- Temporary batch, asphalt, and crushing plants, even when subject to a State permit
- Drilling sites, excluding soil sampling for geotechnical investigations
- Any project that the City Public Works Department determines to have potential impact to the health, safety and welfare of people and/or the environment

1.5.2 Exempt Projects

Some types of project, listed below, are exempt from the Grading Permit program.

- Routine agricultural practices, including tilling, planting, harvesting, or livestock operations
- Pavement repair on public and private roadways (although a grading permit is not required, erosion and sediment control BMPs and a right-way permit are required
- Emergency situations that pose an imminent risk to life or property, such as hazardous waste clean-up and fire operations
- Livestock grazing
- Mowing
- Weed control
- Burning
- Irrigation and associated activities including operation, maintenance of irrigation facilities, ditch maintenance and pumping, and maintenance, and operation of diversions and headgate structures

The projects that do not need a Grading Permit are not free from the obligation to control erosion and sediment; BMPs will still be required in accordance with the information shown in the Grading Manual.

1.5.3 Projects Covered Under Other Permits

Grading Permits are required for projects meeting the above criteria even if a Federal or State agency or another jurisdiction has approved the project and issued a permit for the work. Examples include State permitted mining projects and projects for which a Nationwide or Individual Section 404 permit has been obtained from the Corps of Engineers.

1.6 Grading Permit Types

Washington City issues two types of grading permits as described in the following subsections.

1.6.1 Standard Grading Permit

A standard Grading permit is required for all of the land-disturbing activities identified in Section 2 other than the activities qualifying for a Low Impact Grading permit.

1.6.2 Low Impact Grading Permit

Some land-disturbing activities may have a negligible negative impact on adjacent properties and downstream receiving water. For projects with a disturbed area less than an acre where insignificant negative impact can be adequately demonstrated to the Public Works Department, streamlined submittal requirements apply. If, after reviewing the submitted information, City staff concur that there is low impact, a Low Impact Grading Permit will be designated for the project.

1.7 Grading Permit Applicants

Typically, Grading Permits are signed by both the Owner and the Contractor. Prior to issuance of a Grading Permit the Owner and the Contractor are referred to as “Applicants”. After the Permit is issued, both are considered “Permittee(s).

A permittee is any person who is issued a Grading Permit by the City. The Permittee(s) are legally responsible for compliance with the Grading Permit. If an Applicant is a corporation, a manager or officer of the corporation or other authorized person must sign the permit as the Permittee.

Permittee(s) undertaking land-disturbing activities are responsible for meeting all of the requirements of the City's Grading Permit. Failure to meet the requirements of the Grading Permit may lead to enforcement.

1.8 Grading Permit Process Steps

The 20 steps involved in the grading permit process for Standard Grading Permit are shown in Figure 1.1. Figure 1.1 shows approximate schedules for City reviews and identifies portions of Section 2 through 6 of this Grading Manual that should be referenced for information on each step of the Grading Permit Process.

The steps involved in the Low Impact Grading Permit are outlined in Section 7.

Although the grading permit process is organized into the distinct steps shown in Figure 1.1, the process as a whole is intended to be dynamic, responding to individual site conditions to provide effective erosion and sediment control during construction.

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FIGURE 1.1: WASHINGTON CITY GRADING PERMIT PROCESS

for Standard Grading Permits

Days shown refer to business days

Phase	Refer to these Sections of the Manual		Steps in the Permit Process		Washington City Involvement
Grading Permit Application	Section 2. Getting Started	Sec 2.1	Step 1	Confirm that a Grading Permit is required	
		Sec 2.1	Step 2	Retain a Professional Engineer to prepare the Grading Plan	
		Sec 2.1	Step 3	Determine type of Grading Drawings and Confirm what Additional Permits are required (Presubmittal meeting with the City is recommended)	5 days notice: Staff Development Review
	Section 3. Grading Plan	Sec 3.1 - Sec 3.8	Step 4	Prepare a Grading Plan utilizing the Recommneded Practices, Design and Sizing Criteria for BMPs, Grading Drawing Requirements, and Grading Report Requirements	
	Section 4. Grading Plan Review, Acceptance, and Permitting	Sec 4.1	Step 5	Submit 2 copies of the Grading Plan and related plans and permits to the City for review and acceptance and revise documents as necessary to address City comments	3 days +/-: Pre-review of submittal (completeness check); 5 business days +/-: Initial Review of submittal; 5 business days +/-: Re-review of revised submittal (may not be required or may need to repeat)
		Sec 4.1	Step 6	After City acceptance of the Grading Plan, submit 3 sets of the drawings, bound and folded, for signatures, along with the Grading Permit Application, Fee, and Fiscal Security	7 days +/-: Acceptance signatures on Grading Drawings; Review and acceptance of Grading Permit Application, Fee, and Fiscal Security
		Sec 4.1	Step 7	When ready, obtain the signed Grading Drawings and a copy of the Grading Field Manual	
Construction	Section 5. Field Section	Sec 5.1	Step 8	Select a Grading Manager; review the Grading Field Manual and ensure that the Permittees and their representatives, including field personnel, understand Grading Permit requirements	
		Sec. 5.2	Step 9	Install the Initial BMPs as shown on the accepted Grading Drawings and schedule a Preconstruction Meeting with the City	
		Sec. 5.3	Step 10	Attend the onsite Preconstruction Meeting, designate the Grading Manager, confirm an understanding of the Grading Permit requirements, review the Initial BMPs, and make any corrections required	3 days notice: Preconstruction Meeting; 24 hours: Inspect any required corrections to Initial BMPs and sign Grading Permit; 24 hours: Sign Grading Permit
		Sec. 5.4	Step 11	Pick up the executed Grading Permit and start construction	
		Sec. 5.4	Step 12	Ensure that the BMPs are correctly installed, that the BMPs are inspected and maintained in accordance with the required timeframes, and that all of the General Construction Requirements described in the Grading Field Manual are complied with	
		Sec. 5.5	Step 13	Ensure that the mandatory inspections by the City are scheduled and completed and that corrections requested by the City during these or any inspection are made	24 hours: Inspection if Grading Manager changes; 24 hours: Inspections for Phased Construction
		Sec. 5.6	Step 14	Ensure that the Interim and Final BMPs are installed at the appropriate times in accordance with the accepted Grading Drawings and Grading Manual	City scheduled: Periodic inspections
	Section 6. Project Acceptance and Close-out	Sec. 6.1	Step 15	Prepare the site for the Initial Close-out Inspection and schedule the inspection at least one week prior to an anticipated request for a Certificate of Occupancy (CO), Building Permit, or Initial Close-out Acceptance	
		Sec. 6.2	Step 16	Attend Initial Close-out Inspection, make any corrections requested by the City, and obtain Initial Close-out Acceptance	3 day notice: Initial Close-out Inspection (repeats as necessary until all items are complete and Grading Inspector grants Initial Close-out Acceptance)
Post-Construction		Sec. 6.4	Step 17	Conduct monthly site inspections of BMPs. Make necessary corrections to the onsite BMPs and control weeds as necessary. Make corrective actions as required by Washington City	City Scheduled: Periodic BMP inspections
		Sec. 6.5	Step 18	Schedule the BMP Acceptance Inspection	24 hours: BMP Acceptance Inspection; 5 days +/-: Prepare written acceptance of BMPs
		Sec. 6.6	Step 19	After receiving written acceptance of the post construction BMPs from the City, remove the onsite BMPs if needed and schedule the Final Close-out Inspection	24 hours: Final Close-out Inspection; 5 days +/-: Prepare written acceptance of all Grading requirements
		Sec. 6.7	Step 20	After receiving written notice from the City that all Grading requirements have been addressed, submit a signed Fiscal Security Release Form to the City. After the Fiscal Security is released by the City, the project is complete	5 days +/-: Review Fiscal Security Release Form and release Fiscal Security

Does regulatory authority shift from the Grading Permit Process to the Building Permit Process?

1.9 GESC Manual Authorization

This Manual is authorized by Washington City's City Council through ordinance.

1.9.1 Jurisdiction

The Grading Permit Program shall apply to all land within the incorporated areas of Washington City.

1.9.2 Amendments and Revisions

These policies and criteria may be amended and revised as new technology is developed and experience is gained.

1.9.3 Enforcement Responsibility

The City Council acting through the Public Works Department shall enforce the provisions of this Manual.

1.9.4 Reviews and Acceptance

The City shall review all Grading Plan submittals for general compliance with the criteria contained in this Manual. An acceptance by the City does not relieve the Permittee(s) or Design Engineer from responsibility of ensuring that calculations, plans, specifications, construction and as-built drawings are in compliance with this Manual. Additionally, acceptance by Washington City does not alleviate the Permittee(s) or Design Team from complying with other applicable Federal, State, Local, or Tribal laws and regulations.

1.9.5 Interpretation

In the interpretation and application of the provisions of this Manual, the following shall govern: Whenever a provision in these criteria and any other provision of the Washington City Subdivision Regulations or any provision in any law, ordinance, resolution, rule or regulation of any kind, contain any restrictions covering any of the same subject matter, whichever are more restrictive or impose higher standards shall govern. In the event that there is a discrepancy in the interpretation of this Manual, the Public Works Department shall have the final determination of the intent of this Manual.

1.9.6 Relationship to Other Standards

If special districts impose more stringent criteria, differences are not considered conflicts. When differences arise, the more stringent requirements shall apply. If the Federal or State government imposes stricter criteria, standards or requirements, these shall be incorporated in the City's requirements after due process and public hearing(s) needed to modify City regulations, standards, and ordinances. This Manual shall not abrogate or annul any permits or accepted drainage reports and construction plans issued.

SECTION 2: GETTING STARTED

Section 2 clarifies that a Professional Engineer shall prepare a Grading Plan, describes Grading Plans types, and identifies related plans and permits that must be addressed.

2.1: Grading Permit Process Steps 1 to 3

Section 2.1 includes Steps 1 to 3 of the permitting process. Step 1 is to confirm whether a permit is needed and whether a Low Impact or Standard Grading permit is required for the project as described in Section 1.5 and 1.6 of this Manual. Step 2 requires the preparation of a grading plan by a professional engineer. Step 3 involves setting up a pre-submittal meeting prior to application for a grading permit.

***Permit Step 1**: Confirm that a permit is required and which type of permit will need to be obtained.*
The first step in the Grading Permit process is to examine the information in Section 1.5 to confirm that a Low Impact or Standard Grading Permit is required for the project. The Standard Grading Permits apply to most land disturbing activities in the City other than small (less than 1 acre) projects with negligible negative impact (requiring a Low Impact Grading Permit) and most agricultural or emergency activities. Washington City Public Works Department can be contacted to clarify Grading Permit requirements and to help interpret which Grading Permit, if any, applies to a particular project.

***Permit Step 2**: Retain a professional engineer to prepare a grading plan.*
Designing grading, erosion, and sediment controls on a site may involve engineering issues such as embankment stability and spillway sizing (for sediment basins), pipe strength calculations (for temporary stream crossings), and peak discharge estimates and hydraulic computations (for determination of flood elevations and velocities and for sizing conveyance facilities). Because of these issues, Washington City requires that grading plans be prepared by or under the responsible charge of, and signed and stamped by, a professional engineer (PE) registered in the State of Utah. For the purpose of this Manual, the professional engineer is referred to as the Design Engineer. Non-PEs with experience in erosion and sediment control may assist in the development of a grading plan, but they must conduct their work under the supervision of the Design Engineer. It is the responsibility of the Design Engineer to use professional judgment in the development of the grading plans. If the Design Engineer determines that any grading plan requirements, as applied to their specific project, pose a safety hazard, it is the Design Engineer's responsibility to notify Washington City of these issues, as well as to recommend an approach to alleviate the concerns.

The Design Engineer is responsible for preparing the grading plan in accordance with the requirements of this Manual and is one of the key personnel who should attend the on-site pre-construction meeting at the start of the construction phase.

Specific drawings that are required as part of the grading plan are described further in ***Section 2.2*** of this Manual.

***Permit Step 3**: Schedule a pre-submittal meeting to determine what additional City, State, or Federal permits may be required.*

A Pre-submittal Meeting with City staff is recommended prior to preparing Grading Plans and other submittal documents for a proposed construction project. The meeting will make City staff available to clarify questions regarding the Grading Permit Program and discuss what related plans and permits may be required. Additional plans and permit requirements are described further in ***Section 2.3*** of this Manual.

Also, staff will discuss the general configuration of controls that may be appropriate for the site. The pre-submittal meeting, although optional, gives City staff an opportunity to understand the Applicant's plans for the site and to offer guidance during the development of the grading plan.

The City highly recommends that the Grading Plan Design Engineer attend the Pre-submittal Meeting. The Owner or Owner's representative shall bring the following information to the meeting.

- Name, type, and location of development.
- Brief description of site topography and drainage features.
- Size of development site and anticipated disturbed area, in acres
- Anticipated plans and permits to accompany the Grading Plan.

2.2 Drawings Needed

As previously stated, two types of grading drawings are required; depending on the size and nature of the construction project, either a Low Impact or Standard Grading Permit is required. All grading drawings shall comply with Appendix J of the International Building Code (IBC). Additionally, Washington City requires that the final three sheets of the grading plan should describe the erosion and sediment control measures to be used as follows:

- Sheet ESC-A: should describe in detail the pre-construction BMPs to be used.
- Sheet ESC-B: should describe in detail construction BMPs.
- Sheet ESC-C: should detail the post-construction BMPs that will be employed on the site.

2.3 Other Plans and Permit Requirements

When applicable, Grading Drawings shall be submitted with other necessary plans and permits as described in the following sections.

2.3.1 Other City Plans and Permits

This section describes the related plans and permits that may need to be submitted along with the development of a Grading Plan, including the following:

- Construction Plans for the Project
- Drainage Plans
- Storm Water Pollution Prevention Plans (SWPPP)
- Single Family Residential
- Right-of-Way and Construction Permit
- Temporary Construction Access Permit
- Floodplain Development Permit

The Grading Plan shall be submitted concurrently with, or included within, the construction plans for a proposed construction project, when applicable. The submittal package will include an acceptable form of plat or improvement plan, construction plans, drainage report, traffic study, geotechnical report, and payment of applicable City fees.

Projects that include use of or construction in the city right-of-way must obtain an Encroachment Permit. Information on Right-of-Way Use and Construction permitting is found in the Washington City Standard Drawings and Details.

2.3.2 State Permitting

The State of Utah requires permits for construction related activities, which are in addition to permitting requirements for Washington City. The applicants or the Design Engineer shall contact the State of Utah Department of Water Rights, a division of the State of Utah Natural Resources for specific State permitting information for their projects.

2.3.3 Federal Permitting

Applicants are responsible for complying with applicable Federal permitting. This may include, but is not limited to the FEMA map revision process, the Department of the Army Corps of Engineers Section 404 Permit, US Fish and Wildlife Service, Threatened and Endangered Species Clearance, and Wetlands

SECTION 3: PREPARING A GRADING PLAN

Section 3 provides guidance for the Design Engineer for Step 4 of the grading permit process and includes the elements of an effective Grading Plan, Design and sizing criteria for BMPs, Grading Drawing requirements, and Grading Report requirements. Section 3 also includes detailed instructions for preparing the drawings, report, and other documents that make up the Grading Plan.

***Permit Step 4*: Prepare a grading plan following the 10 elements of an effective grading plan, design and sizing criteria for BMPs, grading drawing requirements, and grading report requirements.**

A key step in preparing a grading plan is to evaluate potential Best Management Practices (BMP)s. Various standard BMPs that are accepted for use in Washington City to control erosion and sediment on construction sites are identified in ***Section 3.1*** of this Manual.

There are 10 Elements that should be utilized in the selection of BMPs and the development of a grading plan. Each of these elements are listed below and described in detail in ***Section 3.2*** of this Manual.

1. Preserve and stabilize drainageways
2. Avoid the clearing and grading of sensitive areas
3. Balance earthwork on site
4. Limit the size of grading phases to reduce soil exposure
5. Stabilize exposed soils in a timely manner
6. Implement effective perimeter controls
7. Use sediment basins for areas exceeding one acre
8. Protect steep slopes
9. Protect inlets, storm sewer outfalls, and culverts
10. Provide access and general construction controls

Utility construction includes additional requirements which are described in ***Section 3.3*** of this Manual. The drawing requirements for grading plans are provided in ***Section 3.4*** and the grading report requirements are provided in ***Section 3.5***. BMP cost considerations such as issues associated with the installation and maintenance of BMPs are discussed in ***Section 3.6***. Guidance for requesting deviations from the criteria presented in this Manual is provided in ***Section 3.7***.

3.1 Best Management Practices

Standard BMPs acceptable for use in Washington City are shown in Table 3.1. The shaded cells indicate which stage each BMP may be utilized at. Additional descriptions of the information presented in the table is provided in the sections that follow.

Table 3.1: Standard BMPs in Washington City

No.	BMP	ID	Control Type	Initial Stage	Construction Stage	Post-Construction Stage
1	Check Dam	CD	Sediment			
2	Concrete Washout	CW	Construction			
3	Earth Dikes and Drainage Swales	ED	Construction			
4	Entrance/Outlet Tire Wash	EOT	Construction			
5	Fiber Rolls	FR	Sediment			
6	Geotextiles and Mats	GM	Erosion			
7	Gravel Bag Berm	GBB	Sediment			
8	Hydraulic Mulch	HM	Erosion			
9	Hydroseeding	HS	Erosion			
10	Rip Rap	RR	Erosion			
11	Sandbag Barrier	SBB	Sediment			
12	Sediment Basin	SB	Sediment			
13	Sediment Trap	ST	Sediment			
14	Silt Fence	SF	Sediment			
15	Slope Drain	SD	Erosion			
16	Soil Binders	SB	Erosion			
17	Stabilized Construction Entrance	SCE	Sediment			
18	Stabilized Construction Roadway	SCR	Sediment			
19	Storm Drain Inlet Protection	SDP	Sediment			
20	Straw Bale Barrier	SWB	Sediment			

21	Straw Mulch	SM	Erosion			
22	Street Sweeping and Vacuuming	SV	Sediment			
23	Velocity Dissipation Device	VD	Erosion			
24	Wind Erosion Control	WE	Sediment			

3.1.1 Standard Detail Number and Identifier

The number indicated in the first column of Table 3.1 corresponds to the number of the standard construction detail shown in Washington City's BMP Handbook. BMPs are called out on a Grading Drawings using the two or three letter identifier and symbol shown in the BMP legend.

3.1.2 Type of Control

Three general types of BMPs are shown.

1. **Construction Control:** These BMPs are related to construction access and staging.
2. **Erosion Control:** These BMPs are used to limit the amount and extent of erosion.
3. **Sediment Control:** Sediment control BMPs are designed to capture eroded sediments prior to their conveyance off site.

3.1.3 Phase of Construction

The BMPs listed apply to one or more of the following construction phases. All BMPs shall be indicated in the Grading Drawings as being part of the Initial Stage, Construction Stage, or Post-Construction Stage of construction. This is to help clarify when each BMP is to be installed.

Initial Stage: These BMPs shall be installed at the outset of construction, prior to the initial pre-construction meeting and any other land-disturbing activities. Initial controls are to be placed on existing grades, but shall be based in part on proposed grading operations.

Construction Stage: These BMPs shall be based on proposed grades and drainage features and are installed after initial site grading. For some BMPs such as Inlet Protection, interim controls are installed after the construction of site infrastructure.

Post-Construction Stage: BMPs shown in the post-construction stage Grading Drawings shall be installed as one of the last steps in the construction process, such as final seeding and mulching.

3.1.4 Guideline Questions for Selecting BMPs

Guidelines for the selection of BMPs on a project should include asking the following seven questions:

1. **Land Use:** Which practices are best suited for the proposed land use at this site?
2. **Physical Feasibility Factors:** Are there any physical constraints at the project site that may restrict or preclude the use of a particular BMP?
3. **Climate/Regional Factors:** Are there any regional characteristics that restrict or modify the use of certain BMPs?
4. **Watershed Factors:** What watershed protection goals need to be met in the resource where my site drains?
5. **Stormwater Management Capability:** Can one BMP meet all design criteria, or is a combination of practices needed?
6. **Pollutant Removal:** How does each of the BMP options compare in terms of pollutant removal?
7. **Community and Environmental Factors:** Do BMPs have important community or environmental benefits or drawbacks that might influence the selection process?

3.1.5 Standard BMPs

When preparing Grading Drawings, the Design Engineer shall use the standard BMPs previously shown in Table 3.1. These BMPs have proven effective under actual construction site conditions within Washington City and are therefore accepted for use.

The Grading Drawings submitted to the City for final signatures and subsequently provided to the Contractor as construction drawings shall include a set of the Grading Plan Standard Notes and Details. Other details shall not be used.

The Washington City Best Management Practices: Grading Plan Standard Notes and Details is a complete set of details for these accepted BMPs. It provides comprehensive installation and maintenance information for all accepted BMPs.

The Best Management Practices: Standard Notes and Details comprise minimum measures to be adhered to on a construction site. The Permittee(s) and Design Engineer may select more conservative approaches than indicated herein and exceed minimum criteria.

3.1.6 Alternative BMPs

The Public Works Department recognizes that there will be new advances in the development of erosion and sediment control BMPs that may prove effective. Washington City will consider alternative BMPs on an individual basis.

Washington City reserves the right to reject any BMP proposed, either in the initial, construction, or post-construction stages if the BMP does not perform with sufficient effectiveness. In case of rejection, Washington City may replace the unsuccessful BMP with a standard BMP listed in Table 3.1 at the Owner's expense.

3.1.7 BMP Grading Plan Standard Notes and Details

The Standard Notes and Details serve several purposes as identified below:

Increased Consistency: Consistent details and notes for a standard set of BMPs will increase the likelihood that BMPs will function effectively and will be installed and maintained correctly.

Time Savings: The set of standard drawings will save the Design Engineer the effort associated with developing and drawing their own notes and details. Less time will be needed to review plans and inspect the BMPs, and as field personnel gain experience constructing the standard BMPs, it is anticipated that installation and maintenance will become more efficient.

Definition of sizing variables: The standard details identify the critical variables that the Design Engineer must specify on the Grading Plan to locate and size the BMPs. This will reduce the likelihood that information will be missing or unclear, or that BMPs are improperly sized.

3.2 Ten Elements of an Effective Grading Plan

This section describes a systematic approach to control erosion and sediment on a construction site. Ten elements of an effective grading plan are summarized; Washington City requires that each of these elements be addressed in a Grading Plan.

A set of example grading drawings (shown in ***Appendix A***) have been prepared in accordance with the Ten Elements to illustrate the concepts discussed herein and depict the information that shall be shown on Grading Drawings. Figure 3.1 relates the Ten Elements to the example Grading Drawings.

1. Preserve and stabilize drainageways
2. Avoid clearing and grading sensitive areas
3. Balance earthwork on site
4. Limit grading phase size to reduce soil exposure

5. Stabilize exposed soils in a timely manner
6. Implement effective perimeter controls
7. Use sediment basins for areas exceeding 1.0 acre
8. Protect steep slopes
9. Protect inlets, storm sewers, and culverts
10. Provide access and general construction controls

The following information has also been included in this Manual or other publications to assist the Design Engineer in developing a Grading Plan:

- ***Appendix A*** provides example Grading Drawings for each type of Grading Plan.

- ***Appendix B*** provides a detailed checklist that shall be followed when developing a Grading Plan.

- The Washington City Best Management Practices Grading Plan Standard Notes and Details that shall be provided with all Grading Drawings are provided in ***Appendix C*** and are available at the City offices or on the City website..

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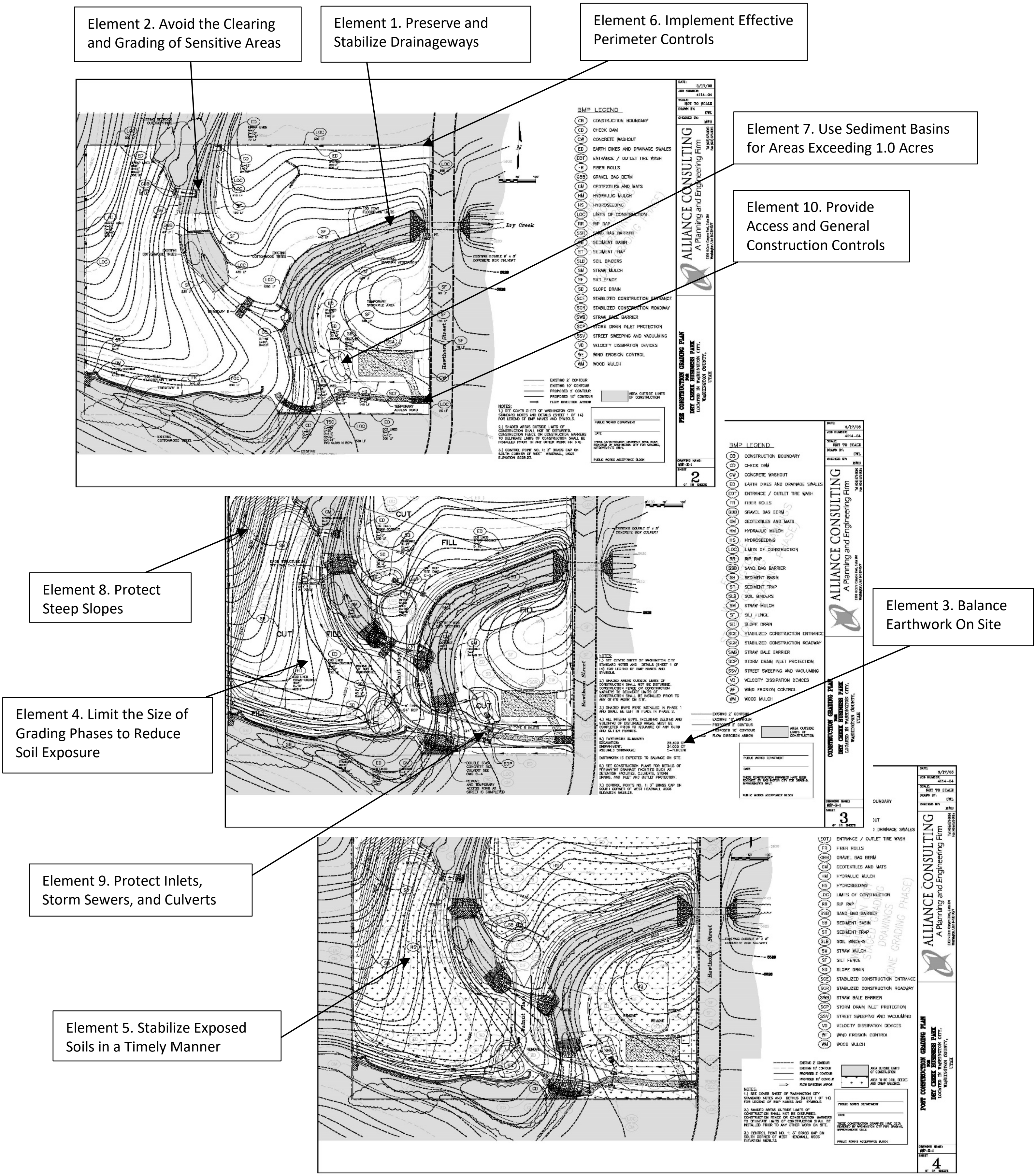
Figure 3.1: Ten Elements of an Effective Grading Plan (See Appendix A for Full-Size Plans)



Element 1: Preserve and Stabilize Drainage Ways

Work in drainageways requires special care and attention:

Drainageway corridors comprise an important natural resource with habitat, open space, and aesthetic value. Since drainageways also function to convey stormwater runoff, they are susceptible to damage from the erosive forces of water, especially if they are disturbed. It is critical that construction activities be designed to reduce any adverse impacts to drainageways and that City State, and Federal permitting processes be complied with.

Drainageways shall not be filled, regraded or realigned:

Existing drainageways shall not be filled within the limits of the 100-year floodplain or the existing top of banks of incised channels, whichever is more restrictive, without the approval of Washington City. The Design Engineer shall define a 100-year floodplain on all drainageways not defined by FEMA. If riparian vegetation, desirable habitat, or other stream resources exist beyond the limits of the 100-year floodplain, consideration shall be given to avoiding impacts to those areas as well. Existing drainageways shall not be regarded or realigned without the approval of the City. Physical barriers, such as fencing, shall be required to limit access into stream corridors. Perimeter sediment controls shall be implemented to protect drainageways.

All existing drainageways on the site shall be delineated on the Grading Drawings to the limit of their 100-year floodplains (based on future development peak discharges.) Limits of construction shall be clearly shown on the Grading Drawings to indicate the exact limits of grading adjacent to a drainageway and to delineate the limits of the undisturbed riparian corridor.

2-foot freeboard above the 100-year Floodplain shall be provided:

Floodplain elevations can rise over time due to the following:

- Increased baseflows and runoff from development can promote increases in growth of wetland and riparian vegetation, making drainageways hydraulically rough and leading to higher flow depths.
- Stream stabilization work can raise the bed of the drainageway at the crests of drop structures and flatten the channel slope, leading to higher flow depths.
- Upstream bank erosion or watershed erosion, flatter slopes, or increased channel vegetation can lead to sediment deposition and channel aggradation, raising the streambed and floodplain elevation.
- These conditions are generally positive, since they decrease flow velocities, improve stream stability, and enhance water quality through sediment trapping. For these conditions to occur over time without jeopardizing properties during floods, a 2-foot freeboard must be provided at the outset of development.

Existing Drainageways Shall Be Stabilized:

It may be impossible, or undesirable, to avoid all construction in an existing drainageway. Most natural channels cannot be left in their pre-development condition. Increased runoff from development can shift the natural balance of a stream over time, tending toward degradation and bank erosion as the stream tries to flatten its grade.

Grade control features are usually necessary to reduce the channel slope to future equilibrium conditions and to control flow velocity. Bank or toe protection may also be necessary to reinforce weak, unstable channel banks. Grade control structures and other channel stabilization improvements shall be designed according to the criteria shown in the Hydrology Manual.

Disturbance to Existing Drainageways Shall be Minimized and Quickly Restored:

In addition to the construction of grade control and bank stabilization improvements, there may be other unavoidable instances where construction must occur in existing drainageways. Examples include bridges and culverts for road crossings, utility crossings, storm sewer outfalls, and temporary stream crossings for construction access. However, it is critical that construction disturbance within drainageways be minimized and quickly restored.

When construction within a drainageway is unavoidable, the Design Engineer shall delineate construction limits that restrict activities to the smallest area possible.

Construction Fencing (CF) or **Construction Markers** (CM) shall be indicated on the Grading Drawing within the drainageway corridor to indicate the allowable limits of disturbance. In the same manner, construction fencing or construction markers shall be shown throughout the site to identify all limits of construction (along all perimeters of the site, along all stream corridors to be preserved, and around any other preservation zones). Coordinates or other information shall be provided to establish the location of the fence.

If disturbance to a drainageway is significant, such that excessive amounts of sediment may be transported downstream, a **Check Dam** (CD) reinforced or non-reinforced, shall be installed immediately downstream of the disturbed area in the drainageway. If several areas of disturbance are located in close proximity, one check dam at the downstream end of the construction may be appropriate. Generally, BMPs shall be configured to control erosion and trap sediment outside of the limits of drainageways to enable check dams to be used infrequently. Sizing criteria for check dams is provided in the Best Management Practices and Standard Grading Notes and Details Handbook.

Crossing drainageways with construction equipment requires a Temporary Stream Crossing (TSC). Temporary stream crossings shall be limited to one per 2000 lineal feet of drainageway unless otherwise approved by the City.

As soon as possible after construction of facilities in drainageways, or after removal of a temporary stream crossing, all disturbed areas within streams and drainage channels shall be rip-rapped, unless otherwise approved. Additional plantings shall be considered to enhance channel stability, habitat, and aesthetics. Rip-rap shall be required on all channel banks to 1 foot above the 100-year floodplain.

The Design Engineer shall indicate approximate limits of rip-rap on the Grading Drawings. These limits shall extend to the tops of the banks. Additional design information is available in the Best Management Practices Grading Plan Standard Notes and Details Handbook.

Any New Drainageway Shall Be Designed and Stabilized:

Even after existing drainageways are identified and preserved, new development projects usually require an additional network of small drainageways, swales and storm sewer facilities. During grading operations, prior to the construction of storm sewer facilities, additional temporary ditches or dikes may be necessary to control site stormwater runoff.

Upgradient properties will generate runoff that may need to be intercepted and conveyed through the site in drainageways that don't necessarily correspond to existing stream channels. Off-site flow impacts the layout of perimeter drainage facilities and starts to set the location and size of the on site drainage network.

Permanent drainage facilities, including roadside ditches, shall be designed and stabilized in accordance with Section 8 of this Manual .

Temporary diversion ditches may be necessary at upslope and downslope perimeters, at the top of steep slopes, and downstream of slope drains. **Diversion Ditches** (DD) shall be located, sized and stabilized according to the criteria set forth in the Hydrology Manual and the Best Management Practices Handbook.

Element 2: Avoid the Clearing and Grading of Sensitive Areas

In addition to drainageways, other sensitive resources may exist on a site. These could include:

- Protected habitat for threatened or endangered species
- Wetlands
- Nesting bird habitat
- Riparian corridors
- Forested areas
- Mature cottonwood stands
- Bedrock outcroppings
- Steep slopes and ridges

- Potential stormwater infiltration areas
- Historic, cultural, or archeological resources
- Areas of unique or pristine vegetation, habitat, or landform

A resource inventory should be conducted for the site including the location, areal extent, and type of resources, including stream floodplains.

Disturbance to sensitive resource areas shall be avoided or minimized. Destroying or disturbing wetlands, nesting bird habitat, and protected habitat for threatened or endangered species is sharply restricted; these restrictions shall be addressed through the appropriate Federal or State agency permitting process.

Element 3: Balance Earthwork On Site

To reduce impacts on City roadways, development projects are required to balance earthwork quantities on site:

In the event that it is impractical to balance earthwork quantities, a variance shall be requested during the review of the Grading Drawings. The variance shall address the following, at a minimum:

- Reason for variance
- Amount of material to be imported or exported
- Location of disposal site if export or source site if import
- Grading Permit numbers for disposal or source sites
- Detailed haul route plan and traffic control plan for haul route
- Type and number of trucks required to complete import or export
- BMPs for variant projects will be required to increase the size of the stabilized staging area (SSA) and in some cases will be required to provide Vehicle Tracking Control with Wheel Wash (WW) and/or Street Washing (SW). Sizing information is available in the BMP Handbook.
- If the variance is accepted, Grading Drawings shall be prepared for the import or export site in accordance with this Manual and additional Fiscal Security shall be required.

Element 4: Limit the Size of Grading Phases to Reduce Soil Exposure

Washington City strongly recommends that large projects (over 40 acres) conduct phased grading operations:

During construction, each grading phase shall be accepted by the Grading Inspector prior to starting work on the next phase. Seeding and crimp mulching shall be completed within five days of the Grading Inspector's acceptance of the phase or a Stop Work Order shall be issued.

The following list comprises the **Design Requirements for Phased Grading**:

1. Determine the number of grading phases.
2. Clearly identify the sequence of construction of each phase and entire project on drawings.
3. Balance earthwork within each phase, if possible.
4. Locate temporary stockpiles and staging areas in each phase to prevent additional soil disturbance.
5. Accommodate water/sewer and other utility construction within each phase.
6. Incorporate road segments, temporary turn-arounds, and emergency access within each phase.
7. Segregate temporary construction access in each phase from access for permanent residents.
8. Show both the temporary and permanent stormwater management facilities in each phase.
9. Develop Initial, Construction and Post-Construction Drawings for each Phase
10. Ensure that the Grading Plan for later upstream phases address potential impacts to already completed downstream phases.

Element 5: Stabilize Exposed Soils in a Timely Manner

All areas disturbed by construction shall be stabilized as soon as possible to reduce the duration of soil exposure and the potential amount of erosion:

Unless otherwise approved, Washington City requires that disturbed areas be seeded and crimp mulched, or permanently landscaped, within 30 days from the start of land disturbance activities or within 7 days of substantial completion of grading and topsoiling operations, whichever duration is shorter. Topsoil stripping, stockpiling, and re-spreading in areas to be vegetated shall be a mandatory practice called for in all Grading Drawings. Adequate "footprints" for topsoil stockpiles shall be shown assuming stockpile slopes are no steeper than 3:1.

The BMPs applicable to stabilizing soils consist of **Surface Roughening** (SR), **Seeding and Mulching** (SM), **Erosion Control Blanket** (ECB), and **Compost Blanket** (CB).

Surface roughening shall be shown for all disturbed areas and drill seeding and crimp mulching shall be shown for all areas that shall not be paved, sodded, landscaped or otherwise stabilized in an approved manner.

Compost blanket may be considered as an alternative to erosion control blanket and crimp mulch for stabilizing exposed soils.

Element 6: Implement Effective Perimeter Controls

Effective perimeter controls consist of upslope and downslope BMPs:

Upslope Perimeters: If the upstream off-site area is developed, runoff will generally enter the site at one or more discrete outfalls; drainage facilities shall be sized and stabilized to convey off-site runoff through the site. The Design Engineer should consider the need for a **Construction Fence** (CF) to discourage public entry to the site during construction.

If the upstream off-site area is undeveloped, runoff may enter the site in a defined natural channel or via sheet flow (or both). Runoff in existing channels shall be conveyed through the site in a stabilized stream or drainage channel. Runoff entering the site via sheet flow shall be captured in a **Diversion Ditch** (DD) and directed to a stream or drainage channel. Diversion ditches that have mild slopes may be unlined, whereas steeper ditches and rundowns must be lined with erosion control blanket (for moderate slopes), plastic (temporary installations only), or rip-rap. For detailed information on mild and moderate open channels please see Section 8 of this Manual.

A **Temporary Slope Drain** (TSD) conveys runoff down a channel bank or slope to the bottom of a drainage-way. When diversion ditches intersect a slope or channel bank, a temporary slope drain, consisting of pipe, plastic, or rip-rap shall be required to convey diverted water from the diversion ditch down the slope or channel bank.

Downslope Perimeters: BMPs apply to the downslope perimeters of construction disturbance (generally the downhill site perimeters), perimeters along drainageways, and downslope perimeters adjacent to other areas to be left undisturbed. Sediment controls shall be located as close to the source of erosion as possible, on the downslope side of any disturbed area.
If the upstream disturbed drainage area is less than 1.0 acre, a **Reinforced Rock Berm** (RRB), **Fiber Roll** (FR), **Silt Fence** (SF), or a **Diversion Ditch** (DD), shall be shown along the perimeter.

Construction Fence (CF) is also recommended along the downslope perimeters if the adjacent area is developed or consists of a public use area.

In drainageways with an upstream watershed area of 20 acres or more that exit the site and where disturbance is such that excessive amounts of sediment may move downstream, a **Check Dam** (CD) is recommended at the downgradient perimeter. For areas exceeding 130 acres a **Reinforced Check Dam** (RCD) is recommended. In disturbed drainageways having an upstream watershed area of less than 20 acres that exit the site, a **Reinforced Rock Berm** (RRB) is recommended at the downgradient perimeter. However, if possible, BMPs are to be configured to control erosion and sediment outside the limits of drainageways so that instream BMPs are used infrequently and only as a last resort. Design details and guidance on each BMP is contained in the BMP Handbook (***Appendix C***).

Element 7: Use Sediment Basins for Areas Exceeding 1.0 Acre

Runoff from all disturbed drainage areas exceeding 1.0 acre shall be treated in a **Sediment Basin** (SB). Runoff from disturbed areas less than 1.0 acre may be treated in a sediment basin, a **Sediment Trap** (ST), or one of the down slope perimeter BMPs described in Element 6. Design guidance for sediment basins is provided in the BMP Handbook (***Appendix C***).

Any permanent detention or water quality facilities shall incorporate a sediment basin with at least half of the sediment basin storage volume required provided below the lowest outlet of a permanent detention facility or water quality basin.

A stable drainage path shall be shown downstream of the outlet and spillway of a sediment basin. If the sediment basin is located within a permanent detention facility or water quality basin, the drainageway downstream is likely to be a permanent feature and shall be shown in a separate design detail. Temporary drainage paths shall consist of a Diversion Ditch (DD), or, if appropriate, a rip-rap apron or other stable feature that is detailed by the Design Engineer.

Permanent detention facilities shall be constructed as early in the development process as possible. If site planning has identified easements for permanent detention facilities, the Design Engineer shall locate sediment basins in these locations even if permanent detention facilities are not planned until later in the development.

Sediment Basins in Detention and Water Quality Facilities

Including sediment basins in permanent detention or water quality facilities is recommended for several reasons:

- The need for a temporary outlet and spillway are eliminated.
- Detention and water quality basins are generally located at a low point in the drainage system enabling site runoff to be conveyed to the sediment basin.

- The sediment basin ends up being "out of the way" of other construction and doesn't have to be relocated.

Element 8: Protect Steep Slopes

Steep slopes may either consist of steep existing slopes that are to be preserved or cut or fill slopes created during the grading process. In either case, the measures in this section shall be taken to protect these slopes against erosion.

Proposed slopes shall be no steeper than 3 to 1, unless approved and documented by a Geotechnical Engineer:

Slopes steeper than 3:1 are difficult to vegetate and maintain. Long term rill and gully erosion are likely on such slopes. Approved permanent stabilization shall be required to control grades on all sites that cannot be graded at a 3:1 slope. Retaining walls may be necessary to control grades on a site. Slopes steeper than 4:1 shall be protected with **Erosion Control Blanket** (ECB).

Runoff shall be diverted away from steep slopes:

A permanent or temporary diversion ditch (DD) shall be depicted above all steep slopes on the site that may receive concentrated or sheet flows. Where steep cut slopes are planned near the site perimeters, a minimum of six feet between the property line and the top of the cut slope shall be reserved for the diversion ditch, unless otherwise accepted by the City.

Terracing shall be incorporated into the grading of steep slopes:

To break up the flow of incidental runoff down slopes and reduce the development of rill and gully erosion, grading of new steep slopes shall incorporate **Terracing** (TER). Design criteria are provided in the BMP Handbook (***Appendix C***).

Element 9: Protect Inlets, Storm Sewer Outfalls and Culverts

The entrances to storm sewer inlets shall be protected using Inlet Protect (IP) or Reinforced Rock Berm (RRB) to reduce inflow of sediment:

Likewise, storm sewer outfalls and culvert outlets shall be protected against scour and erosion. All storm sewer inlets on site shall be provided with Inlet Protection (IP). The Grading Drawings shall specify whether area, sump, or continuous grade protection is to be used in a particular location. The half Y-shaped continuous grade inlet protection is intended to trap sediment upstream of an inlet on a continuous grade street without causing any bypass of flow around the inlet. Sump and area inlet protection is also designed to maintain inlet capacity after runoff flows over the wire-enclosed rock. The only inlet protection that blocks an inlet opening is temporary inlet protection discussed in the BMP manual, which is only used to keep soil out of an inlet prior to paving operations. All culvert inlets on a site shall be provided with a **Reinforced Rock Berm** (RRB).

Storm sewer outfalls and culvert outlets shall be permanently protected against erosion with a rip-rap apron or other approved means in accordance with the Hydrology Manual. Rip-rap shall be installed as part of construction of the storm sewer outfall or culvert. In addition, **Erosion Control Blanket** (ECB) shall be provided in the area disturbed by the construction of the storm sewer outfall or culvert.

Element 10: Provide Access and General Construction Controls

Limits of Construction (LOC) shall be shown on Grading Drawings and shall include all utility tie-ins. The Design Engineer shall delineate construction limits that provide adequate room for the necessary work, including vehicular and temporary storage of equipment and materials, while at the same time limiting the disturbed area to the minimum necessary. Unless otherwise accepted by the City for utility work, all excavated materials stockpiles shall be placed on the uphill side of the trench within the limits of construction.

Construction Fence (CF) or **Construction Markers** (CM) shall be shown throughout the site to delineate all limits of construction along all perimeters of the site, all stream corridors to be preserved, and around any other preservation zones. Construction fence or other means defining all limits of construction shall be installed as the first step in the construction phase, prior to any other work or disturbance on the site.

Vehicle Tracking Control (VTC) shall be provided at all entrance/exit points on the site. The number of access points shall be minimized A location shall be selected that accounts for the safety of the traveling public and avoids disturbance of trees, desirable vegetation, and low, wet areas. Grades greater than eight percent shall be avoided.

A **Stabilized Staging Area** (SSA) shall be provided near the main access point and connected to the vehicle tracking control.

A **Concrete Washout Area** (CWA) shall be indicated in a location near all concrete areas.

All stockpile areas shall be shown on the Grading Drawings. Adequate “footprints” for stockpiles shall be shown assuming stockpile slopes are no steeper than 3 to 1. Stockpiles shall not be shown outside the limits of construction.

All Temporary Access roads shall be shown on the Grading Drawings.

3.3 Special Requirements for Utility Construction

As Washington City grows, so does the demand for installation of new underground utility lines, and upgrade and maintenance of existing lines. Many times this work is located in streets where storm sewer inlets can be impacted, or along or across drainageways. Although the work is generally short lived, the close proximity to storm drainage systems provides an ample opportunity for contamination of stormwater runoff. A Grading Plan for underground utility work should configure BMPs to reduce the contamination of stormwater runoff from construction erosion and sediment.

At a minimum all utility line construction shall comply with the following:

- Obtain a Grading Permit prior to construction
- All utility work within a Washington City right-of-way shall be required to obtain a Washington City Right-of-Way Use and Construction Permit.
- Provide adequate erosion and sediment controls.
- No more than 200 linear feet of trench shall be open at any one time.
- Where consistent with safety and space considerations, excavated material is to be placed on the uphill side of trenches.
- At no time shall excavated material be placed in the curb, gutter, sidewalk, or in the street within 6-feet of the flow line.
- Limits of construction shall be large enough for a work area, temporary storage of excavated material and imported material, and equipment access to the project.
- Downslope perimeter controls shall be installed according to the element 6 and BMP handbook.
- Trench dewatering devices must discharge in a manner that will not affect streams, wetlands, drainage systems, or off-site property. Discharge from the trench shall be free of any sediment. A rock rip-rap pad shall be placed at the discharge end of the hose to prevent any additional erosion. The Dewatering (DW) detail shall be complied with at the suction and discharge ends of the pumping facilities.
- Inlet protection (IP) shall be provided whenever soil erosion from the excavated area has the potential of entering a storm sewer system.
- All disturbed areas shall be seeded and crimp mulched within seven days after utility work is completed. For larger projects, seeding and mulching shall be done in phases rather than at the end of construction.
- Comply with all other applicable criteria as outlined in this Manual.

3.4 Standard Grading Plan Drawing Requirements

The following sections list Grading Drawing Requirements which shall be adhered to when preparing a Grading Drawing. Specific requirements vary based on the two types of Standard Grading Drawings described in Section 2.

All Grading Drawings, which are also required for off-site borrow or disposal areas, shall be prepared on 24x36 sheets at a scale of 1:20 up to 1:200 as appropriate, to clearly show sufficient detail for review. Electronic submission procedures are expected to be implemented by the City in the future. Submitted files shall be of sufficient quality for review and archiving.

3.4.1 Grading Drawing Cover Sheet

At a minimum, the following list of items shall be included on the Grading Drawing Cover Sheet:

1. Project Name
2. Project Address
3. Owner Address
4. Design firm's name and address
5. Design Engineer's signature block
6. Plan sheet index
7. The following note: The Grading Plan included herein has been placed in the Washington City file for this project and appears to fulfill applicable Washington City Grading Criteria. Additional grading, erosion and sediment control measures may be required of the permittee(s) due to unforeseen erosion problems or if the submitted Grading Plan does not function as intended. The requirements of this Grading Plan shall run with the land and be the obligation of the permittee(s) until such time as the Grading Plan is properly completed, modified or voided.
8. Grading Design Engineer's signature block with name, date, and professional engineer registration number. Signature block shall include the following note: The Grading Plan included herein has been prepared under my direct supervision in accordance with the requirements of the GESC Manual of Washington City.
9. City Acceptance Block (see ***Appendix A***).
10. General Location Map at a Scale of 1:1000-8000 feet indicating:
11. General vicinity of the site location
12. Major roadway names
13. North arrow and scale

3.4.2 Grading Drawing Index Sheet

Projects that require multiple plan-view sheets to adequately show the project area (based on the specified scale ranges), will be required to provide a single plan-view sheet at a scale appropriate to show the entire site on one sheet. Areas of coverage of the multiple blow-up sheets are to be indicated as rectangles on the index sheet.

3.4.3 Initial Grading Drawing

This plan sheet shall provide grading, erosion and sediment controls for the initial clearing , grubbing and grading of a project. At a minimum, it shall contain:

1. Property lines
2. Existing and proposed easements
3. Existing topography at one or two-foot contour intervals extending a minimum of 100 feet beyond the property line
4. Location of any existing structures of hydrologic features within the mapping limits
5. USGS benchmark used for project
6. Limits of construction encompassing all areas of work, access points, storage and staging areas, borrow areas, stockpiles, and utility tie-in locations in on-site and off-site locations. Stream corridors and other resource areas to be preserved and all other areas outside the limits of construction shall be lightly shaded to clearly show area not to be disturbed
7. Location of stockpiles, including topsoil, imported aggregates, and excess material
8. Location of storage and staging areas for equipment, fuel, lubricant, chemicals (and other materials) and waste storage
9. Location of borrow or disposal areas
10. Location of temporary roads
11. Location, map symbol, and letter callouts of all initial erosion and sediment control BMPs
12. Information to be specified for each BMP, such as type and dimensions, as called for in the BMP handbook
13. The following note: See Washington City BMP Handbook for legend of BMP names and symbols
14. Washington City approval block (see ***Appendix A***)
15. Grading Design Engineer's signature block with name, date, and professional engineer registration number.
16. Other information as may be reasonably required by Washington City

3.4.4 Interim Grading Drawing

This plan sheet shows BMPs to control grading, erosion and sediment during the initial overlot grading, site construction and site post construction process. At a minimum, it shall contain the following information:

The Interim Grading Drawing shall show all information included on the Initial Grading Drawing, as noted below:

1. Existing topography at one-or two-foot contour intervals extending a minimum of one hundred (100) feet beyond the property line, as shown on Initial Grading Drawing. These contours shall be screened.
2. Location of all existing erosion and sediment control measures on site, as shown on the Initial Grading Drawing Sheet. These control measures shall be screened. Dimension information for initial stage BMPs shall not be shown.
3. Items 1, 2,and 4 through 10 from the Initial Grading Drawing.

In addition, the Interim Grading Drawing shall include the following:

4. Proposed topography at one- or two-foot intervals, showing elevations, dimension, locations, and slope of all proposed grading.
5. Outlines of cut and fill areas.
6. Location of all interim erosion and sediment controls, designed in conjunction with the proposed site topography, but also considering the control designed in the Initial Grading Drawing.
7. Location of all buildings, drainage features and facilities, paved area, retaining walls, cribbing, water quality facilities, or other permanent features to be constructed in connection with, or as a part of, the proposed work, per approved, plat, or other improvement plan.
8. The following notes:
    - See Washington City BMP Handbook for legend of BMP Names and Symbols.
    - Shaded BMPs were installed in the initial stage and shall be left in place in the interim stage unless otherwise noted.
    - All interim erosion and sediment control BMPs including seeding and crimp mulching of disturbed areas, must be installed, inspected, and approved by the City prior to the issuance of a Right-of-Way Construction Permit for the purpose of paving or installation of curb and gutter.

- See Construction Plans for details of permanent drainage facilities such as detention facilities, water quality facilities, culverts, storm drains, and outlet protection.

9. Summary of cut and fill volumes showing how earthwork balances on site.
10. Washington City acceptance block (See ***Appendix A***)
11. Grading Design Engineer's signature block with name, date, and professional engineer registration number. Signature block shall include the following note: The Grading Plan included herein has been prepared under my direct supervision in accordance with the requirements of the GESC Manual of Washington City.

3.4.5 Final Grading Drawing

This plan sheet shows controls for final completion of the site. At a minimum, this plan sheet shall contain the indicated information:

The Final Grading Drawing shall show all information included on the Initial and Interim Grading Drawings, as noted below:

1. Existing topography in areas of proposed contours need not be shown.
2. Existing Initial and Interim BMPs shall be shown as screened. Dimension information shall not be shown.

In addition, the Final Grading Drawing shall include the following:

3. Directional flow arrows on all drainage features.
4. Any Initial or Interim BMPs that are to be removed and any resulting disturbed area to be stabilized.
5. Location of all final erosion and sediment control BMPs, permanent landscaping, and measures necessary to minimize the movement of sediment off site until permanent post-construction BMPs can be established.
6. Show area of buildings, pavement, sod, and permanent landscaping (define types) as per approved plat, or other improvement plan.
7. Show seeding and mulching (SM) everywhere except buildings, pavement areas and permanent landscaping areas.
8. Show other BMPs considered by the Design Engineer to be appropriate.
9. Show the following BMPs to be removed at the end of construction:
    - dewatering (DW)
    - temporary stream crossings (TSC)

- stabilized staging area (SSA)
- Street inlet protection (IP)
- vehicle tracking control (VTC)
- construction fence (CF)

10. Include the following notes:
    - See Washington City BMP Handbook for legend of BMP names and symbols
    - Shaded BMPs were installed in initial or interim Grading Drawing and, unless otherwise indicated, shall be left in place until post-construction BMPs are approved by the City.
    - See Construction Plans for details of permanent drainage facilities such as detention facilities, culverts, storm drains, and outlet protection.
11. Washington City Acceptance Block (see ***Appendix A***)
12. Grading Design Engineer's signature block with name, date, and professional engineer registration number.
13. Other information may be reasonably required by Washington City.

3.5 Storm Water Pollution Prevention Plan Requirements

A storm water pollution prevention plan (SWPPP) is required by the UPDES Construction General Permit (CGP) permit to address the exposure of pollutants inherent in each proposed construction process at each site. The purpose is to ensure that activities, materials, and processes are managed by Best Management Practices (BMPs) to minimize pollutants being transported off the site by storm water runoff.

The SWPPP shall at a minimum include the following items and descriptions:

1. Contact information of responsible parties
2. Proposed construction activities
3. Anticipated site discharges and receiving waters
4. Potential sources of pollution
5. List of erosion and sediment control BMPs
6. Response procedure for spills
7. Inspections and corrective actions

Additional information regarding SWPPP requirements and preparation can be found on the Utah DEQ website through the following link General Construction (Storm Water): UPDES

Permits - Utah Department of Environmental Quality. Available resources include a SWPPP CGP Template from the Utah DEQ and a SWPPP guidance manual from the U.S. EPA.

Construction operators shall frequently perform inspections to ensure maintenance and effectiveness of BMPs. Stabilization of the site is required prior to termination of permit coverage to prevent the discharge of pollutants after the completion of construction.

3.6 Grading Report Requirements

Mass grading projects with a disturbed area equal to or greater than 5 acres shall include the preparation of a Grading Report with additional project information. The following Information relating to grading, erosion and sediment control shall be included in a separate Grading Report submitted with the Grading Drawings. This report will only be required for mass grading projects. An example Grading Report is provided in ***Appendix A***:

1. **Name, address, and telephone number of the applicant** - The name, address, and telephone number of the Design Engineer preparing the Grading Plan shall also be included.
2. **Project Description** - A description of the nature and purpose of the land-disturbing activity, the total area of the site, the area of disturbance involved, related project reference, and project location including township, range, section and quarter-section.
3. **Existing Site Conditions** - A description of the existing topography; drainage; wetlands; and other property features.
4. **Adjacent Areas** - A description of neighboring areas which might be affected by the land disturbance.
5. **Soils** - A brief description of the soils on the site including information on soil type and names, mapping unit, erodibility, permeability, hydrologic soil group, depth, texture, and soil structure. (This information may be obtained from the soil report for the site or the applicable Soil Survey prepared by the Natural Resources Conservation Service (NRCS)).
6. **Areas and Volumes** - A cubic yard estimate of the quantity of excavation and fill involved (showing earthwork balance), and the surface area (in acres) of the proposed disturbance.
7. **Erosion and sediment control measures** - A description of the methods presented in this Manual that will be used to control erosion and sediment on the site.
8. **Timing/Phasing Schedule** - A schedule indicating the anticipated starting and completion times of the site grading and/or construction sequence, including the installation and removal of erosion and sediment control BMPs. Indicate the anticipated starting and completion time period of individual project phases.

9. **Permanent Stabilization** - A brief description, including applicable specifications, of how the site will be stabilized after construction is completed.
10. **Stormwater Management Considerations** - Explain how stormwater runoff from and through the site will be handled during construction. Specific reference should be made to the project drainage study regarding anticipated stormwater volumes.
11. **Maintenance** - Any special maintenance requirements over and above what is identified in the standard notes and details.
12. **Engineer's estimate for installation of BMPs** - An engineer's estimate for erosion and sediment control, including anticipated maintenance during the construction phase, shall be submitted with the Grading Drawing. This will be reviewed by City staff and used as a basis for Fiscal Security.
13. **Calculations** - Any calculation made for the design of such items as sediment basins or erosion control matting selection.
14. **Other Information or data** - as may be reasonably requested by Washington City.
15. **The following note** - "This Grading Plan has been placed in the Washington City file for this project and appears to fulfill the applicable Washington City Grading Criteria. Additional grading, erosion and sediment control measures may be required of the owner or his/her agents due to unforeseen erosion problems or if the submitted plan does not function as intended. The requirements of this plan shall run with the land and be the obligation of the land owner, or his/her designated representative(s) until such time as the plan is properly completed, modified or voided."
16. **Signature Page** - For owner/developer acknowledging the review and acceptance of responsibility, and statement by the Design Engineer acknowledging responsibility for the preparation of the Grading Plan.

3.7 BMP Cost Issues

Costs associated with grading, erosion, and sediment control BMPs include the following:

1. Installation of the BMPs indicated on the Initial, Interim, and Final Grading Drawings according to the number, types, dimensions, and quantities called for.
2. Provision of Grading Manager to supervise, inspect, and interface with Washington City on the project's Grading Drawings.
3. Installation of additional BMPs that the Permittee(s) think are appropriate or that are called for by the Grading Inspector to address actual site conditions.
4. Maintenance costs for BMPs. Maintenance costs will vary based on many factors, including the magnitude and number of storm events occurring during the project.

5. Permittee(s) are required to provide an opinion of probable cost associated with implementing the Grading Drawing.

3.8 Hillside Protection Overlay Zone

Hillside protection zones have been mapped by Washington City and included the Washington City GIS maps. Any projects that will extend into the Hillside Protection Overlay Zone shall meet all requirements of Title 9 Chapter 12A of the Washington City Zoning Ordinance.

3.9 Variance Submittal Requirements

Any **request for a variance** shall be in a separate letter to the City Engineer. The letter shall define:

- The criteria from which the applicant seeks a variance.
- The justification for not complying with the criteria.
- Alternate criteria or standard measure to be used in lieu of these criteria. The criteria and practices specified within this section of this Manual relate to the application of specific erosion and sediment control practices. Other practices or modification to specified practices may be used if approved by Washington City prior to installation. Such practices must be thoroughly described and detailed.

Some variances may be minor in nature. A minimum amount of supporting documentation will be required for such variances. More complicated variances will require a more extensive review. All variances will be granted solely at the discretion of the Washington City Engineer.

SECTION 4: GRADING PLAN ACCEPTANCE AND GRADING PERMIT APPLICATION

Section 4 describes the Grading Permit application process from the review and approval of the Grading Plan documents to filling out the Permit Application, paying the permit fee, and posting Fiscal Security.

4.1 Grading Permit Process Steps 5 to 7

<u>Permit Step 5</u>: Submit the Grading Plan and related plans and permits to the City for review.

Grading Plan Submittal: After the Grading Plan has been prepared according to the requirements of Section 3, the drawings and report, along with the related plans and permits discussed in Section 2, shall be submitted to the Public Works Department. The Grading Plan shall not be accompanied by the Grading Permit Application Form, Fee, or Fiscal Security at this time; these documents shall be submitted only after the Grading Plan is reviewed and accepted.

Completeness Evaluation: After the Grading Plan is submitted to the Public Works Department, the City shall, within approximately three working days, evaluate the Grading plan for completeness based on the submittal requirements described in Section 3. Any submittal that does not reflect a basic level of completeness shall be returned to the Design Engineer. This process shall be repeated until a complete Grading plan set is submitted to the Public Works Department. The review period of a Grading Plan will not start until a complete Grading plan is submitted.

City Review: The Grading Plan will be reviewed for effectiveness of the overall plan. The appropriateness, timing, and placement of the proposed erosion and sediment control will be reviewed. After review, written comments will be provided to the applicant.

Review Schedule: Approximate review periods are indicated on the Grading Permit Process flowchart shown in Section 1. Typically, written review comments will be provided by the Public Works Department within 5 business days of Grading Plans to be evaluated as complete. Written comments on re-submittals are also provided within 5 business days of receiving the revised plans and the summary of how previous comments were addressed. The length of time to achieve final City acceptance is directly related to the level of accuracy, concurrence with Washington City design and construction criteria and standards, and the thoroughness of addressing written review comments.

Plan Revisions Based on City Comments: Grading Plan review comments are to be addressed by the applicant and the revised Grading Plan resubmitted to the City for a follow-up review. The applicant shall submit a letter or memorandum with the revised Grading Plan summarizing how each review comment was addressed. If review comments are not addressed, the Grading Plan will not be accepted, and written comments will again be provided to the applicant. This cycle will be repeated as many times as necessary for the applicant to fully address the City's review comments to the satisfaction of City Staff.

***Permit Step 6*: Preliminary Acceptance of Grading Plan, Permit Applications, Fees, and Fiscal Security**

Preliminary Acceptance of the Grading Plan: When all Grading Plan review comments have been addressed, the Applicants will be notified by the City that the Grading Plan is preliminarily accepted (final acceptance occurs when additional copies of the Grading Drawings are submitted to the City and signed by the city Public Works Department). The City will specify the number of copies of the Grading Drawings that shall be submitted for the City Engineer's signature (typically three sets are requested). It should be noted that the City is currently working on an electronic submittal procedure that will be implemented in the future, which will replace the requirement for additional copies.

Each set of Grading Drawings shall be signed and stamped by a Professional Engineer registered in the State of Utah, bound and stapled, then rolled. The Grading Drawings shall be submitted to the City along with the Grading Permit Application, Permit Fee, and Fiscal Security, described in Section 4.7 through 4.10.

Applying for a Grading Permit: Once the Public Works has notified the Applicants that the Grading Plan is accepted, the Applicants may apply for a Grading Permit. The information required on the Permit Application shall be filled out and the form shall be signed by personnel who are legally authorized to sign on behalf of the company, corporation, entity, or organization. A copy of the grading permit application is provided in ***Appendix D***.

Permit Fees: Permit fees are to be paid to the Public Works Department secretary. Fees may be paid by check or in cash. Fees for a Grading Permit are collected in accordance with Appendix J of the International Building Code. These fees shall be paid with the submittal of the Permit Application and other documents shown in Section 4.6.

Fiscal Security: Posting Fiscal Security is required of all projects requiring a Grading Permit. The condition under which the Grading Fiscal Security is held is separate from any other security relating to the project, or any other permits relating to the site and may be held and released separately. The amount of fiscal security for a Grading Permit is based on the probable cost of installing the grading erosion and sediment controls required on a site. An engineer's estimate must be completed by the Design Engineer as part of the Grading Report as described in Section 3.15.

The Fiscal Security is accepted in the form of a cashier's check or irrevocable letter of credit or bond. A copy of the Washington City Fiscal Security Form is located in ***Appendix E***. Financial institutions have varying guidelines for cashier's checks; the Applicant is advised to contact their financial institutions to learn their regulations regarding cashier's checks. Non-certified funds will need to clear the financial institution prior to issuance of a Grading Permit. Cash deposits will be held in a non-interest bearing account.

The conditions of each form of security shall allow for the security to be held by Washington City for a minimum of two years. The two-year period should allow for completion of all grading and site improvements requirements, including two seasons to allow time for post-construction controls to be proved. Information regarding the release of Fiscal Security is provided in Section 6.8. If the construction of the project and/or post-construction process takes longer than two years, the Permittee shall extend the posted letter of credit a minimum of sixty days prior to the expiration date. Failure to extend the Fiscal Security, for a minimum of one additional year, prior to the fourteen day deadline shall result in the City drawing upon the fiscal security.

***Permit Step 7*: Obtain Signed Grading Drawings and Field Manual**

Grading Plan Acceptance: The Grading Plan will be considered accepted when the submitted copies of the Grading Drawings are signed by the Public Works Department. The City will notify applicants when the Grading Drawings will be ready. Typically, approximately seven days after the Grading Drawings are submitted. Washington City will typically retain two of the three sets of the signed Grading Drawings. However, the number of drawings retained by the City is project-specific. It should be noted that the City is also working on an electronic submittal procedure which will be implemented in the future. Grading Drawing sets will always be retained for the project file and the Grading Inspector. Additional copies may be required by other City departments. Grading Plans are considered valid for two years following the signature date. After this time Grading Plans will need to be re-submitted to the City for re-review and re-acceptance.

Field Manual: A copy of the Grading Field Manual shall be obtained from the City at the same time the signed Drawings are received. The grading Field Manual provides information pertaining to the construction phase of the Grading Permit process and is discussed further in Section 5.

4.2 Expiration of Grading Permit

A Grading Permit is valid for one year from the date the permit is granted (the date the Grading Permit Application form is signed by the Public Works Department.) A Grading Permit shall be renewed prior to its expiration. The Permittee(s) shall contact the City and start the renewal process at least 14 days prior to the original Grading Permit's expiration date. Permittee(s) shall have a valid Grading Permit until Final Close-Out Acceptance.

4.3 Transference of Grading Permit

If a project or portion of a project is sold to a new Owner, or if the Contractor that is identified on the Grading Permit is replaced by a different Contractor the Grading Permit shall be transferred to the new Owner and/or Contractor using a specific transfer procedure. The transfer shall require a new Grading Permit Application Form, payment of a transfer fee, new Fiscal Security (if new Owner), and another Pre-construction Meeting on site (the Pre-construction meeting is discussed in Section 5.4). Failure to transfer the Grading Permit if the Owner or Contract Changes will result in issuance of a Stop Work Order, per section 5.10.3.

SECTION 5: FIELD SECTION

Section 5 provides construction information for field personnel and includes designation of the Grading Manager, installation of Initial BMPs, the mandatory Pre-construction Meeting, picking up the completed Grading Permit, the construction inspection process, and violations and enforcement

5.1 Grading Permit Process Step 8

<u>Permit Step 8</u>**: Select a Grading Manager; Review the Grading Field Manual and ensure that the Permittee(s) Understand the Grading Permit Requirements***

Grading Manager: As the Permittee(s) focus shifts from applying for the Grading Permit to constructing the projects, the first task is to select a Grading Manager. The Grading Manager is the Permittee(s), contact person with the City for all matters pertaining to the Grading Plan and Permit. The Grading Manager may be an employee of the Owner or Contractor, but shall have the authority to act on behalf of the permittee(s) to ensure that the site remains in compliance with the Grading Permit, however the Permittee(s) shall remain the legally responsible party. The Grading Manager shall respond to requests made by Washington City staff and have any deficiencies in the work corrected. The Grading Manager and Alternate Grading Manager shall be named at the on site pre-construction meeting discussed in Section 5.2.

Alternate Grading Manager: An Alternate Grading Manager who is able to serve in the same capacity as the Grading Manager shall also be selected. The Alternate shall be the contact person if the Grading Manager is not available. The Grading Manager shall inform the Alternate Grading Manager of any absences, fill the Alternate in on the status of the Grading Plan implementation, and ensure that the Alternate Grading Manager assumes the Grading Manager’s responsibilities during any absence.

Availability of the Grading Manager: The Grading Manager shall be present at the project site a majority of the time and (along with the Alternate Grading Manager) shall provide the City with a 24-hour emergency contact number. In the event the Grading Manager (or Alternate Grading Manger) is not on site, and cannot be reached during any level of violation a Stop Work Order shall be issued.

5.1.1 Changing the Grading Manager or Alternate

Notification in writing shall be provided to the City if the Grading Manger or Alternate leaves the company or the Permittee(s) intend to change personnel. A field meeting with the Grading Inspector and new Grading Manger or Alternate shall be scheduled within 7 days of the change to discuss site conditions and responsibilities of the Grading Manger.

5.1.2 Implementing the Grading Plan in the Field

Constructing the project and implementing the Grading Plan in the field is a challenging part of the Grading Permit process. The Grading Plan will not be effective unless the required measures are properly installed and maintained by the Permittee(s).

5.1.3 Review of the Grading Field Manual, Grading Plan, and Related Plans and Permits

Prior to the Preconstruction Meeting, the Grading Manager shall thoroughly review the Grading Field Manual, Grading Plan, Standard Notes and Details, and related plans and permits for the project. A review of the 10 Elements of an Effective Grading Plan in Section 3 will provide valuable insight. It is the Grading Manager's responsibility to understand all of the requirements of the Grading Permit Process as laid out in these documents. In addition, it is the Grading Manager's responsibility to ensure that other field personnel are aware of the grading requirements. Washington City welcomes calls from Permittee(s) during this process to answer any questions that the Grading Manger or other Permittee staff may have regarding the Grading Permit Process.

5.1.4 Documents Shall Remain On Site

A copy of the Grading Field Manual, Grading Drawings, Standard Notes and Details, and any project permits shall remain on the site at all times. Once the grading Permit is obtained, it shall remain on site at all times as well.

5.2 Preparation for the Pre-construction Meeting

Section 5.2 describes preparation for the pre-construction meeting, summarizes the activities to occur prior to the meeting which includes installation of the pre-construction BMPs. Other than the installation of the pre-construction BMPs, no other construction shall start prior to the pre-construction meeting.

<u>Permit Step 9</u>: Install the Pre-Construction BMPs and Schedule a Pre-Construction Meeting

Installation of Pre-Construction BMPs: Installation of the pre-construction BMPs shown on the Grading Drawings shall be installed prior to the on site preconstruction meeting. No formal notification needs to be given to the City to install the pre-construction BMPs, other than receiving the signed Grading Drawings and a copy of the Grading Field Manual. However, all of the requirements of this Manual and the Grading Plan, including the Standard Notes and details, shall be complied with. See Section 5.4 for a description of proper installation and maintenance of BMPs.

If the Permittee(s) think that modifications to pre-construction BMPs shown on the Grading Drawings should be made to provide for a more effective plan, the Permittee(s) shall contact the Washington City Public Works Department to obtain acceptance of the proposed modifications prior to installing the BMPs.

Other than the installation of the Preconstruction BMPs shown on the Grading Plan, no other construction shall occur. If the Permittee(s) begin work on the site (other than installing pre-construction BMPs) prior to obtaining an approved Grading Permit, the City will issue a Stop Work Order and assess a fee of three times the Grading Permit fee.

Scheduling the Pre-Construction Meeting: The permittee(s) shall contact the Washington City Public Works Department to schedule the on site Preconstruction Meeting. Three business days notice shall be provided to schedule the meeting.

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5.3 Pre-construction Meeting

***Permit Step 10*: Attend the Pre-Construction Meeting, Designate the Grading Permit Requirements, Review the Pre-Construction BMPs, and Make Any Correction Required**

Attendees at the Pre-Construction Meeting: The on site Preconstruction Meeting is a critical milestone prior to the start of construction. In addition to the grading Inspector, the following representatives shall attend:

1. **Owner or Owners Representative.** The Contractor may not act as the owner's representative.
2. **General Contractor**
3. **Grading Manager and Alternate Grading Manager.** One or both may be the same as the Owner of General Contractor Representative.
4. **Grading Subcontractor**, if different than the general contractor.
5. **Design Engineer**. The Design Engineer's attendance is not mandatory; however, it is strongly recommended that the Design Engineer attend, to avoid possible delays if the City or the Permittee(s) determine that modifications to the Grading Plan are necessary.

General Meeting Agenda: The following agenda items are addressed at the Preconstruction Meeting:

1. **Introductions.** Introductions of attendees, including the grading Manager and alternate Grading Manager, will take place.
2. **Contact Information.** Attendees will exchange contact information.
3. **Review of Grading Field Manual**. The Grading inspector will confirm the Permittee(s) understanding of the Grading Field Manual.
4. **Field Review of Grading Drawings**. The Grading Drawings will be reviewed to confirm the attendees' understanding of the Grading Plan and to discuss any modifications to the plan. If modifications to the grading plan are thought to be advantageous, input will be sought from the Design Engineer and final acceptance of changes will be as determined by the Grading Inspector. Limits of construction shall be confirmed.
5. **Inspection of Pre-construction BMPs**. A visual inspection of all of the pre-construction BMPs that have been installed will take place. The Grading Inspector will confirm if any corrections are required.
6. **Acceptance of Initial BMPs**. If the initial BMPs are accepted by the Grading Inspector, as is or with minor corrections, the Grading Inspector will inform the Permittee(s), sign the Grading Permit Application, and submit the Grading Permit Application to the Public Works Department for processing. Construction shall not start until an executed Grading Permit is obtained from the City as described in Section 5.5.

Corrections to the BMPs: If the Grading Inspector determines that significant modifications or corrections to the BMPs are necessary, the Grading Inspector will inform the Permittee(s) that such corrections shall be made, that a follow-up inspection shall be scheduled with the City, and that acceptance of the corrected BMPs by the Grading Inspector shall take place prior to the signing of the Grading Permit or prior to any additional inspections. Modifications to the grading Plan will, in most cases, require acceptance by the Design Engineer who signed and stamped the Grading Drawings. The re-inspection requires a one-day notice (by 3:00 pm the weekday prior to the inspection) and shall be scheduled with the Public Works Department.

5.4 Executed Grading Permit

Section 5.4 provides guidance for picking up the Grading Permit from the City, the duration that the Grading Permit is valid, procedures for transferring the Grading Permit, and summarizes procedures to be completed at the start of construction.

***Permit Step 11*: Pick up the Executed Grading Permit and Start Construction**

Pick up the Executed Grading Permit: Washington City will execute the Grading Permit generally within 24 hours of acceptance of the Pre-construction BMPs (either at the pre-construction meeting or at a follow-up inspection). Once the Permittee(s) pick up the executed Grading Permit, construction can start.

Start of Construction: With the executed Grading Permit picked up and on site, construction can start.

5.4.1 Duration of the Grading Permit

A Grading Permit is valid for one year from the date the grading Permit is granted (the date the grading Permit is executed). A Grading Permit shall be renewed prior to its expiration. The Permittee(s) shall contact the City and start the renewal process at least 14 days prior to the original Grading Permit's expiration date. Permittee(s) shall have a valid Grading Permit until Final Close-out Acceptance.

5.4.2 Transfer of a Grading Permit

If a project or portion of a project is sold to a new Owner, or if the Contractor that is identified on the Grading Permit is replaced by a different Contractor, the Grading Permit shall be transferred to the new Owner and/or Contractor using a specific transfer procedure. The Transfer shall require a new Grading Permit application, payment of a transfer fee, new Fiscal Security (if new Owner), and an additional Pre-construction Meeting on site (the Pre-construction meeting is discussed in section 5.4). Failure to transfer the Grading Permit if the Owner or Contractor changes will result in issuance of a Stop Work Order.

5.4.3 No Filling in Drainageways

Existing Drainageways shall not be filled in beyond the limits of the 100-year floodplain or the existing top of bank incised channels, whichever is more restrictive, without the acceptance of Washington City.

***Permit Step 12**: Ensure that the BMPs are Correctly Installed, are Inspected and Maintained in Accordance with the Required Timeframes, and that all of the General Construction Requirements Described in the Grading Field Manual are Met*
Correct Installation and Maintenance of BMPs and General Construction Practices: Correct Installation and Maintenance of BMPs and General Construction practices are detailed in the Best Management Practices Handbook included in ***Appendix C***, or available as a separate publication. This handbook provides installation and maintenance information and shows photographs of field installations of each of the City's Standard Erosion and Sediment Control BMPs. Both correct installation and maintenance as well as practices that should be avoided are shown.

5.5 City Grading Inspection Process

Section 5.5 discusses inspections related to the City Grading Permitting Program and identifies steps in the construction process that require mandatory inspections and acceptance before work may proceed.

***Permit Step 13**: Ensure that Inspections by the City are Scheduled by Permittee(s) and Completed and that Corrections Requested by the City during these or any other Inspections are Made*
City Grading Inspections: During the construction phase, BMP's will be inspected by a Grading Inspector. Grading Inspectors will consider the overall effectiveness of the controls for reducing erosion and trapping sediment on the site and will check for proper installation and maintenance of the controls. Grading Inspectors will coordinate with the Grading Manager, whose responsibility it is to ensure that the site remains in compliance with all grading requirements. **Mandatory City Inspections:** The Permittee(s) shall call the Public Works Department to schedule the following mandatory inspections: 1. Pre-construction Meeting/Inspection of Initial BMP's. 2. Any time during construction when a new Grading Manager of Alternate Grading Manager is chosen.

3. Initial close-out inspection.
4. Final Close-out Inspection when post-construction BMPs are in place.
5. For Staged and Phased Grading Plans where more than 40 acres needs to be disturbed and where work occurs in multiple grading phases, the following inspection process is required:
    a. A phase project starts in the same manner as any other Grading permitted project, with the installation of the Initial BMPs as shown on the Initial Grading Drawing. The difference is that only the Initial BMPs for Phase I need to be installed and inspected in order to obtain the Grading Permit.
    b. Once the Permittee(s) have obtained the Grading permit, grading may begin on Phase I only. Failure to restrict grading operations to the limits of Phase I shall result in issuance of a Stop Work Order.
    c. When the Permittee(s) are nearing the end of grading on Phase I, the Interim BMPs for Phase I shall be installed per the Interim Grading Drawing, in addition, the Initial BMPs shall be installed on Phase II as shown on the Initial Grading Drawing.
    d. A mandatory inspection shall be scheduled, in accordance with this section, to inspect the Initial and Interim BMPs on Phase I as well as the Initial BMPs for Phase II. If the Grading Inspector finds the BMPs to be installed and maintained in accordance with the approved Grading Plan and this Manual, the Grading Inspector will sign the Grading Phasing Acceptance Sheet.
    e. Once the Grading Inspector has signed the Grading Phase Acceptance Sheet, grading may commence on Phase II.
    f. All disturbed areas on Phase I shall be stabilized in accordance with the accepted Grading Plan within 5 calendar days from the Grading Inspector's sign off for commencement of the next phase. Failure to complete the required stabilization within the allotted time shall result in issuance of a Stop Work Order for the entire project. No time extensions shall be granted.
    g. This process shall be repeated for each additional phase until all earthwork is complete.

All inspections shall be coordinated through the Washington City Public Works Department. All inspection requests need to be called into the Public Works Department by 2:00 p.m. the day before the inspection (three business days prior to the inspection for the Pre-construction meeting). Inspection personnel shall be provided access to private property to inspect construction stormwater BMPs.

5.5.1 Penalties and Enforcement

Failure to comply with any term, condition, limit, deadline or other provision of the Grading Permit or failure to obtain a Grading Permit constitutes a violation of Washington City Ordinance and may constitute a violation of the Federal Clean Water Act and the Utah Water Quality Control Act.

In addition to any other legal or equitable remedies that the City may have for Grading Permit violations, the City may cease issuances of all building permit approvals and other permissions until such violation is corrected and the Permittee(s) takes additional steps to ensure compliance with the Grading Permit, by the Grading Inspector.

5.5.2 Levels of Violations

Washington City classifies violations in one of two categories, depending on the severity of the violation. Enforcement action varies for each category. Level I violations have the most severe impact on people and the environment and Level II violations have the least severe impact.

Level I Violations are viewed by the City to pose an immediate serious risk to the health, safety, or welfare of people and/or the environment. Level I Violations result in an immediate issuance of a Stop Work Order. Example Level I violations include:

- Clearing, grubbing, or grading without a Washington City Grading Permit
- Failure to schedule a Pre-Construction Meeting
- Failure to be able to contact the Grading Manager or Alternate Grading Manager during any level of violation
- Failure to restrict operations to approved limits of construction
- Failure to clean up tracking of material onto roadways and adjacent paved areas
- Exporting material to or importing material from a non-permitted site
- Exporting/importing material without a variance
- Failure to follow approved phasing plan
- Failure to make required plan revisions
- Failure to perform BMP maintenance as directed by the Washington City Grading Inspector
- Failure to correct Level II violations per the directives of the Grading Inspector

Level II violations are viewed by the City to pose a moderate to low immediate risk to the health, safety, or welfare of people and/or the environment, however, if not corrected quickly, will pose a more serious risk. Level II violations shall be corrected within 48 hours of inspection unless otherwise specified in writing by the Grading Inspector. Example Level II Violations include the following:

- Failure to provide routine maintenance for erosion and sediment controls.
- Installation of non Washington City accepted BMPs.
- Failure to provide temporary inlet protection within 48 hours of pouring of inlet.
- Failure to provide inlet protection within 48 hours of placement of asphalt or concrete pavement.
- Staging of equipment outside of the stabilized staging area.
- Failure to have accepted Grading Permit, accepted Grading Drawings and Grading Field Manual onsite.

5.5.3 Stop Work Orders

The Public Works Department is authorized to order work to be stopped on any project that disturbs the land and which is not in compliance with the requirements of the Grading Permit. When a Stop Work Order is issued, the Grading Permit for that project is revoked. In addition, the State of Utah Department of Environmental Quality may be notified.

If a project is issued a Stop Work Order, all work on site shall be stopped. Safety related items (e.g. backfilling of holes and trenches) as well as corrective actions may be completed; however, the Permittee(s) shall inform the Grading Inspector of such activities.

The Permittee(s) shall do the following to reinstate a grading Permit and resume work on the site:

1. Correct the deficient practices that precipitated the Stop Work Order.
2. Reapply for a Grading Permit and pay the Permit fee at the Washington City Public Works Department.
3. Call the Public Works Department to schedule a site inspection.
4. Obtain a new Grading Permit after approval of the corrected work from a Grading Inspector.

A posted Stop Work Order shall not be removed from the site, except by the City. A Washington City Inspector is the only authorized agent to remove a posted Stop Work Order.

5.5.4 Re-inspection Fees

To offset the cost of additional inspections on non-compliant sites, Washington City requires that re-inspection fees of $50.00 per inspection be paid in person at Washington City offices prior to receiving subsequent inspections and approval of work. Re-inspection fees shall be charged for all projects that are deficient due to the following:

- Permittee(s) fail to properly install all Initial BMPs prior to the scheduled Pre-Construction Meeting.
- The required attendees fail to attend the scheduled Pre-Construction Meeting.
- Permittee(s) fail to have the Grading Field Manual and grading Drawings on site during the Pre-Construction Meeting.
- Permittee(s) receive a Stop Work Order (fee consists of new Permit fee in this case).
- Permittee(s) failed to obtain Post-Construction BMP acceptance from the City prior to requesting a final release of fiscal Security.
- Permittee(s) remove any BMPs prior to receiving authorization by Washington City.
- Grading Inspector finds violations of Grading Permit requirements during routing inspections.
- Failure to cancel any inspection before 2:00 pm the day prior to the inspection in the event that a site is not ready for an inspection and an inspection had already been scheduled.

5.6 Installation and Construction of Post-Construction BMPs

Section 5.6 discusses the general schedule for installing Construction and Post Construction BMPs.

***Permit Step 14**: Ensure that the Construction and Post-Construction BMPs are Installed at the Appropriate Times in Accordance with the Accepted Grading Drawings and this Manual*
Installation and Construction of BMPs: It is the responsibility of the Grading Manager to ensure that Interim and Final BMPs are installed at the earliest opportunity that grading or construction of new facilities allows. Some BMPs have specific time requirements for installation that are identified on the Grading Plan Standard Notes and Details; these time requirements shall be adhered to. For BMPs where a specific time frame is not given, the controls shall be installed as soon as construction of the infrastructure is substantially complete or when grading activities have produced grades close to the final grade. In any case, it is up to the discretion of the Grading Inspector to make the final determination of Interim and Final BMP installation time frames.

SECTION 6: PROJECT ACCEPTANCE AND CLOSE-OUT

Section 6 describes the Initial Close-out Inspection, requirements for post construction BMPs, final inspections, removal of temporary BMPs, and the release of Fiscal Security.

6.1 Preparation for Initial Close-out Inspection

Section 6.1 describes the tasks the Permittee(s) must complete prior to the Close-Out Inspection. Closeout Inspections must be scheduled at least one week prior to an anticipated request for Certificate of Occupancy (CO), Building Permit, or Initial Close-Out Inspection.

***Permit Step 15**: Prepare the Site for Initial Close-Out Inspection and Schedule the Inspection*

Preparation for Inspection: In preparation for the initial Grading Acceptance Inspection the Grading Manager should complete the following:

- Clean all streets, sidewalks, and flow lines of sediment with a street sweeper. Washing of streets, sidewalks and flow lines is in direct violation of Washington City criteria.
- Remove temporary erosion and sediment controls (if directed by approved Grading Plan or Grading Inspector) and install/maintain erosion and sediment control BMPs per the Washington City approved Grading Plan.
- Ensure all disturbed areas are stabilized, as per Washington City criteria.

Scheduling the Inspection: Once all items are completed, the Grading Manager shall contact the Washington City Public Works Department by 3:00 p.m. three days prior to the inspection. To allow time for resolution of issues, the Initial Acceptance inspection should be scheduled a minimum of one week prior to a scheduled request for a Building Permit or Certificate of Occupancy. Inspection personnel shall be provided access to private property to inspect construction stormwater BMPs.

6.2 Initial Close-out Inspection and Acceptance

Section 6.2 discusses the requirements for the Initial Close-Out Inspection and Acceptance and special requirements for phased projects.

Permit Step 16: Attend Initial Close-Out Inspection, Make any Corrections Requested by the City, and Obtain Initial Close-Out Acceptance

Close-Out Inspection Attendees: Representatives of the Permittee(s), including the Grading Manager, shall attend the Initial Close-out Inspection along with the Grading Inspector.

General Meeting Agenda: The following agenda items are addressed at the Initial Close-out Inspection.

- **Inspection of Final BMPs**. Installation of all Final BMPs are inspected.
- **Inspection of Site Cleanup**. Cleanup of the site and adjoining streets are verified.
- **Discussion of the Post-Construction Requirements**. Regulations governing projects requiring post construction BMPs are discussed.

Corrections to the Site: The permittee(s) shall make any corrections to the site as requested by the City Inspector. If the corrections are substantial, the Grading Inspector may require a follow-up inspection prior to issuing Initial Close-out Acceptance.

6.3 Phased Grading

For phased Grading Plans requirements shall be complete for each phase for which Initial Close-out Acceptance is applied for. Detention and water quality facilities that serve one or more phases shall be installed when the first phase that drains to the facility is constructed. Once all the streets, curb and gutter and storm sewer drainage improvements have been completed in a phase and all the grading, erosion and sediment controls have been installed or repaired per the Final Grading Plan, inspection shall be made by the Grading Inspector.

6.4 Control of Noxious Weeds

Section 6.4 describes the types of weeds designated by the City as noxious.

Permit Step 17: Conduct Monthly Site Inspection of BMPs during the Revegetation Process, Make Necessary Corrections to the Onsite BMPs, and Control Noxious Weeds as Necessary

Control of Noxious Weeds: Washington City requires owners/developers to control noxious weeds on their property. Washington City has designated the following as noxious weeds based on the Utah Department of Agriculture and Food Noxious Weeds Program. A list and description of applicable noxious weeds that will need to be controlled can be seen below. More information can be found in the Noxious Weed Field Guide from Utah State University. This guide is presented in ***Appendix H*** of this Manual.

Canada thistle (Cirsium arvense) is a perennial, developing from deep and extensive horizontal roots. Stems are 1 to 4 feet tall, ridged, branching above. Leaves are alternative, lacking petioles, oblong or lance-shaped, divided into spiny-tipped irregular lobes.	
Diffuse knapweed (Centaurea diffusa) is an annual, biennial, or short-lived perennial that can grow to a height of 3 feet, with a single, much-branched stem that gives the plant a bushy appearance. Basal leaves are pinnately divided and up to 6 inches long; stem leaves are entire and smaller. Tips of each branch have a 1/3-inch wide white or sometimes pinkish flower head that appears from midsummer to fall.	
Dyers woad (Isatis tinctoria L) grows as a winter annual, biennial or short-lived perennial, ranging from 1 to 4 feet tall, from a 3-5 foot long taproot. The basal rosette produces stalked, bluish-green leaves covered with fine hair. The rosette leaves range from 1 ½ to 7" long, and they are succulent. All leaves have a cream colored mid-rib from tip to base.	
Field bindweed (Wild Morning Glory) (Convolvulus arvensis) is a perennial weed that spreads from an extensive rootstock as well as from seed. Seed leaves are nearly square with a shallow notch at the tip. Plants sprouting from rhizomes lack seed leaves. Early true leaves are spade- or bell-shaped. Leaves on mature plants are similar to younger leaves but are lobed at the base. Stems may be several feet long and trail along the ground or climb on upright plants such as shrubs. Trumpet-shaped white to purplish white flowers close each afternoon and reopen the following day.	

Hoary cress (Cardaria drabe) is a perennial that grows up to 3 feet tall. Leaves are grayish-green, clasping, slightly pubescent, up to 4 inches long, and are shaped like arrowheads. Flowers are white with 4 petals, ¼ inch across, and borne in April and May; these dense flower clusters give the weed a flat-topped appearance early in the season, but this is lost as the stem elongates. Two small, flat, reddish-brown seeds are contained in each of the heart-shaped seed pods.	
Johnsongrass (Sorghum halepense) is a tall, coarse grass with stout rhizomes. It grows in dense clumps or nearly solid stands and can reach 8 feet (2.4 meters) in height. Leaves are smooth, 6-20 inches (15.2-50.8 cm) long and have a white midvein. Stems are pink to rusty red near the base. Panicles are large, loosely branched, purplish, and hairy. Spikelets occur in pairs or threes and each has a conspicuous awn. Seeds are reddish-brown and nearly 1/8 inch long.	
Leafy spurge (Euphorbia esula) is characterized by plants containing a white milky sap and flower parts in three's. Leafy spurge is an erect, branching, perennial herb 2 to 3½ feet tall, with smooth stems and showy yellow flower bracts. Stems frequently occur in clusters from a vertical root that can extend many feet underground. The leaves are small, oval to lance-shaped, somewhat frosted and slightly wavy along the margin. The flowers of leafy spurge are very small and are borne in greenish-yellow structures surrounded by yellow bracts.	

Musk Thistle (Carduus mutans) is an aggressive, biennial herb with showy red-purple flowers and painful spiny stems and leaves. Mature plants range in height from 1½ to 6 feet tall, and have multi-branched stems. Leaves are dark green, coarsely lobed, with a smooth waxy surface and a yellowish to white spine at the tip. The large disk-shaped flower heads, containing hundreds of tiny individual flowers, are 1½ to 3½ inches in length and occur at the tips of stems. Flower heads will droop to a 90-degree angle from the stem when mature, hence its alternate name, nodding thistle. Each plant may produce thousands of straw-colored seeds adorned with plume-like bristles.	
Perennial Pepperweed (Lepidium latifolium) Perennial pepperweed grows up to 6 feet tall and has basal leaves that are lance shaped, have long petioles, are up to 12 inches long, and are covered with a waxy layer. Stem leaves are smaller and have shorter petioles, but don't clasp the stem. Leaves have a prominent, whitish midvein. Flowers are white, less than 1/8 inch wide, and are borne in dense, rounded clusters at the branch tips from early summer until fall. Fruits are roundish, slightly hairy, measure 1/16 inch in diameter, and contain 2 tiny seeds.	
Perennial Sorghum (Sorghum halepense L & sorghum almum) is a tall, robust perennial tetraploid, spreading by short stout rhizomes; culms normally about 2 m tall, sometimes up to 4.5 m tall; leaves resembling those of johnsongrass but wider, waxy, 30–100 cm long, 5–4 cm broad; heads longer, lax, more spreading with more branches at whorl than in johnsongrass; the panicle 3–10 cm wide; articulation of pedicelled spikelet breaking off at maturity with the uppermost portion of the pedicel; seed slightly larger than in johnsongrass, brown, ovate, 3.3–4 mm long, 2–2.3 mm broad.	

Quackgrass (Agropyron repens) is aggressive perennial grass with long slender white rhizomes; rhizome tips are yellowish and sharp-pointed; base of leaf blade with claw-like appendage that clasps the stem; spikelets, up to 15 cm long, are in 2 long rows borne flatwise to the stem.	
Russian Knapweed (Centaurea repens) is a greyish perennial up to 3' tall and typically in dense clumps. Leaves are alternate and of several types. Upper are small, narrow, smooth edged; stems are larger with small toothed margins; basals are deeply notched. Stems branch profusely with terminal flowers. Flowers are thistle-like with scaly seed head and lavender color. Roots are very dark and heavily scaled. Seeds are flattened, ivory in color and held in cup shaped seed heads.	
Saltcedar (Tamarix ramosissima) is a perennial plant that grows 5 to 20 feet tall. Stems are reddish brown and leaves are small and scale-like. White to pink flowers have five petals and are born in finger-like clusters. The plants have long and slender branches with an extensive root system and may exhibit either deciduous or evergreen traits.	
Scotch thistle (Onopordum acanthium) is a biennial that can reach a height of 8 feet. Large, coarsely lobed, hairy leaves have a velvety-grey appearance. The rosette forms the first year and can have leaves up to 2 feet long and 1 foot wide. The spiny-edged, alternate leaves form leaf wings that extend down onto the stem. This branching plant has reddish-purple to violet flowers and a large, fleshy taproot. Seeds are about 3/16 inch long and tipped with slender bristles.	

Spotted knapweed (Cenaurea maculosa) is a biennal or short lived perennial. A rosette forms the 1st year and a flowering stalk elongates the 2nd year. Leaves are long divided below, short and narrow above and covered with fine hair. Stems are erect with wiry branches also covered with fine hair. Flowers are usually pink or purple. Seed heads are solitary, up to 1'' across and have black tipped bracts with 5 to 7 pairs of short feathery appendages. Seeds are brownish, 1/8" long, notched on one side of the base with short bristles at the tip.	
Sulfur cinquefoil (Potentilla recta L) is a perennial plant that grows 1 to 3 feet tall and may have branching near the top. Single or multiple stems sprout from a woody crown. Long stiff hairs on the stems and the leaves stick straight out. Plants may reproduce and spread vegetatively and by seed. The seed sprouts in early spring and flowers from May to July. Leaves have toothed edges and there are usually 5 to 7 leaflets per leaf. Flowers are pale yellow and they contain 5 heart-shaped petals.	
Yellow starthistle (Centaurea solstitialis) is an erect, rigid, branching annual. Leaves are deeply lobed at the base but not lobed further up. Leaves are small and pointed. Stems have winged structures, are covered with a cottony fiber and are up to 30" tall. Flowers are yellow and terminal. Flower bracts are tipped with a straw-colored 3/4 inch thorn. The root is taproot in form. Seeds are smooth, light-colored, often mottled, 1/8" long and notched just above the base.	

6.5 BMP Acceptance Inspection

Section 6.5 requires that once post-construction BMPs are in operation, a BMP Acceptance Inspection should be scheduled.

Permit Step 18: Schedule BMP Acceptance Inspection

Schedule BMP Acceptance Inspection: Once post-construction BMPs have been installed, the permittee(s) shall schedule a BMP acceptance inspection.

Written Acceptance: The Grading Inspector will confirm that post-construction BMPs have been installed and that noxious weeds have been controlled. If the post construction BMPs are accepted, the Grading Inspector will issue written acceptance and give the Permittee(s) instructions regarding temporary BMPs. If the BMPs have been improperly installed, repairs or corrections will have to be made by the Permittee(s) and a follow-up BMP Acceptance Inspection scheduled.

6.6 Final Close-out Inspection

Section 6.6 requires that all on-site BMPs be removed and the Final Close-Out Inspection scheduled.

Permit Step 19: After Receiving Written Acceptance of the Post-Construction BMPs from the City, Remove the Onsite BMPs if Needed and Schedule the Final Close-Out Inspection

Removal of Onsite BMPs: After obtaining written acceptance of post-construction BMPs, temporary on-site BMPs shall be removed and properly disposed of. The site shall be cleaned and any areas disturbed as a result of the BMP removal shall be mitigated. The Final Close-out Inspection shall then be scheduled with the City.

Final Close-out Inspection: The Grading Inspector will verify the removal of temporary BMPs and either accept the work or stipulate the corrections needed. If corrections are substantial, the Grading Inspector may require that a follow-up inspection be scheduled with the City.

6.7 Release of Fiscal Security

Section 6.7 discusses the procedures for releasing the project's Fiscal Security.

Permit Step 20: After Receiving Written Notice from the City that all Grading Requirements Have Been Addressed, Submit a Signed Fiscal Security Release Form to the City. After the Fiscal Security is Released by the City, the Project is Complete

Release of Fiscal Security: Once Final Close-out Acceptance has been obtained, the Permittee(s) may submit a Release of Grading Fiscal Security Request Form to the Washington City Public Works Department. A copy of the form is included in ***Appendix E***. The completed form will be signed by the Grading Inspector and the project's Fiscal Security will be released.

6.8 Revocation of Fiscal Security due to Default

Section 6.8 describes procedures where the City revokes the developer's Fiscal Security and uses the funds to complete the Grading Requirements.

6.8.1 Default by Permittee(s)

In the event that the Permittee(s) default on any of the requirements of the Grading Permit, Grading Plan, or GESC Manual, remedies will be in accordance with the remedies identified in this Manual, and any other remedies provided by law.

6.8.2 Notice of Default

If the City Public Works Director, or representative of the Public Works Director, gives notice that a Default by Permittee(s) exists, and if the Permittee(s) fails to cure such default within the time specified by the Public Works Director, the City shall be entitled to (a) make a draw on the letter of credit for the amount reasonably determined by the City to be necessary to cure the default in a manner consistent with the approved Grading Plan up to the face amount of the letter of credit; and sue the Permittee(s) for recovery of any amount necessary to cure the default over and above the amount available under the letter of credit.

6.8.3 City Right to Complete Grading Improvements

The City shall have the right to complete the grading improvements, in substantial accordance with the Grading Plan, the engineer's estimate, and other requirements of this Manual, either itself or by contract with a third party or by assignment of its rights to a successor Permittee(s) who has acquired the project by purchase, foreclosure, or otherwise. The City, and Contractor under contract with the City, or any such successor Permittee(s), their agents, subcontractors and employees shall have the non-exclusive right to enter upon the subject property for the purpose of completing the grading improvements.

6.8.4 Use of Funds by the City

Any funds obtained by the City under a letter of credit, or recovered by the City from the Permittee(s) suit or otherwise, will be used by the City to pay the costs of completion of the Grading Improvements substantially in accordance with the Grading plan and the other requirements of this Manual and to pay the reasonable costs and expenses of the City in connection with the Default by Permittee(s), including reasonable attorneys' fees, with the surplus, if any, to be returned to the Permittee(s).

6.9 Post-Construction BMP Database

Washington City maintains an inventory of Post-Construction BMPs that are implemented at development projects that disturb greater than or equal to one acre. As part of project close-out, the permittee will be required to provide basic information on the stormwater control measures for each project which will include the following items:

- Name of project
- Owner's name
- Owner's contact information
- Location of project
- Project start date
- Project end date
- Short description of each stormwater control measure
- Short description of maintenance requirements

In addition to the items above, the owner/developer must provide the City information on who will be responsible for maintaining the post-construction stormwater control. If this information changes, the owner shall notify the City.

SECTION 7: LOW IMPACT GRADING PERMIT

Section 7 addresses a streamlined 10-step process for the Low Impact Grading Permit.

7.1 Qualifications for Low Impact Grading Permit

Section 7.1 identifies the qualifications for a Low Impact Grading Permit.

***Step 1*: Confirm that a Low Impact Permit is Required**

The first step in the process is to examine the information in Section 1.4 and 1.5 to confirm that a Low Impact Grading Permit is required for the project. This Low Impact Grading Permit applies to projects with a disturbed area less than one acre where insignificant negative impact can be adequately demonstrated to City staff.

The Public Works Department can be contacted to clarify Grading Permit requirements and interpret which Grading Permit, if any, applies to a particular project. A simplified permitting process is associated with a Low Impact Grading Permit. A Low Impact Grading Permit does not require Grading Drawings to be prepared or stamped by a Professional Engineer because typically the work does not involve engineering design.

Even with streamlined application and inspection procedures, the BMPs discussed herein shall be followed. If the City finds a Low Impact Permittee to be non-compliant, the Permit may be revoked and a Stop Work Order issued in accordance with Section 5.9.1.

7.2 Preparation Requirements for Low Impact Permit Applications and Drawings

Section 7.2 discusses the preparation requirements for a low impact permit application and drawing.

***Step 2*: Prepare a Low Impact Permit Application and Drawing**

7.2.1 Low Impact Permit Application Requirements

For Low Impact Permits, Grading Drawings shall be accompanied by a completed Low Impact Grading Permit Application (a copy is included at the end of this section). Nor Grading Report is required, but the application form requires descriptive information regarding the proposed project.

7.2.2. Low Impact Drawing Requirements

Although a detailed Grading Plan need not be prepared for sites where a Grading Low Impact Permit is sought, the following drawings shall be prepared and submitted to the City to provide enough information to determine if a Low Impact Permit is acceptable for the proposed work:

1. General Location Map-at a scale of 1 inch to 1000 feet to 1-inch to 8000 feet, indicating the general vicinity of the site location, including all roadways and a north arrow.
2. Detailed plan showing:
    - North arrow.
    - Approximate scale of drawing.
    - Limits of work area.
    - Proximity of work area to property lines.
    - All surface water hydrologic features within 100-feet of proposed work area and directional flow arrows indicating stormwater runoff.
    - Erosion and sediment control BMPs in accordance with these criteria.
    - An example Grading Drawing for a Low Impact Permit is included at the end of this section.

7.2.3. Required BMPs

A Low Impact Grading Permit requires at a minimum the installation of three basic BMPs.

The initial BMP is SCE: Stabilized Construction Entrance designed to reduce tracking of mud and dirt onto public roads adjacent to the construction site. Detailed information of its purpose, application, limitation, implementation, inspection and maintenance, and detailed drawings are available at the end of this section.

Construction BMPs include SSA: Stabilized Staging Area, and SWB: Straw Bale Barrier. These BMPs are designed to control sediment flow from the construction site. Detailed design information on the application, limitations, implementation, inspection and maintenance, and detailed drawings are available at the end of this section. Alternative BMPs are available in the BMP handbook included in Section 5. These BMPs may be used with the approval of the Washington City Public Works Department.

The purpose of Post Construction BMPs are to prevent disturbed areas from eroding on to adjacent areas. WM: Wood Mulch BMP is provided as an example BMP for post-construction use. Available alternatives such as hydroseeding, straw mulch, hydraulic mulch, and soil binders are presented in the BMP Manual in ***Appendix C***. These alternative BMPs may be used with the approval of the Washington City Public Works Department.

7.3 Low Impact Grading Submittal, Review, Acceptance, and Revision Process

***Step 3**: Submit the Low Impact Permit Application and Drawing to the City for Review and Acceptance and Revise Documents as Necessary to Address City Comments*

After the Grading Drawing has been prepared and a Low Impact Permit Application form has been filled out and signed, the items shall be submitted to the Public Works department. The Grading Plan will be reviewed for the effectiveness of the overall plan. After review, written comments will be provided to the applicant.

7.4 City Acceptance, Fees, and Fiscal Security

***Step 4**: After City Acceptance, Pay Fee, Submit Fiscal Security if Required, and Pick Up Low Impact Permit, Grading Drawing, and Grading Field Manual*

Once the Grading Drawing and Permit have been accepted by Washington City, the Applicant shall pick up the drawing, Permit, and a copy of the Grading Field Manual. At the same time, the Applicant shall pay permit fees to the City, and, if the City requires, submit Fiscal Security for the work. Permit fees shall be paid in accordance with Section 4.8 and Fiscal Security shall be submitted in accordance with Section 4.9.

7.5 Grading Field Manual and Permit Requirements

***Step 5**: Review Field Manual and Ensure that Permittee(s) Understand Permit Requirements*

The Permittee(s) shall thoroughly review the Grading Field Manual and the Grading Drawing for any BMPs that will be installed to understand all of the requirements of the Grading Permit Process and subcontractors or field personnel also need to be made aware of the grading requirements.

7.6 Installation of Initial BMPs

***Step 6**: Install Initial BMPs on the Project Site*

Once a copy of the Grading Field Manual has been picked up and reviewed, the Initial BMPs shown on the approved Grading Low Impact Drawing shall be installed.

7.7 Construction Start and Grading Requirements

***Step 7*: Start Construction, Implementing the Appropriate BMPs as Shown on the Permit Drawings. Approved Drawings and Permits Must be Available on Site at all Times**

After installation of the Initial BMPs, construction may begin. The approved Grading Permit, the accepted construction drawings and the Grading Field Manual are to be kept on site in the Permittee(s)' possession at all times.
During construction all grading criteria shall be adhered to. If Washington City finds a Low Impact Permit holder to be non-compliant with the Grading Permit or any other grading criteria, the Permit may be revoked and a Stop Work Order issued. The City may then require the Permittee(s) to obtain a Standard Grading Permit per Sections 2 through 6 of this Manual.

7.8 Inspection Schedules, Violations, and Stop Work Orders

***Step 8*: Address issues during any City inspections**

Under a Low Impact Grading Permit, only a final close-out inspection is required (and this only for certain cases); however, Grading Inspectors may visit a Low Impact site at any time. Permittee(s) shall address any comments or corrections required by the Grading Inspector. Failure to correct issues raised by the City may result in a Stop Work Order.

7.9 Post-Construction BMPs

***Step 9*: Install Post-Construction BMPs in Accordance with Grading Field Manual**

All disturbed areas shall be mulched in accordance with the Field Manual provided at the end of this section.

7.10 Final Close-out Inspection, Project Completion, and Release of Fiscal Security

***Step 10:* Schedule City Inspection when Construction is Complete and Post Construction BMPs are Installed. After Receiving Written Acceptance of Post Construction BMPs, the Project is Complete**

When required by the City, (refer to permit instructions) schedule an acceptance inspection with the Public Works Department.

After receiving written acceptance of the post construction BMPs, the project is complete; on-site BMPs may be removed and the fiscal security, if provided, will be released.

SECTION 8: HYDROLOGY

This section describes the minimum design and technical criteria for the analysis of storm drainage facilities. All new development and redevelopment projects in Washington City shall include adequate storm drainage system analysis and appropriate drainage system design which meets or exceeds the criteria provided in this Manual.

8.1 Hydrology Manual

For their hydrology manual, Washington City has adopted the manual by the Washington County Flood Control Authority (WCFCA) titled "*Storm Drainage Systems Design and Management Manual*" which was prepared as a collaboration effort between WCFCA and Bowen, Collins and Associates. The manual is located in ***Appendix F*** of this Grading Manual. All sections of the Hydrology Manual shall be applicable in Washington City except as described below.

8.1.1 Exceptions to WCFCA Hydrology Manual

Section 4.4 of the WCFCA Hydrology Manual titled "*Sediment/Debris Bulking*" is not applicable to the design of stormwater facilities within Washington City and the use of a bulking factor will not be required when determining peak stormwater discharge.

Appendix A of the WCFCA Hydrology Manual provides a checklist which can be utilized for the preparation of drainage reports. Washington City has developed their own checklist which will be utilized to evaluate drainage reports within the City. This Washington City checklist is provided in ***Appendix B*** of this Manual.

8.2 Green Infrastructure and Low-Impact Development (LID)

Washington City is a participating member of the Southwest Utah Stormwater Coalition (formerly known as the Dixie Stormwater Coalition) who has developed an LID Guidance Manual titled *"Green Infrastructure and Low-Impact Development Application Guidance for Washington County, Utah"*. The manual was developed to serve as a reference and guide for incorporating LID approaches into new development and redevelopment projects with specific guidance on the applicability and feasibility as it relates to the Dixie Metropolitan Area within Washington County. The complete manual is adopted into this Grading Manual and is located in ***Appendix G***.

SECTION 9: BIBLIOGRAPHY

The following is a list of references used in the development of the Grading Manual:

Douglas County Department of Public Works Engineering Division. *GESC Manual*. March 2004

City and County of Denver. Storm Drainage Design and Technical Manual. November 1999

City of Colorado Springs City Engineering Division. Drainage Criteria Manual Volume 2 Stormwater Quality Policies, Procedures and Best Management Practices. November 1, 2002.

California Stormwater Quality Association. California BMP Handbook. January 2003

Clark County Regional Flood Control District. Hydrologic Criteria and Drainage Design Manual. August 12, 1999

State of Utah Department of Agriculture and Food. Utah Noxious Weeds List.

Washington County. Noxious Weed. 2000

SECTION 10: APPENDICES

This section includes a number of appendices containing supplemental information, including sample drawings and review checklists. The following is a list of the items included in the appendices.

Appendix A: Sample Grading Plans and Grading Report

Appendix B: Drawings and Report Checklists for Standard Grading Permits

Appendix C: Washington City Best Management Practices Standard Notes and Details

Appendix D: Grading Permit

Appendix E: Fiscal Security Letter Form

Appendix F: Washington County Flood Control Authority Hydrology Manual

Appendix G: Dixie Stormwater Coalition Low Impact Development Guidance Manual

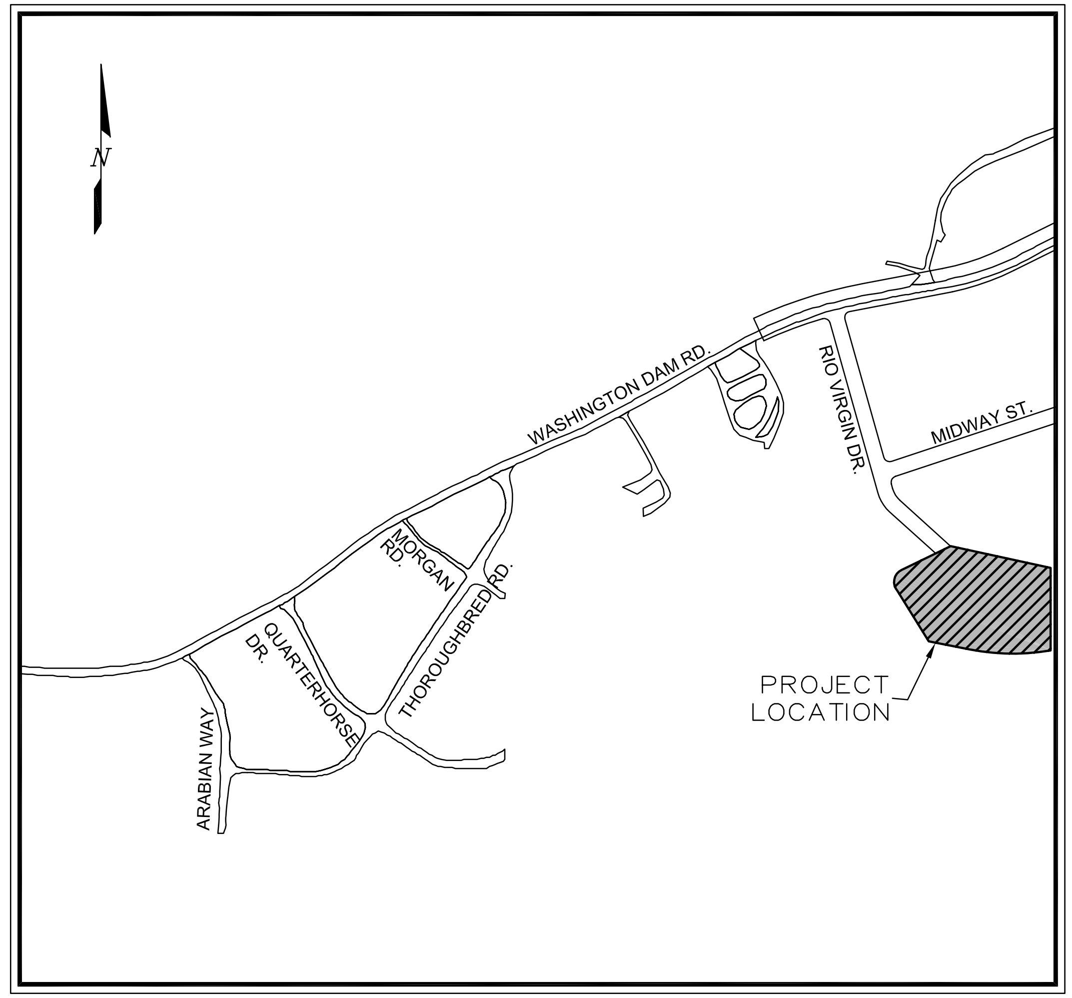
Appendix H: Noxious Weed Field Guide

Appendix A:

Sample Grading Plans and Grading Report

CONTRACT DRAWINGS FOR CONSTRUCTION OF

RESIDENTIAL SITE A GRADING PLAN



PROJECT LOCATION: SOUTHWEST QUARTER OF SECTION 25 TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE & MERIDIAN, WASHINGTON COUNTY, UTAH.

LOCATION MAP

SHEET INDEX	
1	COVER SHEET
2	PHASE I PRE CONSTRUCTION GRADING PLAN
3	PHASE I CONSTRUCTION GRADING PLAN
4	PHASE I POST CONSTRUCTION GRADING PLAN
5	PHASE II PRE CONSTRUCTION GRADING PLAN
6	PHASE II CONSTRUCTION GRADING PLAN
7	PHASE II POST CONSTRUCTION GRADING PLAN
8	PHASE I EARTHWORK BALANCE
9	PHASE II EARTHWORK BALANCE
10	BMP GENERAL NOTES AND LEGEND
11–22	BMP DETAILS AND INSTALLATION

THE GRADING PLAN INCLUDED HEREIN HAS BEEN PLACED IN THE WASHINGTON CITY FILE FOR THIS PROJECT AND APPEARS TO FULFILL APPLICABLE WASHINGTON CITY GRADING CRITERIA. ADDITIONAL GRADING MEASURES MAY BE REQUIRED OF THE OWNER OR HIS/HER AGENTS DUE TO UNFORESEEN EROSION PROBLEMS OR IF THE SUBMITTED PLAN DOES NOT FUNCTION AS INTENDED. THE REQUIREMENTS OF THIS PLAN SHALL RUN WITH THE LAND AND SHALL BE THE OBLIGATION OF THE LANDOWNER, OR HIS/HER DESIGNATED REPRESENTATIVE, UNTIL SUCH TIME AS THE PLAN IS PROPERLY COMPLETED, MODIFIED OR VOIDED.

PUBLIC WORKS DEPARTMENT

DATE

THESE CONSTRUCTION DRAWINGS HAVE BEEN REVIEWED BY WASHINGTON CITY FOR GRADING, IMPROVEMENTS ONLY.

PUBLIC WORKS ACCEPTANCE BLOCK

THE GRADING PLAN INCLUDED HEREIN HAS BEEN PREPARED UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH THE REQUIREMENTS OF THE WASHINGTON CITY GRADING MANUAL .

GRADING PLANS PREPARED BY:

ALLIANCE CONSULTING　　DATE　　PE NUMBER

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

ALLIANCE CONSULTING
A Planning and Engineering Firm
2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577
Tel (435) 673-8060
Fax (435) 673-8065

COVER SHEET FOR RESIDENTIAL SITE A GRADING PLAN LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB COVER

BMP LEGEND

- (CB) CONSTRUCTION BOUNDARY
- (CD) CHECK DAM
- (CW) CONCRETE WASHOUT
- (ED) EARTH DIKES AND DRAINAGE SWALES
- (EOT) ENTRANCE / OUTLET TIRE WASH
- (FR) FIBER ROLLS
- (GBB) GRAVEL BAG BERM
- (GM) GEOTEXTILES AND MATS
- (HM) HYDRAULIC MULCH
- (HS) HYDROSEEDING
- (LOC) LIMITS OF CONSTRUCTION
- (RR) RIP RAP
- (SSB) SAND BAG BARRIER
- (SB) SEDIMENT BASIN
- (ST) SEDIMENT TRAP
- (SLB) SOIL BINDERS
- (SM) STRAW MULCH
- (SF) SILT FENCE
- (SD) SLOPE DRAIN
- (SCE) STABILIZED CONSTRUCTION ENTRANCE
- (SCR) STABILIZED CONSTRUCTION ROADWAY
- (SWB) STRAW BALE BARRIER
- (SCP) STORM DRAIN INLET PROTECTION
- (SSV) STREET SWEEPING AND VACUUMING
- (VD) VELOCITY DISSIPATION DEVICES
- (WE) WIND EROSION CONTROL
- (WM) WOOD MULCH

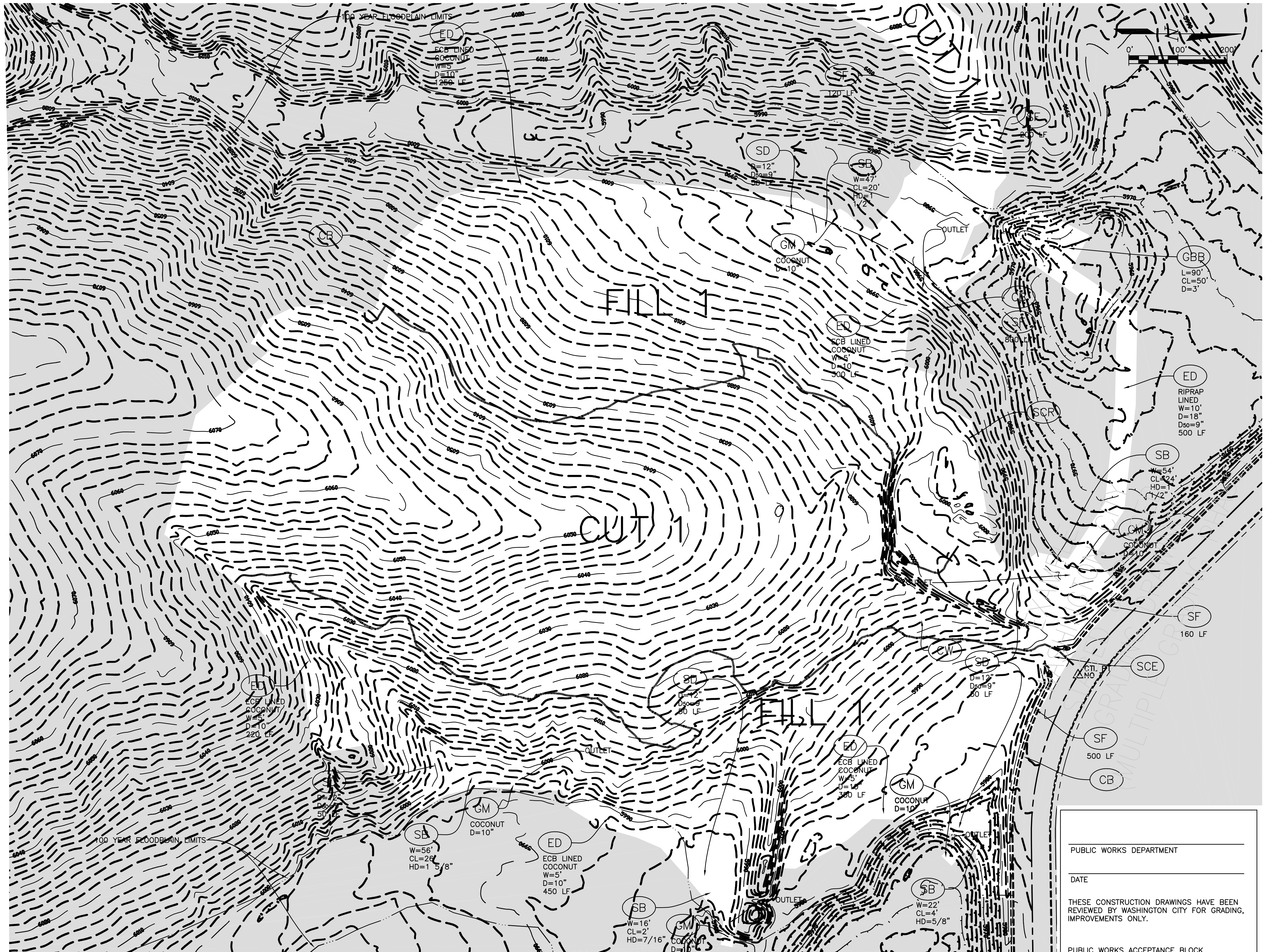
EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW
AREA OUTSIDE LIMITS OF CONSTRUCTION

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND OUTLET PROTECTION.



PUBLIC WORKS DEPARTMENT

DATE

THESE CONSTRUCTION DRAWINGS HAVE BEEN REVIEWED BY WASHINGTON CITY FOR GRADING, IMPROVEMENTS ONLY.

PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

ALLIANCE CONSULTING
A Planning and Engineering Firm
2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577
Tel (435) 673-8060
Fax (435) 673-8065

PHASE I PRE CONSTRUCTION GRADING PLAN
FOR
RESIDENTIAL SITE A
LOCATED IN WASHINGTON CITY,
WASHINGTON COUNTY,
UTAH

DRAWING NAME: SUB-ph1-ini.dwg

SHEET 2 OF 22 SHEETS

BMP LEGEND

- (CB) CONSTRUCTION BOUNDARY
- (CD) CHECK DAM
- (CW) CONCRETE WASHOUT
- (ED) EARTH DIKES AND DRAINAGE SWALES
- (EOT) ENTRANCE / OUTLET TIRE WASH
- (FR) FIBER ROLLS
- (GBB) GRAVEL BAG BERM
- (GM) GEOTEXTILES AND MATS
- (HM) HYDRAULIC MULCH
- (HS) HYDROSEEDING
- (LOC) LIMITS OF CONSTRUCTION
- (RR) RIP RAP
- (SSB) SAND BAG BARRIER
- (SB) SEDIMENT BASIN
- (ST) SEDIMENT TRAP
- (SLB) SOIL BINDERS
- (SM) STRAW MULCH
- (SF) SILT FENCE
- (SD) SLOPE DRAIN
- (SCE) STABILIZED CONSTRUCTION ENTRANCE
- (SCR) STABILIZED CONSTRUCTION ROADWAY
- (SWB) STRAW BALE BARRIER
- (SCP) STORM DRAIN INLET PROTECTION
- (SSV) STREET SWEEPING AND VACUUMING
- (VD) VELOCITY DISSIPATION DEVICES
- (WE) WIND EROSION CONTROL
- (WM) WOOD MULCH

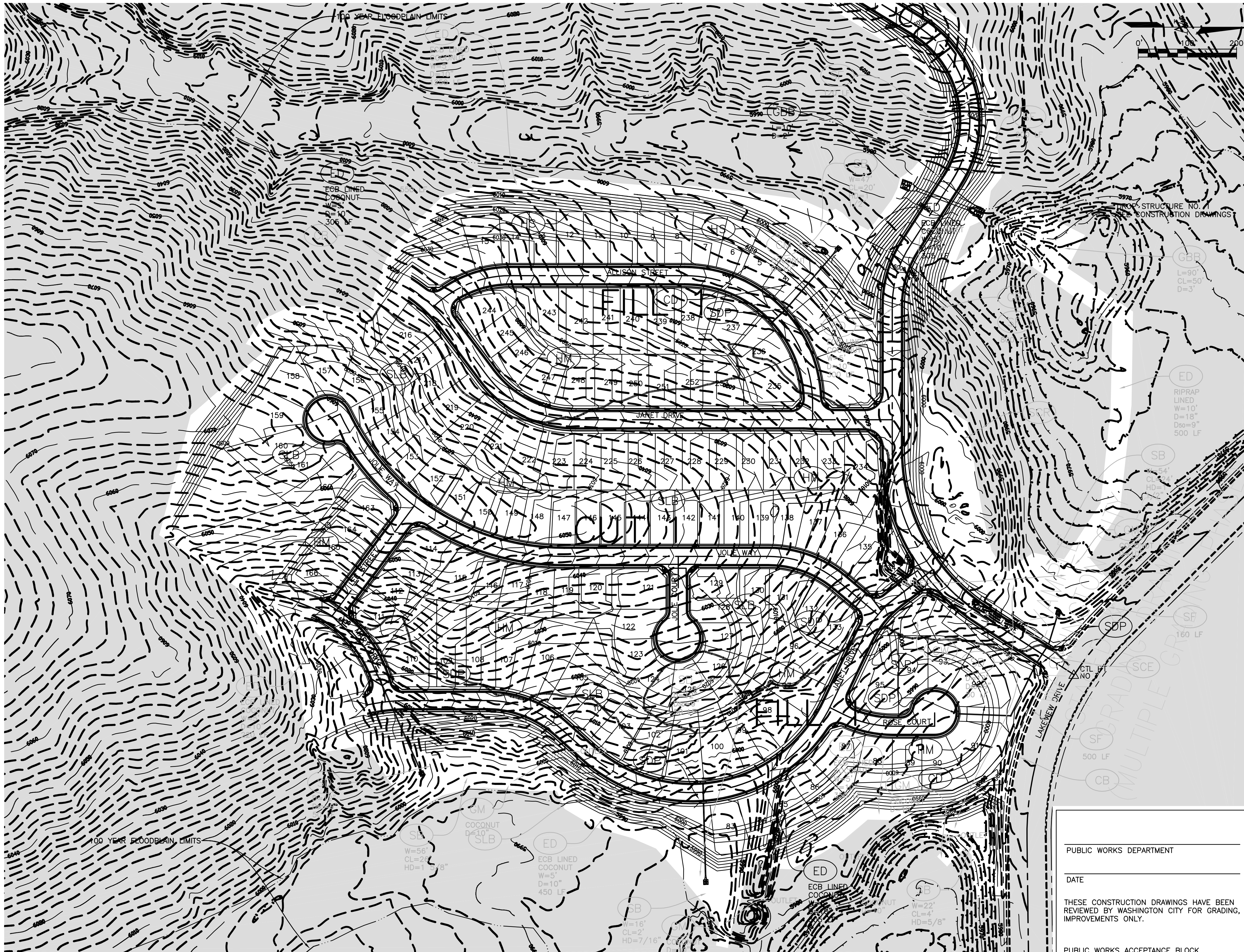
EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW
AREA OUTSIDE LIMITS OF CONSTRUCTION

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND OUTLET PROTECTION.



PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

DATE:	3/17/05
JOB NUMBER:	4114-04
SCALE:	NOT TO SCALE
DRAWN BY:	CWL
CHECKED BY:	MWB

ALLIANCE CONSULTING
A Planning and Engineering Firm
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PHASE I CONSTRUCTION GRADING PLAN FOR RESIDENTIAL SITE A

LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB-ph1-int.dwg

SHEET 3 OF 22 SHEETS

BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
HS	HYDROSEEDING
LOC	LIMITS OF CONSTRUCTION
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SB	SEDIMENT BASIN
ST	SEDIMENT TRAP
SLB	SOIL BINDERS
SM	STRAW MULCH
SF	SILT FENCE
SD	SLOPE DRAIN
SCE	STABILIZED CONSTRUCTION ENTRANCE
SCR	STABILIZED CONSTRUCTION ROADWAY
SWB	STRAW BALE BARRIER
SCP	STORM DRAIN INLET PROTECTION
SSV	STREET SWEEPING AND VACUUMING
VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW
AREA OUTSIDE LIMITS OF CONSTRUCTION

NOTES:
1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

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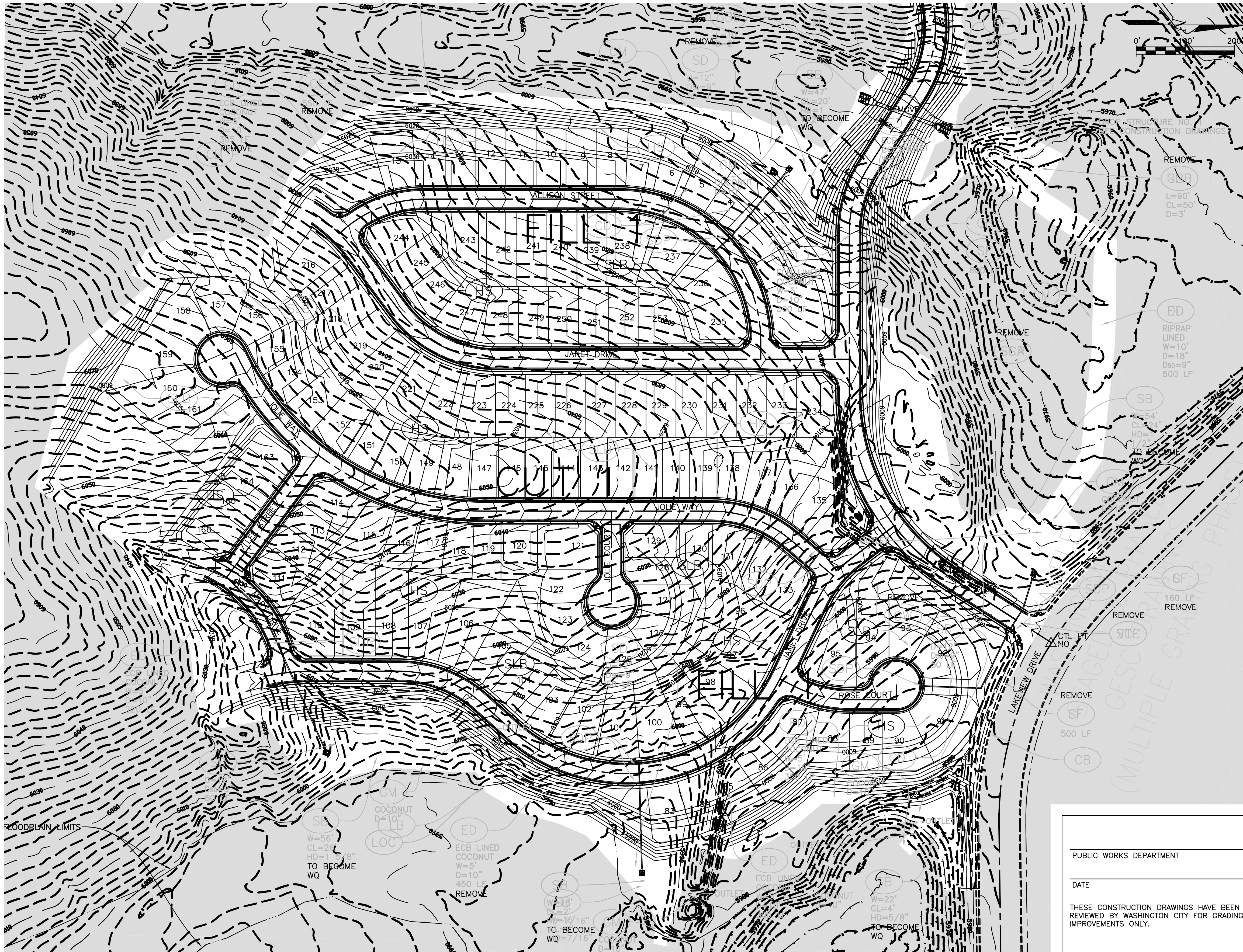

PUBLIC WORKS DEPARTMENT

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PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05
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PHASE I POST CONSTRUCTION GRADING PLAN FOR RESIDENTIAL SITE A
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

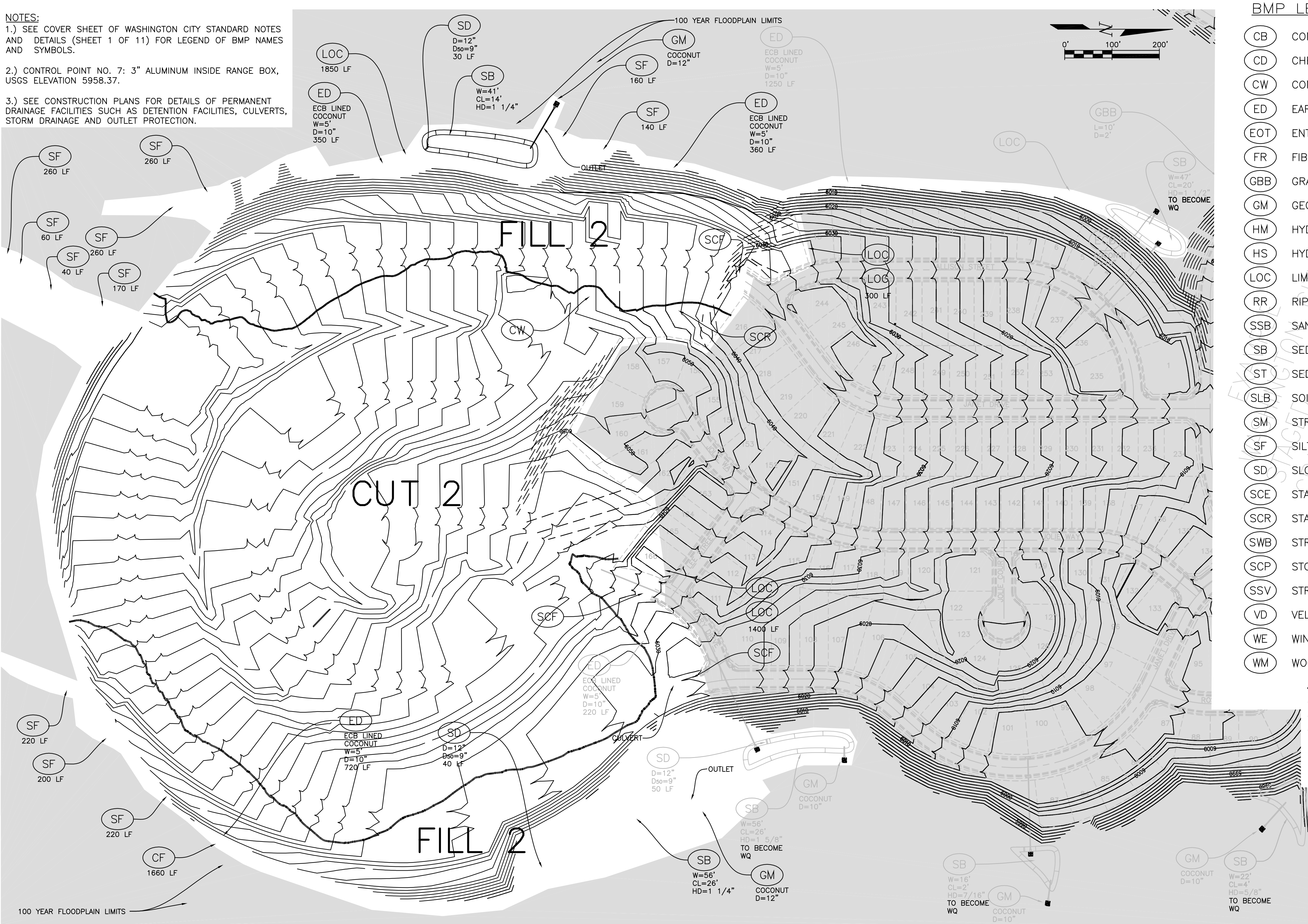
DRAWING NAME: SUB-ph1-fin.dwg
SHEET 4 OF 22 SHEETS

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND OUTLET PROTECTION.



BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
HS	HYDROSEEDING
LOC	LIMITS OF CONSTRUCTION
RR	RIP RAP
SSB	SAND BAG BARRIER
SB	SEDIMENT BASIN
ST	SEDIMENT TRAP
SLB	SOIL BINDERS
SM	STRAW MULCH
SF	SILT FENCE
SD	SLOPE DRAIN
SCE	STABILIZED CONSTRUCTION ENTRANCE
SCR	STABILIZED CONSTRUCTION ROADWAY
SWB	STRAW BALE BARRIER
SCP	STORM DRAIN INLET PROTECTION
SSV	STREET SWEEPING AND VACUUMING
VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW

AREA OUTSIDE LIMITS OF CONSTRUCTION

PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

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PHASE II PRECONSTRUCTION GRADING PLAN FOR RESIDENTIAL SITE A
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

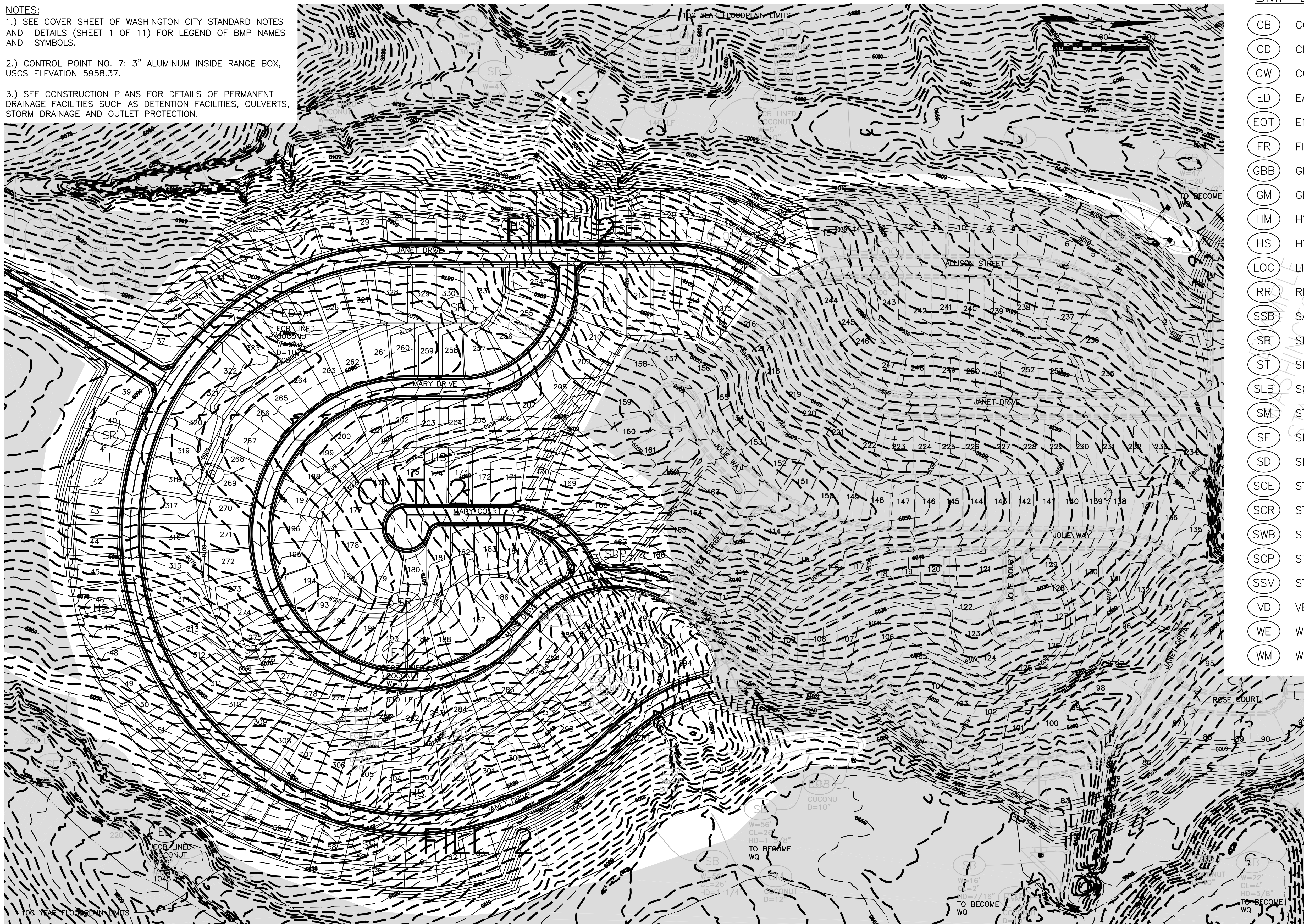
DRAWING NAME: SUB-ph2ini.dwg

SHEET 5 OF 22 SHEETS

NOTES:
1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND OUTLET PROTECTION.



BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
HS	HYDROSEEDING
LOC	LIMITS OF CONSTRUCTION
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WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW
AREA OUTSIDE LIMITS OF CONSTRUCTION

PUBLIC WORKS DEPARTMENT

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PHASE 2 CONSTRUCTION GRADING PLAN FOR RESIDENTIAL SITE A
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB ph2int.dwg

SHEET 6 OF 22 SHEETS

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 11) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) CONTROL POINT NO. 7: 3" ALUMINUM INSIDE RANGE BOX, USGS ELEVATION 5958.37.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND OUTLET PROTECTION.

BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
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SSB	SAND BAG BARRIER
SB	SEDIMENT BASIN
ST	SEDIMENT TRAP
SLB	SOIL BINDERS
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SF	SILT FENCE
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SCE	STABILIZED CONSTRUCTION ENTRANCE
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SWB	STRAW BALE BARRIER
SCP	STORM DRAIN INLET PROTECTION
SSV	STREET SWEEPING AND VACUUMING
VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW

AREA OUTSIDE LIMITS OF CONSTRUCTION

PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05
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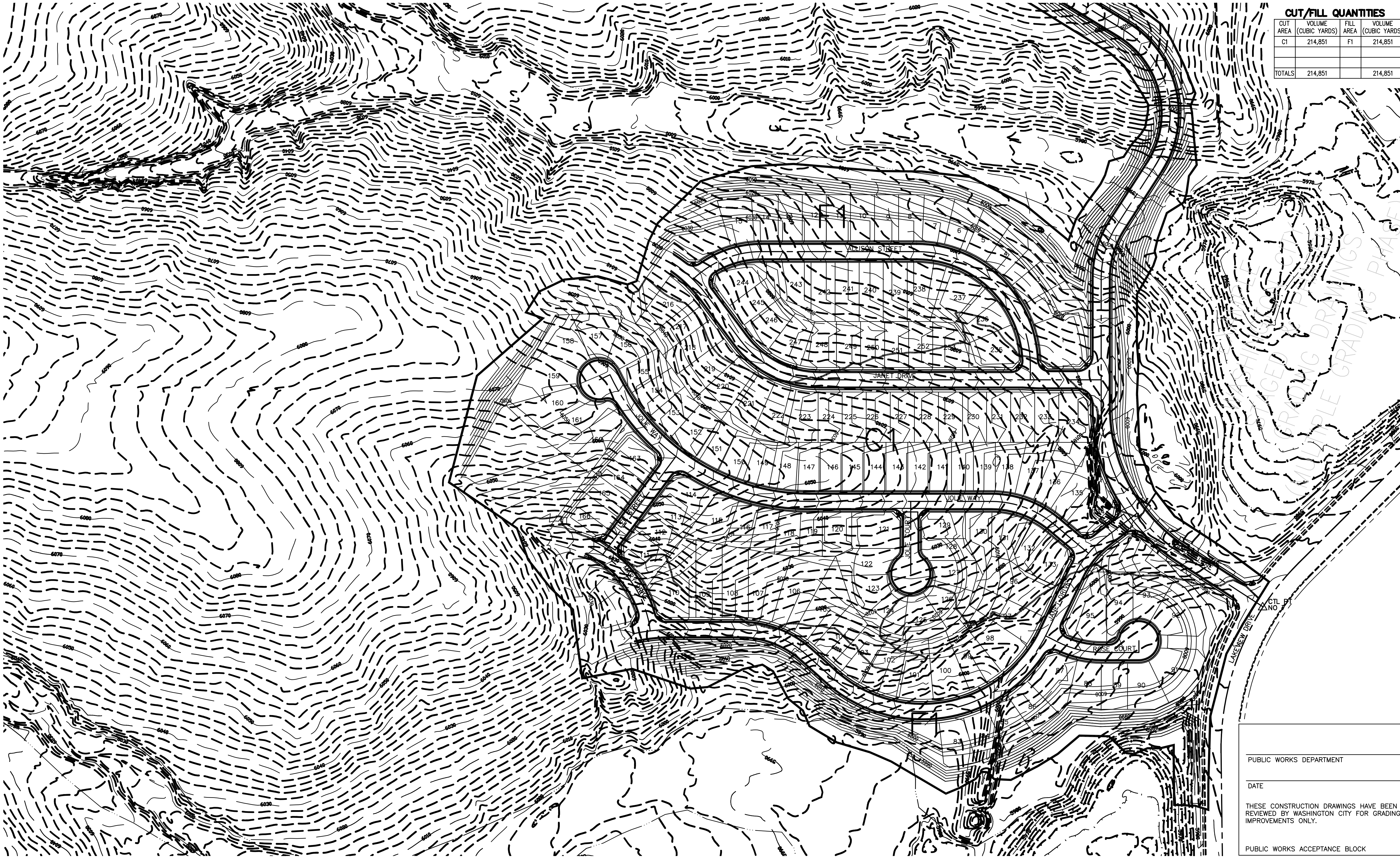
PHASE II POST CONSTRUCTION GRADING PLAN FOR RESIDENTIAL SITE A
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB ph2-fin.dwg

SHEET 7 OF 22 SHEETS



CUT/FILL QUANTITIES

CUT AREA	VOLUME (CUBIC YARDS)	FILL AREA	VOLUME (CUBIC YARDS)
C1	214,851	F1	214,851
TOTALS	214,851		214,851

PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05

JOB NUMBER: 4114-04

SCALE: NOT TO SCALE

DRAWN BY: CWL

CHECKED BY: MWB

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2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577
Tel (435) 673-8060
Fax (435) 673-8065

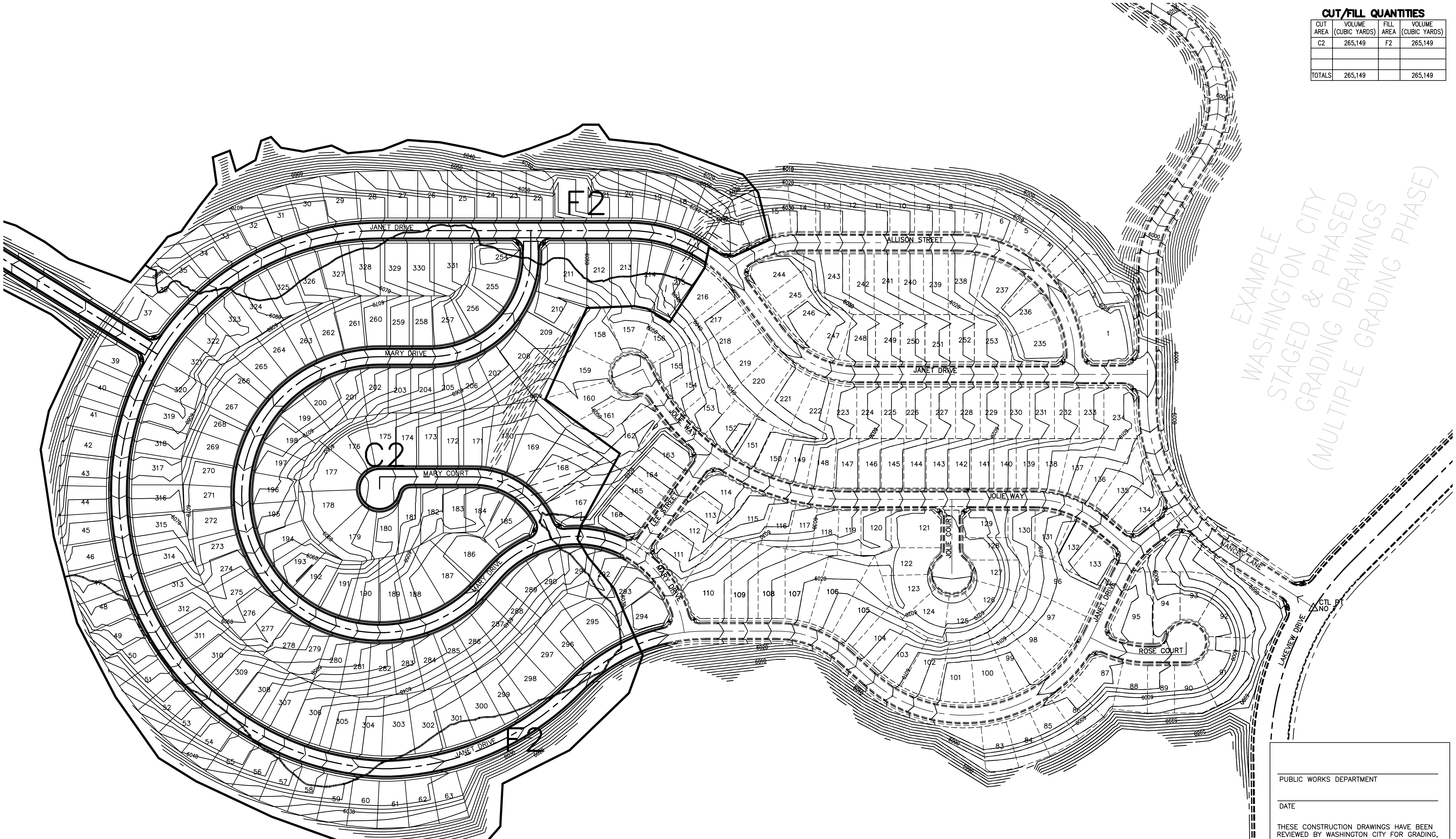
PHASE I EARTHWORK BALANCE PLAN FOR RESIDENTIAL SITE A

LOCATED IN WASHINGTON CITY,
WASHINGTON COUNTY,
UTAH

DRAWING NAME: SUB-ph1earthwork.dwg

PHASE II EARTHWORK BALANCE PLAN FOR RESIDENTIAL SITE A

LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH



CUT/FILL QUANTITIES

CUT AREA	VOLUME (CUBIC YARDS)	FILL AREA	VOLUME (CUBIC YARDS)
C2	265,149	F2	265,149
TOTALS	265,149		265,149

PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05

JOB NUMBER: 4114-04

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Washington, Utah 84780-0577
Tel (435) 673-8060
Fax (435) 673-8065

DRAWING NAME: SUB phase2earthwork

WASHINGTON CITY STANDARD
BMP NOTES AND DETAILS TO
GO HERE

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

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2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577
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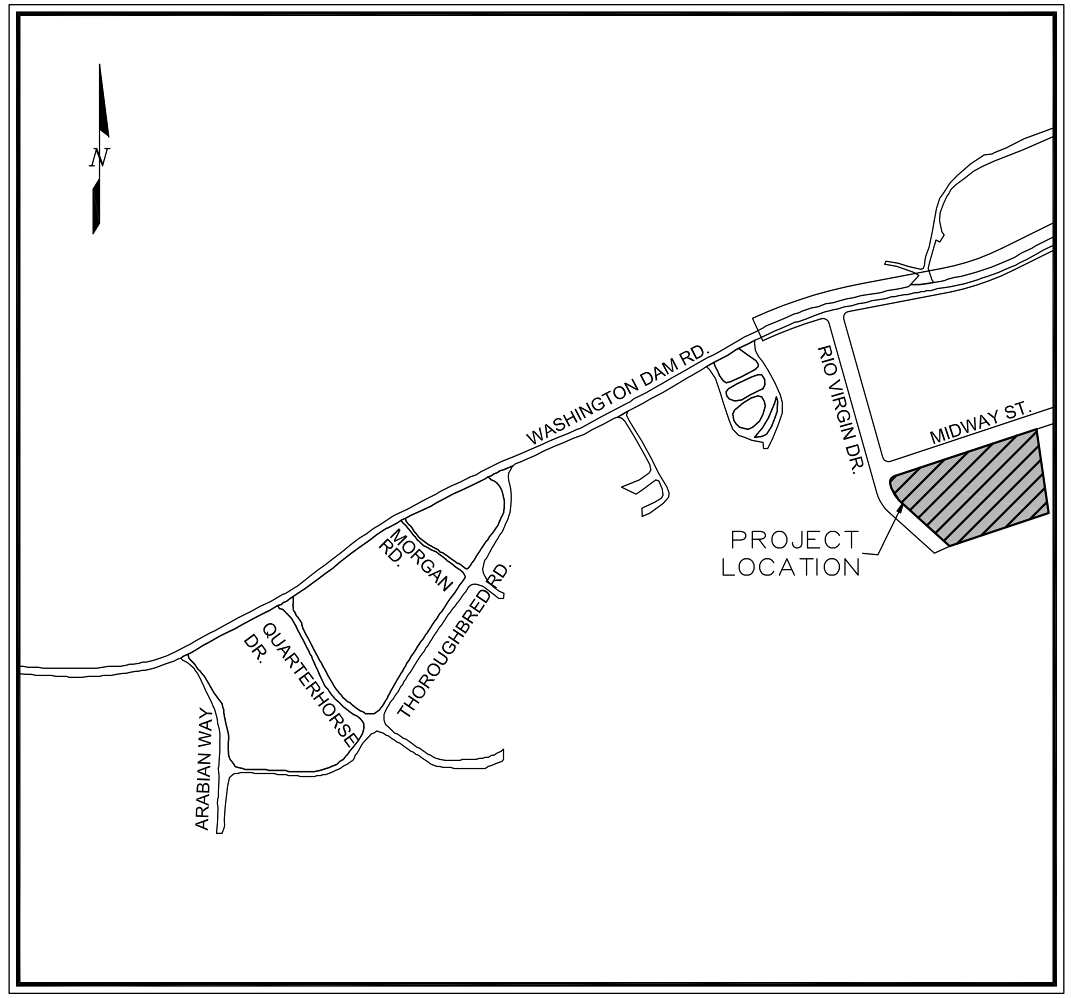
BMP GENERAL NOTES AND LEGEND
FOR
RESIDDINTIAL SITE A
LOCATED IN WASHINGTON CITY,
WASHINGTON COUNTY,
UTAH

DRAWING NAME: SUB-NOTES
SHEET 10 OF 22 SHEETS

CONTRACT DRAWINGS FOR CONSTRUCTION OF

DRY CREEK BUSINESS PARK GRADING PLAN



PROJECT LOCATION: SOUTHWEST QUARTER OF SECTION 25 TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE & MERIDIAN, WASHINGTON COUNTY, UTAH.

LOCATION MAP

SHEET INDEX	
1	COVER SHEET
2	SMALL SITE GRADING PLAN
3	BMP GENERAL NOTES AND LEGEND
4–17	BMP DETAILS AND INSTALLATION/MAINTANCE NOTES
18	ROCK AND RIP RAP GRADATIONS

THE GRADING PLAN INCLUDED HEREIN HAS BEEN PLACED IN THE WASHINGTON CITY FILE FOR THIS PROJECT AND APPEARS TO FULFILL APPLICABLE WASHINGTON CITY GRADING CRITERIA. ADDITIONAL GRADING MEASURES MAY BE REQUIRED OF THE OWNER OR HIS/HER AGENTS DUE TO UNFORESEEN EROSION PROBLEMS OR IF THE SUBMITTED PLAN DOES NOT FUNCTION AS INTENDED. THE REQUIREMENTS OF THIS PLAN SHALL RUN WITH THE LAND AND SHALL BE THE OBLIGATION OF THE LANDOWNER, OR HIS/HER DESIGNATED REPRESENTATIVE, UNTIL SUCH TIME AS THE PLAN IS PROPERLY COMPLETED, MODIFIED OR VOIDED.

PUBLIC WORKS DEPARTMENT

DATE

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PUBLIC WORKS ACCEPTANCE BLOCK

THE GRADING PLAN INCLUDED HEREIN HAS BEEN PREPARED UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH THE REQUIREMENTS OF THE WASHINGTON CITY GRADING MANUAL .

GRADING PLANS PREPARED BY:

ALLIANCE CONSULTING   DATE   PE NUMBER

DATE:	3/17/05
JOB NUMBER:	4114–04
SCALE:	NOT TO SCALE
DRAWN BY:	CWL
CHECKED BY:	MWB

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Washington, Utah 84780-0577
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COVER SHEET FOR DRY CREEK BUSINESS PARK GRADING PLAN
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB COVER

SHEET 1 OF 16 SHEETS

DATE:	3/17/05
JOB NUMBER:	4114-04
SCALE:	NOT TO SCALE
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CHECKED BY:	MWB

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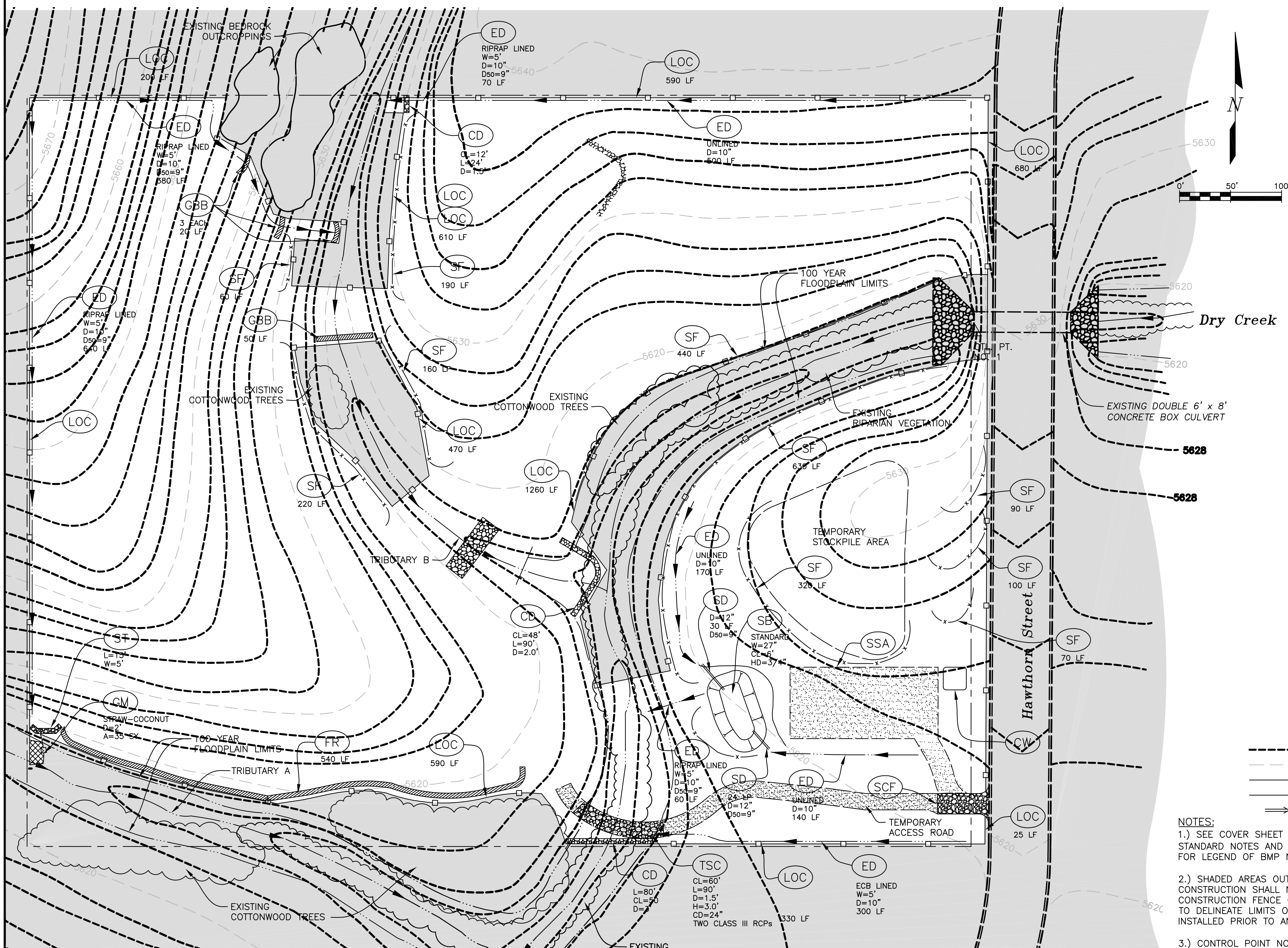

BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
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HS	HYDROSEEDING
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VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW

AREA OUTSIDE LIMITS OF CONSTRUCTION

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 14) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) SHADED AREAS OUTSIDE LIMITS OF CONSTRUCTION SHALL NOT BE DISTURBED. CONSTRUCTION FENCE OR CONSTRUCTION MARKERS TO DELINEATE LIMITS OF CONSTRUCTION SHALL BE INSTALLED PRIOR TO ANY OTHER WORK ON SITE.

3.) CONTROL POINT NO. 1: 3" BRASS CAP ON SOUTH CORNER OF WEST HEADWALL, USGS ELEVATION 5628.23.

PUBLIC WORKS DEPARTMENT

DATE

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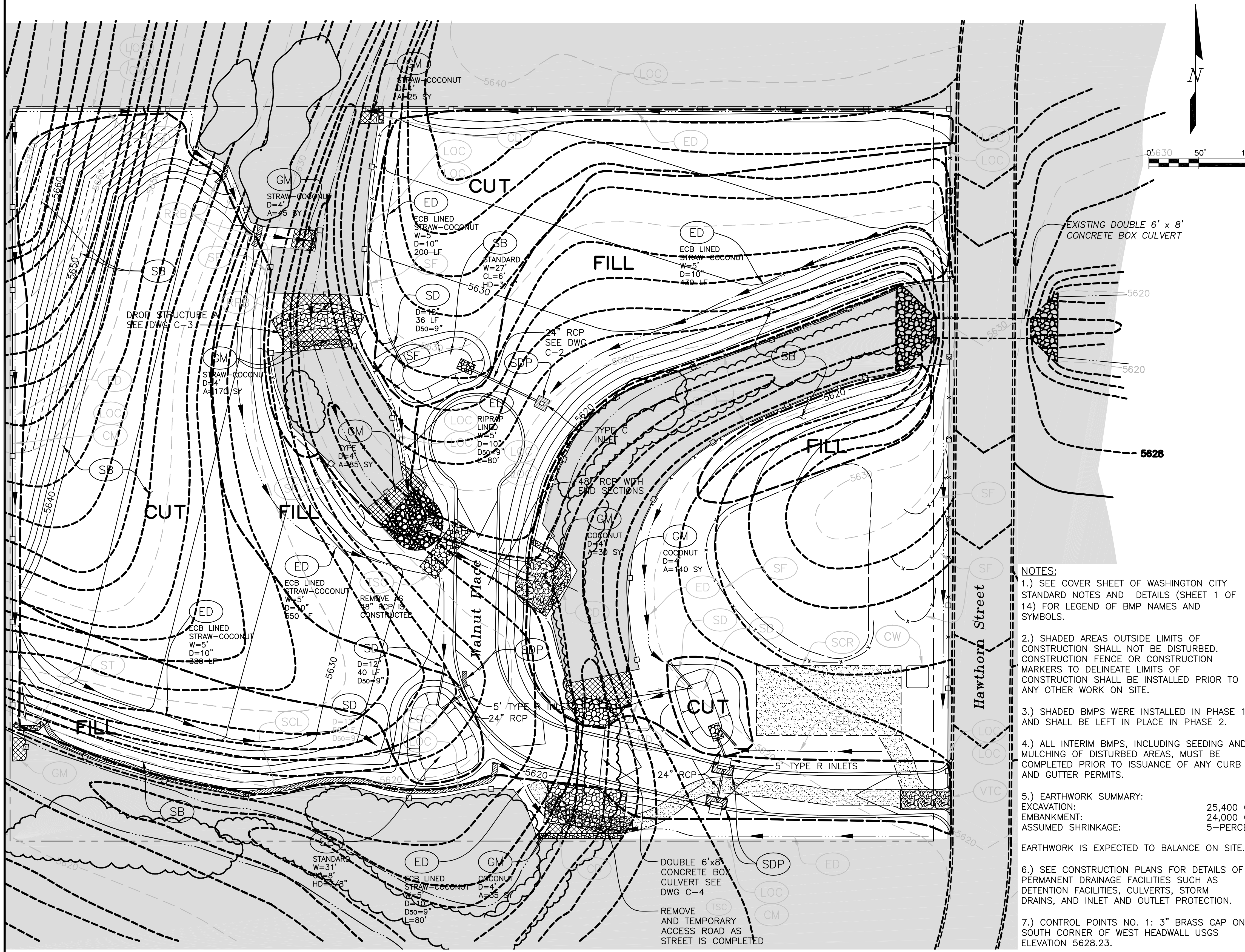
PUBLIC WORKS ACCEPTANCE BLOCK

PRE CONSTRUCTION GRADING PLAN FOR DRY CREEK BUSINESS PARK
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: MSP-E-1

SHEET 2 OF 18 SHEETS



BMP LEGEND

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VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 14) FOR LEGEND OF BMP NAMES AND SYMBOLS.

2.) SHADED AREAS OUTSIDE LIMITS OF CONSTRUCTION SHALL NOT BE DISTURBED. CONSTRUCTION FENCE OR CONSTRUCTION MARKERS TO DELINEATE LIMITS OF CONSTRUCTION SHALL BE INSTALLED PRIOR TO ANY OTHER WORK ON SITE.

3.) SHADED BMPS WERE INSTALLED IN PHASE 1 AND SHALL BE LEFT IN PLACE IN PHASE 2.

4.) ALL INTERIM BMPS, INCLUDING SEEDING AND MULCHING OF DISTURBED AREAS, MUST BE COMPLETED PRIOR TO ISSUANCE OF ANY CURB AND GUTTER PERMITS.

5.) EARTHWORK SUMMARY:

EXCAVATION:	25,400 CY
EMBANKMENT:	24,000 CY
ASSUMED SHRINKAGE:	5-PERCENT

EARTHWORK IS EXPECTED TO BALANCE ON SITE.

6.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINS, AND INLET AND OUTLET PROTECTION.

7.) CONTROL POINTS NO. 1: 3" BRASS CAP ON SOUTH CORNER OF WEST HEADWALL USGS ELEVATION 5628.23.

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW
AREA OUTSIDE LIMITS OF CONSTRUCTION

PUBLIC WORKS DEPARTMENT

DATE

THESE CONSTRUCTION DRAWINGS HAVE BEEN REVIEWED BY WASHINGTON CITY FOR GRADING, IMPROVEMENTS ONLY.

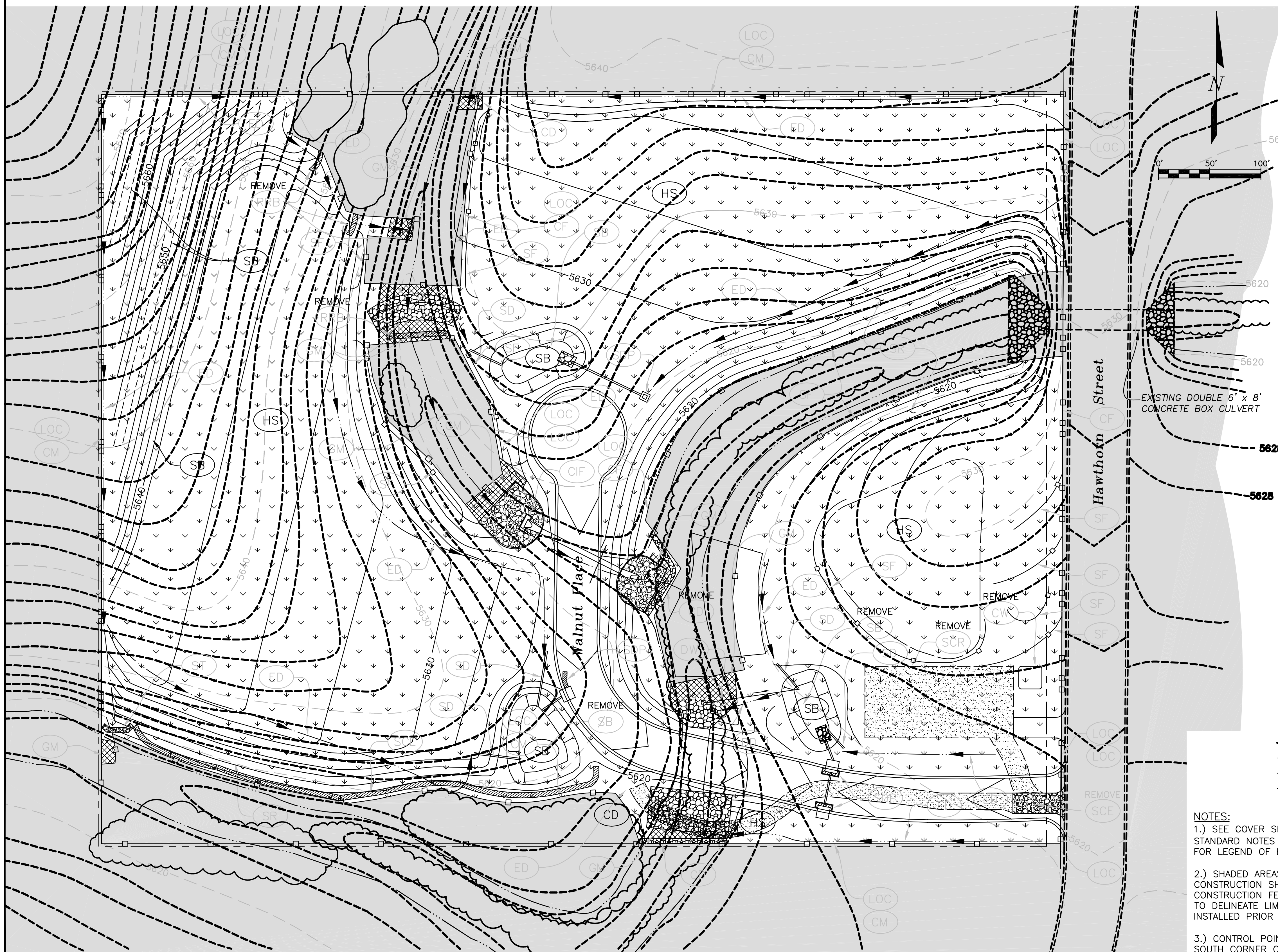
PUBLIC WORKS ACCEPTANCE BLOCK

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

ALLIANCE CONSULTING
A Planning and Engineering Firm
2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577
Tel (435) 673-8060
Fax (435) 673-8065

CONSTRUCTION GRADING PLAN FOR DRY CREEK BUSINESS PARK
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: MSP-E-1
SHEET 3 OF 18 SHEETS



BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
HS	HYDROSEEDING
LOC	LIMITS OF CONSTRUCTION
RR	RIP RAP
SSB	SAND BAG BARRIER
SB	SEDIMENT BASIN
ST	SEDIMENT TRAP
SLB	SOIL BINDERS
SM	STRAW MULCH
SF	SILT FENCE
SD	SLOPE DRAIN
SCE	STABILIZED CONSTRUCTION ENTRANCE
SCR	STABILIZED CONSTRUCTION ROADWAY
SWB	STRAW BALE BARRIER
SCP	STORM DRAIN INLET PROTECTION
SSV	STREET SWEEPING AND VACUUMING
VD	VELOCITY DISSIPATION DEVICES
WE	WIND EROSION CONTROL
WM	WOOD MULCH

EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DIRECTION ARROW

AREA OUTSIDE LIMITS OF CONSTRUCTION
AREA TO BE DRILL SEEDED AND CRIMP MULCHED.

NOTES:

1.) SEE COVER SHEET OF WASHINGTON CITY STANDARD NOTES AND DETAILS (SHEET 1 OF 14) FOR LEGEND OF BMP NAMES AND SYMBOLS

2.) SHADED AREAS OUTSIDE LIMITS OF CONSTRUCTION SHALL NOT BE DISTURBED. CONSTRUCTION FENCE OR CONSTRUCTION MARKERS TO DELINEATE LIMITS OF CONSTRUCTION SHALL BE INSTALLED PRIOR TO ANY OTHER WORK ON SITE.

3.) CONTROL POINT NO. 1: 3" BRASS CAP ON SOUTH CORNER OF WEST HEADWALL, USGS ELEVATION 5628.23.

PUBLIC WORKS DEPARTMENT

DATE

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Washington, Utah 84780-0577
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POST CONSTRUCTION GRADING PLAN
FOR
DRY CREEK BUSINESS PARK
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: MSP-E-1
SHEET 4 OF 18 SHEETS

WASHINGTON CITY STANDARD GESC NOTES AND DETAILS TO GO HERE

DATE: 3/17/05

JOB NUMBER: 4114-04

SCALE: NOT TO SCALE

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BMP GENERAL NOTES AND LEGEND FOR DRY CREEK BUSINESS PARK
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SP-E-4

SHEET 5 OF 18 SHEETS

CONTRACT DRAWINGS FOR CONSTRUCTION OF

BUSINESS SITE A GRADING PLAN

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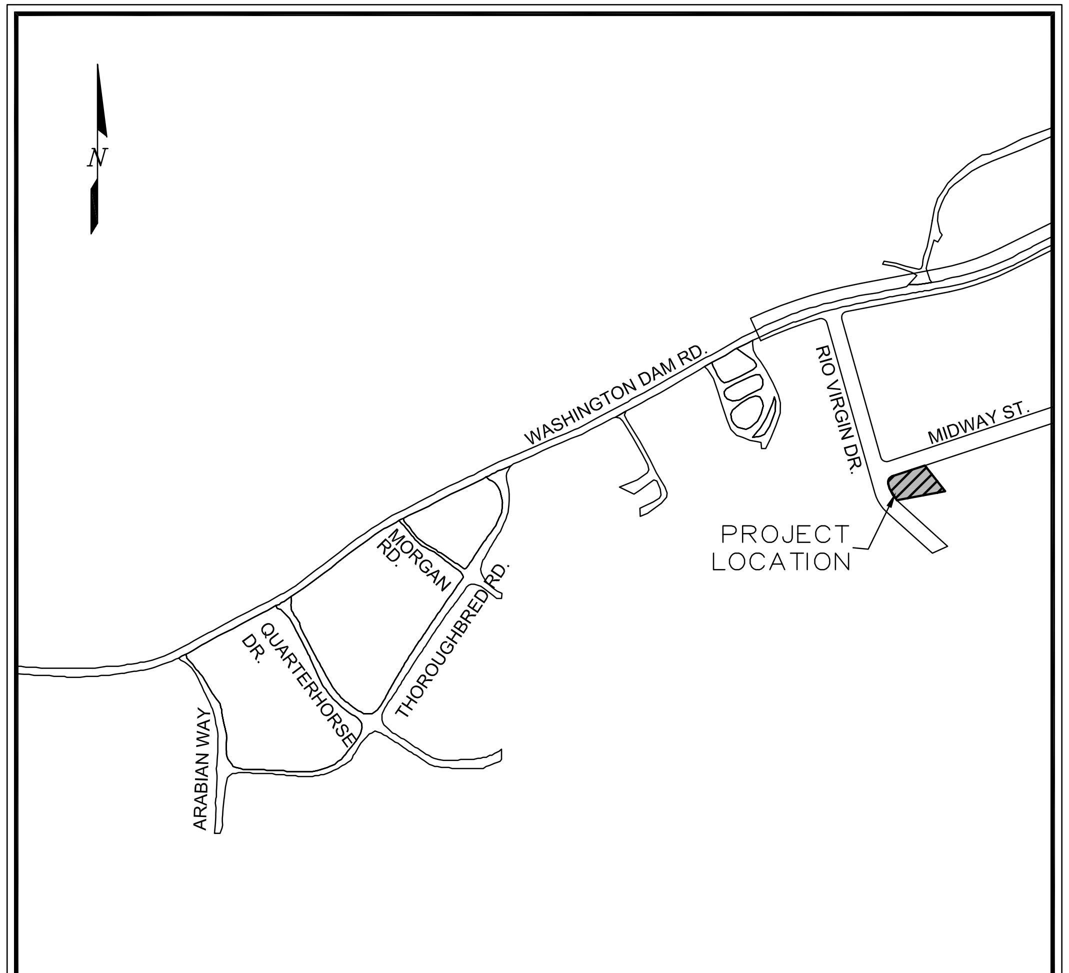

PROJECT LOCATION: SOUTHWEST QUARTER OF SECTION 25 TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE & MERIDIAN, WASHINGTON COUNTY, UTAH.

LOCATION MAP

SHEET INDEX	
1	COVER SHEET
2	SMALL SITE GRADING PLAN
3	BMP GENERAL NOTES AND LEGEND
4–15	BMP DETAILS AND INSTALLATION/MATINANCE NOTES
16	ROCK AND RIP RAP GRADATIONS

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GRADING PLANS PREPARED BY:

ALLIANCE CONSULTING

DATE

PE NUMBER

PUBLIC WORKS DEPARTMENT

DATE

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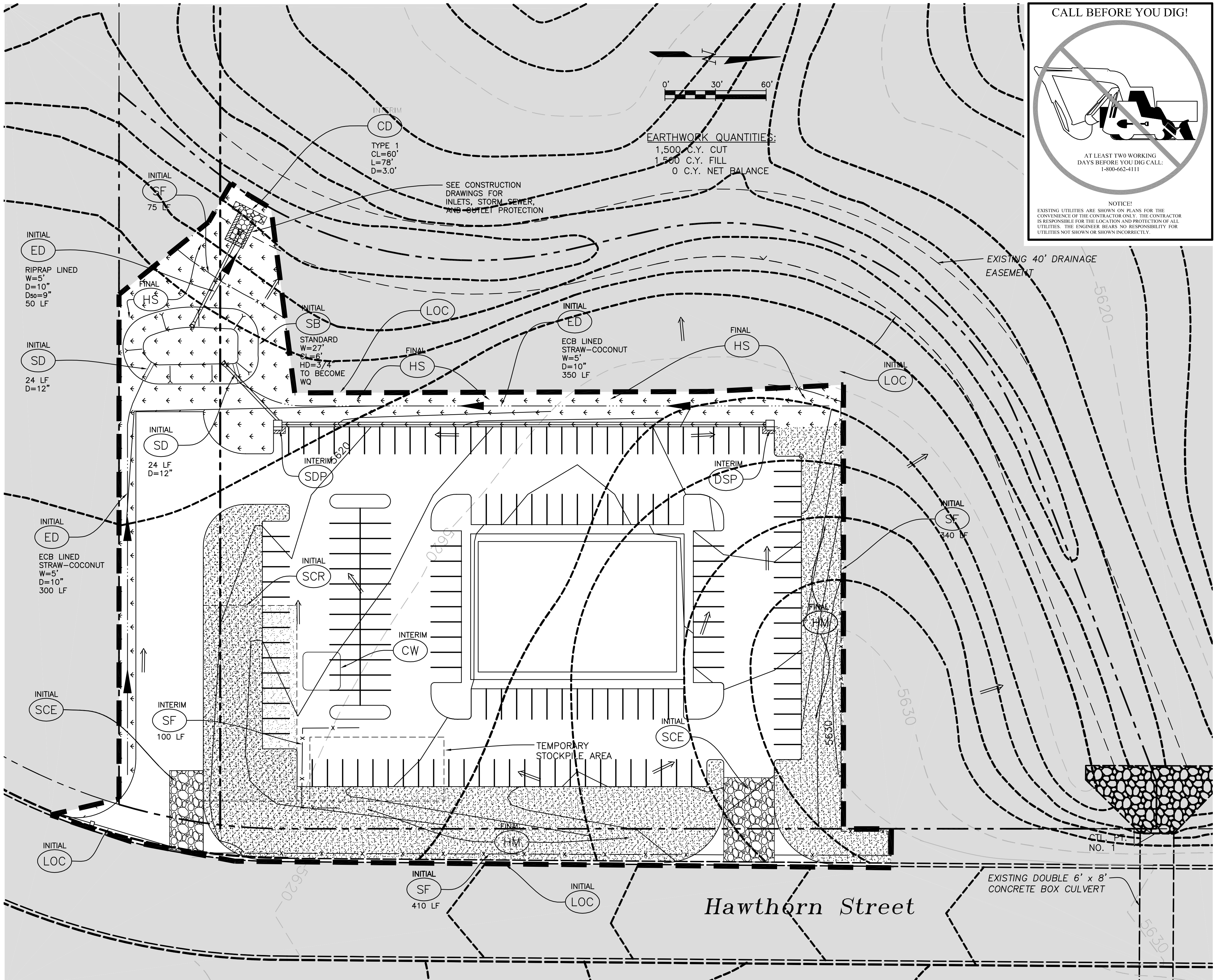
COVER SHEET FOR BUSINESS SITE A GRADING PLAN
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB COVER
SHEET 1 OF 16 SHEETS



BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
ED	EARTH DIKES AND DRAINAGE SWALES
EOT	ENTRANCE / OUTLET TIRE WASH
FR	FIBER ROLLS
GBB	GRAVEL BAG BERM
GM	GEOTEXTILES AND MATS
HM	HYDRAULIC MULCH
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EXISTING 2' CONTOUR
EXISTING 10' CONTOUR
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FLOW DIRECTION ARROW

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NOTES:

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2.) CONTROL POINT NO. 1: 3" BRASS CAP ON SOUTH CORNER OF WEST HEADWALL, USGS ELEVATION 5628.23.

3.) SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINAGE AND INLET AND OUTLET PROTECTION.

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Fax (435) 673-8065

GRADING PLAN FOR SMALL SITE
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: MSP-E-1

WASHINGTON CITY STANDARD
BMP NOTES AND DETAILS TO GO
HERE

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

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A Planning and Engineering Firm
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Fax (435) 673-8065

GENERAL BMP NOTES AND LEGEND
FOR
SMALL SITE / COMMERCIAL SITE A
LOCATED IN WASHINGTON CITY,
WASHINGTON COUNTY,
UTAH

DRAWING NAME: MSP-E-1
SHEET 3 OF 16 SHEETS

CONTRACT DRAWINGS FOR CONSTRUCTION OF

UTILITY GRADING PLAN

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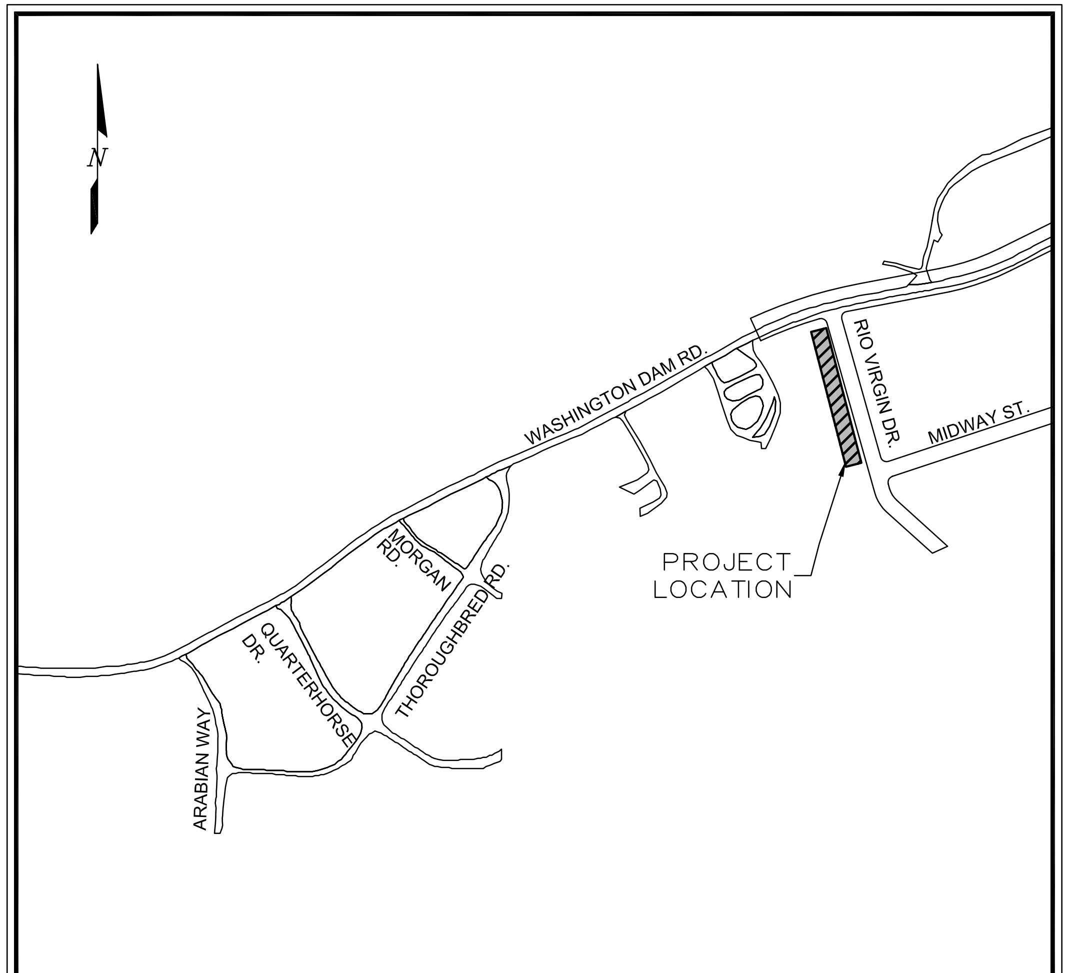

PROJECT LOCATION: SOUTHWEST QUARTER OF SECTION 25 TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE & MERIDIAN, WASHINGTON COUNTY, UTAH.

LOCATION MAP

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GRADING PLANS PREPARED BY:

ALLIANCE CONSULTING | DATE | PE NUMBER

DATE: 3/17/05
JOB NUMBER: 4114-04
SCALE: NOT TO SCALE
DRAWN BY: CWL
CHECKED BY: MWB

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A Planning and Engineering Firm
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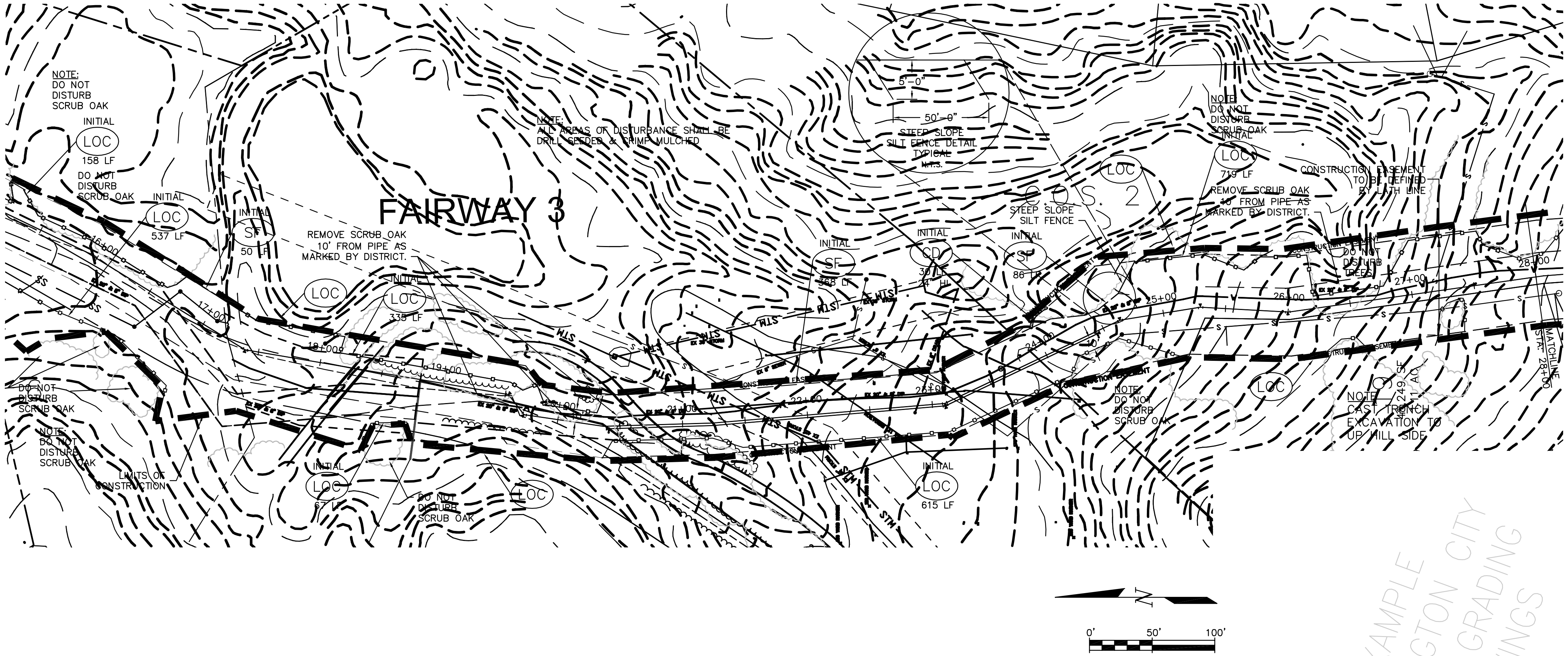
Fax (435) 673-8065
2303 N Coral Canyon Blvd., Suite 201
Washington, Utah 84780-0577

COVER SHEET FOR UTILITY GRADING PLAN
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: SUB COVER



BMP LEGEND

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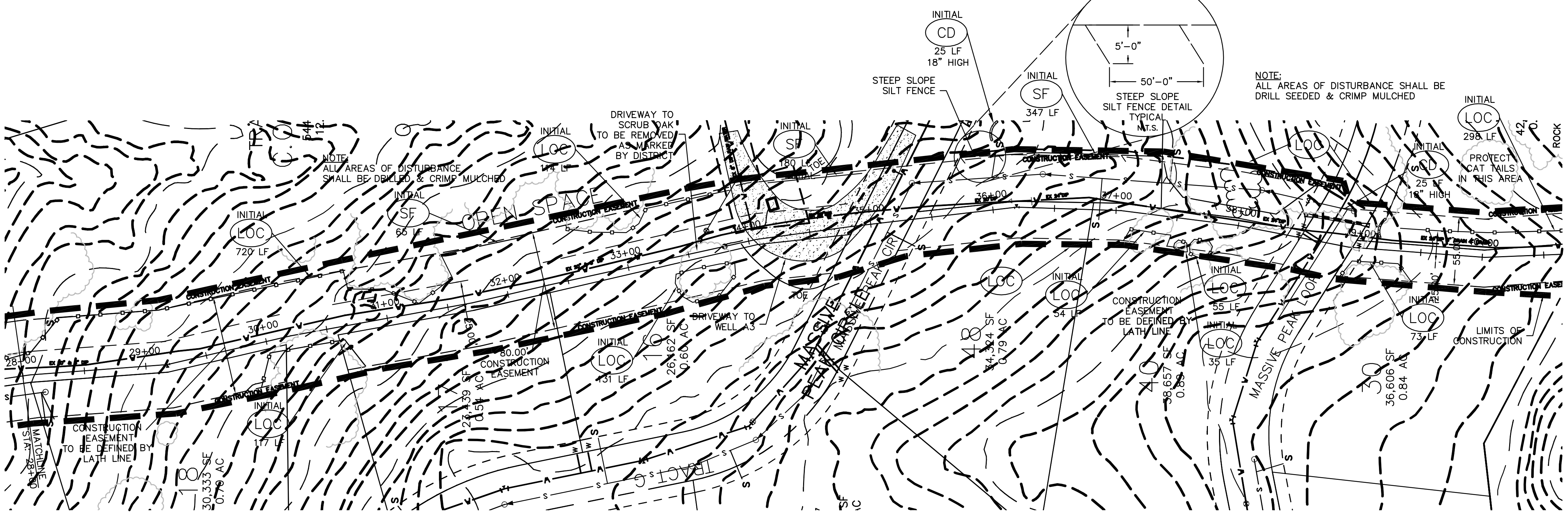
UTILITY GRADING PLAN FOR WATERLINE PLAN
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: UTIL-1 .dwg
SHEET 2 OF 17 SHEETS



NOTE
CAST TRENCH
EXCAVATION TO
UP HILL SIDE

0' 50' 100'

NOTE
CAST TRENCH
EXCAVATION TO
UP HILL SIDE

BMP LEGEND

CB	CONSTRUCTION BOUNDARY
CD	CHECK DAM
CW	CONCRETE WASHOUT
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EXISTING 10' CONTOUR
PROPOSED 2' CONTOUR
PROPOSED 10' CONTOUR
FLOW DRIECTION ARROW

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UTILITY GRADING PLAN FOR WATERLNE PLAN
LOCATED IN WASHINGTON CITY, WASHINGTON COUNTY, UTAH

DRAWING NAME: UTIL-1 .dwg

WASHINGTON CITY STANDARD GESC NOTES AND DETAILS TO GO HERE

DATE: 3/17/05

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BMP GENERAL NOTES AND LEGEND
FOR
GESC UTILITY PLAN
LOCATED IN WASHINGTON CITY,
WASHINGTON COUNTY,
UTAH

DRAWING NAME: UTIL-NOTES.dwg

SHEET 4 OF 17 SHEETS

Grading Report

Owner:
Okiobi Development
800 South 100 East
Washington, UT 84780

Project Number 4114-04:
Desert Sage Subdivision

Engineer's Seal:

Prepared By:
ALLIANCE CONSULTING
A Planning and Engineering Firm
2303 N. Coral Canyon Blvd
Suite 201
Washington, UT 84780
P 435.673.8060
F 435.673.8065

June 2006

Project Description

The Desert Sage Subdivision is located adjacent to Washington Dam Road on the southeast side of Shinob Kibe. The Desert Sage Subdivision encompasses approximately 27-acres and is located in Section 24 & 25, T42S, R15W, Salt Lake Base and Meridian, Washington City, Washington County, Utah. Desert Sage Subdivision is an industrial development and will include a combination of office, warehouse, and storage. Due to the location and nature of the existing raw ground the entire area will be disturbed.

Existing Site Conditions

The existing site conditions of the Desert Sage Subdivision are native ground covered with sparse amounts of desert vegetation. The average slope prior to grading is approximately 18.5%.

Existing Drainage

The existing drainage patterns on the site run through several small washes and concentrate along the north boundary of the proposed site. The runoff flows east to an area adjacent to the Indian Knolls Subdivision. A small portion of the proposed development drains toward Washington Dam Road.

Proposed Drainage

Drainage from the site will generally be directed to the southwest corner of the property. A small portion of the property will drain towards Washington Dam Road. The site will feature full retention of both onsite runoff and offsite run-on. A large retention pond will be constructed in the southwest corner of the project. A small retention pond will be constructed adjacent to Washington Dam Road to capture runoff from the entrance of the site.

Existing Jurisdictional Wetlands

The proposed Desert Sage Subdivision does not have jurisdictional wetlands within the project boundary.

Adjacent Areas

The area directly adjacent to the proposed Desert Sage Subdivision is currently undeveloped. The grading of the site will not negatively affect the adjacent properties. The drainage break occurs near the east boundary of the project. Stormwater runoff will not exit the site to the east and all onsite and offsite runoff will be captured in a retention basin located near the west boundary of the project. Emergency access will be provided to the property adjacent to west boundary.

Soils

The soil type existing within the proposed Desert Sage Subdivision is Badlands with a hydrologic group designation "D". Clay soils are not present on the site. The soils onsite are not collapsible. A report with greater detail concerning the soils existing within the project will be prepared by an independent geotechnical engineering firm and will be provided with the grading report. A considerable amount of rock may exist a short depth under the surface.

Areas and Volumes

Due to the steep slopes prevalent with the Desert Sage Development a significant amount of grading will be required to create a usable space. The site is a considerable elevation above the access point located on Washington Dam Road. A significant amount of export will be required to lower the sight elevation to a level where access can be achieved. The total volume of material moved is calculated to be approximately 233,458 cubic yards. 77,306 cubic yards of the material will be used to fill low points located on the project and to level building pads. A material volume of 156,152 cubic yards will be exported from the site. The exported material will be hauled to projects within a ten mile radius requiring fill material to raise existing elevations. The total area to be disturbed is approximately 27-acres.

Erosion and Sediment Control Measures

The existing site location offers unique challenges to prevent erosion and sediment control. All controls listed below will be installed in accordance to the BMP Manual and Washington City Standards.

Initial Controls

Initially the boundary along Washington Dam Road will have a silt fence installed adjacent to the right-of-way to prevent sediment from exiting the site. A stabilized construction access will be provided at the project entrance off of Washington Dam Road. Before mass grading begins a dike will be constructed around the site to prevent sediment laden runoff from exiting the site. A sediment basin will be provided at the low point to collect the runoff and discharge the stormwater after the majority of the sediment has settled to the bottom of the basin. Construction fence will be installed around the perimeter of the project to prevent unnecessary disturbance of areas not to be graded.

Interim Controls

As mass grading begins and material must be exported from the site a stabilized construction road will be constructed to the area where loading will be performed. Due to the volume of material being exported a wheel wash will be installed at the entrance of the site. Dust control will be accomplished by watering of the soil on a regular basis as conditions require. As the site is lowered the dike around the site will be lowered to ensure runoff will not leave the site at any time during grading. Street sweeping and vacuuming will be provided as conditions require or on an every other day schedule.

Final Controls

After grading is complete hydroseeding of slopes that will not be disturbed during the construction of structures will be performed. The retention ponds will be completed and runoff will concentrate at the ponds. Drainage channels will be lined with rock to prevent erosion. Where stormwater will cross roads culverts will be installed to prevent the road from being washed out. The entrance will be paved as soon after grading finalization has been achieved and weather conditions allow. A stabilized staging area will be provided for the contractor constructing the onsite structures. Landscaping will be provided to reduce surface erosion. All disturbed areas not landscaped will have a soil binder applied and reapplied as conditions require or site is built on.

Time/Phasing Schedule

The total time allotted for the grading portion of the project is six months. The construction of structures will begin when grading is finished and will continue at a rate determined by market conditions until the site is fully built out. A Microsoft Project Gant chart is provided to illustrate the schedule of the project and the times at which BMPs will be installed and removed.

Permanant Stabilization

After grading is complete hydroseeding of slopes that will not be disturbed during the construction of structures will be performed. The retention ponds will be completed and runoff will concentrate at the ponds. Drainage channels will be lined with rock to prevent erosion. Where stormwater will cross roads culverts will be installed to prevent the road from being washed out. The entrance and roadways will be paved as soon after grading finalization has been achieved and weather conditions allow. A stabilized staging area will be provided for the contractor constructing the onsite structures. Landscaping will be provided to reduce surface erosion. All disturbed areas not landscaped will have a soil binder applied and reapplied as conditions require or site is built on.

Stormwater Management Considerations

During a storm event occurring during the grading of the project the offsite stormwater will be captured by the drainage channel constructed along the boundary of the project and directed to the sediment basin located at the low point of the project. This will prevent the site from becoming a quagmire due to areas not being graded. Onsite storm water will be directed to sediment basin. A small portion of the site drains to Washington Dam Road. This runoff must pass through silt fence adjacent to Washington Dam Road before being able to enter the storm drain system. The silt fence will filter out the majority of the sediment before it exits the site. The stabilized entrance and wheel wash will help prevent mud from the site from exiting the project. Street sweeping and vacuuming will clean up whatever sediment is able to leave the site and is deposited on the road.

Maintanence

Plant incorporated in the landscape plan must be watered and maintained. All other BMPs will be provided as detailed in the BMP Manual.

Engineers Estimate

Below is a table showing the engineers estimate of installing, maintaining, and removing proposed BMPs.

Item	Description	Quantity	Unit	Unit Price	Extended Price
	Initial Controls				
1	Silt Fence	1,100	LN.FT.	$2.75	$3,025.00
2	Stabilized Construction Entrance	1	EACH	$1,250.00	$1,250.00
3	Drainage Dike	2,475	LN.FT.	$1.75	$4,331.25
4	Sediment Basin	1	EACH	$2,250.00	$2,250.00
5	Construction Fence	7,500	LN.FT.	$1.75	$13,125.00
	Interim Controls				
6	Stabilized Construction Road	350	LN.FT.	$50.00	$17,500.00
7	Wheel Wash	1	EACH	$2,000.00	$2,000.00
8	Watering	1	LS	$5,000.00	$5,000.00
9	Street Sweeping/Vacuuming	1	LS	$4,500.00	$4,500.00
	Final Controls				
10	Hydroseeding	6,500	SQ.FT.	$0.17	$1,105.00
11	Rip Rap	1,400	LN.FT.	$3.50	$4,900.00
12	Stabilized Staging Area	1	EACH	$1,500.00	$1,500.00
13	Landscaping	1	LS	$7,500.00	$7,500.00
14	Soil Binder	7,500	SQ.FT.	$0.92	$6,900.00
				Total	**$21,905.00**

*the above engineers estimate is meant to illustrate the format Washington City desires and is not meant to be utilized to prepare actual engineers estimates.

Calculations

No calculations were required to determine the required BMP sizing.

Other Information or Data

Section intended to be included in the event Washington City requires additional information or additional information is included but not required.

This Grading Plan has been placed in the Washington City file for this project and appears to fulfill the applicable Washington City Grading Criteria. Additional grading erosion and sediment control measures may be required of the owner or his/her agents, due to unforeseen erosion problems or if the submitted plan does not function as intended. The requirements of this plan shall run with the land owner, or his/her designated representative(s) until such time as the plan is properly completed modified or voided.

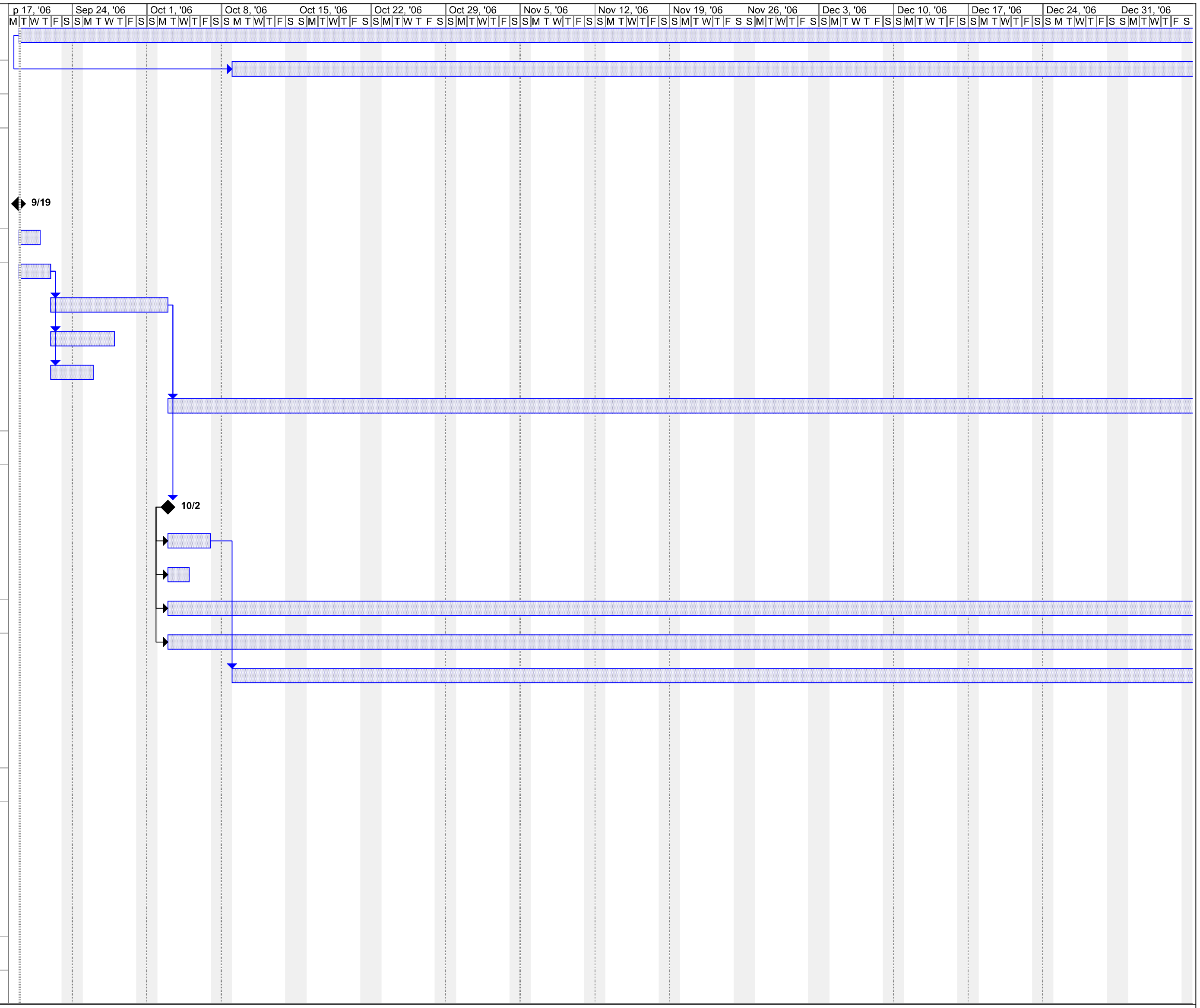
____
Owner Name (print)

____
Engineers Name (print)

____
Owner Signature

____
Engineers Signature

ID		Task Name	Duration	Start	Finish	Predecessors
1		Initial Controls	150 days	Tue 9/19/06	Mon 4/16/07	
2		Interim Controls	136 days	Mon 10/9/06	Mon 4/16/07	1SS+14 days
3		Final Controls	40 days	Tue 4/17/07	Mon 6/11/07	2
4						
5						
6		**Initial Controls**	0 days	Tue 9/19/06	Tue 9/19/06	
7		Silt Fence	2 days	Tue 9/19/06	Wed 9/20/06	
8		Stabilized Construction Entranc	3 days	Tue 9/19/06	Thu 9/21/06	
9		Drainage Dike	7 days	Fri 9/22/06	Mon 10/2/06	8
10		Sediment Basin	4 days	Fri 9/22/06	Wed 9/27/06	8
11		Construction Fence	2 days	Fri 9/22/06	Mon 9/25/06	8
12		Maintenance	140 days	Tue 10/3/06	Mon 4/16/07	9
13						
14						
15		**Interim Controls**	0 days	Mon 10/2/06	Mon 10/2/06	9
16		Stabilized Construction Road	4 days	Tue 10/3/06	Fri 10/6/06	15SS
17		Wheel Wash	2 days	Tue 10/3/06	Wed 10/4/06	15SS
18		Watering	140 days	Tue 10/3/06	Mon 4/16/07	15SS
19		Street Sweeping/Vacuuming	140 days	Tue 10/3/06	Mon 4/16/07	15SS
20		Maintenance	136 days	Mon 10/9/06	Mon 4/16/07	16
21						
22						
23		**Final Controls**	0 days	Mon 4/16/07	Mon 4/16/07	20
24		Hydroseeding	2 days	Tue 4/17/07	Wed 4/18/07	23
25		Rip Rap	14 days	Tue 4/17/07	Fri 5/4/07	23
26		Stabilized Staging Area	3 days	Tue 4/17/07	Thu 4/19/07	23
27		Landscaping	7 days	Tue 4/17/07	Wed 4/25/07	23
28		Soil Binder	3 days	Tue 4/17/07	Thu 4/19/07	23
29		Maintenance	26 days	Mon 5/7/07	Mon 6/11/07	25



Project: Project1
Date: Tue 9/19/06

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

Appendix B:

Drawings and Report Checklists for Standard Grading Permits

Washington City Public Works Department
Report Checklist for Grading Permit Process

Project:_____________________________

Date Grading Items Submitted:_________________

Checklist Items

Grading Items Submitted	☐ Yes	☐ No	☐ N/A
Required Engineering Drawing	☐ Yes	☐ No	☐ N/A
Grading Plans Checklist	☐ Yes	☐ No	☐ N/A
Drainage Report	☐ Yes	☐ No	☐ N/A
Drainage Report Checklist	☐ Yes	☐ No	☐ N/A
Grading Report	☐ Yes	☐ No	☐ N/A
Grading Report Checklist	☐ Yes	☐ No	☐ N/A
L.I.D. Report	☐ Yes	☐ No	☐ N/A
Soil Report	☐ Yes	☐ No	☐ N/A
Small Dam Report	☐ Yes	☐ No	☐ N/A
Grading Permit Application	☐ Yes	☐ No	☐ N/A

Date Completed:_________________

Stormwater Management Agreement
Date Submitted:______________________

Stormwater Management Plan
Date Submitted:_____________________

Grading Permit Fee Paid
Date Paid:_________________________

Restoration Bond (10% of Engineer's Estimate)
Date Submitted:_____________________

Release for Grading Only
Date Authorized:____________________

Released for Construction
Date Authorized:____________________

PUBLIC WORKS DEPARTMENT
DRAWINGS CHECKLIST FOR STANDARD GRADING PERMITS

Owner:	**Reviewer:** **Bob Butler**
Contactor:	**Date:**
Project:	**Review No:**

Cover Sheet

☐ Yes ☐ No 1. Project Name
☐ Yes ☐ No 2. Project Address
☐ Yes ☐ No 3. Owner Address
☐ Yes ☐ No 4. Design firm's name and address
☐ Yes ☐ No 5. Plan Sheet Index
☐ Yes ☐ No 6. Designers Signature Block
☐ Yes ☐ No 7. The following note:
The Grading Plan included herein has been placed in the Washington City file for this project and appears to fulfill applicable Washington City Grading Criteria. Additional grading, erosion and sediment control measures may be required of the permitee(s) due to unforeseen erosion problems or if the submitted plan does not function as intended. The Requirements of this plan shall run with the land and be the obligation of the permitee(s), until such time as the plan is properly completed, modified or voided.
☐ Yes ☐ No 8. Grading Plan Designer's signature block with name, date, and Professional Engineer registration number. Signature block shall include the following note:
The Grading Plan included herein has been prepared under my direct supervision in accordance with the requirements of the Grading Manual of Washington City.
☐ Yes ☐ No 9. City acceptance block
☐ Yes ☐ No 10. General location map at a scale of 1:1000-8000 feet indicating
- General vicinity of the site location
- Major road names
- North arrow and scale

Grading Drawing Index Sheet

For projects that require multiple plan-view sheets to adequately show the project area (based on the specified scale ranges), a single plan-view sheet shall be provided at a scale appropriate to show the entire site on one sheet. Areas of coverage of the multiple blow-up sheets are to be indicated as rectangles on the index sheet.

PUBLIC WORKS DEPARTMENT
DRAWINGS CHECKLIST FOR STANDARD GRADING PERMITS

INITIAL GRADING PLAN
This plan sheet shall provide grading, erosion and sediment controls for the initial clearing, grubbing and grading of a project. At a minimum, it shall contain:

☐ Yes	☐ No	1.	Property lines
☐ Yes	☐ No	2.	Existing and proposed easements
☐ Yes	☐ No	3.	Existing topography at one- or two-foot contour intervals, extending a minimum of 100 feet beyond the property line
☐ Yes	☐ No	4.	Location of any existing structures or hydrologic features within the mapping limits
☐ Yes	☐ No	5.	USGS Benchmark used for project
☐ Yes	☐ No	6.	Limits of construction encompassing all areas of work, access points, storage and staging areas, borrow areas, stockpiles, and utility tie-in locations in on-site and off-site locations. Stream corridors and other resource areas to be preserved and all other areas outside the limits of construction shall be lightly shaded to clearly show area not to be disturbed
☐ Yes	☐ No	7.	Location of stockpiles, including topsoil, imported aggregates, and excess material
☐ Yes	☐ No	8.	Location of storage and staging areas for equipment, fuel, lubricant, chemical (and other materials) and waste storage
☐ Yes	☐ No	9.	Location of borrow or disposal areas
☐ Yes	☐ No	10.	Location of temporary roads
☐ Yes	☐ No	11.	Location, map symbol, and letter callouts of all initial erosion and sediment control BMPs
☐ Yes	☐ No	12.	Information to be specified for each BMP, such as type and dimensions, as called for in the Standard Notes and Details
☐ Yes	☐ No	13.	The following note: *See Washington City Standard Notes and Details for Legend of BMP Names and Symbols*
☐ Yes	☐ No	14.	Washington City approval block
☐ Yes	☐ No	15.	Other information as may be reasonably required by Washington City

INTERIM GESC PLAN
This plan sheet shows BMPs to control grading, erosion and sediment during the initial overlot grading, site construction and site revegetation process. At a minimum, it shall contain the following information:

The Interim Grading Plan shall show all the information included on the Initial Grading Plan, as noted below:

☐ Yes	☐ No	1.	Existing topography at one- or two-foot contour intervals extending a minimum of 100 feet beyond the property line, as shown on Initial Grading Plan. These contours shall be screened.
☐ Yes	☐ No	2.	Location of all existing erosion and sediment control measures on site, as shown on the Initial Grading Plan Sheet. These control measures shall be screened. Dimension information for intital stage BMPs shall not be shown

☐ Yes ☐ No 3. Items 1, 2, and 4 through 10 from the Initial Grading Plan (see Section 3.17.3)

In addition, the Interim Grading Plan shall include the following:

☐ Yes ☐ No 4. Proposed topography at one- or two-foot contour intervals, showing elevations, dimensions, locations, and slope of all proposed grading

☐ Yes ☐ No 5. Outlines of cut and fill areas

☐ Yes ☐ No 6. Location of all interim erosion and sediment controls, designed in conjunction with the proposed site topography, but also considering the controls designed for the existing topography.

☐ Yes ☐ No 7. Locations of all buildings, drainage features and facilities, paved areas, retaining walls, cribbing, water quality facilities, or other permanent features to be constructed in connection with, or as a part of, the proposed work, per approved plat, or other improvement plan

☐ Yes ☐ No 8. The following notes:

- *See Washington City Standard Notes and Details for Legend of BMP Names and Symbols.*
- *Shaded BMPs were installed in initital stage and shall be left in place in interim stage.*
- *All interim BMPs, including seeding and mulching of disturbed areas, must be completed prior to any curb and gutter.*
- *See construction plans for details of permanent drainage facilites such as detention facilitites, culverts, storm drains, and inlet and outlet protection.*

☐ Yes ☐ No 9. Summary of cut and fill volumes

☐ Yes ☐ No 10. Washington City acceptance block

☐ Yes ☐ No 11. Other information or data as may be reasonably required by Washington City

Final Grading Plan.

This plan sheet shows controls for final completion of the site. At a minimum, this plan sheet shall contain the indicated information.

The Final Grading Plan shall include all information shown on the Initial and Interim Plans, as noted below:

☐ Yes ☐ No 1. Existing topography in areas of proposed contours need not be shown

☐ Yes ☐ No 2. Existing Initial and Interim BMPs shall be shown, (screened). Dimension information shall not be shown.

In addition, the following information shall be shown:

☐ Yes ☐ No 3. Directional flow arrows on all drainage features

☐ Yes ☐ No 4. Any Initial or Interim BMPs that are to be removed and any resulting disturbed area to be stabilized

☐ Yes ☐ No 5. Location of all Final erosion and sediment control BMPs (including seeding and mulching of any areas not stabilized in the Interim Plan), permanent landscaping, and measures necessary to minimize the movement of sediment off site until permanent post-construction controls can be established

PUBLIC WORKS DEPARTMENT
DRAWINGS CHECKLIST FOR STANDARD GRADING PERMITS

☐ Yes ☐ No 6. Show area of buildings, pavement, sod, and permanent landscaping (define types) per accepted plat, or other improvement plan

☐ Yes ☐ No 7. Show seeding and mulching (SM) or other post-construction control everywhere except buildings and pavement areas.

☐ Yes ☐ No 8. Show other BMPs considered by the designer to be appropriate

☐ Yes ☐ No 9. Show the following BMPs to be removed prior to end of construction:
- Indicate dewatering (DW) to be removed.
- Indicate temporary stream crossings (TSC) to be removed.
- Indicate stabilized staging area (SSA) to be removed.
- Indicate street inlet protection (IP) to be removed.
- Indicate vehicle tracking control (VTC) to be removed.
- Indicate construction fence (CF) to be removed.

☐ Yes ☐ No 10. The following notes:
- *See Washington City Standard Notes and Details for Legend of BMP Names and Symbols.*
- *Shaded BMPs were installed in initital or interim grading stage and unless otherwise indicated, shall be left in place until post-construction controls are approved by Washington City..*
- *See construction plans for details of permanent drainage facilites such as detention facilitites, culverts, storm drains, and inlet and outlet protection.*

☐ Yes ☐ No 10. Washington City acceptance block

☐ Yes ☐ No 11. Other information or data as may be reasonably required by Washington City

Grading Report Checklist

TO BE SUBMITTED BY THE DESIGN ENGINEER

Washington City
An Oasis of Opportunity

Owner: ____

Project: ____ **Date:** ______________

Engineer: ____ **Review #**___________

Report Requirements

☐Yes ☐No 1. Name, address, and telephone number of the applicant—
The name, address, and telephone number of the Professional Engineer preparing (or supervising the preparation of) the Grading Plan shall also be included, if different from the Applicants.

☐Yes ☐No 2. Project description—A brief description of the nature and purpose of the land-disturbing activity the total area of the site, the area of disturbance involved, and project location including township, range, section and quarter-section, or the latitude and longitude, of the approximate center of the project.

☐Yes ☐No 3. Existing site conditions—A description of the existing topography, vegetation, and drainage; a description of any wetlands on the site; and, or any other unique features of the property.

☐Yes ☐No 4. Adjacent areas—A description of the neighboring areas such as streams, lakes, residential areas, roads, etc., which may be affected by the land disturbance.

☐Yes ☐No 5. Soils—A brief description of the soils on the site including information on soil type and names, mapping unity, erodibility, permeability, hydrologic soil group, depth, texture, and soil structure (this information may be obtained from the soil report for the site or the applicable Soil Survey prepared by the Natural Resources Conservation Service).

☐Yes ☐No 6. Areas and Volumes—An estimate of the quantity (in cubic yards) of excavation and fill involved (indicating a balance with the phase), and the surface area (in acres) of the proposed disturbance.

☐Yes ☐No 7. Erosion and sediment control measures—A description of the methods presented in the Grading Manual that will be used to control erosion and sediment on the site.

☐Yes ☐No 8. Timing/Phasing schedule—A schedule indicating the anticipated starting and completion time periods of the site grading and/or construction sequence, including the installation and removal of erosion and sediment control BMP's. Indicate the anticipated starting and completion time periods of individual project phases.

☐Yes ☐No 9. Permanent stabilization—a brief description, including applicable specifications, of how the site will be stabilized after construction is completed.

☐Yes ☐No 10. Stormwater management considerations—Explain how stormwater runoff from and through the site will be handled during construction.

☐Yes ☐No 11. Maintenance—Any special maintenance requirements over and above what is identifies in the standard notes and details.

☐Yes ☐No 12. Engineer's Estimate for installation and maintenance of controls—An engineer's estimate for erosion and sediment control costs, including anticipated maintenance during the construction phase, shall be submitted with the Grading Plan. This will be reviewed by City staff and used as a basis for fiscal security.

☐Yes ☐No 13. Calculations—Any calculations made for the design of such items as sediment basins or erosion control blankets selection.

☐Yes ☐No 14. Other information or data—As may be reasonably required by Washington City. Including Sediment calculations. (otherwise 3600cf/acre)

☐Yes ☐No 15. The following note—*"This Grading Plan has been placed in the Washington City file for this project and appears to fulfill the applicable Washington City Grading Criteria. I understand that additional grading; erosion and sediment control measures may be required of the Permittee's, due to unforeseen erosion problems or if the submitted plan does not function as intended. The requirements of this plan shall run with the land and be the obligation of the Permittee's until such time as the plan is properly completed, modified or voided."*

☐Yes ☐No 16. Signature Page for Permittee's acknowledging the review and acceptance of responsibility, and a statement by the Professional Engineer acknowledging responsibility for the preparation of the Grading Plan

Engineer's Seal:

Reviewed By: ____________________________________

Drainage Report Check List

Washington City
An Oasis of Opportunity

Owner: ____

Project: ____ **Date:** ______________

Engineer: ____ **Review #**___________

I. GENERAL LOCATION AND DESCRIPTION

A. Location

- ☐ Township, range, section, 1/4 section
- ☐ Local streets within and adjacent to the subdivision with ROW width shown
- ☐ Major drainageways, facilities, and easements within and adjacent to the site
- ☐ Names of surrounding developments

B. Description of Property

- ☐ Area in acres
- ☐ Ground cover (type of trees, shrubs, vegetation, general soil conditions, topography, and slope)
- ☐ Major drainageways
- ☐ General project description
- ☐ Irrigation facilities
- ☐ Proposed land use

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

- ☐ Reference to major drainageway planning studies such as flood hazard delineation report, Storm Water Capital Facilities Master Plan, and flood insurance rate maps
- ☐ Major basin drainage characteristics, existing and planned land uses
- ☐ Identification of all irrigation facilities within the basin which will influence or be influenced by the local drainage

B. Sub-Basin Description

- ☐ Discussion of historic drainage patterns of the property in question
- ☐ Discussion of offsite drainage flow patterns and impact on development under existing and fully developed basins (include a table showing pre-developed and post-developed flows for each sub basin)

III. DRAINAGE DESIGN CRITERIA

A. Regulations

- ☐ Discussion of the optional provisions selected or the deviation from the HYDROLOGY MANUAL, if any, and its justification.

B. Development Criteria Reference and Constraints

- ☐ Discussion of previous drainage studies (i.e., project master plans) for the site in question that influence or are influenced by the drainage design and how the plan will affect drainage design for the site
- ☐ Discussion of the effects of adjacent drainage studies
- ☐ Discussion of the drainage impact of site constraints such as streets, utilities, transitways, existing structures, and development or site plan

C. Hydrological Criteria

- ☐ Identify design rainfall
- ☐ Identify runoff calculation method
- ☐ Identify detention discharge and storage calculation method
- ☐ Identify design storm recurrence intervals
- ☐ Discussion and justification of other criteria or calculation methods used that are not presented in or referenced by the HYDROLOGY MANUAL

D. Hydraulic Criteria

- ☐ Identify various capacity references
- ☐ Discussion of other drainage facility design criteria used that are not presented in the HYDROLOGY MANUAL

IV. DRAINAGE FACILITY DESIGN

A. General Concept

- ☐ Discussion of concept and typical drainage patterns
- ☐ Discussion of compliance with offsite runoff considerations
- ☐ Discussion of the content of tables, charts, figures, plates, or drawings presented in the report
- ☐ Discussion of anticipated and proposed drainage patterns

B. Specific Details

- ☐ Discussions of drainage problems encountered and solutions at specific design points
- ☐ Discussion of detention storage and outlet design
- ☐ Discussion of maintenance access and aspects of the design
- ☐ Discussion of easements and tracts for drainage purposes, including the conditions and limitations for use

V. CONCLUSIONS

A. Compliance with Standards

- ☐ "HYDROLOGY MANUAL"
- ☐ "Storm Water Capital Facilities Master Plan"

- ☐ “GRADING MANUAL”

B. Drainage Concept

- ☐ Effectiveness of drainage design to control damage from storm runoff
- ☐ Influence of proposed development on the Storm Water Capital Facilities Master Plan recommendation(s)

VI. REFERENCES

- ☐ Reference all criteria and technical information used

VII. APPENDICES

A. Hydrologic Computations*

- ☐ Land use assumptions regarding adjacent properties
- ☐ Initial and major storm runoff at specific design points
- ☐ Historic and fully developed runoff computations at specific design points
- ☐ Hydrographs at critical design points
- ☐ Time of concentration and runoff coefficients for each basin

B. Hydraulic Computations *

- ☐ Culvert capacities
- ☐ Storm sewer capacity, including energy grade line (EGL) and hydraulic grade line (HGL) elevations
- ☐ Street capacity as compared to allowable ref. 3.4.4 of HYDROLOGY MANUAL
- ☐ Storm inlet capacity including inlet control rating at connection to storm sewer
- ☐ Open channel design
- ☐ Check and/or channel drop design
- ☐ Detention area/volume capacity and outlet capacity calculations; depths of detention basins
- ☐ Downstream/outfall system capacity to the Storm Water Capital Facilities Master Plan

* Include any input and output listings and diskettes for computer models used.

☐ Contains Stamped Statement

“This report for the drainage design of (Name of Development) was prepared by me (or under my direct supervision) in accordance with the provisions of City of Washington Storm Drainage Design and Technical Criteria, and was designed to comply with the provisions thereof. I understand that the City of Washington does not and will not assume liability for drainage facilities design.”

Reviewed By: ___________________________________

Appendix C:

Washington City Best Management Practices
Standard Notes and Details

CD: Check Dams

Description & Purpose

A check dam is a small barrier constructed of rock, gravel bags, sandbags, fiber rolls, or reusable products, placed across a constructed swale or drainage ditch. Check dams reduce the effective slope of the channel, thereby reducing the velocity of flowing water, allowing sediment to settle and reducing erosion.

Suitable Applications

Check dams may be appropriate in the following situations:

- To promote sedimentation behind the dam
- To prevent erosion by reducing the velocity of channel flow in small intermittent channels and temporary swales
- In small open channels that drain 10 acres or less
- In steep channels where stormwater runoff velocities exceed 5 ft/s
- During the establishment of grass linings in drainage ditches or channels
- In temporary ditches where the short length of service does not warrant establishment of erosion-resistant linings.

Limitations

- Not to be used in live streams or in channels with extended base flows
- Not appropriate in channels that drain areas greater than 10 acres
- Not appropriate in channels that are already grass-lined unless ersoion is expected, as installation may damage vegetation
- Require extensive maintenance following high velocity flows
- Promotes sediment trapping which can be re-suspended during subsequent storms or removal of the check dam.

Objectives

EC	Erosion Control
SE	Sediment Control

Potential Alternatives

FR	Fiber Rolls
GB	Gravel Bag Berm
SB	Sandbag Barrier

Implementation

General

Check dams reduce the effective slope and create small pools in swales and ditches that drain 10 acres or less. Reduced slopes reduce the velocity of stormwater flows, thus reducing erosion of the swale or ditch and promoting sedimentation. Use of check dams for sedimentation will likely result in little net removal of sediment because of the small detention time and probable scour during longer storms. Using a series of check dams will generally increase their effectiveness. As sediment trap (ST) may be placed immediately upstream of the check dam to increase sediment removal efficiency.

Design and Layout

Check dams work by decreasing the effective slope in ditches and swales. An important consequence of the reduced slope is a reduction in capacity of the ditch or swale. This reduction in capacity must be considered when using this BMP, as reduced capacity can result in overtopping of the ditch or swale and resultant consequences. In some cases, such as a "permanent" ditch or swale being constructed early and used as a "temporary" conveyance for construction flows, the ditch or swale may have sufficient capacity such that the temporary reduction in capacity due to check dams is acceptable. When check dams reduce capacities beyond acceptable limits, there are several options:

- Don't use check dams. Consider alternative BMPs
- Increase the size of the ditch or swale to restore capacity.

Maximum slope and velocity reduction is achieved when the toe of the upstream dam is at the same elevation as the top of the downstream dam. The center section of the dam should be lower that the edge sections so that the check dam will direct flows to the center of the ditch or swale.

Check dams are usually constructed of rock, gravel bags, sandbags, and fiber rolls. A number of products manufactured specifically for use as check dams are also being used, and some of these products can be removed and reused. Check dams can also be constructed of log or lumber and have the advantage of a longer lifespan when compared to gravel bags, sandbags, and fiber rolls. Due to their high failure rate, check dams should not be constructed from straw bales or silt fences since concentrated flows quickly wash out these materials.

Rock check dams are usually constructed of 8 to 12 in. rock. The rock is placed either by hand or mechanically, but never just dumped into the channel. The dam must completely span the ditch or swale to prevent washout. The rock used must be large enough to stay in place given the expected design flow through the channel.

Log check dams are usually constructed of 4 to 6 in. diameter logs. The logs should be embedded into the soil at least 18 in. Logs can be bolted or wired to vertical support logs that have been driven or buried into the soil.

Gravel bag and sandbag check dams are constructed by stacking bags across the ditch or swale, shaped as shown in the drawing at the end of the BMP fact sheet.

Manufactured products should be installed in accordance with the manufacturer's instructions. If grass is planted to stabilize the ditch or swale, the check dam should be removed when the grass has matured (unless the slope of the swales is greater than 4%.

The following guidance should be followed for the design and layout of check dams:

- Install the first check dam approximately 16 ft from the outfall device and at regular intervals based on slope gradient and soil type.
- Check dams should be placed at a distance and height to allow small pools to form between each check dam.
- Backwater from a downstream check dam should reach the toes of the upstream check dam.
- A sediment trap provided immediately upstream of the check dam will help capture sediment. Due to the potential for this sediment to be re-suspended in subsequent storms, the sediment trap must be cleaned following each storm event.
- High flows (typically a 2-year storm or larger) should safely flow over the check dam without an increase in upstream flooding or damage to the check dam.
- Where grass is used to line ditches, check dams should be removed when grass has matured sufficiently to protect the ditch or swale.
- Gravel bags may be used as check dams with the following specifications:

Materials

Gravel bags used for check dams should conform to the requirements of GB, Gravel Bag Berms. Sandbags used for check dams should conform to SB, Sandbag Barrier. Fiber rolls used for check dams should conform to FR, Fiber Rolls.

Do. *Properly installed series of check dams creating settling ponds and slowing water velocity.*

Don't. *Straw or Hay bales should not be used as check dams. Even if "properly" installed, they have a high failure rate.*

Installation

- Rock should be placed individually by hand or by mechanical methods (no dumping of rock) to achieve complete ditch or swale coverage.
- Tightly abut bags and stack according to detail shown in the figure at the end of this section.
- Gravel bags and sandbags should not be stacked any higher than 3 ft.
- Fiber rolls and straw bales must be trenched in and firmly staked in place.

.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Replace missing rock, bags, bales, etc. Replace bags or bales that have degraded or have become damaged.
- If the check dam is used as a sediment capture device, sediment that accumulates in the BMP must be periodically removed in order to maintain BMP effectiveness. Sediment should be removed when the sediment accumulation reaches one-third of the barrier height.
- Sediment removed during maintenance may be incorporated into earthwork on the site or disposed at an appropriate location.
- If the check dam is used as a grade control structure, sediment removal is not required as long as the system continues to control the grade.
- Remove accumulated sediment prior to permanent seeding or soil stabilization.
- Remove check dam and accumulated sediment when check dams are no longer needed.

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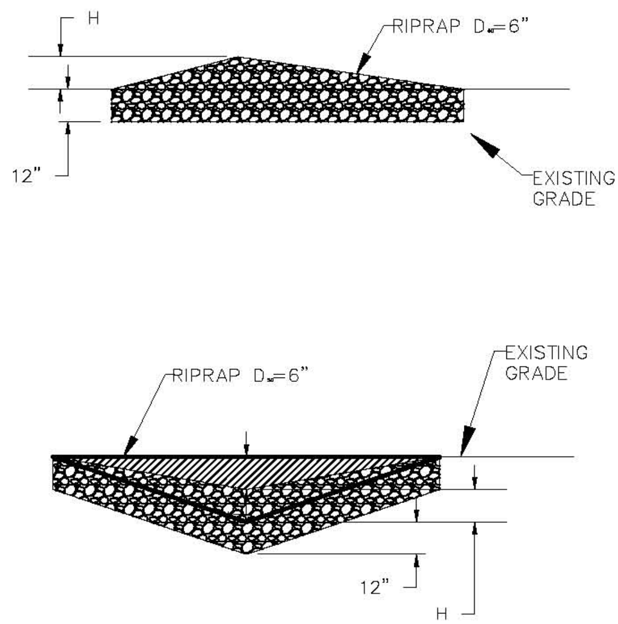
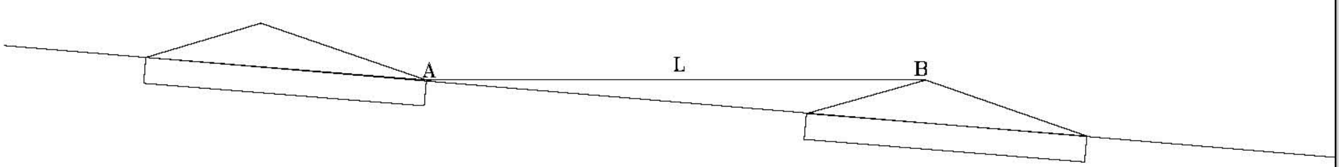
CHECK DAM



A. ROCK DAM



L=THE DISTANCE SUCH THAT POINTS A AND B ARE AT THE SAME ELEVATION.

B. SPACING CHECK DAM

HM: Hydraulic Mulch

Description & Purpose

Hydraulic mulch consists of applying a mixture of shredded wood fiber of a hydraulic matrix, and a stabilizing emulsion of tackifier with hydro-mulching equipment, which temporarily protects exposed soil from erosion by raindrop impact or wind.

Suitable Applications

Hydraulic Mulching may be appropriate in the following situations:

- Disturbed areas requiring temporary protection until permanent stabilization is established
- Disturbed areas that will be re-disturbed following an extended period of time.

Limitations

- Hydraulic mulches are generally short lived
- A minimum of 24 hours is required for drying before effective
- May required more than one application to last a full rainy season

Objectives

EC Erosion Control

WE Wind Erosion Control

Potential Alternatives

HS Hydroseeding

GM Geotextiles and Mats

WM Wood Mulch

SM Straw Mulch

SLB Soil Binders

Implementation

General

Prior to application, roughen embankment and fill areas by rolling crimping or punching type roller or by track walking. Track walking shall only be used where other methods are impractical.

To be effective, hydraulic matrices require 24 hours to dry before rainfall occurs.

Avoid mulch spray onto roads, sidewalks, drainage channels, existing vegetation, etc.

Paper based hydraulic mulches alone shall not be used for erosion control.

Hydraulic Mulches

Wood fiber much can be applied alone or as a component of hydraulic matrices. Wood fiber applied alone is typically applied at the rate of 2,000 to 4,000 lb/acre. Wood fiber mulch is manufactured from wood or wood waste from lumber mills of from urban sources.

Hydraulic Matrices

Hydraulic matrices include a mixture of wood fiber and acrylic polymer or other tackifier as binder. Apply as a liquid slurry using a hydraulic application machine (i.e., hydro seeder) at the following minimum rates, or as specified by the manufacturer to achieve complete coverage of the target area: 2,000 to 4,000 lbs/acre wood fiber mulch, and 5 to 10% (by weight) of tackifier (acrylic copolymer, guar, psyllium, etc.)

Bonded Fiber Matrix

Bonded fiber matrix (BFM) is a hydraulically applied system of fibers and adhesives that upon drying forms an erosion resistant blanket that promotes vegetation and prevents soil erosion. BFM's are typically applied at rates from 3,000 lb/acre to 4,000 lb/acre based on the manufacturer's recommendation. A biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM should also be biodegradable and should no dissolve or disperse upon re-wetting. Typically, biodegradable BFM's should not be applied immediately before, during or immediately after rainfall if the soil is saturated. Depending on the product, BFMs typically require 12 to 24 hours to dry and become effective.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Areas where erosion is evident shall be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damager will require re-application of BMPs.
- Maintain an unbroken, temporary mulched ground cover throughout the period of construction.

HS: Hydroseeding

Description & Purpose

Hydroseeding typically consists of applying a mixture of wood fiber, seed fertilizer, and stabilizing emulsion with hydro-mulch equipment, to temporarily protect exposed soils from erosion by water and wind.

Suitable Applications

Hydroseeding may be appropriate in the following situations:

- Disturbed areas requiring temporary protection until permanent stabilization is established
- Disturbed areas that will be re-disturbed following an extended period of time.

Limitations

- May be used alone only when there is sufficient time in the season to ensure adequate vegetation establishment and coverage to provide adequate erosion control. Otherwise, hydroseeding must be used in conjunction with mulching (i.e., straw mulch).
- Steep slopes are difficult to protect with temporary seeding
- Temporary seeding may not be appropriate in dry periods without supplemental irrigation
- Temporary vegetation may have to be removed before permanent vegetation is applied
- Temporary vegetation is not appropriate for short term inactivity.

Objectives

EC	Erosion Control
WE	Wind Erosion Control

Potential Alternatives

HM	Hydraulic Mulch
GM	Geotextiles and Mats
WM	Wood Mulch
SM	Straw Mulch
SLB	Soil Binders

Implementation

General
In order to select appropriate hydroseeding mixtures, and evaluation of site conditions shall be performed with respect to:

- Soil Condition
- Site Topography
- Season and climate
- Vegetation types
- Maintenance requirements
- Sensitive adjacent areas
- Water availability
- Plans for permanent vegetation

The local office of the U.S.D.A. Natural Resource Conservation Service (NRCS) is an excellent source of information on appropriate seed mixes.

The following steps shall be followed for implementation:

- Avoid use of hydroseeding in areas where the BMP would be incompatible with future earth work activities and would have to be removed.
- Hydroseeding can be accomplished using a multiple step or one step process. The multiple step process ensures maximum direct contact of the seeds to soil. When the one step process is used to apply the mixture of fiber, seed, etc, the seed rate shall be increased to compensate for all seeds not having direct contact with the soil.
- Prior to application, roughen the area to be seeded with the furrows trending along the contours.
- Apply a straw mulch to keep seeds in place and to moderate soil moisture and temperature until the seeds germinate and grow.
- Commercial fertilizer shall conform to the requirements of the Utah Food and Agricultural codes. Fertilizers shall be pelleted or granular form.
- Follow up applications shall be made as needed to cover weak spots and to maintain adequate soil protection.
- Avoid over spray onto roads, sidewalks, drainage channels, existing vegetation, etc.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Areas where erosion is evident shall be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damager will require re-application of BMPs.
- Where seeds fail to germinate, or the germinate and die, the area must be re-seeded, fertilized, and mulched within the planting season, using not less than half the original application rates.
- Irrigation systems, if applicable, should be inspected daily while in use to identify system malfunctions and line breaks. When line breaks are detected, the system must be shut down immediately and breaks repaired before the system is put back into operation.
- Irrigation systems shall be inspected for complete coverage and adjusted as needed to maintain complete coverage.

SLB: Soil Binders

Description & Purpose

Soil binders consist of applying and maintaining a soil stabilizer to exposed soil surfaces. Soil binders are materials applied to the soil surface to temporarily prevent water induced erosion of exposed soils on construction sites. Soil binders also prevent wind erosion.

Suitable Applications

Soil Binders may be appropriate in the following situations:

- Disturbed areas requiring short term temporary protection until permanent stabilization is established.
- Because soil binders can often be incorporated into the work, they are good alternatives to mulches where grading activities will soon resume.
- Stockpiles.

Limitations

- Soil binders are temporary in nature and may need reapplication.
- Soil binders require a minimum curing time until fully effective, as prescribed by the manufacturer. Curing time may be 24 hours or longer. Soil binders may need reapplication after storm events.
- Soil binders will generally experience spot failures during heavy rainfall events. If runoff penetrates the soil at the top of a slope treated with a soil binder, it is likely that the runoff will undercut the stabilized soil layer and discharge at a point further down the slope.
- Soil binders do not hold up to pedestrian or vehicular traffic across treated areas.
- Soil binders may not penetrate soil surfaces made up primarily of silt and clay, particularly when compacted.
- Some soil binders may not perform well with low relative humidity. Under rainy conditions, some agents may become slippery or leach out of the soil.
- Soil binders may not cure if low temperatures occur within 24 hours after application.
- The water quality impacts of soil binders are relatively unknown and some may have water quality impacts due to their chemical makeup.
- A sampling and analysis plan must be incorporated into the Grading Plan as soil binders could be a source of non-visible pollutants.

Objectives

EC Erosion Control

WE Wind Erosion Control

Potential Alternatives

HM Hydraulic Mulch

GM Geotextiles and Mats

WM Wood Mulch

SM Straw Mulch

HS Hydroseeding

Implementation

General

- Regional soil types will dictate appropriate soil binder to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and should not stain paved or painted surfaces. Soil binders should not pollute stormwater.
- Some soil binders may not be compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity, and traffic across treated areas.
- Avoid over spray onto roads, sidewalks, drainage channels, existing vegetation, etc.

Selection a Soil Binder

Properties of common soil binders used for erosion control are provided on Table 1 ate the end of this BMP. Use Table 1 to select an appropriate soil binder.

Factors to consider when selecting a soil binder include the following:

- Suitability to situation – Consider where the soil binder will be applied, if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor for the listed soil binders
- Soil types and surface materials – Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.
- Frequency of application – The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent application could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean up.

Plant-Material Based (Short Lived) Binders

Guar – Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersant agents for easy field mixing. It should be mixed with water at the rate of 11 to 15 lb per 1,000 gallons. Recommended minimum application rates are as follows:

Slope (H:V)	Flat	4:1	3:1	2:1	1:1
lb/acre	40	45	50	60	70

Psyllium - Psyllium is composed of the finely ground mucilloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Application rates should be from 80 to 200 lb/acre, with enough water in solution to allow for a uniform slurry.

Starch – Starch is a non-ionic, cold water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 150 lb/acre. Approximate drying time is 9 to 12 hours.

Plant-Material Based (Long Lived) Binder

Pitch and Rosin Emulsion – Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin should be a minimum of 26% of the total solids content. The soil stabilizer should be non-corrosive, water dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and should be applied as follows:

- For clayey soil: 5 parts water to 1 part emulsion
- For sandy soil: 10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion and product mixture applied at the rate specified by the manufacturer.

Polymeric Emulsion Blend Binders

Acrylic Copolymers and Polymers – Polymeric soil stabilizers should consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound should be handled and mixed in a manner that will not cause foaming or should contain and anti-foaming agent. The polymeric emulsion should not exceed its shelf life or expiration date; manufacturers should provide the expiration date. Polymeric soil stabilizer should be readily miscible in water, non-injurious to seed or animal life, non-flammable, should provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and should re-emulsify when cured. The applied compound should air cure within a maximum of 36 to 48 hours. Liquid copolymer should be diluted at rate of 10 parts water to 1 part polymer and the mixture applied to soil at a rate of 1,175 gallon/acre.

Liquid Polymers of Methacrylates and Acrylates – This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization application, it is diluted with water in accordance with manufacturer's recommendations and applied with a hydraulic seeder at the rate of 20 gallons/acre. Drying time is 12 to 18 hours after application.

Copolymers of Sodium Acrylates and Acrylamides – These materials are non-toxic, dry powders that are nopolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rats that are determined by slope gradient:

Slope Gradient (H:V)	lb/acre
Flat to 5:1	3.0 – 5.0
5:1 to 3:1	5.0 – 10.0
2:1 to 1:1	10.0 – 20.0

Polyacrylamide and Copolymer of Acrylamide – Linear copolymer polyacrilamide is packaged as a dry flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 11 lb/1,000 gal of water and applied at the rate of 5.0 lb/acre.

Hydro-Colloid Polymers - Hydro-Colloid Polymers are various combinations of dry flowable polyacrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 55 to 60 lb/acre. Drying time is 0 to 4 hours.

Cementitious-Based Binders

Gypsum – This is a formulated gypsum-based product that readily mixes with water and much to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86%. It is mixed in hydraulic seeder and applied at rates 4,000 to 12,000 lb/acre. Drying time is 4 to 8 hours.

Applying Soil Binders

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps should be followed:

- Follow manufacturer's written recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas,
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders should no be applied during or immediately before rainfall.
- Avoid over spray onto roads, sidewalks, drainage channels, sound walls, existing vegetation, etc.
- Soil binders should not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the temperature is below 40°F during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacture's instructions for specific cure time.
- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.03 to 0.3 gal/yd^2 or according to manufacturer's recommendations
  - Apply solution under pressure. Overlap solution 6 to 12 in.
  - Allow treated area to cure for the time recommended by the manufacturer; typically, at least 24 hours.
  - Apply second treatment before first treatment becomes ineffective, using 50% application rate
  - In low humidities, reactivate chemicals by re-wetting with water at 0.1 to 0.2 gal/yd^2.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Areas where erosion is evident shall be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damager will require re-application of BMPs.
- Reapply the selected soil binder as needed to maintain effectiveness.

Table 1 Properties of Soil Binders for Erosion Control

Evaluation Criteria	Binder Type			
	Plant Material Based (Short Lived)	**Plant Material Based (Long Lived)**	**Polymeric Emulsion Blends**	**Cementitious-Based Binders**
Relative Cost	Low	Low	Low	Low
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time Before Rain	9 to 18 hours	19 to 24 hours	0 to 24 hours	4 to 8 hours
Compatibility with Existing Vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/Chemically Degradable	Photodegradable/Chemically Degradable
Labor Intensive	No	No	No	No
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies[1]	Varies[1]	Varies[1]	4,000 to 12,000 lbs/acre

[1] See Implementation for Specific Rates.

SM: Straw Mulch

Description & Purpose

Straw mulch consists of placing a uniform layer of straw and incorporating it into the soul with a studded roller or anchoring it with a tackifier stabilizing emulsion. Straw mulch protects the soil surface from the impact of rain drops, preventing soil particles from becoming dislodged.

Suitable Applications

Straw Mulching may be appropriate in the following situations:

- A disturbed area requiring temporary protection until permanent stabilization is established.
- For disturbed areas requiring protection until permanent vegetation is installed.
- In combination with temporary and/or permanent seeding strategies to enhance plant establishment.

Limitations

- Availability of straw and straw blowing equipment may be limited just prior to the rainy season and prior to storms due to high demand.
- There is a potential for introduction of weed seed and unwanted plant material.
- May required more than one application to last a full rainy season
- When straw blowers are used to apply straw mulch, the treatment areas must be within 150 ft of a road or surface capable of supporting trucks.
- Straw mulch applied by hand is more time intensive and potentially costly.
- Wind may limit application of straw and blow straw into undesired locations.
- May have to be removed prior to permanent seeding or prior to further earthwork.
- “Punching” of straw does not work in sandy soils, necessitating the use of tackifiers.

Objectives

EC Erosion Control

Potential Alternatives

HS Hydroseeding

GM Geotextiles and Mats

WM Wood Mulch

HM Hydraulic Mulch

SLB Soil Binders

Implementation

General

- Straw shall be derived from wheat, rice, or barley. Where required by the plans, specifications, permits, or environmental documents, native grass straw shall be used.
- A tackifier is the preferred method for anchoring straw mulch to the soil on slopes.
- Crimping, punch roller-type rollers, or track walking may be used to incorporate straw mulch into the soil on slopes. Track walking shall only be used where other methods are impractical.
- Avoid placing straw onto roads, sidewalks, drainage channels, sound walls, existing vegetation, etc.
- Straw mulch with tackifier shall not be applied during or immediately before rainfall.
- Use of straw near wood frame home construction may be frowned on by the fire marshal.

Application Procedure

- Apply straw at a minimum rate of 4,000 lbs/acre, either by machine or by hand distribution.
- Roughen embankments and fill rills before placing the straw mulch by rolling with a crimping or punching type roller or by track walking.
- Evenly distributing straw mulch on the soil surface.
- Anchor straw mulch to the soil surface by “punching” it into the soil mechanically (incorporating). Alternatively, use tackifier to adhere straw fibers.
- Methods for holding straw mulch in place depend upon the slope steepness, accessibility, soil conditions, and longevity.
  - On small areas, a spade or shovel can be used to punch in straw mulch.
  - On slopes with soil that are stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw can be “punched” into the ground using a knife blade roller or a straight bladed coulter, known commercially as a “crimper”.
  - On small areas and/or steep slopes, straw can also be held in place using plastic netting or jute. The netting shall be held in place using 11-gauge wire staples, geotextile pins or wooden stakes as described in GM, Geotextiles and Mats.
  - A tackifier acts to glue the straw fibers together and to the soil surface. The tackifier shall be selected based on longevity and ability to hold the fibers in place. A tackifier is typically applied at a rate of 125 lb/acre. In windy conditions, the rates are typically 180 lbs/acre.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Areas where erosion is evident shall be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damager will require re-application of BMPs.
- The key consideration in inspection and maintenance is that the straw needs to last long enough to achieve erosion control objectives.
- Maintain an unbroken, temporary mulched ground cover while disturbed soil areas are inactive. Repair any damaged ground cover and re-mulch exposed areas.
- Reapplication of straw mulch and tackifier may be required to maintain effective soil stabilization over disturbed areas and slopes.

WM: Wood Mulch

Description & Purpose

Wood mulching consists of applying a mixture of shredded wood mulch, bark, or compost to disturbed soils. The primary Function of wood mulching is to reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff.

Suitable Applications

Wood Mulching may be appropriate in the following situations:

- A disturbed area requiring temporary protection until permanent stabilization is established.

Limitations

- Not suitable for use on slopes steeper than 3:1 (H:V). Best suited to flat areas or gentle slopes or 5:1(H:V) or flatter
- Wood much and compost may introduce unwanted species.
- Not suitable for areas exposed to concentrated flows.
- May need to be removed prior to further earthwork.

Objectives

EC Erosion Control

WE Wind Erosion

Potential Alternatives

HS Hydroseeding

GM Geotextiles and Mats

SM Straw Mulch

HM Hydraulic Mulch

SLB Soil Binders

Implementation

Mulch Section
There are many types of mulches. Selection of the appropriate typed of mulch should be based on the type of application, site condition, and compatibility with planned or future uses.

Application Procedure
Prior to application, existing vegetation has been removed, roughen embankment and fill areas by rolling with a device such as a punching type roller or by track walking. The construction application procedures for mulches vary significantly depending upon the type of mulching method specified. Two methods are highlighted here:

- Green Material – This type of mulch is produced by the recycling of vegetation trimmings such as grass, shredded shrubs, and trees. Methods of application are generally by hand although pneumatic methods are available.
  - Green material can be used as a temporary ground cover with or without seeding.
  - The green material should be evenly distributed on site to a depth not more than 2 in.
- Shredded Wood – Suitable for ground cover in ornamental or revegetated plantings.
  - Shredded wood/bark is conditionally suitable. See note under limitations.
  - Distribute by hand or use pneumatic methods.
  - Evenly distribute the mulch across the soil surface to a depth of 2 to 3 in.
- Avoid mulch placement onto roads, sidewalks, drainage channels, existing vegetation, etc.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Areas where erosion is evident shall be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damager will require re-application of BMPs.
- Regardless of the mulching technique selected, the key consideration in inspection and maintenance is that the mulch needs to last long enough to achieve erosion control objectives. If the mulch is applied as a stand-alone erosion method over disturbed areas (without seed), it should last the length of time the site will remain barren or until final re-grading and revegetation.
- Where vegetation is not the ultimate cover, such as ornamental and landscape application of made or wood chips, inspection and maintenance should focus on longevity and integrity of the mulch
- Reapply mulch when bare earth becomes visible.

VD: Velocity Dissipation Devices

Description & Purpose

Outlet protection is a physical device composed of rock or grouted riprap, which is place at the outlet of a pipe or channel to prevent scour of the soil caused by concentrated, high velocity flows.

Suitable Applications

Velocity dissipation devices are required in the following situations:

- Whenever discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach.

Velocity dissipation devices may be used at the following locations:

- Outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, of channels.
- Outlets located at the bottom of mild to steep slopes.
- Discharge outlets that carry continuous flows of water.
- Outlets subject to short, intense flows of water, such as flash floods.
- Points where lined conveyances discharge into unlined conveyances.

Limitations

- Large storms or high flows can wash away the rock outlet protection and leave the area susceptible to erosion.
- Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- Outlet protection may negatively impact the channel habitat.
- Grouted riprap may break up in areas of freeze thaw.
- If there is not adequate drainage, and water builds up behind grouted riprap, it may cause to grouted riprap to break up due to the resulting hydrostatic pressure.

Objectives

EC Erosion Control

Potential Alternatives

None

Implementation

General
Outlet protection is needed where discharged velocities and energies at the outlets of culvers, conduits, or channels are sufficient to erode the immediate downstream reach. This practice protects the outlet from developing small, eroded pools (plunge pools), and protects against gully erosion resulting from scouring at a culvert mouth.

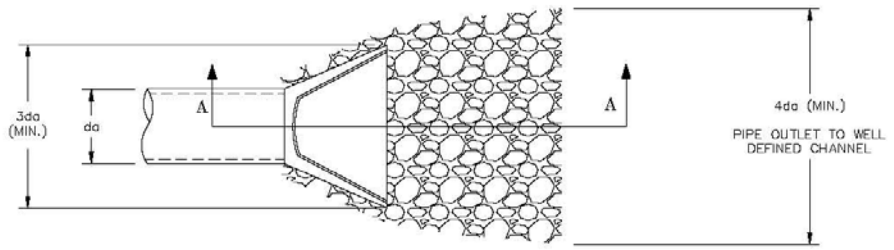
Design and Layout
As with most channel design projects, depth of flow, roughness, gradient, side slopes, discharge rate, and velocity should be considered in the outlet design. Compliance to local and state regulations should also be considered while working in environmentally sensitive streambeds. General recommendations for rock size and length of outlet protection mat are shown in the rock outlet protection figure in this BMP and should be considered minimums. The apron length and rock size gradation are determined using a combination of the discharge pipe diameter and estimated discharge rate: Select the longest apron length and largest rock size suggested by the pipe size and discharge rate. Where flows are conveyed in open channels such as ditches and swales, use the estimated discharge rate for selecting the apron length and rock size. Flows should be same as the culvert or channel design flow but nevertheless than the peak 5-year flow for temporary structures planned for one rainy season, or the 10-year peak flow for temporary structures planned for two or three rainy seasons.

- There are many types of energy dissipaters, with rock being the one that is represented in the attached figure.
- Best results are obtained when sound, durable, and angular rock is used.
- Install riprap, grouted riprap, or concrete apron at selected outlet. Riprap aprons are best suited for temporary use during construction. Grouted or wired tied rock riprap can minimize maintenance requirements.
- Rock outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipaters. It also serves to trap sediment and reduce flow velocities.
- Carefully place riprap to avoid damaging filter fabric.
  - Stone 4 in. to 6 in. may be carefully dumped onto filter fabric from a height not to exceed 12 in.
  - Stone 8 in. to 12 in. must be hand placed onto filter fabric, or the filter fabric may be covered with 4 in. of gravel and the 8 in. to 12 in. rock may be dumped from a height not to exceed 16 in.
  - Stone greater than 12 in. shall only be dumped onto filter fabric protected with a layer of gravel with a thickness equal to one half the D_{50} rock size, and the dump height limited to twice the depth of the gravel protection layer thickness.
- For proper operation of apron: Align apron with receiving stream and keep straight throughout its length. If a curve is needed to fit site conditions, place it in the upper section of the apron.
- Outlets on slopes steeper than 10 percent should have additional protection.

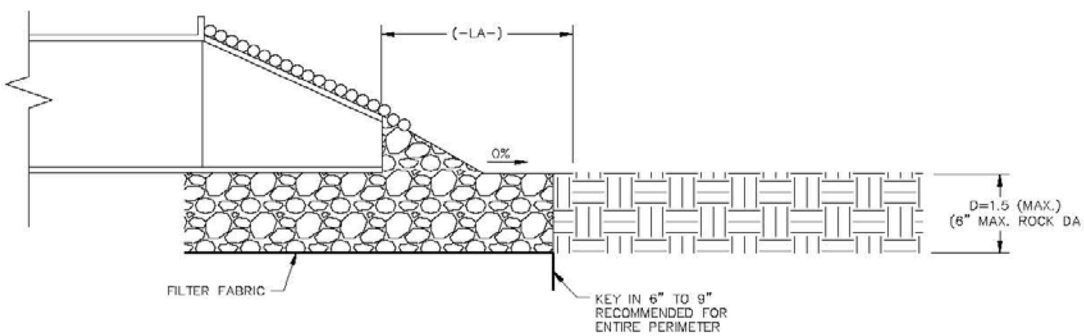
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Inspect BMPs subjected to non-stormwater discharges daily while non-stormwater discharge occurs.
- Inspect aprons for displacement of the riprap and damage to the underling fabric. Repair fabric and replace riprap that has washed away. If riprap continues to wash away, consider using larger material.
- Inspect for scour beneath the riprap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.
- Temporary devices should be completely removed as soon as the surrounding drainage area has been stabilized or at the completion of construction.

VELOCITY DISSIPATION DEVICES



PLAN VIEW
NOT TO SCALE



SECTION A-A
NOT TO SCALE

PIPE DIAMETER (IN INCHES)	DISCHARGE (FT3/S)	APRON LENGTH, (-LA- IN FEET)	RIP RAP DIAMETER (MIN. INCHES)
12	5	10	4
	10	13	6
18	10	10	6
	20	16	8
	30	23	12
	40	26	16
18	30	16	8
	40	26	8
	50	26	12
	60	30	16

SD: Slope Drain

Description & Purpose

Mattings of natural materials are used to cover the soil surface to reduce erosion from rainfall impact, hold soil in place, and absorb and hold moisture near the soil surface. Additionally, matting may be used to stabilize soils until vegetation is established.

Objectives

EC Erosion Control

Potential Alternatives

ED Earthen Dike

DS Drainage Swell

Suitable Applications

Slope drain may be appropriate where:

- Concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion.
- Drainage for top of slope diversion dikes or swales.
- Drainage for top of cut and fill slopes where water can accumulate.
- Emergency spillway for a sediment basin.

Limitations

Installation is critical for effective use of the pipe slope drain to minimize potential gully erosion.

- Maximum drainage area per slope drain is 10 acres. (For large areas used a paved chute, rock lined channel, or additional pipes.)
- Severe erosion may result when slope drains fail by overtopping, piping, or pipe separation.
  - During large storms, pipe slope drains may become clogged or over charged, forcing water around the pipe and causing extreme slope erosion.
  - If the sectional downdrain is not sized correctly, the runoff can spill over the drain sides causing gully erosion and potential failure of the structure.
- Dissipation of high flow velocities at the pipe outlet is required to avoid downstream erosion.

Implementation

General
The slope drain is applicable for any construction site where concentrated surface runoff can accumulate and must be conveyed down the slope in order to prevent erosion. The slope drain is effective because it prevents the stormwater from flowing directly down the slope by confining all the runoff into an enclosed pipe or channel. Due to the time lag between grading slopes and installation of permanent stormwater collection systems and slope stabilization measures, temporary provisions to intercept runoff are sometimes necessary. Particularly in steep terrain, slope drains can protect unstabilized areas from erosion.

Design and Layout
The capacity for temporary drains should be sufficient to convey at least the peak runoff from a10-year rainfall event. The pipe size may be computed using the Rational Method or a method established by the local municipality. Higher flows must be safely stored or routed to prevent any offsite concentration of flow and any erosion of the slope. The design storm is purposely conservative due to the potential impacts associated with system failures.

As a guide, temporary pipe slope drains should not be sized smaller than shown in the following table:

Minimum Pipe Diameter (Inches)	Maximum Drainage Area (Acres)
4	1.0
6	3.0
8	5.0
10	7.0
12	10.0

Larger drainage areas can be treated if the area can be subdivided into areas of 10 acres or less and each area is treated as a separate drainage.

Materials
Soil type, rainfall patterns, construction schedule, local requirements, and available supply are some of the factors to be considered when selecting materials. The following types of slope drains are commonly used:

- Rigid Pipe – This type of slope drain is also known as a pipe drop. The pipe usually consists of corrugated metal pipe or rigid plastic pipe. The pipe is placed on undisturbed or compacted soil and secured onto the slope surface or buried in a trench. Concrete thrust bocks must be used when warranted by the calculated thrust forces. Collars should be properly installed and secured with metal strapping or watertight collars.
- Flexible Pipe – The flexible pipe slope drain consists of a flexible tube of heavy-duty plastic, rubber, or composite material. The tube material is securely anchored onto the slope surface. The tube should be securely fastened to the metal inlet and outlet conduit sections with metal strappings or watertight collars.
- Section Downdrains – The section downdrain consists of pre-fabricated, section conduit or half round or third round material. The sectional downdrain performs similar to a flume or chute. The pipe must be placed on undisturbed or compacted soil and secured into the slope.
- Concrete-lined Terrace Drain – This is a concrete channel for draining water from a terrace on a slope to the next level. These drains are typically specified as permanent structures and, if installed early, can serve as slope drains during construction, which should be designed according to local drainage design criteria.

Installation

The slope drain may be a rigid pipe, such as corrugated metal, a flexible conduit, or a lined terrace drain with the inlet placed on the top of the slope and outlet at the bottom of the slope. This BMP typically is used in combination with a diversion control, such as an earth dike or drainage swale at the top of the slope.
The following criteria must be considered when sitting slope drains:

- Permanent structures included in the project plans can often serve as construction BMPs if implemented early. However, the permanent structures must meet or exceed the criteria for the temporary structure.
- Inlet structures must be securely entrenched and compacted to avoid severe gully erosion.
- Slope drains must be securely anchored to the slope and must be adequately sized to carry the capacity of the design storm and associated forces.
- Outlets must be stabilized with riprap, concrete, or other type of energy dissipater, or directed into a stable sediment trap or basin. See VD, Velocity Dissipation Devices.
- Debris racks are recommended at the inlet. Debris racks located several feet upstream of the inlet can usually be larger than racks at the inlet, and thus provide enhanced debris protection and less plugging.
- Safety racks are also recommended at the inlet and outlet of pipes where children and animals could become entrapped.

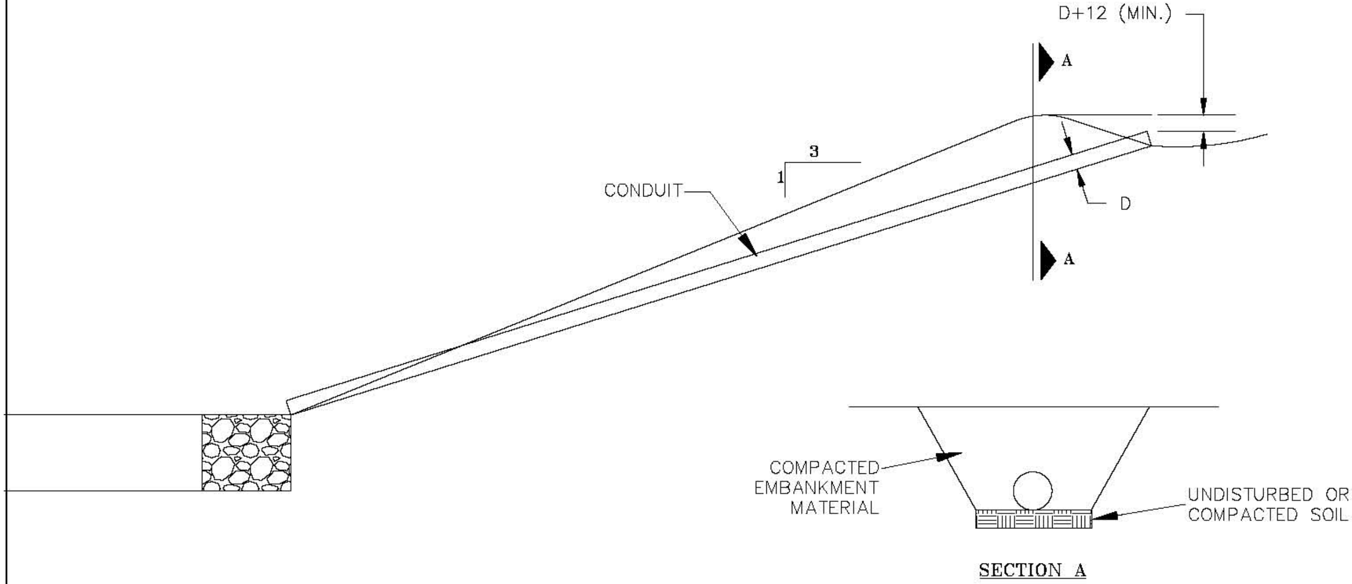
Do. *Properly installed slope drains to ensure erosion of the slope will not occur*

- Secure inlet and surround with dikes to prevent gully erosion and anchor pipe slope.
- When using slope drains, limit drainage area to less than 10 acres per pipe. For larger areas, use a rock lined channel or a series of pipes.
- Size to convey at least the peak flow of a 10-year storm. The design storm is conservative due to the potential impact of system failures.
- Maximum slope generally limited to 2:1 (H:V) as energy dissipation below steeper slopes is difficult.
- Direct surface runoff to slope drains with interceptor dikes. See BMP ED, Earth Dikes and Drainage Swales. Top of interceptor dikes should be 12 in. higher than the top of the slope drain.
- Slope drains can be placed on or buried underneath the slope surface.
- Recommended materials include both metal and plastic pipe, either corrugated or smooth wall. Concrete pipe can also be used.
- When installing slope drains:
  - Install slope drains perpendicular to slope contours.
  - Compact soil around and under entrance, outlet, and along length of pipe.
  - Securely anchor and stabilize pipe and appurtenances into soil.
  - Check to ensure that pipe connections are watertight.
  - Protect area around inlet with filter fabric cloth. Protect outlet with riprap or other energy dissipation device. For high energy discharges, reinforce riprap with concrete or use reinforced concrete device.
  - Protect outlet of slope drains using a flared end section when outlet discharges to a flexible energy dissipation device.
  - A flared end section installed at the inlet will improve flow into the slope drain and prevent erosion at the pipe entrance. Use a flared end section with a 6 in. minimum to plate to help prevent undercutting. The flared section should slope towards the pipe inlet.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Inspect BMPs subjected to non-stormwater discharges daily while non-stormwater discharge occurs.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the channel unless preventative measures are implemented.
- Inspect inlet for clogging or undercutting. Remove debris from inlet to maintain flows. Repair undercutting at inlet and if needed, install flared section or riprap around the inlet to prevent further undercutting.
- Inspect pipes for leakage. Repair leaks and restore damaged slopes.
- Inspect slope drainage for accumulations of debris and sediment.
- Remove built up sediment from entrances and outlets as required. Flush drains if necessary; capture and settle out sediment from discharge.
- Make sure water is not ponding onto inappropriate areas (e.g., active traffic lanes, material storage areas, etc.)
- Pipe anchors must be checked to ensure that the pipe remains anchored to the slope. Install additional anchors if pipe movement is detected.

SLOPE DRAIN



SLOPE DRAIN NOTES

INSTALLATION REQUIREMENTS

1. THE SLOPE DRAIN IS TO BE DESIGNED TO CONVEY THE PEAK RUNOFF FOR THE 2–YEAR STORM EVENT.

2. PIPE MATERIAL MAY INCLUDE CORRUGATED METAL, OR RIDGID OR FLEXIBLE PLASTIC.

3. EMBANKMENT MATERIAL SHALL CONSIST OF SOIL WITH A MINIMUM OF 15% PASSING A #200 SIEVE. EXCAVATED SOIL CAN BE USED IF IT MEETS THIS REQUIREMENT.

4. EMBANKMENT IS TO BE COMPACTED TO AT LEAST 90% OF MAXIMUM DENSITY AND WITHIN 2% OF THE OPTIMUM MOISTURE CONTENT ACCORDING TO ASTM D698.

5. SLOPE DRAIN SECTIONS ARE TO BE SECURELY FASTENED TOGETHER AND HAVE WATERTIGHT FITTINGS.

6. THE OUTLET IS TO BE STABILIZED AND, UNLESS THE DRAIN DISCHARGES DIRECTLY TO A SEDIMENT BASIN, A TEMPORARY SURFACE IS TO BE PROVIDED TO CONVEY FLOWS DOWN STREAM.

7. IMMEDIATELY STABILIZE ALL AREAS DISTURBED BY INSTALLATION OR REMOVAL OF THE PIPE SLOPE DRAIN.

MAINTENANCE REQUIREMENTS

1. INLET AND OUTLET POINTS ARE TO BE CHECKED REGULARLY, AND AFTER HEAVY STORMS FOR CLOGGING AND OVERCHARGING. ANY BREAKS IN THE PIPE ARE TO BE PROMPTLY REPAIRED, AND CLOGS REMOVED AS NEEDED.

2. WATER IS NOT TO BYPASS OR UNDERCUT THE INLET OR PIPE. IF THESE PROBLEMS DO EXIST, THE HEADWALL NEEDS TO BE REINFORCED WITH COMPACT EARTH OR SANDBAGS.

3. THE OUTLET POINT IS TO BE FREE OF EROSION AND, IF NECESSARY, ADDITIONAL OUTLET PROTECTION SHOULD BE INSTALLED.

4. CONSTRUCTION TRAFFIC IS NOT TO CROSS THE SLOPE DRAIN AND MATERIALS ARE NOT TO BE PLACED ON IT.

5. THE SLOPE DRAIN IS TO REMAIN IN PLACE UNTIL THE SLOPE HAS BEEN COMPLETELY STABILIZED OR UP TO 30 DAYS AFTER PERMANENT SLOPE STABILIZATION.

GM: Geotextiles and Mats

Description & Purpose

Mattings of natural materials are used to cover the soil surface to reduce erosion from rainfall impact, hold soil in place, and absorb and hold moisture near the soil surface. Additionally, matting may be used to stabilize soils until vegetation is established.

Objectives

EC Erosion Control

Potential Alternatives

HS Hydroseeding

WM Wood Mulch

SM Straw Mulch

HM Hydraulic Mulch

SLB Soil Binders

Suitable Applications

Geotextiles and Mats may be suitable in the following situations:

- Short, steep slopes where erosion hazard is high and vegetation will be slow to establish.
- Stream banks where moving water at velocities between 3 ft/sec and 6 ft/sec are likely to wash out new vegetation.
- In areas where the soil surface is disturbed and where existing vegetation has been removed.
- When seeding cannot occur (e.g., late season construction and/or the arrival of an early rain season).
- When the soils are fine grained and potentially erosive. These measures should be considered in the following situations:
  - Steep slopes, generally steeper than 3:1 (H:V).
  - Slopes where the erosion potential is high.
  - Slopes and disturbed soils where mulch must be anchored
  - Disturbed areas where plants are slow to develop.
  - Channels with flows exceeding 3.3 ft/sec.
  - Channels to be vegetated.
  - Stockpiles.
  - Slopes adjacent to water bodies of Environmentally Sensitive Areas (ESAs).

Limitations

- Properly installed mattings provide excellent erosion control but do so at relatively high cost. This high cost typically limits the use of mattings to areas of concentrated channel flow and steep slopes.
- Mattings are more costly that other BMP practices, limiting their use to areas where other BMPs are ineffective (e.g., channel, steep slopes).
- Installation is critical and requires experienced contractors. The contractor should install the matting material in such a manner that continuous contact between the material and the soil occurs.
- Geotextiles and Mats may delay seed germination, due to reduction in soil temperature.
- Blankets and mats are generally not suitable for excessively rocky sites or areas where the final vegetation will be mowed (since staples and netting can catch in mowers).
- Blankets and mats must be removed and disposed of prior to application of permanent soil stabilization measures.
- Plastic sheeting is easily vandalized, easily torn, photodegradable, and must be disposed of at a landfill.
- Plastic results in 100% runoff, which may cause serious erosion problems in the areas receiving the increased flow.
- The use of plastic should be limited to covering stockpiles or very small graded areas for short periods of time (such as through on imminent storm event) until alternative measures, such as seeding and mulching, may be installed
- Geotextiles, mats plastic covers, and erosion control covers have maximum flow rate limitations; consult the manufacturer for proper selection.
- Not suitable for areas that have heavy foot traffic (tripping hazard) – e.g., pad areas around buildings under const.

Implementation

Material Selection

Organic matting materials have been found to be effective where re-vegetation will be provided by re-seeding. The choice of matting should be based on the size of area, side slopes, surface conditions such as hardness, moisture weed growth, and availability of materials. The following natural and synthetic mattings are commonly used:

Geotextiles

- Material should be a woven polypropylene fabric with minimum thickness of 0.06 in., minimum width of 12 ft and should have minimum tensile strength of 150 lbs (warp), 80 lbs (fill) in conformance with the requirements in ASTM Designation: D_{4355}. Geotextile blankets must be secured in place with wire staples or sandbags and be keying into tope of slopes to prevent infiltration of surface waters under geotextile. Staples should be made of minimum 11 gauge steel wire and should be U-shaped with 8 in. legs and 2 in. crown.
- Geotextiles may be reused if they are suitable for the use intended.

Plastic Covers

- Plastic sheeting should have a minimum thickness of 6 mils and must be keyed n at the top of slope and firmly held in place with sandbags or other weights placed no more than 10 ft apart. Seams are typically taped or weighted down their entire length, and there should be at least a 12 in. to 24 in. overlap of all seams. Edges should be embedded a minimum of 6 in. in the soil.
- All sheeting must be inspected periodically after installation and after significant rainstorms to check for erosion, undermining, and anchorage failure. Any failures must be repaired immediately. If washout or breakage occurs, the material should be re-installed after repairing the damage to the slope.

Erosion Control Blankets/Mats

- Biodegradable rolled erosion control products (RECPs) are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials.
  - Jute – a natural fiber that is made into a yarn that is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which should be secured to the solid with u-shaped staples or stakes in accordance with manufacturer's recommendations.
  - Excelsior – (curled wood fiber) blanket material should consist of machine produced mats of curled wood excelsior with 80% of the fiber 6in. or longer. The excelsior blanket should be of consistent thickness. The wood fiber must be evenly distributed over the entire area of the blanket. The top surface of the blanket should be covered with a photodegradable extruded plastic mesh. The blanket should be smolder resistant without the use of chemical additives and should be non-toxic and non-injurious to plant and animal life. Excelsior blankets should be furnished in rolled strips, a minimum of 48 in. wide and should have an average weight of 0.8 lb/yd^2, ±10%, at the time of manufacture. Excelsior blankets must be secured in place with wire staples. Staples should be made of minimum 11-gauge steel wire and should be U-shaped with 8 in. legs and 2 in. crown.
  - Straw Blanket – Should be machine produced mats of straw with lightweight biodegradable netting top layer. The straw should be attached to the netting with biodegradable thread or glue strips. The straw

blanket should be of consistent thickness. The straw should be evenly distributed over the entire area of the blanket. Straw blanket should be furnished in rolled strips a minimum of 6 ft wide, a minimum of 80 ft long and a minimum of 0.5 lb/yd^2. Straw blankets must be secured in place with wire staples. Staples should be made of minimum 11-gauge steel wire and should be U-shaped with 8 in. legs and 2 in. crown.

- Wood Fiber Blanket – Composed of biodegradable fiber mulch with extruded plastic netting held together with adhesives. The material is designed to enhance re-vegetation. The material is furnished n rolled strips, which must be secured to the ground with U-shaped staples or stakes in accordance with manufactures' recommendation.
- Coconut Fiber Blanket – Should be machine produced, 100% coconut fiber with biodegradable netting on the top and bottom. The coconut fiber should be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket should be of consistent thickness. The coconut fiber should be furnished in rolled strips with a minimum of 6. ft wide, a minimum of 80 ft long and a minimum of0.5 lb/yd^2. Coconut fiber blankets must be secured tin place with wire staples. Staples should be made of minimum 11-gauge steel wire and should be U-shaped with 8 in. legs and 2 in. crown.
- Coconut Fiber Mesh – A thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has a longevity of several years. The material is supplied in rolled strips, which must be secured to the soil with U-shaped staple of stakes in accordance with manufacturers' recommendations.
- Straw Coconut Fiber Blanket – Should be machine produced mats of 70% straw and 30% coconut fiber with a biodegradable netting top layer and a biodegradable bottom net. The straw and coconut fiber should be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket should be of consistent thickness. The straw and coconut fiber blanket should be evenly distributed over the entire area of the blanket. Straw coconut fiber blanket should be furnished in rolled strips a minimum of 6.5 ft wide, a minimum of 80 ft long and a minimum of 0.5 lbs/yd^2. Straw coconut fiber blankets must be secured in place with wire staples. Staples should be made of minimum 11-gauge steel wire and should be U-shaped with 8 in. legs and 2 in. crown.

- Non-biodegradable RECPs are typically composed of polypropylene, polyethylene, nylon, or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the RECP. Netting used to hold these fibers together is typically non-biodegradable as well.
  - Plastic Netting – Is a lightweight biaxially oriented netting designed for securing loose mulches like straw or paper to soil surfaces to establish vegetation. The netting is photodegradable. The netting supplied in rolled strips, which must be secure with U-shaped staples or stake in accordance with the manufactures' recommendations.
  - Plastic Mesh – An open weave geotextile that is composed of an extruded synthetic fiber woven into a mesh with an opening size of less that $^1/_4$in. It is used with re-vegetation or may be used to secure loose fiber such as straw to the ground. The material supplied in rolled strips, which must be secure with U-shaped staples or stake in accordance with the manufactures' recommendations.
  - Synthetic Fiber w/Netting – A mat that is composed of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be re-vegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which must be secure with U-shaped staples or stake in accordance with the manufactures' recommendations.
  - Bonded Synthetic Fibers – A three dimensional geomatrix nylon (or other synthetic) matting. Typically, it has more than 90% open area, which facilitates root growth. It's tough root reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. It can be installed over prepared soil, followed by seeding into the mat. Once vegetated, if becomes an invisible composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which must be secure with U-shaped staples or stake in accordance with the manufactures' recommendations.
  - Combination Synthetic and Biodegradable RECPs – Biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched tot eh top and a high strength continuous filament geomatrix or net stitched to the bottom. The material is designed to enhance re-vegetation. The material is furnished in rolled strips, which must be secure with U-shaped staples or stake in accordance with the manufactures' recommendations.

Site Preparation

- Proper site preparation is essential to ensure complete contact of the blanket or matting with the soil.

- Grade and shape the area of installation
- Remove all rocks, clods, vegetation, or other obstructions so that the installed blankets or mats will have complete, direct contact with the soil.
- Prepared seedbed by loosening 2 to 3 in. of topsoil.

Seeding
Seed the area before blanket installation for erosion control and revegetation. Seeding after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be re-seeded. Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Fertilize and seed in accordance with seeding specifications or other types of landscaping plans. When using jute matting on a seeded area, apply approximately half the seed before laying the mat and the remainder after laying the mat. The protective matting can be laid over ground covers are to be planted, lay the protective matting first and then plant through matting according to design of planting.

Check Slots
Check slots are made of glass fiber strips, excelsior matting strips or tight folded jute matting blanket or strips for use on steep, highly erodible watercourses. The check slots are placed in narrow trenches 6 to 12 in. deep across the channel and left flush with the soil surface. They are to cover the full cross section of designed flow.

Layering and Securing Matting
- Before laying the matting, all check slots should be installed and the friable seedbed mad free from clods, rocks, and roots. The surface should be compacted and finished according to the requirements of the of the manufacturer's recommendations.
- Mechanical or manual lay down equipment should be capable of handling full rolls of fabric and laying the fabric smoothly without wrinkles or folds. The equipment should meet fabric manufacturer's recommendations.

Anchoring
- U-shaped wire staple, metal geotextile stake pins, or triangular wooden stakes can be used to anchor mats and blankets tot eh ground surface.
- Wire staples should be made of minimum 11-gauge steel wire and should be u-shaped with 8 in legs and 2 in. crown.
- Metal stake pins should be 0.188 in. diameter steel with a 1.5 in. steel washer at the head of the pin, and 8 in. in length.
- Wire staples and metal stakes should be driven flush with the soil surface.

Installation on Slopes
Installation should be in accordance with the manufacturer's recommendations. In general, these will be as follows:
- Begin at the top of the sloe and anchor the blanket in a 6 in. deep by 6 in. wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket down slope in the direction of water flow.
- Overlap the edges of adjacent parallel rolls 2 to 3 in. and staple every 3 ft.
- When blankets must be spliced place blanket end over end (shingle style) wit 6 in. overlap. Staple through overlapping area, approximately 12 in. apart.
- Lay blankets loosely and maintain direct contact with the soil. Do no stretch.
- Staple blankets sufficiently to anchor blankets and maintain contact with the soil. Staples should be placed down the center and staggered with the staples placed along the edges. Steep slopes, 1:1 (H:V) to 2:1 (H:V), require a minimum of 2 staples/yd^2. Moderate slopes, 2:1 (H:V) to 3:1 (H:V), require a minimum of $1^{1/}{}_{2}$ staples/yd^2.

Installation in Channels
Installation should be in accordance with the manufacturer's recommendations. In general, these will be as follows:
- Dig initial anchor trench 12 in. deep and 6 in. wide across the channel at the lower end of the project area.
- Excavate intermittent check slots, 6 in. deep and 6 in. wide across the channel at 25 to 30 ft intervals along the channels.
- Cut longitudinal channel anchor trenches 4 in. deep and 4 in. wide along each side of the installation to bury edges of matting, whenever possible extend matting 2 o 3 in. above the crest of the channel side slopes.
- Beginning at the downstream end and in the center of the channel, place the initial en of the first roll in the anchor trench and secure with fasting devices at 12 in. intervals. Note: matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 3in.
- Secure these initial ends of mats with anchors at 12 in. intervals, backfill and compact soil.
- Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench. Unroll adjacent mats upstream in similar fashion, maintaining a 3 in. overlap.

- Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then folds back against itself. Anchor through both layers of mat at 12 in. intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
- Alternate method for non-critical installations: Place two rows of anchors on 6 in. centers at 25 to 30 ft. intervals in lieu of excavated check slots.
- Staple shingled lap spliced ends a minimum of 12 in. apart on 12 in. intervals.
- Place edges of outside mats in previously excavated longitudinal slots; anchor using prescribed staple pattern, backfill, and compact soil.
- Anchor, fill, and compact upstream end of mat in a 12 in. by 6 in. terminal trench.
- Secure mat to ground surface using U-shaped wire staples, geotextile pins, or wooden stakes.
- Seed and fill turf reinforcement matting with soil, if specified.

Soil Filling (if specified for turf reinforcement)

- Always consult the manufacturer's recommendations for installation.
- Do not drive tracked or heavy equipment over mat.
- Avoid any traffic over matting if loose or wet soil conditions exist.
- Use shovels, rakes, or brooms for fine grading and touch up.
- Smooth out soil filling just exposing top netting of mat.

Temporary Soil Stabilization Removal

- Temporary soil stabilization removed from the site of the work must be disposed of it necessary.

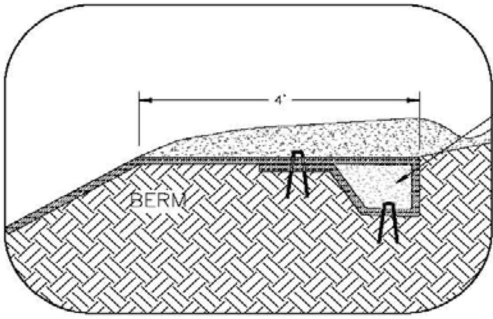
Don't. Leave the blanket unsecured and edges untrenched into the ground.

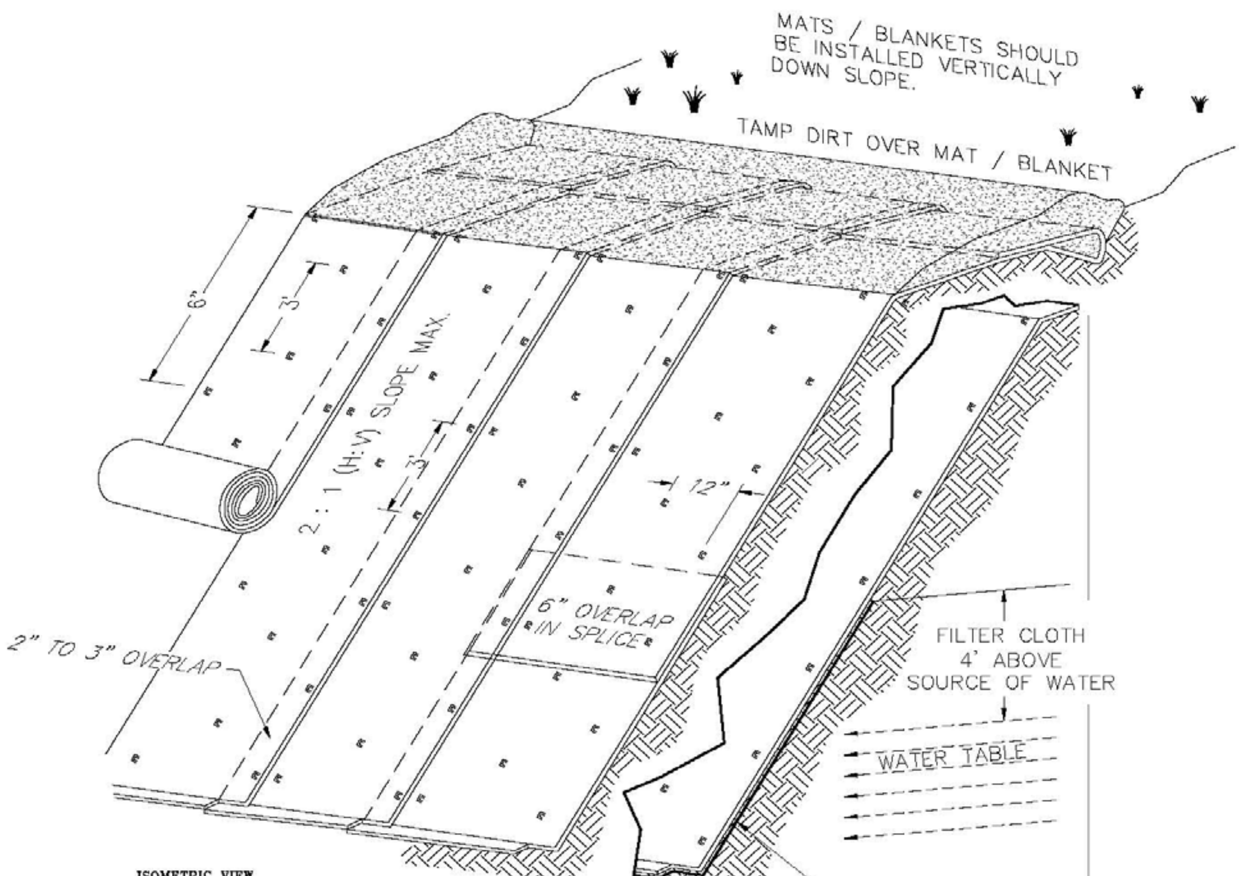
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season, and at two-week intervals during the non-rainy season.
- Inspect BMPs subject to non-stormwater discharges daily while non-stormwater discharges occur.
- Areas where erosion is evident shall be repaired and BMPs reapplied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damaged will require reapplication of BMPs.
- If washout or breakage occurs, re-install the material after repairing the damage to the slope or channel.
- Make sure matting is uniformly in contact with the soil.
- Check that all the lap joints are secure.
- Check that staples are flush with the ground.
- Check that disturbed areas are seeded.

Do. *Properly overlap seam to ensure slope protection.*

GEOTEXTILES AND MATS





ISOMETRIC VIEW
TYPICAL SLOPE SOIL STABILIZATION
NOT TO SCALE

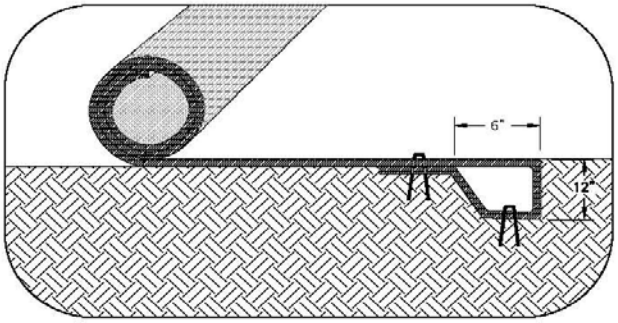
WET SLOPE LINING
NOT TO SCALE

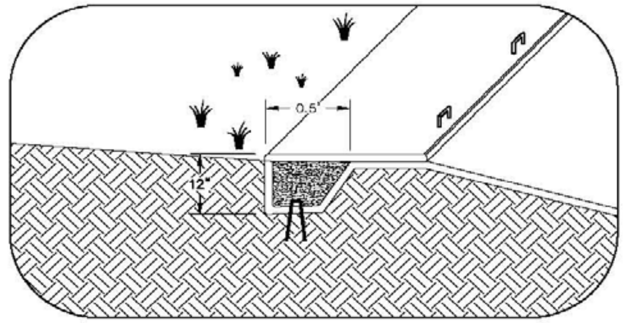
NOTES:

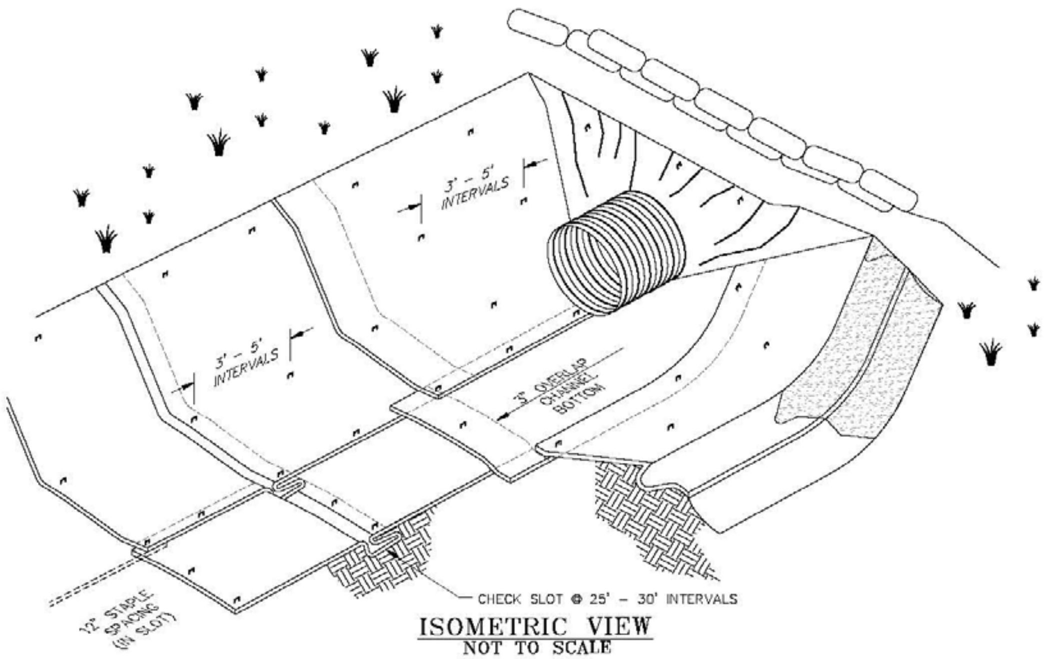
1. SLOPE SURFACE SHALL BE FREE OF ROCKS, STICKS CLODS AND GRASS. MATS / BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH SOIL.
3. INSTALL AS PER MANUFACTURER'S RECOMMENDATIONS.

TYPICAL INSTALLATION DETAIL

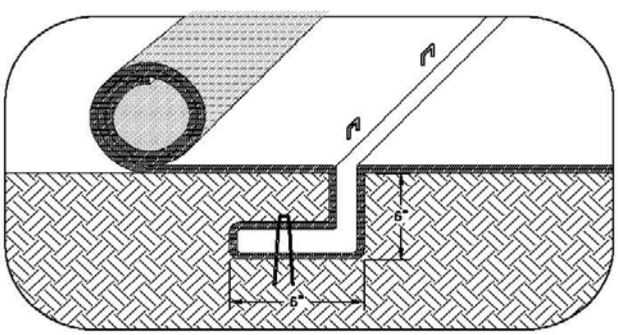
GEOTEXTILES AND MATS

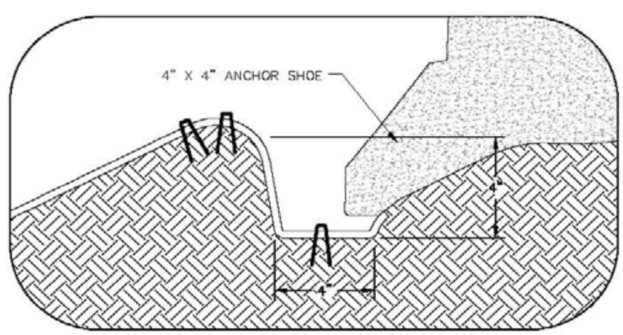






ISOMETRIC VIEW
NOT TO SCALE





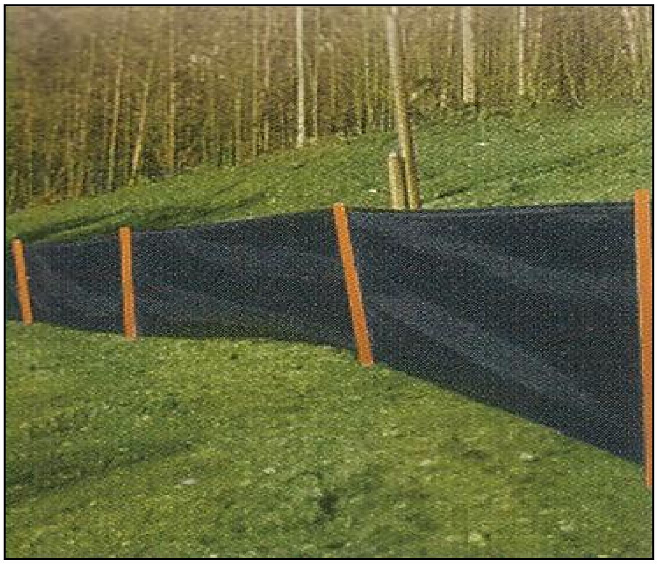
INTERMITTENT CHECK SLOT
NOT TO SCALE

LONGITUDINAL ANCHOR TRENCH
NOT TO SCALE

NOTES:
1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.
3. INSTALL AS PER MANUFACTURERS RECOMMENDATIONS.

TYPICAL INSTALLATION DETAIL

SF: Silt Fence



Description & Purpose

A silt fence is made of a filter fabric that has been entrenched, attached to supporting poles, and sometimes backed by a plastic or wire mesh for support. The silt fence detains sediment-laden water, promoting sedimentation behind the fence.

Objectives

EC Erosion Control

Potential Alternatives

FB Fiber Rolls
GBB Gravel Bag Berm
SBB Sandbag Barrier
SWB Straw Bale Barrier

Suitable Applications

Silt fences may be suitable in the following situations:

- Perimeter control, placed below areas where sheet flows discharge from the site.
- Interior controls below disturbed areas where runoff may occur.
- Silt fences are generally ineffective in locations where the flow is concentrated and are only applicable for sheet or overland flows.
- When used in combination with erosion controls.
- Along streams and channels.
- Around temporary spoil areas and stockpiles.
- Below other small, cleared areas.

Limitations

- Do not use in streams, channels, drain inlets, or anywhere flow is concentrated.
- Do not use in locations where ponded water may cause flooding.
- Do not place fence on a slope, or across any contour line. If not installed at the same elevation throughout, silt fences will create erosion.
- Filter fences will create a temporary sedimentation pond on the upstream side of the fence and may cause temporary flooding. Fences not constructed on a level contour will be overtopped by concentrated flow resulting in failure of the filter fence.
- Improperly installed fences are subject to failure from undercutting, overlapping, or collapsing.
  - Not effective unless trenched and keyed in.
  - Not intended for use as mid-slope protection on slopes greater than 4:1 (H:V).
  - Do not allow water depth to exceed 1.5 ft at any point.

Implementation

General

A silt fence is a temporary sediment barrier consisting of filter fabric stretched across and attached to supporting posts, entrenched, and, depending upon the strength of fabric used, supported with plastic or wire mesh fence. Silt fences trap sediment by intercepting and detaining small amounts of sediment-laden runoff from disturbed areas in order to promote sedimentation behind the fence.

Silt fences are preferable to straw bale barriers in many cases. Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much higher percentage of suspended sediments than can straw bales. While the failure rate of silt fences is lower than that of straw bale barriers, there are many instances where silt fences have been improperly installed. The following layout and installation guidance can improve performance and should be followed.

- Use principally in areas where sheet flow occurs.
- Don't use in streams, channels, or anywhere flow is concentrated. Don't use silt fences to divert flow.
- Don't use below slopes subject to creep, slumping, or landslides.
- Select filter fabric that retains 85% of soil by weight, cased on sieve analysis, but that is not finer than an equivalent opening size of 70.
- Install along a level contour, so water does not pond more that 1.5 ft at any point along the silt fence.
- The maximum length of slope draining to any point along the silt fence should be 200 ft or less.
- The maximum slope perpendicular to the fence line should be 1:1.
- Provide sufficient room for runoff to pond behind the fence and to allow sediment removal equipment to pass between the silt fence and toes of slopes or other obstructions. About 1,200ft^2 of ponding area should be provided for every acre draining to the fence.
- Turn the ends of the filter fence uphill to prevent stormwater from flowing around the fence.
- Leave and undisturbed or stabilized area immediately down slope from the fence where feasible.
- Silt fences should remain in place until the disturbed area is permanently stabilized.

Design and Layout

Selecting of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer should specify a filter fabric that retains the soil found on the construction site yet that it has openings large enough to permit drainage and prevent clogging. The following criteria are recommended for selection of the equivalent opening size:

1. If 50% or less of eh soil, by weight, will pass the U.S. Standard Sieve No. 200, select the EOS to retain 85% of the soil. The EOS should not be finer than EOS 70.
2. For all soil types, the EOS should be no larger than the opening in the U.S. Standard Sieve No. 70 except where direct discharge to a stream, lake, wetland will occur, then the EOS should be no larger that Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with a EOS smaller than U.S. Standard Sieve No. 100. If 85% or more of a soil, by weight, passes through the openings in a No. 200 sieve, filter fabric should not be used. Most of the particles in such a soil would not be retained if the EOS was too large and they would clog the fabric quickly if the EOS were small enough to capture the soil.

The fence should be supported by a plastic or wire mesh if the fabric selected does not have sufficient strength and bursting strength characteristics for the planned application (as recommended by the fabric manufacturer). Filter fabric material should contain ultraviolet inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F to 120°F.

- Layout in accordance with attached figures.
- For slopes steeper than 2:1 (H:V) and that contain a high number of rocks or large dirt clods that tend to dislodge, it may be necessary to install additional protection immediately adjacent tot eh bottom of the slope, prior to installing silt fence. Additional protection may be chain link fence or a cable fence.
- For slopes adjacent to sensitive receiving waters or Environmentally Sensitive Areas (ESAs), silt fence should be used in conjunction with erosion control BMPs.
- Don't use below slopes subject to creep, slumping, or landslides.

Materials

- Silt fence fabric should be woven polypropylene with a minimum width of 36 in. and a minimum tensile strength of 100 lb force. The fabric should conform to the requirements in ASTM designation D_{4632} and should have an integral reinforcement layer. The reinforcement later should be polypropylene, or equivalent, net provided by the manufacturer. The permittivity of the fabric should be between 0.1 sec^{-1} and 0.15 sec^{-1} in conformance with the requirements in ASTM designation D_{4491}.
- Wood stakes should be commercial Quality lumber of the size and shape shown on the plans. Each stake should be free from decay, splits or cracks longer than

Do. *Protect slopes from concentrated flows.*

Don't. *Install silt fence where flow velocity and volume will compromise structural integrity. If necessary, reinforce silt fence in sensitive areas.*

the thickness of the stake or other defects that would weaken the stakes and cause the stakes to be structurally unsuitable.

- Staples used to fasten the fence fabric to the stakes should be not less than 1.75 in. long and should be fabricated from 15 gauge or heavier wire. The wire used to fasten the tops of the stakes together when joining two sections of fence should be 9 gauge or heavier wire. Galvanizing of the fastening wire will not be required.
- There are new products that may use prefabricated plastic holders for the silt fence and use bar reinforcement instead of wood stakes. If bar reinforcement is used in lieu of wood stakes, use number four or greater bar. Provide end protection for any exposed bar reinforcement.

Installation

Silt fences are to be constructed on a level contour. Sufficient area should exist behind the fence for ponding to occur without flooding or overtopping the fence.

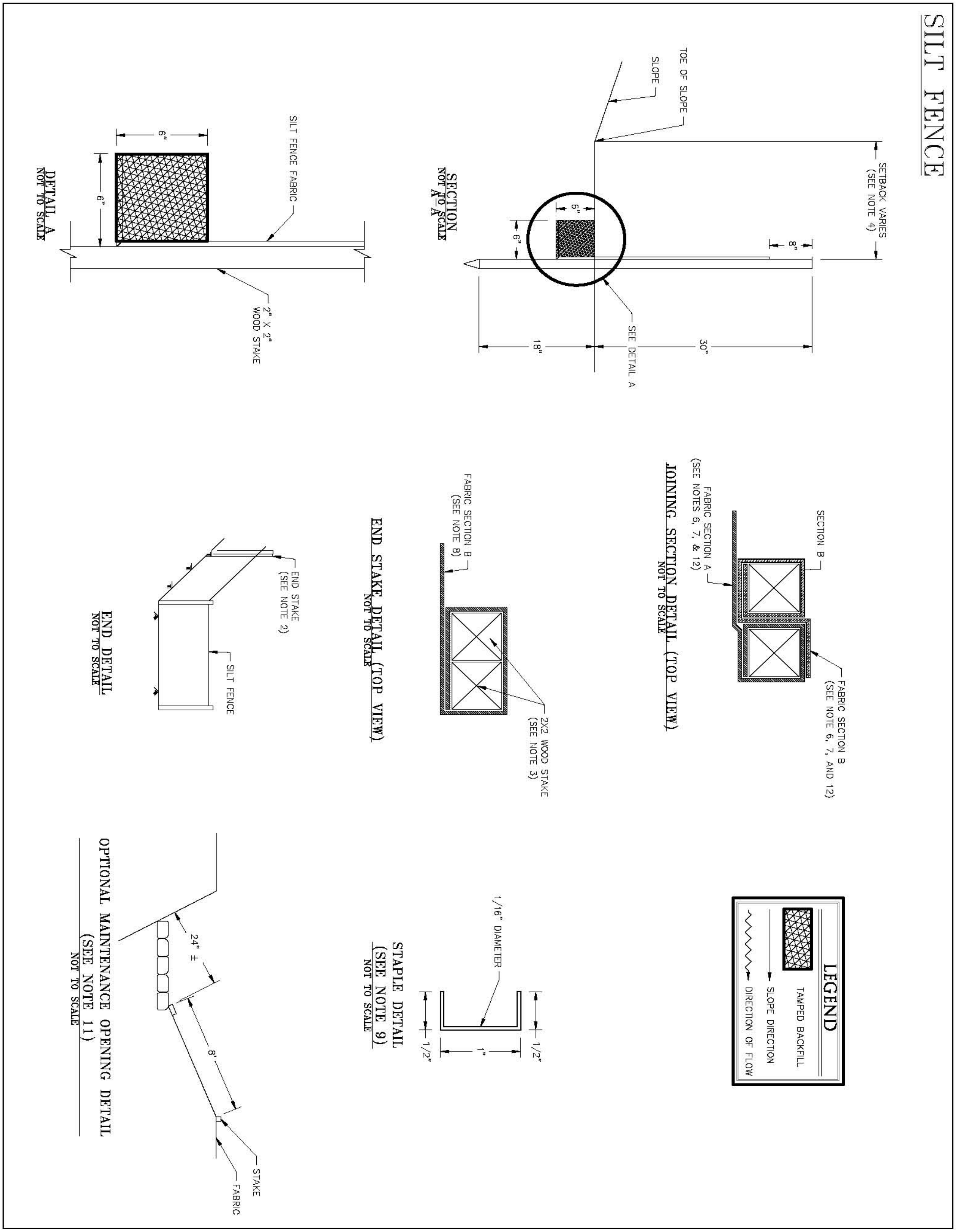
- A trench should be excavated approximately 6 in. wide and 6 in. deep along the line of the proposed silt fence.
- Bottom of the silt fence should be keyed-in a minimum of 12 in.
- Posts should be spaced a maximum of 6 ft apart and driven securely into the ground a minimum of 18 in. or 12 in. below the top of the trench.
- When standard strength filter fabric is used, a plastic or wire mesh support should be fastened securely to the upslope side of posts using heavy-duty wire staples at least 1 in. long. The mesh should extend into the trench. When extra-strength filter fabric should be purchased in a long roll then cut to the length of the barrier. When joints are necessary 6 in. filter cloth should be spliced together only at a support post, with a minimum 6 in. overlap and both ends securely fastened to the post.
- The trench should be backfilled with compacted native material.
- Construct silt fences with a setback of at least 3 ft from the toe of the slope. Where a silt fence is determined to be not practical due to specific site condition, the silt fence may be constructed at the toe of the slope but should be constructed as far from the toe of the slope as practical. Silt fence close to the toe of the slope will be less effective and difficult to maintain.
- Construct the length of each reach so that the change in base elevation along the reach does not exceed $^1/_3$ the height of the barrier, in no case should the reach exceed 500 ft.

Do. Install silt fence to keep sediment laden runoff on site.

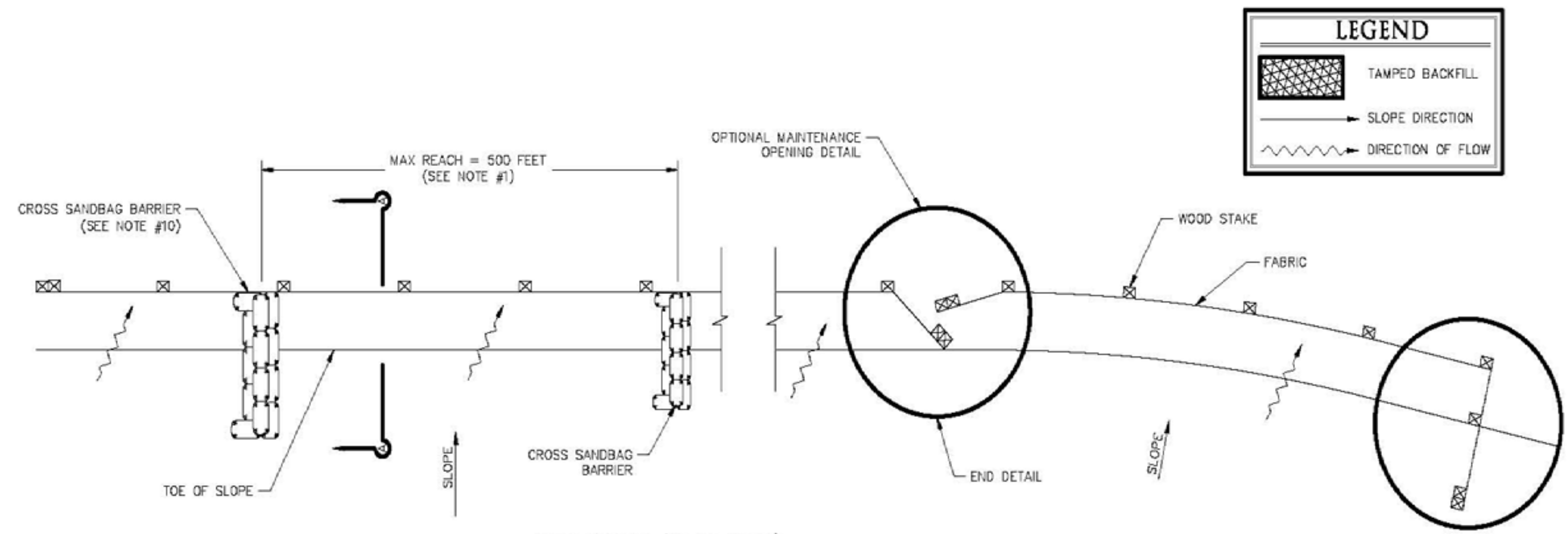
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Repair undercut silt fences.
- Repair or replace split, torn, slumping, or weathered fabric. The lifespan of silt fence fabric is generally 5 to 8 months.
- Silt fences that are damaged and become unsuitable for the intended purpose should be removed from the sire of work, disposed of, and replaced with new silt fence barriers.
- Sediment that accumulates in the BMP must be periodically removed in order to maintain BMP effectiveness. Sediment should be removed when the sediment accumulation reaches one-third of eh barrier height. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed at an appropriate location.
- Silt fence should be left in place until the upstream area is permanently stabilized. Until then, the silt fence must be inspected and maintained.
- Holes, depressions, or other ground disturbance caused by the removal of the silt fences should be backfilled and repaired.

Don’t. Use silt fence as a check dam.


SILT FENCE
SETBACK VARIES (SEE NOTE 4)
TOE OF SLOPE
SLOPE
8"
6"
6"
SEE DETAIL A
30"
18"
SECTION A-A
NOT TO SCALE
SILT FENCE FABRIC
6"
6"
2" X 2" WOOD STAKE
DETAIL A
NOT TO SCALE
SECTION B
FABRIC SECTION A (SEE NOTES 6, 7, & 12)
FABRIC SECTION B (SEE NOTE 6, 7, AND 12)
JOINING SECTION DETAIL (TOP VIEW)
NOT TO SCALE
FABRIC SECTION B (SEE NOTE 8)
2X2 WOOD STAKE (SEE NOTE 3)
END STAKE DETAIL (TOP VIEW)
NOT TO SCALE
END STAKE (SEE NOTE 2)
SILT FENCE
END DETAIL
NOT TO SCALE
LEGEND
TAMPED BACKFILL
SLOPE DIRECTION
DIRECTION OF FLOW
1/16" DIAMETER
1/2"
1"
1/2"
STAPLE DETAIL
(SEE NOTE 9)
NOT TO SCALE
24" ±
8'
STAKE
FABRIC
OPTIONAL MAINTENANCE OPENING DETAIL
(SEE NOTE 11)
NOT TO SCALE

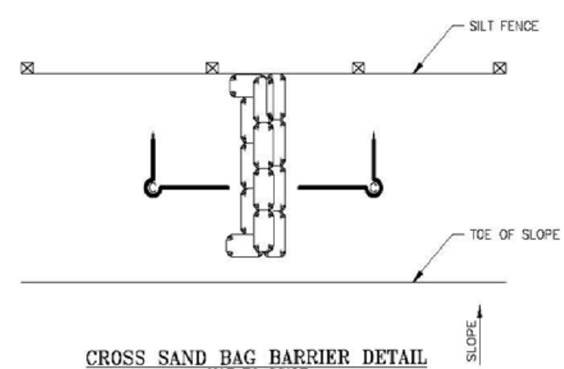
SILT FENCE



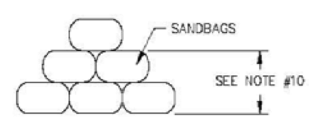
SILT FENCE (PLAN VIEW)
NOT TO SCALE

NOTES

1. CONSTRUCT THE LENGTH OF EACH REACH SO THAT THE CHANGE IN BASE ELEVATION ALONG THE REACH DOES NOT EXCEED 1/3 THE HEIGHT OF THE LINEAR BARRIER. IN NO CASE SHALL THE REACH LENGTH EXCEED 500 FEET.
2. THE LAST 8'-0" OF THE FENCE SHALL BE TURNED UP SLOPE
3. STAKE DIMENSIONS ARE NOMINAL.
4. DIMENSIONS VARY TO FIT FIELD CONDITION.
5. STAKES SHALL BE PLACED 8'-0" MAXIMUM AND SHALL BE POSITIONED ON DOWN SLOPE SIDE OF FENCE.
6. STAKES TO OVERLAP AND FENCE FABRIC TO FOLD AROUND EACH STAKE ONE FULL TURN. SECURE FABRIC TO STAKE WITH FOUR (4) STAPLES.
7. STAKES SHALL BE DRIVEN TIGHTLY TOGETHER TO PREVENT POTENTIAL FOLLOW-THROUGH OF SEDIMENT AT JOINT. THE TOPS OF THE STAKES SHALL BE SECURED WITH WIRE.
8. FOR END STAKE, FENCE FABRIC SHALL BE FOLDED AROUND TWO STAKES ONE FULL TURN AND SECURED WITH FOUR (4) STAPLES.
9. MINIMUM OF STAPLES OF PER STAKE. DIMENSIONS AS SHOWN.
10. CROSS BARRIER SHALL BE A MINIMUM OF 1/3 AND A MAXIMUM OF 1/2 THE HEIGHT OF THE LINEAR LINER BARRIER.
11. MAINTENANCE OPENINGS SHALL BE CONSTRUCTED IN A MANNER TO ENSURE SEDIMENT REMAINS BEHIND FENCE.
12. JOINING SECTIONS MAY NOT BE PLACED AT SUMP LOCATIONS.
13. SANDBAG ROWS AND LAYERS SHALL BE OFFSET TO ELIMINATE GAPS.



CROSS SAND BAG BARRIER DETAIL
NOT TO SCALE



SECTION C-C
NOT TO SCALE

ED: Earth Dikes and Drainage Swales

Description & Purpose

An earth dike is a temporary berm or ridge of compacted soil used to divert runoff or channel water to a desired location. A drainage swale is a shaped and sloped depression in the soil surface used to convey runoff to a desired location. Earth dikes and drainage swales are used to diver off site runoff around the construction site; divert runoff from stabilized areas and disturbed areas, and direct runoff into sediment basins or traps.

Objectives

EC Erosion Control

Potential Alternatives

None

Suitable Applications

Earth Dikes and Drainage Swales may be suitable in the following situations:

- Where runoff needs to be diverted from one area and convey to another.
- To convey surface runoff down sloping terrain.
- To intercept and divert runoff to avoid sheet flow over steep sloped surfaces.
- To divert and direct runoff toward a stabilized watercourse, drainage pipe or channel.
- To intercept runoff from paved surfaces
- Below steep grades where runoff begins to concentrate.
- Along roadways and facility improvements subject to flood drainage.
- At the top of slopes to divert run-on from adjacent or undisturbed slopes.
- At bottom and mid slope location to intercept sheet flow and convey concentrated flows.
- Divert sediment laden runoff into sediment basins or traps.

Limitations

Dikes should not be used for drainage areas greater than 10 acres or along slopes greater than 10%. For larger areas more permanent drainage structures should be built. All drainage structures should be built in compliance with local and municipal requirements.

- Earth dikes may create more disturbed area on site and become barriers to construction equipment.
- Earth dikes must be stabilized immediately, which adds cost and maintenance concerns.
- Diverted stormwater may cause downstream flood damage.

- Dikes should not be constructed of souls that may be easily eroded.
- Re-grading the site to remove the dike may add additional cost.
- Temporary drains and swales or any other diversion of runoff should not adversely impact upstream of downstream properties.
- Temporary drains and swales must conform to local floodplain management requirements.
- Earth dikes/drainage swales are not suitable as sediment trapping devices
- It may be necessary to use other soil stabilization and sediment controls such as check dams, plastics, and blankets to prevent scour and erosion in newly graded dikes, swales, and ditches.

Implementation

The temporary earth dike is a berm or ridge of compacted soil, located in such a manner as to divert stormwater to sediment trapping device or a stabilized outlet, thereby reducing the potential for erosion and offsite sedimentation. Earth dikes can also be used to divert runoff from off site and from undisturbed areas away from disturbed areas and to divert sheet flows away from unprotected slopes.

An earth dike does not itself control erosion or remove sediment from runoff. A dike prevents erosion by directing runoff to an erosion control device such as a sediment trap of directing runoff away from erodible areas. Temporary diversion dikes should not adversely impact adjacent properties and must conform to local floodplain management regulations and should not be used in areas with slopes greater than 10%.

Slopes that are formed during cut and fill operations should be protected from erosion by runoff. A combination of a temporary drainage swale and an earth dike at the top of a slope can divert runoff to a location where it can be brought to the bottom of the slope (se SD, Slope Drain). A combination dike and swale is easily constructed be a single pass of a bulldozer of grader and compacted be a second pass of the tracks or wheels over the ridge. Diversion structures should be installed when the site is initially graded and remain in place until post construction BMPs are installed, and the slopes are stabilized.

Diversion practices concentrate surface runoff, increasing its velocity and erosive force. Thus, the flow out of the drain or swale must be directed onto a stabilized area or into a grade stabilization structure. If significant erosion will occur, a swale should be stabilized using vegetation, chemical treatment, rock riprap, matting, or other physical means of stabilization. Any drain or swale that conveys sediment laden runoff must be diverted into a sediment basin or trap before it is discharged from the site.

General

- Care must be applied to correctly size and locate earth dikes, drainage swales. Excessively steep, unlined dikes and swales are subject to erosion and gully formation.
- Conveyances should be stabilized.
- Use a lined ditch for high flow velocities.
- Select flow velocity based on careful evaluation of the risks due to erosion of the measure, soil types, overtopping, flow backups, washout, and drainage flow patterns for each project site.
- Compact any fills to prevent unequal settlement.
- Do not divert runoff onto other property without securing written authorization from the property owner.
- When possible, install and utilize permanent dikes, swales, and ditches early in the construction process.
- Provide stabilized outlets.

Earth Dikes

Temporary earth dikes are a practical, inexpensive BMP used to divert stormwater runoff. Temporary diversion dikes should be installed in the following manner.

- All dikes should be compacted by earth moving equipment.
- All dikes should have positive drainage to an outlet.
- All dikes should have 2:1 or flatter side slopes, 18 in. minimum height, and a minimum top width of 24 in. Wide top widths and flat slopes are usually needed at crossings for construction traffic.
- The outlet from the earth dike must function with a minimum of erosion. Runoff should be conveyed to a sediment trapping device such as a Sediment Trap (ST) or Sediment Basin (SB) when either the dike channel or the drainage area above the dike are not adequately stabilized.
- Temporary stabilization may be achieved using seed and mulching for slopes less than 5% and either riprap or sod for slopes in excess of 5%. In either case stabilization of the earth dike should be completed immediately after construction or prior tot eh first rain.
- If riprap is used to stabilize the channel formed along the toe of the dike, the following specifications apply:

Channel Grade	Riprap Stabilization
0.5 – 1.0%	4 in. Rock
1.1 – 2.0%	6 in. Rock
2.1 – 4.0%	8 in. Rock
4.1 – 5.0%	8 in. – 12 in. Riprap

- The stone riprap used for stabilization should be pressed into the soil with construction equipment.
- Filter cloth may be used to cover dikes in use for long periods.

- Construction activity on the earth dike should be kept to a minimum.

Drainage Swales

Drainage swales are only effective if they are properly installed. Swales are more effective than dikes because they tend to be more stable. The combination of a swale with a dike of the downhill side is the most cost-effective diversion. Standard engineering design criteria for small open channel and closed conveyance systems should be used. Unless local drainage design criteria state otherwise, drainage swales should be designed as follows:

- No more than 5 acres may drain to a temporary drainage swale.
- Place drainage swales above or below, not on, a cut or fill slope.
- Swale bottom width should be at least 2 ft.
- Depth of the swale should be at least 18 in.
- Side slopes should be 2:1 or flatter.
- Drainage swales should be laid at a grade of at least 1%, but not more than 15%.
- The swale must no be overtopped by the peak discharge from a 10-year storm, irrespective of the design criteria stated above.
- Remove all trees, stumps, obstructions, and other objectionable material from the swale when it is built.
- Compact any dill material along the path of the swale.
- Stabilize all swales immediately. Seed and mulch swales at a slope of less than 5% and use riprap or sod for swales with a slope between 5 and 15%. For temporary swales, geotextiles and mats may prove immediate stabilization.
- Irrigation may be required to establish sufficient vegetation to prevent erosion.
- Do not operate construction vehicles across a swale unless a stabilized crossing is provided.
- Permanent drainage facilities must be design by a professional engineer.
- At a minimum, the drainage swale with a positive grade to a stabilized outlet.
- Provide erosion protection or energy dissipation measures if the flow out of the drainage swale can reach and erosive velocity.

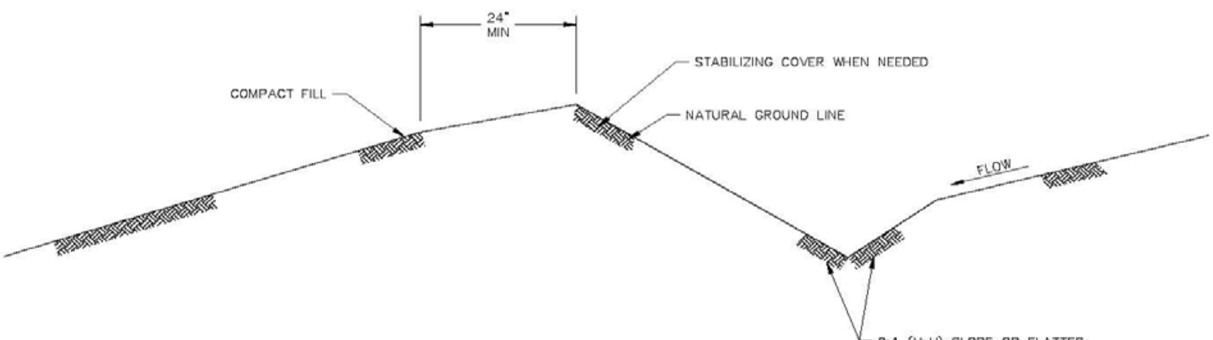
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Inspect BMPs subjected to non-stormwater discharges daily while non-stormwater discharge occurs.
- Inspect ditches and berms for washouts. Replace lost riprap, damaged linings or soil stabilizers as needed.
- Inspect channel linings, embankments, and beds of ditches and berms for erosion and accumulation of debris and sediment. Remove debris and sediment and repair linings and embankments as needed.
- Temporary conveyances should be completely removed as soon as the surrounding drainage area has been stabilized or at the completion of construction.

Do. *Line the channel when highly erodible soils may be encountered.*

Don't. *Wait until the runoff has already created severe erosion areas.*

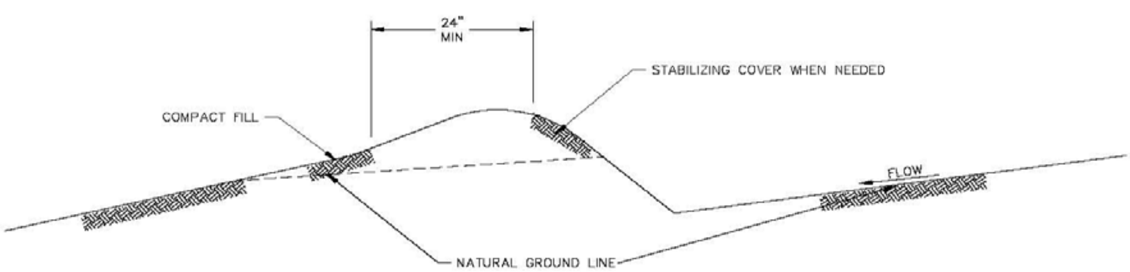
EARTH DIKES AND DRAINAGE SWALES



TYPICAL DRAINAGE SWALE
NOT TO SCALE

NOTES:

1. STABILIZE INLET, OUTLETS AND SLOPES.
2. PROPERLY COMPACT THE SUBGRADE.



TYPICAL EARTH DIKE
NOT TO SCALE

SB: Sediment Basin

Description & Purpose

A sediment basin is a temporary basin formed by excavation or by constructing an embankment so that sediment-laden runoff is temporarily detained under latent conditions, allowing sediment to settle out before the runoff is discharged.

Suitable Applications

Sediment basins may be suitable in the following situations:

- Large projects with room enough to construct the basin.
- Where sediment-laden water may enter the drainage system or watercourse.
- On construction projects with disturbed areas during the rainy season.
- At the outlet of disturbed watersheds between 5 acres and 75 acres.
- At the outlet of large, disturbed watersheds, as necessary.
- Where post construction detention basins are required.
- In association with dikes, temporary channels, and pipes used to convey runoff from disturbed areas.

Limitations

Sediment basins must be installed only within the property limits and where failure of the structure will not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. In addition, sediment basins are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the basin is required, the type of fence and its location should be shown in the grading plan and in the construction specifications.

- Generally, sediment basins are limited to drainage areas of 5 acres or more, but not appropriate for drainage areas greater than 75 acres.
- Sediment basins may become an “attractive nuisance” and care must be taken to adhere to all safety practices. If safety is a concern basin may require protective fencing.
- Sediment basins designed according to this detail are only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) may not be adequately treated unless chemical treatment is used in addition to the sediment basin.

Objectives

SC Sediment Control

Potential Alternatives

ST Sediment Trap (for small areas)

- Sites with very fine sediments (fine silt and clay) may require longer detention times for effective sediment removal.
- Basins with a height of 25 ft or more or an impounding capacity of 50 ac-ft or more must obtain approval from Division of Dam Safety
- Standing water may cause mosquitoes of other pests to breed.
- Basins require large surface areas to permit settling of sediment. Size may be limited by the available area.

Implementation

General

A sediment basin is a controlled stormwater release structure formed by excavation or by construction of an embankment of compacted soil across a drainage way, or other suitable location. It is intended to trap sediment before it leaves the construction site. The basin is a temporary measure with a design life of 12 to 28 months in most cases and is to be maintained until the site area is permanently protected against erosion of a permanent detention basin is constructed.

Sediment basins are suitable for nearly all types of construction projects. Whenever possible, construct the sediment basins before clearing and grading work begins. Basins should be located at the stormwater outlet from the site but not in any natural of undisturbed stream. A typical application would include temporary dikes, pipes, and/or channels to divert runoff to the basin inlet.

Many development projects in Washington City will be required by local ordinance to provide a stormwater detention basin for post-construction flood control, desilting, or stormwater pollution control. A temporary sediment basin may be constructed by rough grading the post-construction control basins early in the project.

Sediment basins trap 70 – 80% of the sediment that flows into them if designed according to this detail. Therefore, they should be used in conjunction with erosion control practices such as mulching, diversion dikes, etc., to reduce the amount of sediment flowing into the basin.

Planning

To improve the effectiveness of the basin, it should be located to intercept runoff from the largest possible amount of disturbed area. The best locations are generally low areas. Drainage into the basin can be improved by the use of earth dikes and drainage swales. The basin must not be located in a stream, but it should be located to trap sediment-laden runoff before it enters the stream. The basin should not be located where its failure would result in the loss of life or interruption of the use of service of public utilities or roads.

- Construct before clearing and grading work begins when feasible.
- Do not locate in stream
- Basin sites should be located where failure of the structure will not cause loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities.
- Large basins are subject to state and local dam safety requirements.
- Limit the contributing area to the sediment basin to only the runoff from the disturbed soil areas. Use temporary concentrated flow conveyance controls to divert run off from undisturbed areas away from the sediment basin.
- The basin should be located: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where post-construction (permanent) detention basins will be constructed, and (3) where the basins can be maintained on a year-round basis to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area, and to maintain the basin to provide the required capacity.

Design

- The volume of the settling zone should be sized to capture runoff from a 2-year storm or other appropriate design storms specified by Washington City. A detention time of 24 to 40 hours should allow 70 to 80% of sediment to settle.
- The basin volume consists of two zones:
  - A sediment storage zone at least 1 ft deep.
  - A settling zone at least 2 ft deep.
- The length to settling depth ratio (L/SD) should be less than 200.
- Sediment basins are best used in conjunction with erosion controls. Sediment basins that are used in conjunction with upstream erosion and sediment control should be designed to have a capacity equivalent to 67 yd^3 of sediment storage per acre of contributory area.
- The length of the basin should be more than twice the width of the basin; the length should be determined by measuring the distance between the inlet and the outlet.
- Limit the contributing area to the sediment basin to only the runoff from the disturbed soil areas. Use temporary concentrated flow conveyance controls to

divert run off from undisturbed areas away from the sediment basin.

- The basin should be located: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where post-construction (permanent) detention basins will be constructed, and (3) where the basins can be maintained on a year-round basis to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area, and to maintain the basin to provide the required capacity.
- Basins with an impounding levee greater than 4.5 ft tall, measured from the lowest point to the impound area to the highest point of eh levee, and basins capable of impounding more that 35,000 ft^3, should be designed be a Registered Civil Engineer. The design should include maintenance requirements, including sediment and vegetation removal, to ensure continuous function of the basin outlet and bypass structures.
- Basins should be designed to drain within 72 hours following storm events. If a basin fails to drain within 72 hours, it must be pumped dry.
- Sediment basins, regardless of size and storage volume, should include features to accommodate overflow or bypass flows that exceed the design storm event.
  - Include and emergency spillway to accommodate flows not carried by the principal spillway. The spillway should consist of an open channel (earthen of vegetated) over undisturbed material (not fill) or constructed of a non-erodible riprap.
  - The spillway control section, which is a level portion of the spillway channel at the highest elevation in the channel, should be a minimum of 20 ft in length.
- Rock or vegetation should be used to protect the basin inlet and slopes against erosion.
- A forebay constructed upstream of the basin may be provided to remove debris and larger particles.
- The outflow from the sediment basin should be provided with velocity dissipation devices to prevent erosion and scouting of the embankment and channel.
- Basin inlets should be located to maximize travel distance to the basin outlet.
- The principal outlet should consist of a corrugated metal, high density polyethylene (HDPE), or reinforced concrete riser pipe with dewatering holes and an anti-vortex device and trash rack attached to the top of the riser, to prevent floating debris from flowing out of the basin or obstruction the system. This principal structure should be designed to accommodate the inflow design storage.
- A rock pile or rock-filled gabions can serve as alternative to the debris screen; although the designer should be aware of the potential for extra maintenance involved should the pore spaces in the rock pile clog.
- The outlet structure should be placed on a firm, smooth foundation with the base securely anchored with concrete or other means to prevent flotation.
- Attach riser pipe (watertight collection) to a horizontal pipe (barrel). Provide anti-seep collars on the barrel.
- Cleanout level should be clearly marked on the riser pipe.
- Proper hydraulic design of the placed on a firm, smooth foundation with the base securely anchored with concrete or other means to prevent floatation.
- The two most common outlet problems that occur are: (1) the capacity of the outlet is too great resulting in only partial filling of the basin and drawdown time less than designed for; and (2) the outlet clogs because it is not adequately protected against trash and debris. To avoid these problems, the following outlet types are recommended for use: (1) a single orifice outlet with or without the protection of a riser pipe, and (2) perforated riser. Design guidance for single and perforated riser outlets follow:
  - Flow Control Using a Single Orifice at the Bottom of the Basin (Figure 1): The outlet control orifice should be sized using the following equation:

$$a = \frac{2A(H - H_o)^{0.5}}{3600CT(2g)^{0.5}} = \frac{(7x10^{-5})A(H - H_o)^{0.5}}{CT}$$

Where: a = area of orifice
A = surface area of the basin at mid elevation (ft^2)
C = orifice coefficient
T = draw down time of full basin (hrs)
g = gravity (32.2 ft/sec^2)
H = elevation when the basin is full (ft)
H_o = final elevation when basin is empty (ft)

With a drawdown time of 40 hours, the equation becomes:

$$a = \frac{(1.75x16^{-6})A(H - H_o)^{0.5}}{C}$$

- Flow Control Using Multiple Orifices (see Figure 2):

$$a_t = \frac{2A(h_{\max})}{3600CT(2g[h_{\max} - h_{centroid\_of\_orifices}])^{0.5}}$$

With terms as described above except:
a_t = total area of orifice

h_{max} = maximum height from lowest orifice to the maximum water surface (ft)

$h_{centroid\ of\ orifice}$ = height from the lowest orifice to the centroid of the orifice configuration (ft)

Allocate the orifices evenly on two rows; separate the holes by 3x hole diameter vertically, and by 120° horizontally (refer to figure 2).

Because basins are not maintained for infiltration, water loss by infiltration should be disregarded when designing the hydraulic capacity of the outlet structure.

Care must be taken in the selection of "C"; 0.60 is most often recommended and used. However, based on actual tests, GKY (1989), "Outlet Hydraulic of Extended Detention Facilities for Northern Virginia Planning District Commission", recommends the following:

C = 0.66 for thin materials; where the thickness is equal to or less than the orifice diameter, or

C = 0.80 when the material is thicker than the orifice

Installation

- Securely anchor and install an anti-seep collar on the outlet pipe/riser and provide an emergency spillway for passing major floods.
- Areas under embankments must be cleared and stripped of vegetation.
- Chain link fencing should be provided around each sediment basin to prevent unauthorized entry to the basin or if safety is a concern.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Examine basin banks for seepage and structural soundness.
- Check inlet and outlet structures and spillway for any damage or obstruction. Repair damage and remove obstruction as needed.
- Check inlet and outlet area for erosion and stabilize if required.
- Check fencing for damage and repair as needed.
- Sediment that accumulates in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage volume. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove standing water from basin within 72 hours after accumulation.
- BMPs that require dewatering shall be continuously attended while dewatering takes place. Dewatering BMPs shall be used at all times during dewatering.
- To minimize vector production:
  - Remove accumulation of live and dead floating vegetation in basins during every inspection.
  - Remove excessive emergent and perimeter vegetation as needed or as advised by local or state vector control agencies.

Do. *Design an outlet structure that slows the flow to allow sediment to settle out of the runoff.*

Don't. *Build a sediment basin without an armored spillway.*

SEDIMENT BASIN

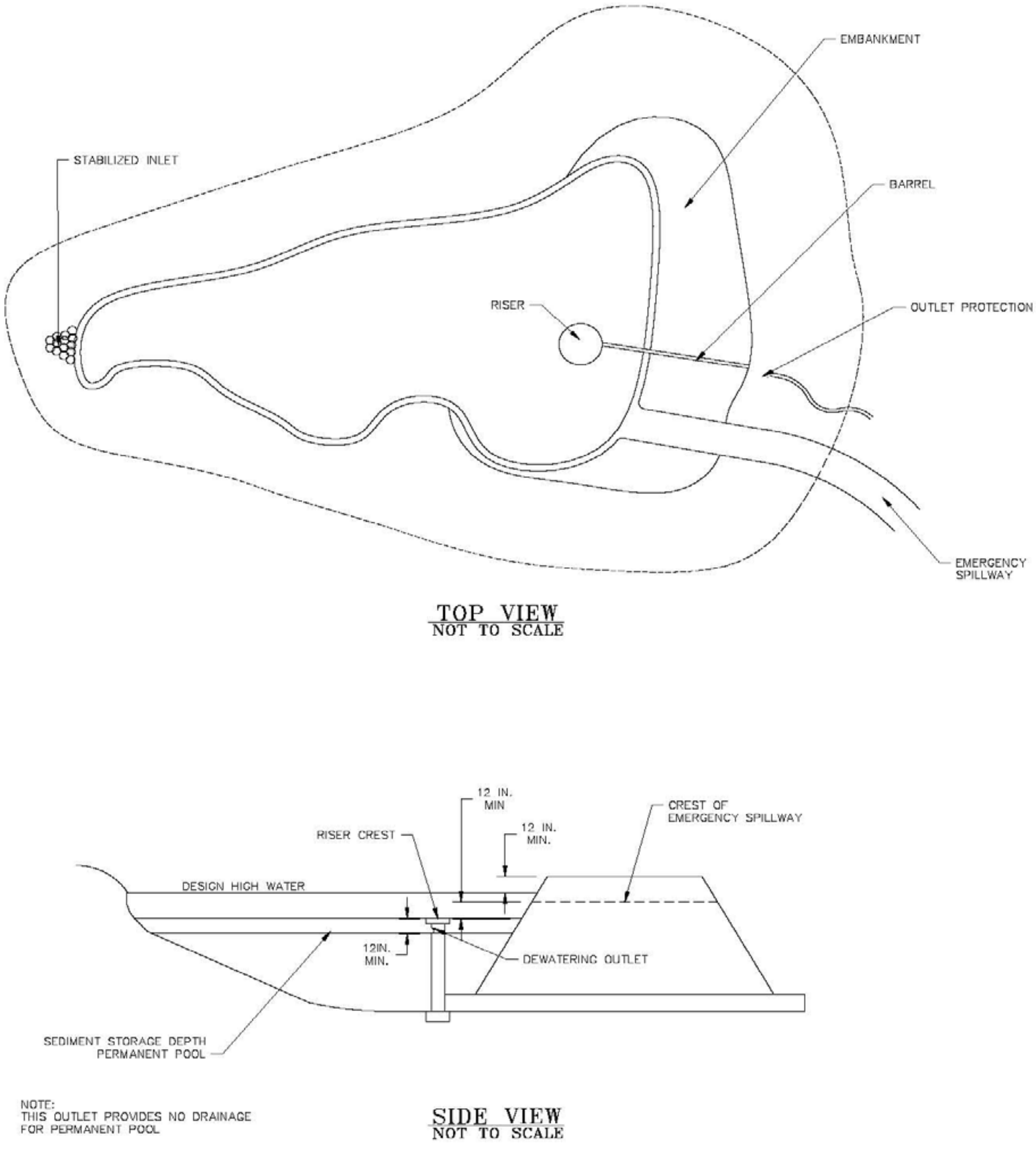
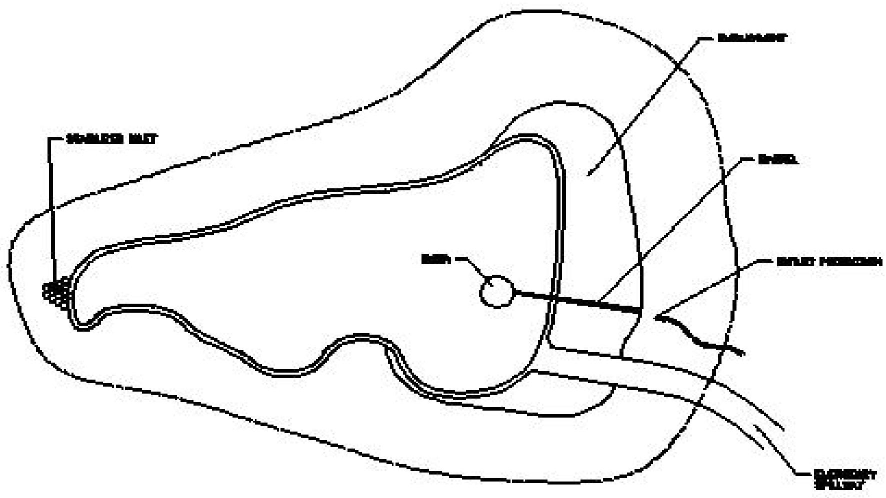
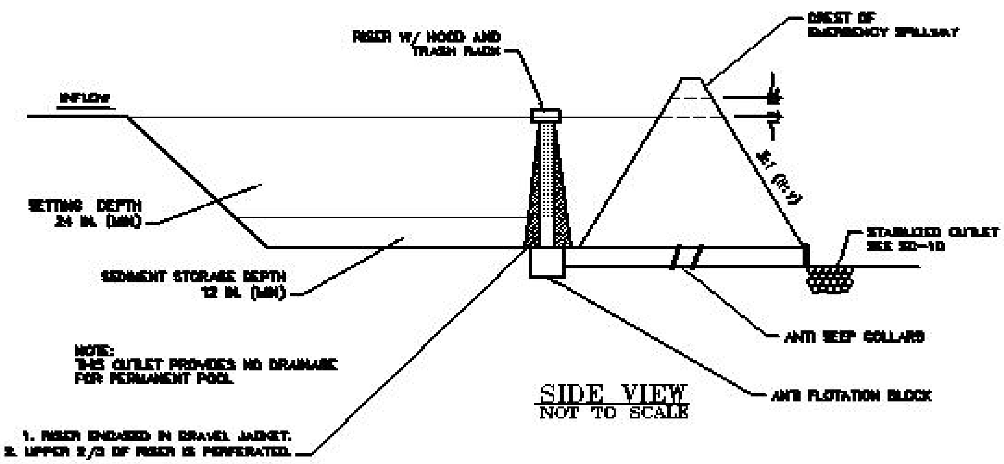


FIGURE 1: TYPICAL TEMPORARY SEDIMENT BASIN
SINGLE ORIFICE DESIGN
NOT TO SCALE

SEDIMENT BASIN



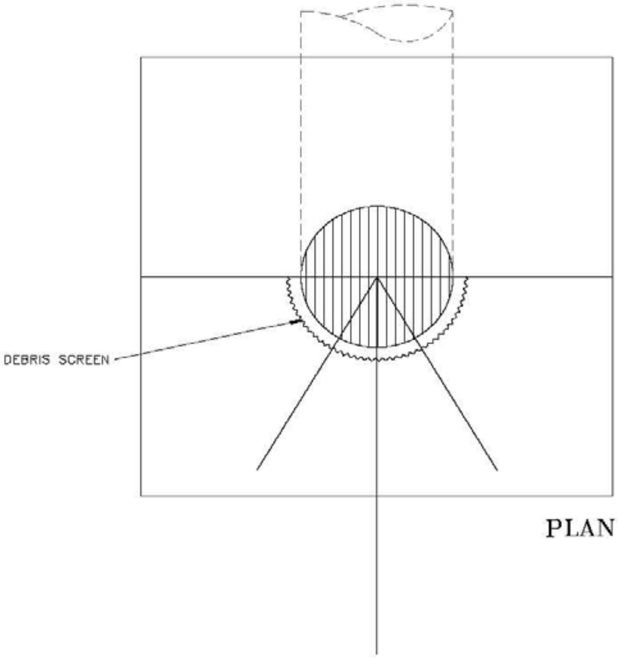
TOP VIEW
NOT TO SCALE



SIDE VIEW
NOT TO SCALE

FIGURE 2: TYPICAL TEMPORARY SEDIMENT BASIN
MULTIPLE ORIFICE DESIGN
NOT TO SCALE

SEDIMENT BASIN



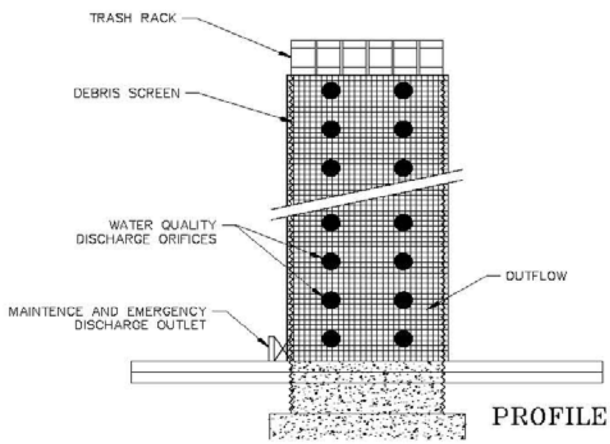


FIGURE 3: MULTIPLE OFIFICE OUTLET RISER
NOT TO SCALE

ST: Sediment Trap

Description & Purpose

A sediment trap is a containment area where sediment-laden runoff is temporarily detained under latent conditions, allowing sediment to settle out of before the runoff is discharged. Sediment traps are formed by excavating or constructing an earthen embankment across a waterway of low drainage area.

Suitable Applications

Sediment traps may be suitable in the following situations:

- At the perimeter of the site at locations where sediment-laden runoff is discharged offsite.
- At multiple locations within the project site where sediment control is needed.
- Around or upslope from storm drain inlet protection measures.
- Construction projects where the drainage area is less than 5 acres. Traps would be placed where sediment-laden stormwater may enter a storm drain or watercourse.
- As a supplemental control, sediment traps provide additional protection for a water body or for reducing sediment before it enters a drainage system.

Limitations

- Requires large surface areas to permit infiltration and settling of sediment.
- Not appropriate for drainage areas greater than 5 acres.
- Only removes large and medium sized particles and requires upstream erosion control.
- Attractive and dangerous to children, requiring protective fencing.
- Conductive to vector production
- Should not be located in live streams.

Objectives

SC Sediment Control

Potential Alternatives

SB Sediment Basin (for larger areas)

Implementation

Design

A sediment trap is a small temporary ponding area, usually with a gravel outlet, formed by excavation or by construction of an earthen embankment. Its purpose is to collect and store sediment from sites cleared or graded during construction. It is intended for use on small drainage areas with no unusual drainage features and projected for a quick build-out time. It should help in removing coarse sediment from runoff. The trap is a temporary measure with a design life of approximately six months to one year and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 5 acres, refer to SB, Sediment Basins, or subdivide the catchment area into smaller drainage basins.

Sediment usually must be removed from the trap after each rainfall event. The drainage plan should detail how this sediment is to be disposed of, such as in fill areas onsite, or removal to an approved offsite dump. Sediment traps used as perimeter controls should be installed before any land disturbance takes place in the drainage area.

Sediment traps are usually small enough that a failure of the structure would not result in a loss of life, damage to homes of buildings, or interruption in the use of public roads or utilities. However, sediment traps are attractive to children and can be dangerous. The following recommendations should be implemented to reduce risks:

- Install continuous fencing around the sediment trap or pond.
- Restrict basin side slopes to 3:1 or flatter.

Sediment trap size depends on the type of soil, size of the drainage area, and desire sediment removal efficiency. As a rule of thumb, the larger the basin volume the greater the sediment removal efficiency. The runoff volume from a 2-year storm is a common design criterion for a sediment trap. The sizing criterion below assumes that this runoff volume is 0.042 acre-ft/acre (0.5 in. of runoff). While the climatic, topographic, and soil type extremes make it difficult to establish broad spectrum standards, the following criteria should trap moderate to high amounts of sediment in most areas of Washington County:

- Locate sediment traps as near as practical to areas producing the sediment.
- Trap should be situated according to the following criteria: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where failure would not cause loss of life or property damage, and (3) to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area.
- Trap should be sized to accommodate a settling zone and sediment storage zone with recommended minimum volumes of 67yd^3/acre and 33 yd^3/acre of contributing drainage area, respectively based on 0.5 in. of runoff volume over a 24-hour period. In many cases, the size of an individual trap is limited by available space. Multiple traps or additional volume may be required to accommodate specific rainfall, soil, and site conditions.
- Traps with an impounding levee greater than 4.5 ft tall, measured from the lowest point to the impounding area to the highest point of the levee, and traps capable of impounding more than 35,000 ft^3 should be designed by a Registered Civil Engineer. The design should include maintenance requirements, including sediment and vegetation removal, to ensure continuous function of the reap outlet and bypass structures.
- The outlet pipe or open spillway must be designed to convey anticipated peak flows.
- Use rock or vegetation to protect the trap outlets against erosion.
- Fencing should be provided to prevent unauthorized entry.

Installation

Sediment traps can be constructed by excavating a depression in the ground or crating an impoundment with a small embankment. Sediment traps should be installed outside the area being graded and should be built prior to the start of the grading activities or removal of vegetation. To minimize the area disturbed by them, sediment traps should be installed in natural depressions or in swales or drainage ways. The following steps must be followed during installation:

- The area under the embankment must be cleared, grubbed, and stripped of any vegetation and root mat. The pool area should be cleared.
- The fill material for the embankment must be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment may be compacted by traversing with equipment while it is being constructed.
- All cut and fill slopes should be 3:1 or flatter.
- When a riser is used, all pipe joints must be watertight.
- When a riser is used, at least the top two-thirds of the riser should be perforated with 0.5 in. diameter holes spaced 8 in. vertically and 10 to 12 in. horizontally.

Do. *Provide sediment trap for areas not large enough to require a sediment basin.*

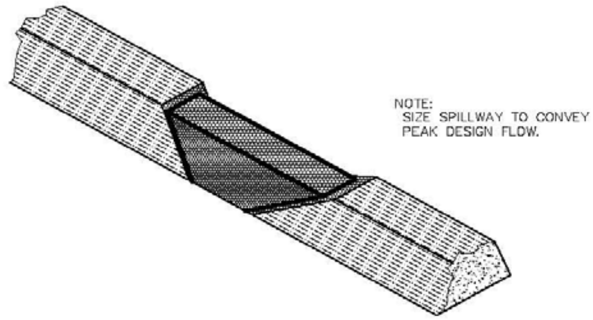
Don't. *Allow sediment to discharge escape the site.*

- When an earth or stone outlet is use, the outlet crest elevation should be at least 1 ft below the top of the embankment.
- When crushed stone outlet is used, the crushed stone used in the outlet should meet AASHTO M_{43}, size No. 2 or 24, or its equivalent. Gravel meeting the above gradation may be used if crushed stone is not available.

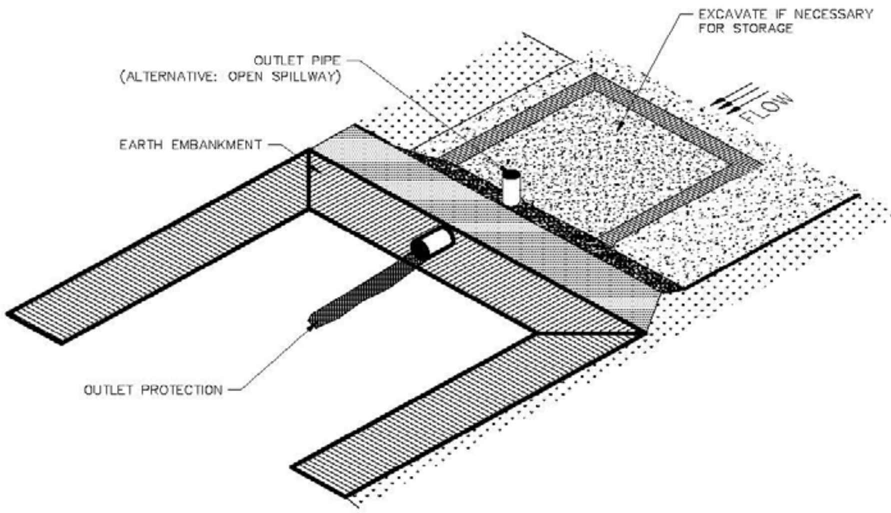
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Inspect outlet area for erosion and stabilize if required.
- Inspect trap banks for seepage and structural soundness, repair as needed.
- Inspect outlet structure and spillway for any damage or obstruction. Repair damage and remove obstructions as needed.
- Inspect fencing for damage and repair as needed.
- Inspect the sediment trap for areas of standing water during every visit. Corrective measures should be taken if the BMP does no dewater completely in 72 hours or less to prevent vector production.
- Sediment that accumulates in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage volume. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove vegetation from the sediment trap when first detected to prevent pools of standing water and subsequent vector production.
- BMPs that require dewatering shall be continuously attended while dewatering takes place. Dewatering BMPs shall be implemented at all times during dewatering activities.

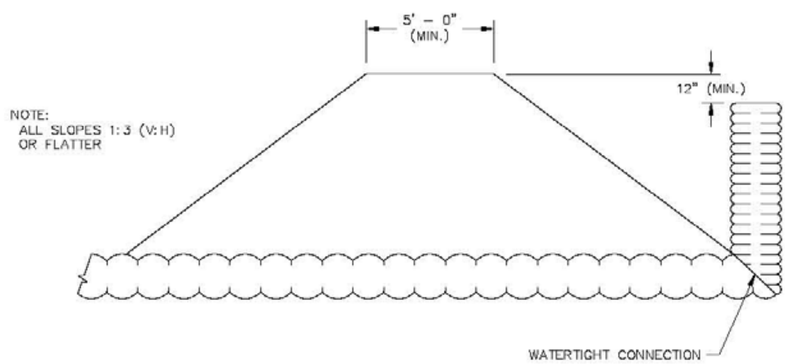
SEDIMENT TRAP



TYPICAL OPEN SPILLWAY
NOT TO SCALE



TYPICAL SEDIMENT TRAP
NOT TO SCALE



EMBANKMENT SECTION THRU RISER

FR: Fiber Rolls

Description & Purpose

A fiber roll consists of straw, flax, or other similar materials bound into a tight tubular roll. When fiber rolls re place at the toe and on the face of slopes, they intercept runoff, reduce its velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of the slope, fiber rolls can also re erosion.

Objectives

SC Sediment Control

Suitable Applications

Fiber rolls may be suitable in the following situations:

- Along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow
- At the end of a downward slope where it transitions to a steeper slope.
- Along the perimeter of a project.
- As check dams in unlined ditches
- Down-slope of exposed soil areas
- Around temporary stockpiles.

Potential Alternatives

SF Silt Fence

GBB Gravel Bag Berm

SBB Sandbag Barrier

SWB Straw Bale Barrier

Limitations

- Fiber rolls are not effective unless trenched.
- Fiber rolls at the toe of slopes greater than 5:1 (H:V) should be a minimum of 20 in. diameter or installations achieving the same protection (i.e. stacked smaller diameter fiber rolls, etc.).
- Difficult to move once saturated.
- If not properly staked and trenched in, fiber rolls could be transported by high flows.
- Fiber rolls have a very limited sediment capture zone
- Fiber rolls should not be used on slopes subject to creep, slumping, or landslides.

Implementation

Fiber Roll Material

- Fiber rolls should be either prefabricated rolls or rolled tubes of erosion control blanket.

Assembly of Field Rolled Fiber Roll

- Roll length of erosion control blanket into a tube of minimum 8 in. diameter.
- Bind roll at each end and every 4 ft long length of roll with jute-type twine.

Installation

- Locate fiber rolls on level contours spaced as follows:
    - Slope inclination of 4:1 (H:V) of flatter: Fiber rolls should be placed at a maximum interval of 20 ft.
    - Slope inclination between 4:1 and 2:1 (H:V): Fiber rolls should be placed at a maximum interval of 15 ft. (a closer spacing is more effective)
    - Slope inclination 2:1 (H:V) or greater: Fiber rolls should be placed at a maximum interval of 10 ft. (a closer spacing is more effective)
- Turn the ends of the fiber roll up slope to prevent runoff from going around the roll.
- Stake fiber rolls into a 2 to 4 in. deep trench with a width equal to the diameter of the fiber roll.
    - Drive stakes at the end of each fiber roll and spaced 4 ft maximum of center.
    - Use wood stakes with a nominal classification of 0.75 by 0.75 in. and minimum length of 24 in.
- If more than one fiber roll is placed in a row, the roll should be overlapped, not abutted.

Removal

- Fiber rolls are typically left in place.
- If fiber rolls are removed, collect and dispose of sediment accumulation, and fill and compact holes, trenches, depressions or any other ground disturbance to blend with adjacent ground.

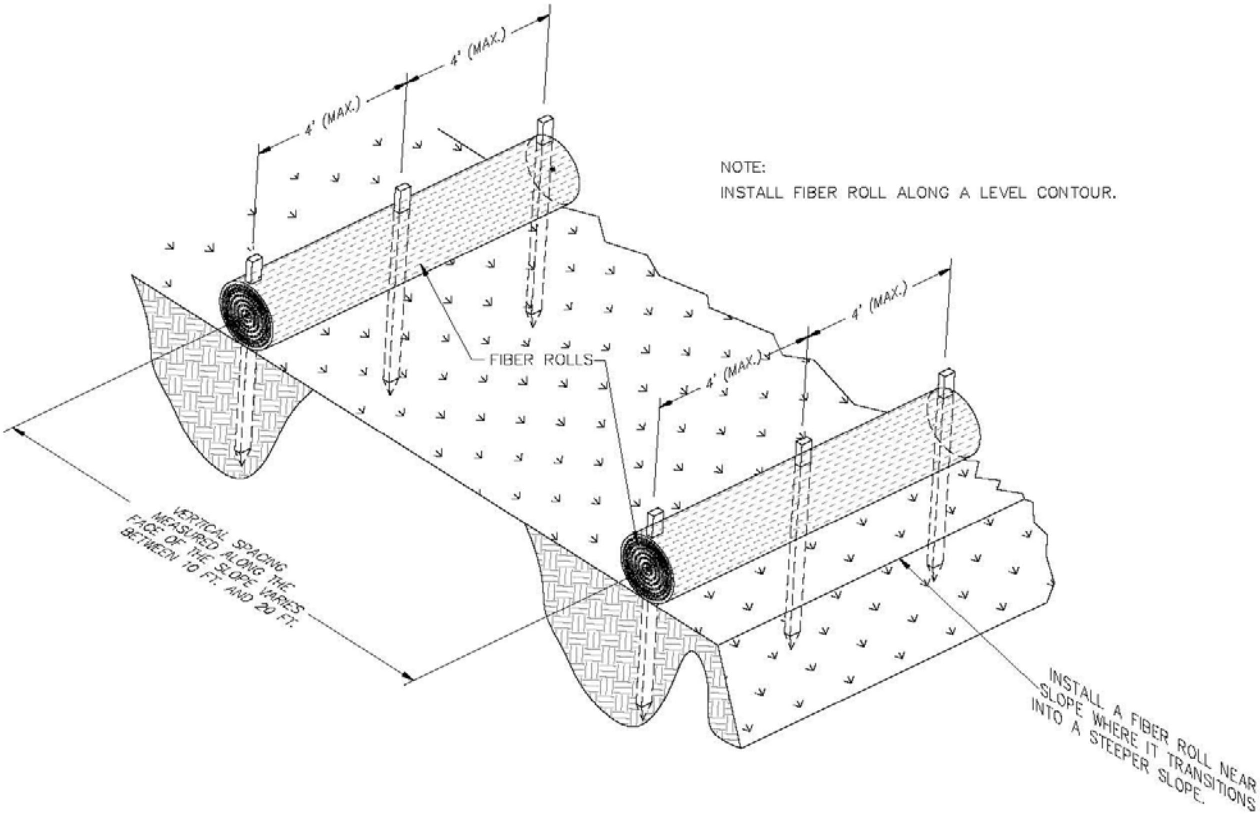
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Repair of replace split, torn, unraveled or slumping fiber rolls.
- If the fiber roll is used as a sediment capture device, or as an erosion control device to maintain sheet flows, sediment that accumulates in the BMP should be removed when sediment accumulation reaches one-half the designated sediment storage depth, usually one-half the distance between the top of the fiber roll and the adjacent ground surface. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- If fiber rolls are used for erosion control, such as in a mini check dam, sediment removal should not be required as long as the system continues to control the grad. Sediment control BMPs will likely be required in conjunction with this type of application.

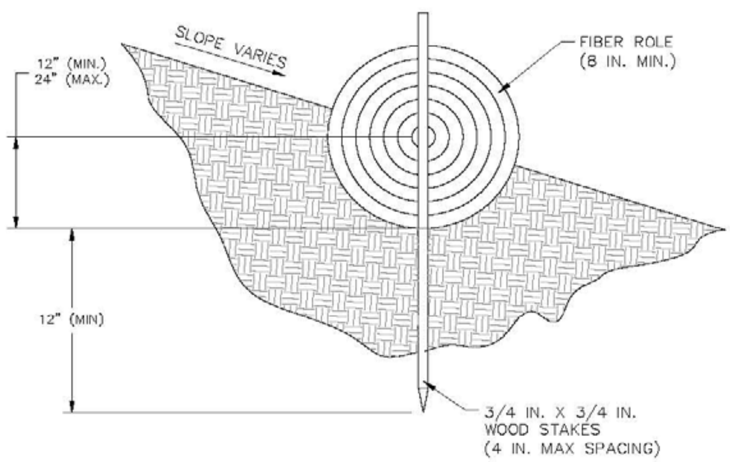
Do. *Securely anchor the fiber roll to level contours with approved stakes.*

Do. *Install fiber rolls with overlapping ends and place end where runoff will accumulate facing uphill.*

FIBER ROLLS



TYPICAL FIBER ROLL INSTALLATION
NOT TO SCALE



ENTRENCHMENT DETAIL
NOT TO SCALE

GBB: Gravel Bag Berm

Description & Purpose

A gravel bag berm is a series of gravel-filled bags placed on a level contour to intercept sheet flows. Gravel bags pond sheet flow runoff, allowing sediment to settle out, and release runoff slowly as sheet flow, preventing erosion.

Suitable Applications

Gravel bag berm may be suitable in the following situations:

- As linear sediment control measure:
  - Below the toe of slopes and erodible slopes.
  - As sediment traps at culvert/pipe outlets.
  - Below other small, cleared areas
  - Along the perimeter of the site.
  - Down slope of exposed soil areas.
  - Around temporary stockpiles and spoil areas.
  - Parallel to a roadway to keep sediment of paved areas.
  - Along streams and channels.
- As linear erosion control measure:
  - Along the face and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
  - At the top of slopes to divert runoff away from disturbed slopes.
  - As check dams across mildly sloped construction roads.

Limitations

- Gravel berms may be difficult to remove.
- Removal problems limit their usefulness in landscaped areas.
- Gravel bag berms may not be appropriate for drainage areas greater than 5 acres.
- Runoff will pond upstream of the filter, possibly causing flooding if sufficient space does not exist.
- Degraded gravel bags may rupture when removed, spilling contents.
- Installation can be labor intensive.
- Berms may have limited durability for long-term projects.
- When used to detain concentrated flows, maintenance requirements increase.

Objectives

SC	Sediment Control

Potential Alternatives

SF	Silt Fence
FB	Fiber Roll
SBB	Sandbag Barrier
SWB	Straw Bale Barrier

Implementation

General

A gravel bag berm consists of a row of open graded gravel-filled bags placed on a level contour. When appropriately placed, a gravel bag berm intercepts and slows sheet flow runoff, causing temporary ponding. The temporary ponding provides latent conditions allowing sediment to settle. The open graded gravel in the bags is porous, which allows the ponded runoff to flow slowly through the bags, releasing the runoff as sheet flows. Gravel bag berms also interrupt the slope length and thereby reduce erosion by reducing the tendency of sheet flows to concentrate into rivulets, which erode rills, and ultimately gullies, into disturbed, sloped soils. Gravel bag berms are similar to sandbag barriers, but more porous.

Design and Layout

- Locate gravel bag berms on level contours.
    - Slopes between 20:1 and 2:1 (H:V): Gravel bags should be placed at a maximum interval of 50 ft (a closer spacing is more effective), with the first row near the slope toe.
    - Slopes 2:1 (H:V) of steeper: Gravel bags should be placed at a maximum interval of 25 ft (a closer spacing is more effective), with the first row placed at the toe of the slope.
- Turn the ends of the gravel bag barriers up slope to prevent runoff from going around the berm.
- Allow sufficient space up slope from the gravel bag berm to allow ponding, and to provide room for sediment storage.
- For installation near the toe of the slope, consider moving the gravel bag barriers away from the slope toe to facilitate cleaning. To prevent flows behind the barrier, bags can be placed perpendicular to a berm to serve as a cross barrier.
- Drainage area should not exceed 5 acres.
- In Non-Traffic Areas:
    - Height = 18 in. maximum.
    - Top width = 24 in. minimum for three or more-layer construction.
    - Top width = 12 in. minimum for one- or two-layer construction.
    - Side slopes = 2:1 of flatter.
- In Construction Traffic Areas:
    - Height = 12 in. maximum.
    - Top width = 24 in. minimum for three or more-layer construction.
    - Top width = 12 in. minimum for one- or two-layer construction.
    - Side slopes = 2:1 of flatter.
- Butt ends of bags tightly.
- On multiple rows, or multiple layer construction, overlap butt joints of adjacent row and row beneath.
- Use a pyramid approach when stacking bags.
- See Sandbag Barrier details for placement information.

Materials

- Bag Material – Bags should be woven polypropylene, polyethylene or polyamide fabric or burlap, minimum unit weight of 4 ounces/yd^2, Mullen burst strength exceeding 300 lb/in^2 in conformance with the requirements in ASTM designation D_{3786}, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D_{4355}.
- Bag Size – Each gravel-filled bag should have a length of 18 in., width of 12 in., thickness of 3 in., and mass of approximately 33 lbs. Bag dimensions are nominal and may vary based on locally available materials.
- Fill Material – Fill material should be 0.5 to 1 in. Class 2 aggregate base, clean and free from clay, organic matter, and other objectionable material, or other suitable open graded, non-cohesive, porous gravel.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Grave bags exposed to sunlight will need to be replaced every two of three months due to degrading of the bags.
- Reshape or replace gravel bags as needed.
- Repair washouts or other damage as needed.
- Sediment that accumulates in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage volume. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove gravel bag berms when no longer needed. Remove sediment accumulation and clean, re-grade, and stabilize area. Removed sediment should be incorporated in the project or disposed of.

Do. *Stack gravel bags with ends overlapping to create a diversion.*

Don't. *Allow bags to disintegrate and rupture spilling gravel. Gravel bag berms must be maintained to be an effective BMP.*

SSV: Street Sweeping and Vacuuming

Description & Purpose

Street sweeping and vacuuming includes use of self-propelled and walk-behind equipment to remove sediment from streets and roadways, and to clean paved surfaces in preparation for final paving. Sweeping and vacuuming prevents sediment from the project site from entering storm drains or receiving waters.

Suitable Applications

Street sweeping and vacuuming may be suitable in the following situations:

- Where sediment is tracked from the project site onto public or private paved streets and roads, typically at points of egress.
- During preparation of paved surfaces for final paving.

Limitations

- Sweeping and vacuuming may not be effective when sediment is wet or when tracked soil is caked (caked soil may need to be scraped loose).

Objectives

TC Tracking Control

Potential Alternatives

None

Implementation

- Controlling the number of points where vehicles can leave the site will allow sweeping and vacuuming efforts to be focused, and perhaps save money.
- Inspect potential sediment tracking locations daily.
- Visible sediment tracking should be swept or vacuumed on a daily basis.
- Do not use kick brooms or sweeper attachments. These tend to spread the dirt rather than remove it.
- If not mixed with debris or trash, consider incorporating the removed sediment back into the project.

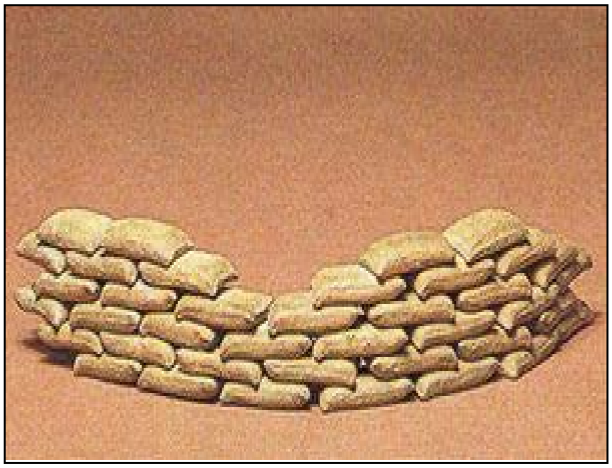
Implementation

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- When actively in use, points of ingress and egress must be inspected daily.
- When tracked or spilled sediment is observed outside the construction limits, it must be removed at least daily. More frequent removal, even continuous removal may be required.
- Be careful not to sweep up any unknown substance or any object that may be potentially hazardous.
- Adjust brooms frequently; maximum efficiency of sweeping operations.
- After sweeping is finished, properly dispose of sweeper wastes at an approved dumpsite.

Do. Sweep up sediment frequently before rainfall can transport the sediment to the stormdrain system.

Don't. Wash sediment into the catch basins. Sediment can be swept into piles and hauled away in truck or wheelbarrow depending on severity of deposits.

SBB: Sandbag Barrier



Description & Purpose

A sandbag barrier is a series of sand-filled bags placed on a level contour to intercept sheet flows. Sandbag barriers pond sheet flow runoff, allowing sediment to settle out.

Suitable Applications

Sandbag Barrier may be suitable in the following situations:

- As a linear sediment control measure:
  - Below the toe of slopes and erodible slopes.
  - As sediment traps at culvert/pipe outlets.
  - Below other small, cleared areas
  - Along the perimeter of the site.
  - Down slope of exposed soil areas.
  - Around temporary stockpiles and spoil areas.
  - Parallel to a roadway to keep sediment of paved areas.
  - Along streams and channels.
- As linear erosion control measure:
  - Along the face and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
  - At the top of slopes to divert runoff away from disturbed slopes.
  - As check dams across mildly sloped construction roads.

Limitations

- It is necessary to limit the drainage area upstream of the barrier to 5 acres.
- Degraded sandbags may rupture when removed, spilling sand.
- Installation can be labor intensive.
- Barriers may have limited durability for long-term projects.
- When used to detain concentrated flows, maintenance requirements increase.
- Burlap should not be used for sandbags.

Objectives

SC Sediment Control

Potential Alternatives

SF Silt Fence

FB Fiber Roll

GBB Gravel Bag Barrier

SWB Straw Bale Barrier

Implementation

General

A sandbag barrier consists of a row of sand-filled bags placed on a level contour. When appropriately placed, a sandbag barrier intercepts and slows sheet flow runoff, causing temporary ponding. The temporary ponding provides latent conditions allowing sediment to settle. While the sand-filled bags are porous, the fine sand tends to quickly plug with sediment, limiting the rate of flow through the barrier. If a porous barrier is desired, consider Silt Fence, Fiber Rolls, Gravel Bag Berm, or Straw Bale Barriers. Sandbag barriers also interrupt the slope length and thereby reduce erosion by reducing the tendency of sheet flows to concentrate into rivulets which erode rills, and ultimately gullies, into disturbed, sloped soils. Sandbag barriers are like ground bag berms, but less porous.

Design and Layout

- Locate sandbag barriers on level contours.
  - Slopes between 20:1 and 2:1 (H:V): Sandbags should be placed at a maximum interval of 50 ft (a closer spacing is more effective), with the first row near the slope toe.
  - Slopes 2:1 (H:V) of steeper: Sandbags should be placed at a maximum interval of 25 ft (a closer spacing is more effective), with the first row placed at the toe of the slope.
- Turn the ends of the sandbag barriers up slope to prevent runoff from going around the barrier.
- Allow sufficient space up slope from the sandbag barrier to allow ponding, and to provide room for sediment storage.
- For installation near the toe of the slope, consider moving the sandbag barriers away from the slope toe to facilitate cleaning. To prevent flows behind the barrier, bags can be placed perpendicular to a berm to serve as a cross barrier.
- Drainage area should not exceed 5 acres.
- Sack sandbags at least three bags high.
- Butt ends of bags tightly.
- Overlap butt joints of row beneath with each successive row.
- In Non-Traffic Areas:
  - Height = 18 in. maximum.
  - Top width = 24 in. minimum for three or more-layer construction.
  - Side slopes = 2:1 of flatter.
- In Construction Traffic Areas:
  - Height = 12 in. maximum.
  - Top width = 24 in. minimum for three or more-layer construction.
  - Side slopes = 2:1 of flatter.

Materials

- Sandbag Material – Sandbags should be woven polypropylene, polyethylene or polyamide fabric or burlap, minimum unit weight of 4 ounces/yd^2, Mullen burst strength exceeding 300 lb/in^2 in conformance with the requirements in ASTM designation D_{3786}, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D_{4355}.
- Sandbag Size – Each sand-filled bag should have a length of 18 in., width of 12 in., thickness of 3 in., and mass of approximately 33 lbs. Bag dimensions are nominal and may vary based on locally available materials.
- Fill Material – All sandbag fill material should be non-cohesive, Class 1 or Class 2 permeable material free from clay and objectionable material.

Do. *Use high quality, sturdy bags that will withstand the environmental abuse. Bags that have been treated to resist damage from UV-rays are most desirable.*

Inspection and Maintenance

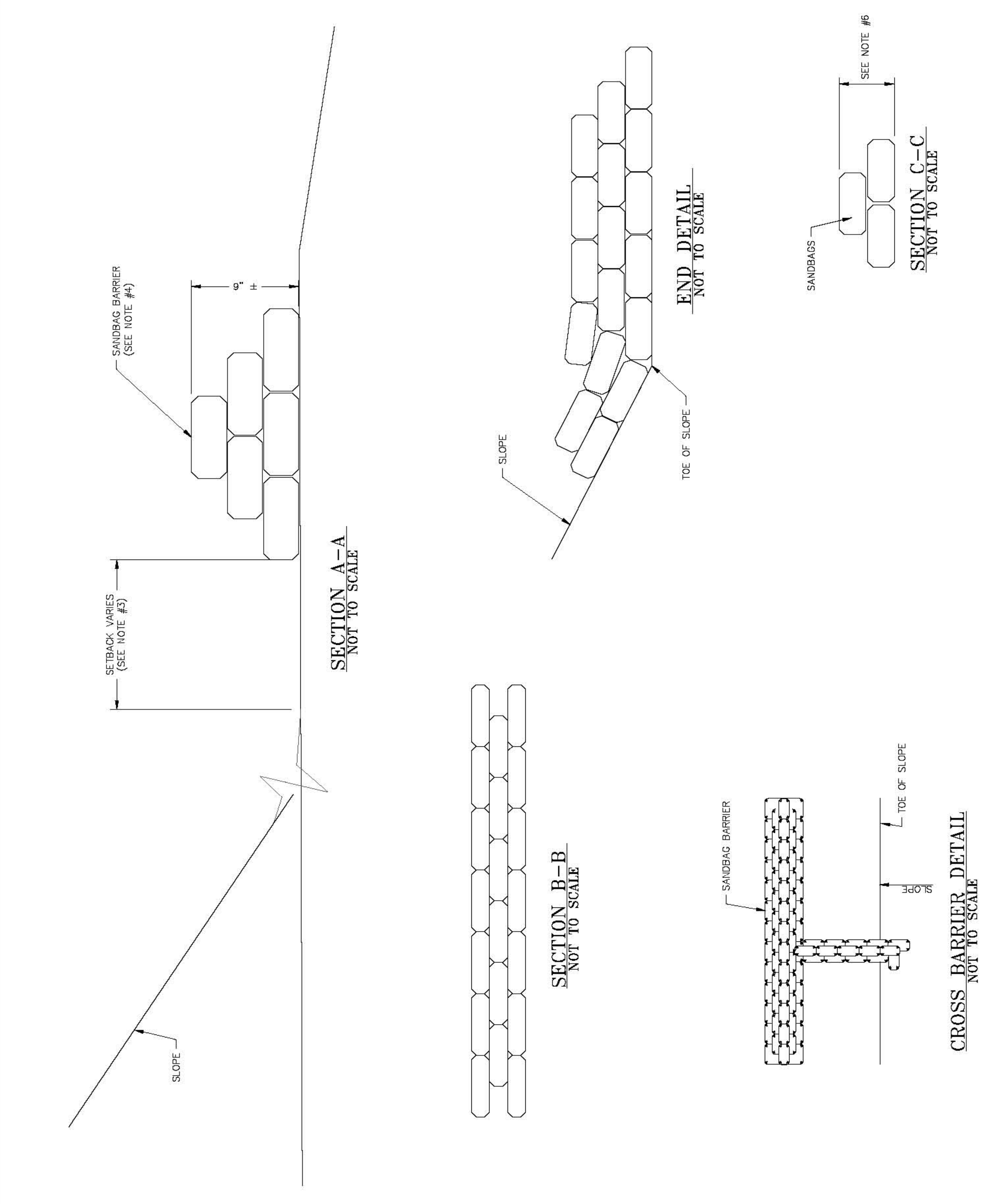
- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Sandbags exposed to sunlight will need to be replaced every two of three months due to degrading of the bags.
- Reshape or replace sandbags as needed.
- Repair washouts or other damage as needed.
- Sediment that accumulates in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage volume. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove sandbag berms when no longer needed. Remove sediment accumulation and clean, re-grade, and stabilize area. Removed sediment should be incorporated in the project or disposed of.

Do. *Stack sandbags with the ends butted tightly together to create a barrier.*

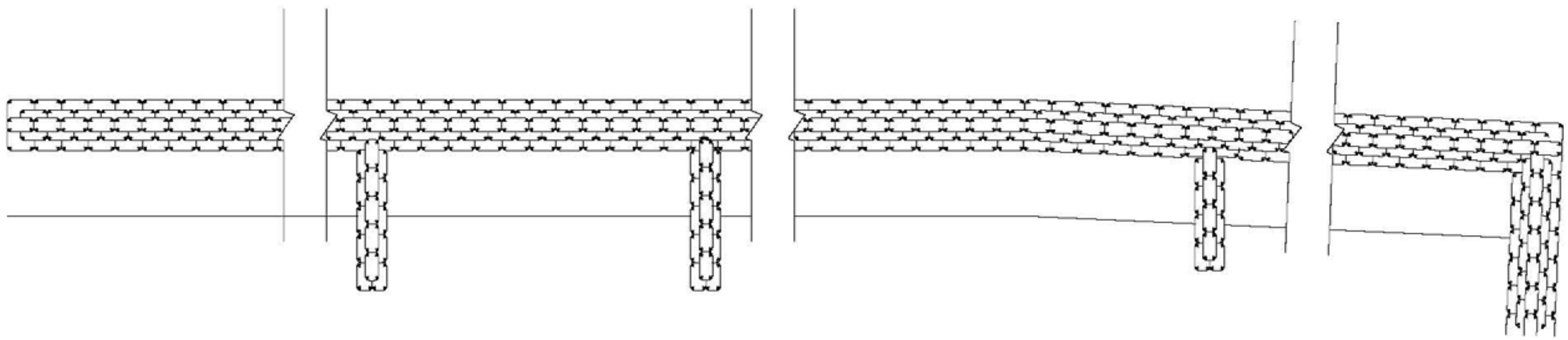
Don't. *Put off maintenance. Sandbags are difficult to cleanup and remove after the bags have ruptured.*

Don't. *Wait until it is raining to place sandbag barriers.*

SANDBAG BARRIERS



SAND BAG BARRIER



SAND BAG BARRIER
NOT TO SCALE

NOTES:

1. CONSTRUCT THE LENGTH OF EACH REACH SO THAT THAT CHANGE IN BASE ELEVATION ALONG THE REACH DOES NOT EXCEED 1/2 THE HEIGHT OF LINEAR BARRIER. IN NO CASE SHALL THE REACH LENGTH EXCEED 500 FEET.

2. PLACE SANDBAGS TIGHTLY.

3. DIMENSION MAY VARY TO FIT FIELD CONDITION.

4. SANDBAG BARRIER SHALL BE MINIMUM OF 3 BAGS HIGH.

5. THE END OF THE BARRIER SHALL BE TURNED UP SLOPE.

6. CROSS BARRIERS SHALL BE A MIN. OF 1/2 AND A MAX. OF 2/3 THE HEIGHT OF THE LINEAR BARRIER.

7. SANDBAG ROWS AND LAYERS SHALL BE STAGGERED TO ELIMINATE GAPS.

SWB: Straw Bale Barrier

Description & Purpose

A straw bale barrier is a series of straw bales placed on a level contour to intercept sheet flows. Sandbag barriers pond sheet flow runoff, allowing sediment to settle out.

Suitable Applications

Straw Bale Barrier may be suitable in the following situations:

- As a linear sediment control measure:
  - Below the toe of slopes and erodible slopes.
  - As sediment traps at culvert/pipe outlets.
  - Below other small, cleared areas
  - Along the perimeter of the site.
  - Down slope of exposed soil areas.
  - Around temporary stockpiles and spoil areas.
  - Parallel to a roadway to keep sediment of paved areas.
  - Along streams and channels.
- As linear erosion control measure:
  - Along the face and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
  - At the top of slopes to divert runoff away from disturbed slopes.
  - As check dams across mildly sloped construction roads.

Limitations

- Are not to be used for extended periods of time because they tend to rot and fall apart.
- Are suitable only for sheet flow on slopes of 0% or flatter.
- Are not appropriate for large drainage areas, limit to one acre or less.
- May require constant maintenance due to rotting.
- Are not recommended for concentrated flow, inlet protection, channel flow, or live stream

Objectives

SC Sediment Control

Potential Alternatives

SF Silt Fence
FB Fiber Roll
GBB Gravel Bag Barrier
SBB Sandbag Barrier

- Cannot be made of bale bindings of jute or cotton.
- Requires labor-intensive installation and maintenance.
- Cannot be used on paved surfaces.
- Should not be used for drain inlet protection.
- Should not be used on lined ditches.
- May introduce undesirable non-native plants to the area.

Implementation

General

A straw bale barrier consists of a row of straw bales placed on a level contour. When appropriately placed, a straw bale barrier intercepts and slows sheet flow runoff, causing temporary ponding. The temporary ponding provides latent conditions allowing sediment to settle. Straw bale barriers also interrupt the slope length and thereby reduce erosion by reducing the tendency of sheet flows to concentrate into rivulets, which erode rills, and ultimately gullies, into disturbed, sloped soils.

Straw bale barriers have not been as effective as expected due to improper use. These barriers have been placed in streams and drainage ways where runoff volumes and velocities have caused the barriers to wash out. In addition, failure to stake and entrench the straw bale has allowed undercutting and end flow. Use of straw bale barriers in accordance with this BMP should produce acceptable results.

Design and Layout

- Locate straw bales barriers on level contours.
  - Slopes up to 10:1 (H:V): Straw bales should be placed at a maximum interval of 50 ft (a closer spacing is more effective), with the first row near the slope toe.
  - Slopes greater than 10:1 (H:V): Not recommended.
- Turn the ends of the straw bale barriers up slope to prevent runoff from going around the barrier.
- Allow sufficient space up slope from the straw bale barrier to allow ponding, and to provide room for sediment storage.
- For installation near the toe of the slope, consider moving the straw bale barriers away from the slope toe to facilitate cleaning. To prevent flows behind the barrier, bales can be placed perpendicular to a berm to serve as a cross barrier.
- Drainage area should not exceed 1 acre, or 0.25 acre per 100 ft of barrier.
- Maximum flow path to the barrier should consist of two parallel rows.
  - Butt ends of bags tightly.
  - Stagger butt joints between front and back row.
  - Each row of bales must be trenched in and firmly staked.
- Straw bale barriers are limited in height to one bale laid on its side.
- Anchor bales with either two wood stakes or four bars driven through the bale and into the soil. Drive the first stake towards the butt joint with the adjacent bale to force the bales together.
- See attached figure for installation details.

Materials

- Straw Bale Size – Each straw bale should be a minimum of 14 in. wide, 18 in. in height, and 36 in. in length and should have a minimum mass of 50 lbs. The straw bale should be composed entirely of vegetative matter, except for the binding material.
- Bale Bindings – Bales should be bound by steel wire, nylon or polypropylene string placed horizontally. Jute and cotton binding should not be used. Baling wire should be a minimum diameter of 14 gauge. Nylon or polypropylene string should be approximately 12 gauge in diameter with a breaking strength of 80 lbs force.
- Stakes – Wood stakes should be commercial quality lumber of the size and shape shown on the plans. Each stake should be free from decay, splits or cracks longer than the thickness of the stake, or other defects that would weaken the stakes and cause the stakes to be structurally unsuitable. Steel bar reinforcement should be equal to a #4 designation or greater. End protection should be provided for any exposed bar reinforcement.

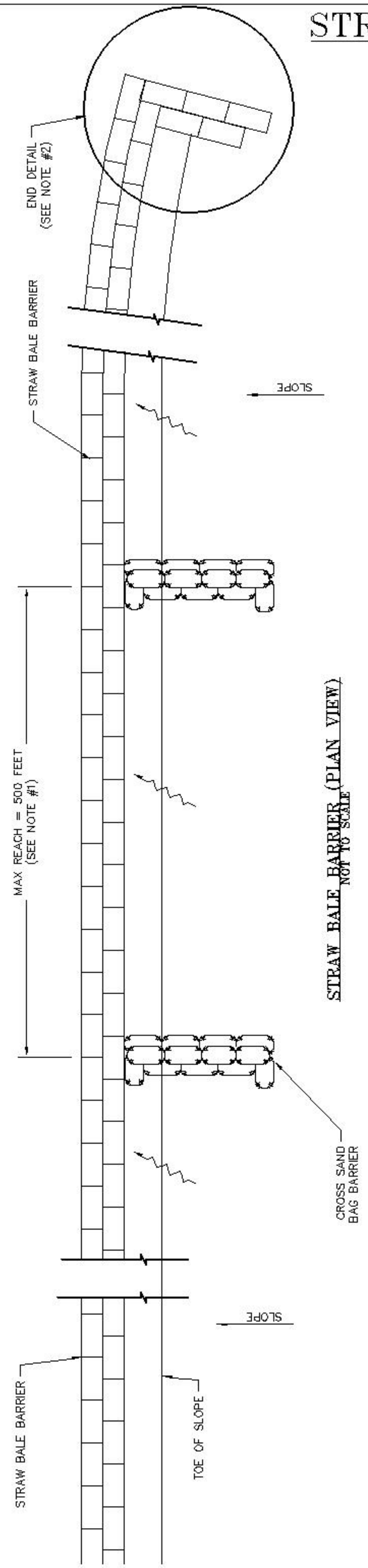
Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Straw bales degrade, especially when exposed to moisture. Rotting bales will need to be replaced on a regular basis.
- Replace or repair damaged bales as needed.
- Repair washouts or other damage as needed.
- Sediment that accumulates in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage volume. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove straw bales when no longer needed. Remove sediment accumulation and clean, re-grade, and stabilize area. Removed sediment should be incorporated in the project or disposed of.

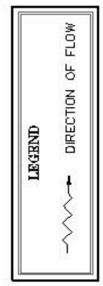
Do. *Use straw bale barriers as perimeter protection and to keep flows from concentrating*

Don't. *Straw or Hay bales should not be used as check dams. Even if "properly" installed, they have a high failure rate.*

STRAW BALE BARRIER



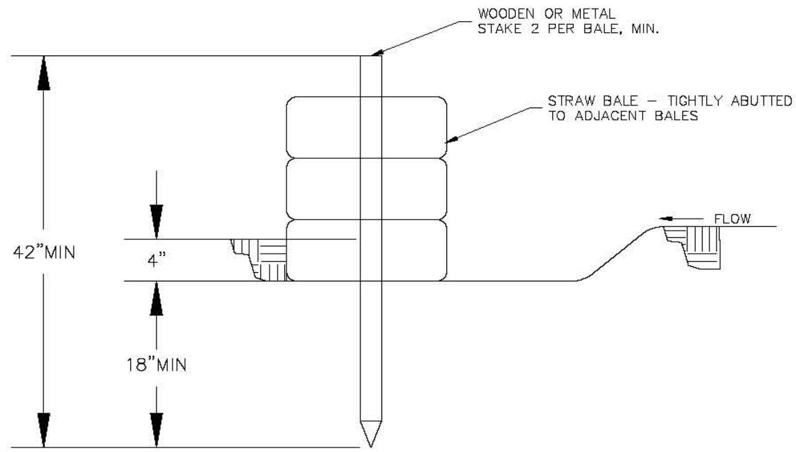
STRAW BALE BARRIER (PLAN VIEW)
NOT TO SCALE



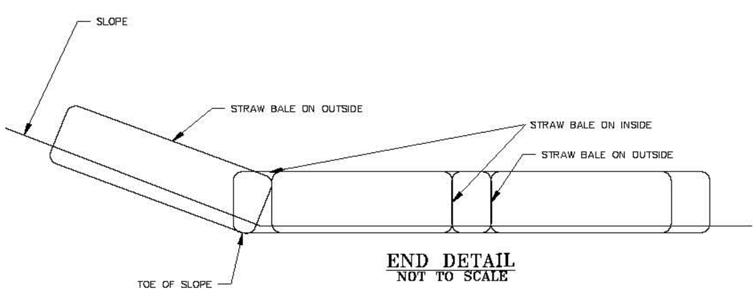
NOTES

1. CONSTRUCT THE LENGTH OF EACH REACH SO THAT THE CHANGE IN BASE ELEVATION ALONG THE REACH DOES NOT EXCEED 1/2 THE HEIGHT OF THE LINEAR BARRIER. IN NO CASE SHALL THE REACH LENGTH EXCEED 500 FEET.
2. THE END BARRIER SHALL BE TURNED UP SLOPE.
3. DIMENSION MAY VARY TO FIT FIELD CONDITION
4. STAKE DIMENSIONS ARE NOMINAL.
5. PLACE STRAW BALES TIGHTLY TOGETHER.
6. TAMP EMBANKMENT SPOILS AGAINST SIDES OF INSTALLED BALES.
7. DRIVE ANGLED WOOD STAKE BEFORE VERTICAL STAKE TO INSURE TIGHT ABUTMENT TO ADJACENT BALE.
8. SANDBAG ACROSS BARRIERS SHOULD BE A MINIMUM OF 1/2 AND A MAX. OF 2/3 THE HEIGHT OF THE LINEAR BARRIER.
9. SANDBAG ROWS AND LAYERS SHOULD BE OFFSET TO ELIMINATE GAPS.

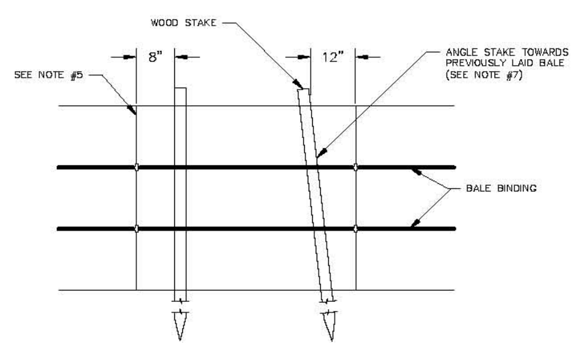
STRAW BALE BARRIER



SECTION VIEW
NOT TO SCALE



END DETAIL
NOT TO SCALE



PROFILE
NOT TO SCALE

SCE: Stabilized Construction Entrance

Description & Purpose

A stabilized construction access is defined by a point of entrance/exit to a construction site that is stabilized to reduce the tracking of mud and dirt onto public roads by construction vehicles.

Suitable Applications

Stabilized construction entrances may be suitable in the following situations:

- Where dirt or mud can be tracked onto public roads.
- Adjacent to water bodies.
- Where poor soils are encountered
- Where dust is a problem during dry weather conditions.

Limitations

- Entrances and exits require periodic top dressing with additional stones.
- This BMP should be used in conjunction with street sweeping on adjacent public right-of-way.
- Entrances and exits should be constructed on level ground only.
- Stabilized construction entrances are rather expensive to construct and when a wash rack is included, a sediment trap of some kind must also be provided to collect wash water runoff.

Objectives

TC Tracking Control

Potential Alternatives

None

Implementation

General

A stabilized construction entrance is a pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk, or parking area. The purpose of a stabilized construction entrance is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets. Reducing tracking of sediments and other pollutants onto paved roads helps prevent deposition of sediments into local storm drains and production of airborne dust.

Where traffic will be entering or leaving the construction site, a stabilized construction entrance should be used. NPDES permits require that appropriate measures be implemented to prevent tracking of sediments onto paved roadways, where a significant source of sediments is derived from mud and dirt carried out from unpaved roads and construction sites.

Stabilized construction entrances are moderately effective in removing sediment for equipment leaving a construction site. The entrance should be built on level ground. Advantages of the stabilized construction entrance/exit are that it does remove some sediment from equipment and serves to channel construction traffic in and out of the site at specified locations. Efficiency is greatly increased when a washing rack is included as part of a stabilized construction entrance/exit.

Design and Layout

- Construct on level ground where possible.
- Select 3 to 6 in. diameter stones
- Use minimum depth of stones of 12 in. or as recommended by soils engineer.
- Construct length of 50 ft minimum, and 30 ft minimum width.
- Rumble racks constructed of steel panels with ridges and installed in the stabilized entrance/exit will help remove sediment and to keep adjacent streets clean.
- Provide ample turning radii as part of the entrance.
- Limit speed of vehicles to control dust.
- Properly grade each construction entrance/exit to prevent runoff from leaving the construction site.
- Route runoff from stabilized entrances/exits through a sediment trapping device before discharge.
- Design stabilized entrance/exit to support heaviest vehicles and equipment that will be use on the construction site.
- Select construction access stabilization (aggregate, asphaltic concrete, concrete) based on longevity, required performance, and site conditions. Do not use asphaltic concrete (AC) grindings for stabilized construction access/roadway.
- If aggregate is selected, place crushed aggregate over geotextile fabric to at least 12 in. depth, or place aggregate to a depth recommended by a geotechnical engineer. A crushed aggregate greater than 3 in. but smaller than 6 in. should be used.
- Designate combination or single purpose entrances and exits to the construction site.
- Require that all employees, subcontractors, and suppliers utilize the stabilized construction access.
- Implement Street Sweeping and Vacuuming, as needed.
- All exit locations intended to be used for more than a two-week period should have stabilized construction entrance/exit BMPs.

Do. *Design the entrance with rocks large enough that they will not be easily displaced by exiting vehicles.*

Inspection and Maintenance

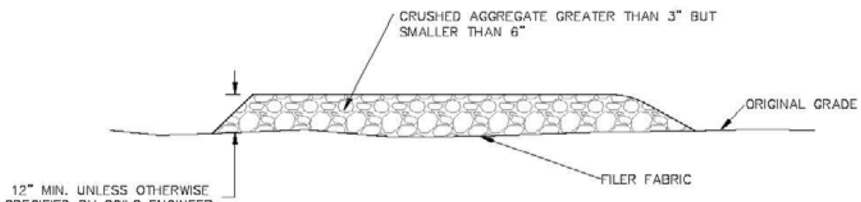
- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Inspect local roads adjacent to the site daily. Sweep or vacuum to remove visible accumulated sediment.
- Remove aggregate, separate and dispose of sediment if construction entrance/exit is clogged with sediment.
- Keep all temporary roadway ditches clear.
- Check for damage and repair as needed.
- Replace gravel material when surface voids are visible.
- Remove all sediment deposited on paved roadways within 24 hours.
- Remove gravel and filter fabric at completion of construction.

Do. *Supply ample length to remove the sediment from equipment and vehicles leaving the site.*

Don't. *Allow vehicles to enter and exit the job site at any location that has not been stabilized.*

Don't. *Spread parking, staging, and storage all over the site, it increases disturbance and erosion.*

STABILIZED CONSTRUCTION ENTRANCE / EXIT



SECTION B–B
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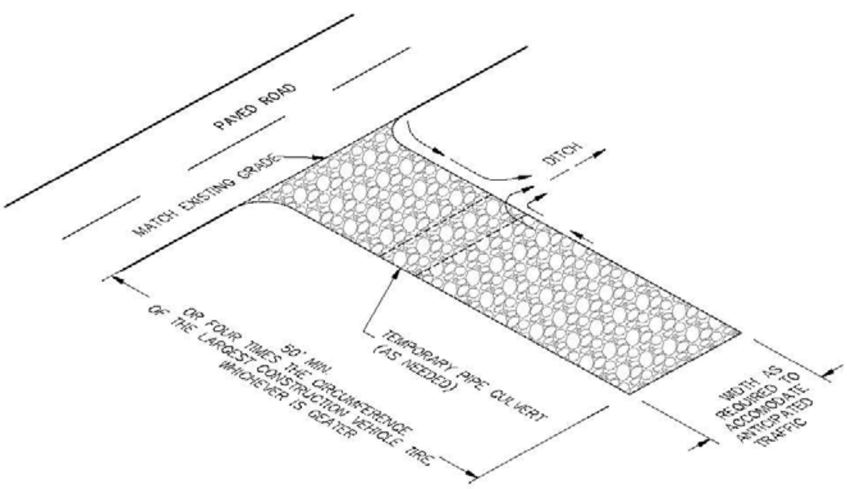
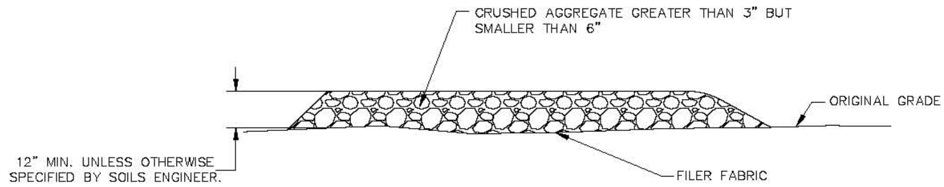


PLAN
NOT TO SCALE

STABILIZED CONSTRUCTION ENTRANCE/EXIT



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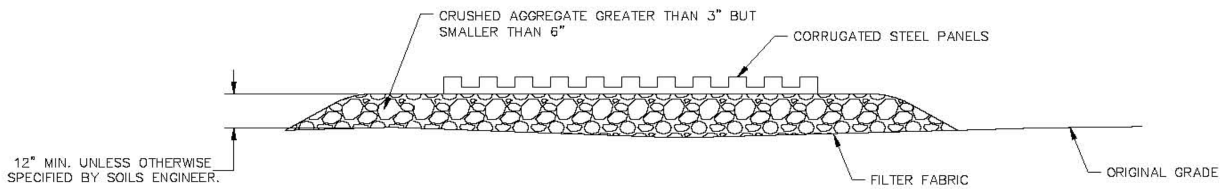

SECTION A–A
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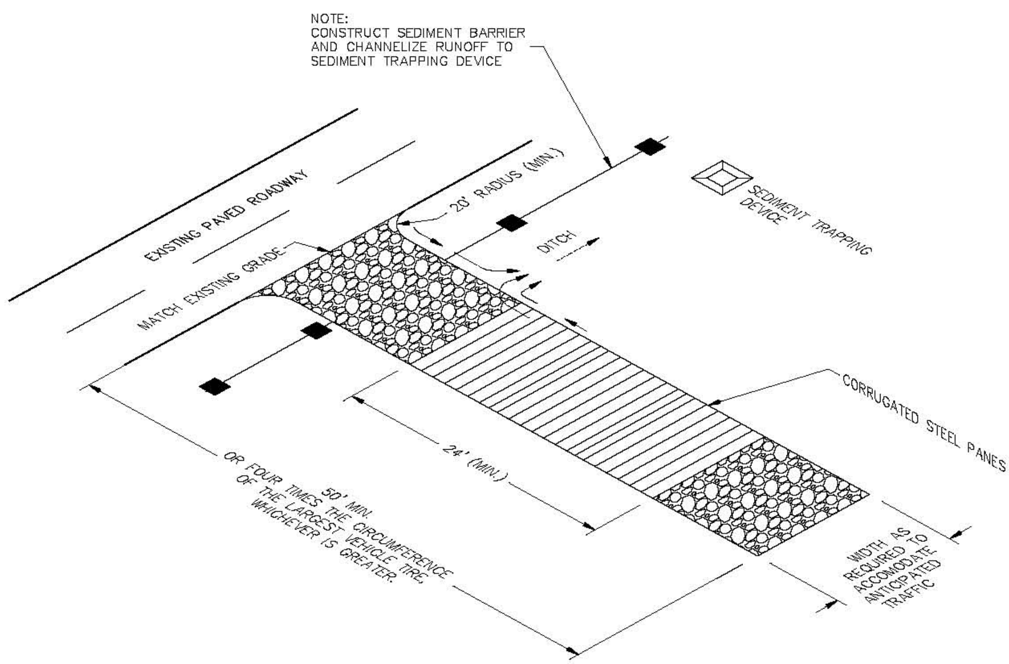


PLAN
NOT TO SCALE

SCR: Stabilized Construction Roadway

Description & Purpose

Access roads, subdivisions roads, parking areas, and other onsite vehicle transportation routes should be stabilized immediately after grading, and frequently maintained to prevent erosion and control dust.

Suitable Applications

Stabilized construction Roadways may be suitable in the following situations:

- Temporary Construction Traffic:
  - Phased construction projects and offsite road access.
  - Construction during wet weather.
- Construction roadways and detour roads:
  - Where mud tracking is a problem during wet weather.
  - Where dust is a problem during dry weather.
  - Adjacent to water bodies
  - Where poor soils are encountered.

Limitations

- The roadway must be removed or paved when construction is complete.
- Certain chemical stabilization methods may cause stormwater pollution and should not be used.
- Materials will likely need to be removed prior to final project grading and stabilization.
- Use of this BMP may not be applicable to very short duration projects.

Objectives

TC Tracking Control

Potential Alternatives

None

Implementation

General

Areas that are graded for construction vehicle transport and parking purposes are especially susceptible to erosion and dust. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires that generate significant quantities of sediment that may pollute nearby streams or be transported offsite on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Efficient construction road stabilization not only reduces onsite erosion but also can significantly speed onsite work, avoid instances of immobilized machinery and delivery vehicles, and generally improve site efficiency and working conditions during adverse weather.

Implementation

Permanent roads and parking areas should be paved as soon as possible after grading. As alternative where construction will be phased, the early application of gravel or chemical stabilization may solve potential erosion and stability problems. Temporary gravel roadways should be considered during the rainy season and on slopes greater than 5%.

Temporary roads should follow the contour of the natural terrain to the maximum extent possible. Slope should not exceed 15%. Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway in the case of a crowned section or one side in the case of a super elevated section. Simple gravel berms without a trench can also be used.

Installed inlets should be protected to prevent sediment laden water from entering the storm sewer system. In addition, the following criteria should be considered:

- Road should follow topographic contours to reduce erosion of the roadway.
- The roadway slope should not exceed 15%
- Water is usually required on gravel or dirt roads to prevent dust.
- Properly grade roadway to prevent runoff from leaving the construction site.
- Design stabilized access to support heaviest vehicles and equipment that will use it.
- Stabilized roadway using aggregate, asphaltic concrete, or concrete based on longevity, required performance, and site conditions. The use of cold mix asphalt or asphaltic concrete (AC) grindings for stabilized construction roadways is not allowed.
- Coordinate materials with those used for stabilized construction entrance/exit points. Installation should be accomplished as outlined in the Stabilized Construction Entrance minus corrugated metal sheets.
- If aggregate is selected, place crushed aggregate over geotextile fabric to at least 12 in. depth. A crushed aggregate greater than 3 in. but smaller than 6 in. should be used.

Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Keep all temporary roadway ditches clear.
- When no longer required, remove stabilized construction roadway and re-grade and repair slopes.
- Periodically apply additional aggregate on gravel roads.
- Active dirt construction roads are commonly watered three or more times per day during the dry season.

Don’t. *Allow vehicle to access construction site by any access that is not stabilized.*

EOT: Entrance/Outlet Tire Wash

Description & Purpose

A tire wash is an area located at stabilized construction access points to remove sediment from tires and under carriages and to prevent sediment from being transported onto public roadways.

Suitable Applications

Entrance/outlet tire wash may be suitable in the following situations:

- Construction sites where dirt and mud tracking onto public roads by construction vehicles may occur.
- Must be implemented where 20,000yd^3 of material is moved onto the project, off of the project, or a combination of both.

Limitations

- Incorporate with a stabilized construction entrance/exit.
- Construct on level ground, when possible, on a pad of coarse aggregate greater than 3 in. but smaller than 6 in. A geotextile fabric should be placed below the aggregate.
- Wash rack should be designed and constructed/manufactured for anticipated traffic loads.
- Provide a drainage ditch that will convey the runoff from the wash area to a sediment trapping device. The drainage ditch should be of significant grade, width, and depth to carry the wash runoff.
- Use hoses with automatic shutoff nozzles to prevent hoses from being left on.
- Require that all employees, subcontractors, and others that leave the site with mud caked tires and undercarriages to use the wash facility.
- Implement Street Sweeping and Vacuuming as needed.

Objectives

TC Tracking Control

Potential Alternatives

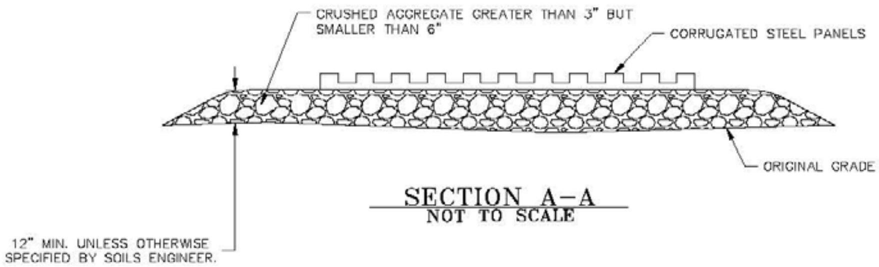
SCE Stabilized Construction Entrance/Exit

Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Inspect BMPs subject to non-stormwater discharge daily while non-stormwater discharges occur.
- Remove accumulated sediment in wash rack and/or sediment trap to maintain system performance.
- Inspect routinely for damage and repair as necessary.

Do. *Establish a designated wash off area that will be utilized for the majority of the project.*

ENTRANCE / OUTLET TIRE WASH



SECTION A–A
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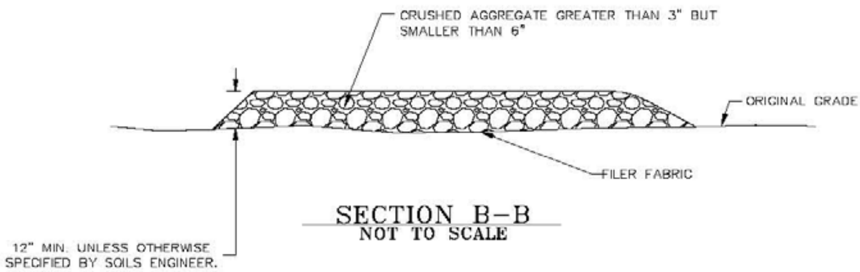

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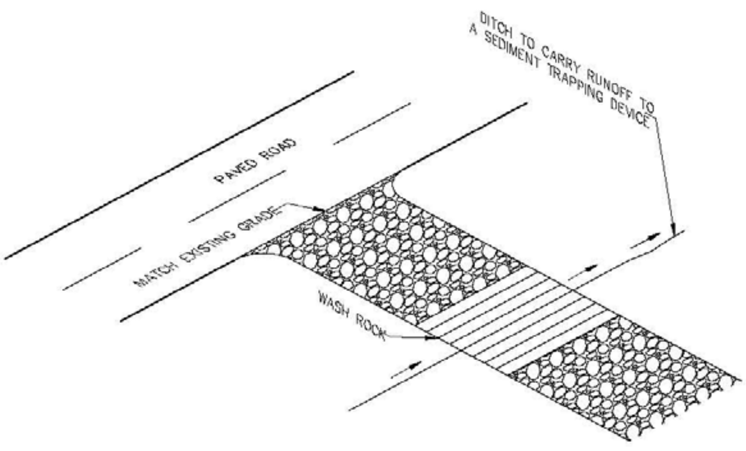


TYPICAL TIRE WASH
NOT TO SCALE

WE: Wind Erosion Control

Description & Purpose

Wind erosion or dust control consists of applying water or other dust palliatives as necessary to prevent or alleviate dust nuisance generated by construction activities. Covering small stockpiles or areas is an alternative to applying water or other dust palliatives.

Suitable Applications

Wind Erosion Control will be suitable during the following construction activities:

- Construction vehicle traffic on unpaved roads.
- Drilling and blasting activities.
- Sediment tracking onto paved roads.
- Soils and debris storage piles.
- Batch drop from front-end loaders.
- Areas with unstabilized soil.
- Final grading/site stabilization.

Limitations

- Watering prevents dust only for a short period and should be applied daily (or more often) to be effective.
- Over watering may cause erosion.
- Oil and oil-treated subgrade should not be used for dust control because the oil may migrate into drainage ways and/or seep into the soil.
- Effectiveness depends on soil, temperature, humidity, and wind velocity.
- Chemically treated sub grades may make the soil water repellant, interfering with long-term infiltration and the vegetation/re-vegetation of the site. Some chemical dust suppressants may be subject to freezing and may contain solvents and should be handled properly.
- Asphalt, as a mulch tack or chemical mulch, requires a 24-hour curing time to avoid adherence to equipment, workers shoes, etc. Application should be limited because asphalt surfacing may eventually migrate into the drainage system.
- In compacted areas, watering and other liquid dust control measures may wash sediment or other constituents into the drainage system.

Objectives

WE Wind Erosion

Potential Alternatives

None

Implementation

General

Washington City's Climate, with short wet seasons and long hot dry seasons, allows the soils to thoroughly dry out. During these dry seasons, construction activities are at their peak, and disturbed and exposed areas are increasingly subject to wind erosion, sediment tracking and dust generated by construction equipment.

Dust Control Practices

Dust control BMPs generally stabilize exposed surfaces and minimize activities that suspend or track dust particles. The following table shows dust control practices that can be applied to site conditions that cause dust. For heavily traveled and disturbed areas, wet suppression (watering), chemical dust suppression, gravel asphalt surfacing, temporary gravel construction entrances, equipment wash-out areas, and haul truck covers can be employed as dust control applications. Permanent or temporary vegetation and mulching can be employed for areas of occasional or no construction traffic. Preventative measures would include minimizing surface areas to be disturbed, limiting onsite vehicle traffic to 15 mph, and controlling the number and activity of vehicles on a site at any given time.

Site Conditions	Dust Control Practices								
	Permanent Vegetation	Mulching	Wet Suppression (Watering)	Chemical Dust Suppresion	Gravel or Asphalt	Silt Fence	Temporary Gravel Construction Entrance/Equipment Wash Down	Haul Truck Covers	Minimize Extent of Disturbed Area
Disturbed Areas not Subject to Traffic	x	x	x	x	x				x
Disturbed Areas Subject to Traffic			x	x	x		x		x
Material Stock Pile Stabilization			x	x		x			x
Demolition			x				x	x	
Clearing/ Excavation			x	x		x			x
Truck Traffic on Unpaved Roads			x	x	x		x	x	
Mud/Dirt Carry Out					x		x		

Additional preventative measures include:

- Schedule construction activities to minimize exposed area.
- Quickly stabilize exposed soils using vegetation, mulching, spray-on adhesives, calcium chloride, sprinkling, and stone/gravel layering.
- Identify and stabilize key access points prior to commencement of construction.
- Minimize the impact of dust by anticipating the direction of prevailing winds.
- Direct most construction traffic to stabilized roadways within the project site.
- Water should be applied by means of pressure-type distributors or pipelines equipped with a spray system or hoses and nozzles that will ensure even distribution.
- All distribution should be equipped with a positive means of shutoff.
- Unless water is applied by means of pipelines, at least one mobile unit should be available at all times to apply water or dust palliative to the project.
- Materials applied as temporary soil stabilizers and soil binders also generally provide wind erosion benefits.
- Pave or chemically stabilize access points where unpaved traffic surfaces adjoin paved roads.
- Provide for wet suppression or stabilization of exposed soils.
- Provide for rapid clean up of sediments deposited on paved roads. Furnish stabilized construction road entrances and vehicle wash down areas.
- Stabilize inactive construction sites using vegetation or chemical stabilization methods.
- Limit the amount of areas disturbed by clearing and earth moving operations by scheduling these activities in phases.

For chemical stabilization, there are many products available for chemically stabilizing gravel roadways and stockpiles. If chemical stabilization is used, the chemicals should not create any adverse effects on stormwater, plant life, or groundwater.

Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Check areas protected to ensure coverage.
- Most Dust control measures require frequent, often daily, or multiple times per day attention.

Do. *Keep wind erosion low by applying water or other dust palliative when necessary.*

Don't. *Apply so much water as to cause erosion from the runoff created.*

SDP: Storm Drain Inlet Protection

Description & Purpose

Storm drain inlet protection consists of a sediment filter or an impounding area around or upstream of a storm drain, drop inlet, or curb inlet. Storm drain inlet protection measures temporarily pond runoff before it enters the storm drain, allowing sediment to settle.

Suitable Applications

Inlet Protection may be suitable in the following situations:

- Whenever a storm drain inlet is receiving or my receive sediment laden runoff.

Limitations

- Drainage area should not exceed 1 acre.
- Straw bales alone cannot be used as inlet protection but can be used to reinforce silt fence inlet protection.
- Requires an adequate area for water to pond without encroaching into portions of the roadway subject to traffic.
- Inlet protection usually requires other methods of temporary protection to prevent sediment laden stormwater and non-stormwater discharges from entering the storm drain system.
- Sediment removal may be difficult in high flow conditions or if runoff is heavily sediment laden. If high flow conditions are expected, use other onsite sediment trapping techniques in conjunction with inlet protection.
- Frequent maintenance is required.
- For drainage areas larger than 1 acre, runoff should be routed to a sediment trapping device designed for larger flow. Such devices are Sediment Traps and Sediment Basins.
- Excavated drop inlet sediment traps are appropriate where relatively heavy flows are expected, and overflow capacity is needed.

Objectives

SE Sediment Control

Potential Alternatives

FB Fiber Rolls

GBB Gravel Bag Berm

SBB Sandbag Barrier

SWB Straw Bale Barrier

SF Silt Fence

Implementation

General

Large amounts of sediment may enter the storm drain system when storm drains are installed before the upslope drainage area is stabilized, or where construction is adjacent to an existing storm drain. In cases of extreme sediment loading, the storm drain itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Inlet control measures presented in this handbook should not be used for inlets draining more than one acre. Runoff from larger disturbed areas should be first routed through a Sediment Basin or a Sediment Trap. Different types of inlet protection are appropriate for different application depending on site conditions and the type on inlet. Inlet protection methods not presented in this handbook should be approved by the Public Works Department.

Design and Layout

Identify existing and planned storm drain inlets that have the potential to receive sediment laden surface runoff. Determine if storm drain inlet protection is needed and which methods to use.

- Limit upstream drainage area to 1 acre maximum. For larger areas use Sediment Basins or Sediment Traps upstream of the inlet protection device.
- The key to successful and safe use of storm drain inlet protection devices is to know where runoff will pond or be diverted.
  - Determine the acceptable location and extent of ponding in the vicinity of the drain inlet. The acceptable location and extent of ponding will influence the type and design of the storm drain inlet protection device.
  - Determine the extent of potential runoff diversion caused by the storm drain inlet protection device. Runoff ponded by inlet protection devices may flow around the device and towards the next downstream inlet. In some cases, this is acceptable; in other cases, serious erosion or downstream property damage can be caused by these diversions. The possibility of runoff diversions will influence whether or not storm drain inlet protection is suitable; and, if suitable, the type and design of the device.
- The location and extent of ponding, and the extent of diversion, can usually be controlled through appropriate placement of the inlet protection device. In some cases, moving the inlet protection device a short distance upstream of the actual inlet can provide more efficient sediment control, limit ponding to desire areas, and prevent or control diversions.
- Four types of inlet protection are presented below. However, it is recognized that other effective methods and proprietary devices exist and may be selected.
  - Filter Fabric Fence – Appropriate for drainage basins with less than a 5% slope, sheet flows, and flows under 0.5cfs.
  - Excavated Drop Inlet Sediment Trap – An excavated area around the inlet to trap sediment.
  - Gravel Bag Barrier – Used to create a small sediment trap upstream of inlets on sloped, paved streets. Appropriate for sheet flow or when concentrated flow may exceed 0.5cfs, and where overtopping is required to prevent flooding.
  - Block and Gravel Filter – Appropriate for flows greater than 0.5cfs.
- Select the appropriate type of inlet protection and design as referred to or as described in this fact sheet.
- Provide area around the inlet for water to pond without flooding structures and property.
- Grates and spaces around all inlets should be sealed to prevent seepage of sediment laden water.
- Excavate sediment sumps (where needed) 1 to 2 feet with 2:1 side slopes around the inlet.

Design and Layout

- DI Protection Type 1 – Filter Fabric Fence – The filter fabric fence (Type 1) protection is shown in the attached figure. Similar to constructing a silt fence. Do not place filter fabric underneath the inlet grate since the collected sediment may fall into the drain inlet when the fabric is removed or replaced.
  1. Excavate a trench approximately 6 in. wide and 6 in. deep along the line of the silt fence inlet protection device.
  2. Place 2 in. by 2 in. wood stakes around the perimeter of the inlet a maximum of 3 ft. apart and drive them at least 18 in. into the ground or 12 in. below the bottom of the trench. The stakes must be at least 48 in. long.
  3. Lay fabric along bottom of trench, upside of trench, and then up stake. The maximum silt fence height around the inlet is 24 in.
  4. Staple the filter fabric to the wooden stakes. Use heavy duty wire staples at least 1 in. in length.
  5. Backfill the trench with gravel or compacted earth all the way around.

- DI Protection Type 2 – Excavated Drop Inlet Sediment Trap – The excavated drop inlet sediment trap (Type 2) is shown in the attached figures. Install filter fabric fence in accordance with DI Protection Type 1. Size excavated trap to provide a minimum storage capacity calculated at the rate of 67 yd^3/acre of drainage area.
- DI Protection Type 3 – Gravel Bag – The gravel bag barrier (Type 3) is shown in the figures. Flow from a severe storm should not overtop the curb. In areas of high clay and silts, use filter fabric and gravel as additional filter media. Construct gravel bags in accordance with the Gravel Bag Berm requirements. Gravel bags should be used due to their high permeability.
  1. Use sandbag made of geotextile fabric (not burlap) and fill with 0.75 in. rock or 0.25 in. pea gravel.
  2. Construct on gently sloping street.
  3. Leave room upstream of barrier for water to pond and sediment to settle.
  4. Place several layers of sandbags – overlapping the bags and packing them tightly together.
  5. Leave gap of one bag on top row to serve as a spillway. Flow from a severe storm (e.g., 10-year storm) should not overtop the curb.
- DI Protection Type 4 – Block and Gravel Filter – The block and gravel filter (Type 4) is shown in the figures. Block and gravel filters are suitable for curb inlets commonly used in residential, commercial, and industrial construction.
  1. Place hardware cloth or comparable wire mesh with 0.5 in. opening over the drop inlet so that the wire extends a minimum of 1 ft beyond each side of the inlet structure. If more than one strip is necessary, overlap the strips. Pace filter fabric over the wire mesh.
  2. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 in., 8 in., and 12 in. wide. The row of blocks should be at least 12 in. but no greater than 24 in. high.
  3. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the block. Use hardware cloth or comparable wire mesh with 0.5 in. opening.
  4. Pile washed stone against the wire mesh to the top of the blocks. Use 0.75 to 3 in.

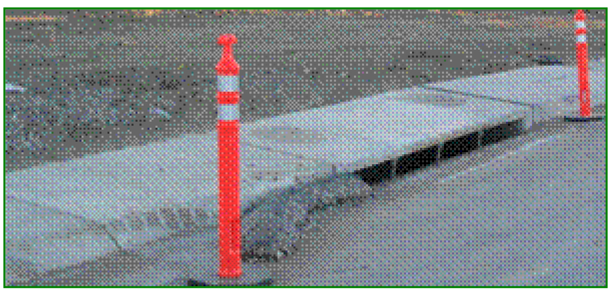
Inspection and Maintenance

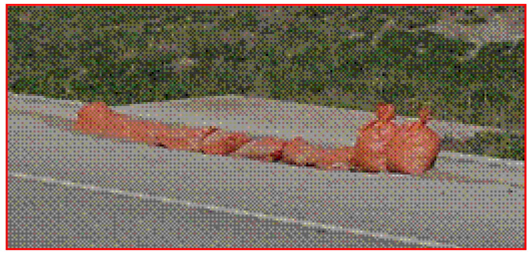
- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Filter Fabric Fence – If the fabric becomes clogged, torn, or degrades, it should be replaced. Make sure the stakes are securely driven in the ground and are in good shape (i.e., not bent, cracked, or splinted, and are reasonably perpendicular to the ground). Replace damaged stakes.
- Gravel Filters – If the gravel becomes clogged with sediment, it must be carefully removed from the inlet and either cleaned or replaced. Since cleaning gravel at a construction site may be difficult, consider using the sediment laden stone as fill material and put fresh stone around the inlet. Inspect bags for holes, gashes, and snags, and replace bags as needed. Check gravel bags for proper arrangement and displacement.
- Sediment accumulated in the BMP must be removed in order to maintain BMP effectiveness. Sediment should be removed when the sediment accumulation reaches one-third of the barrier height. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed at an appropriate location.
- Remove storm drain inlet protection once the drainage area is stabilized.
  - Clean and regrade area around the inlet and clean the inside of the storm drain inlet as it must be free of sediment and debris at the time of final inspection.

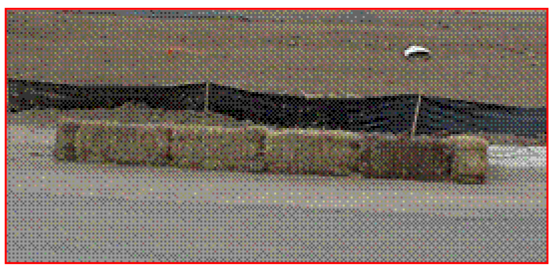
Don't. *Allow the silt fence to be damaged. Stakes must be maintained on a regular basis.*

Do. Use gravel filled bags not constructed of burlap to filter out sediment from runoff.

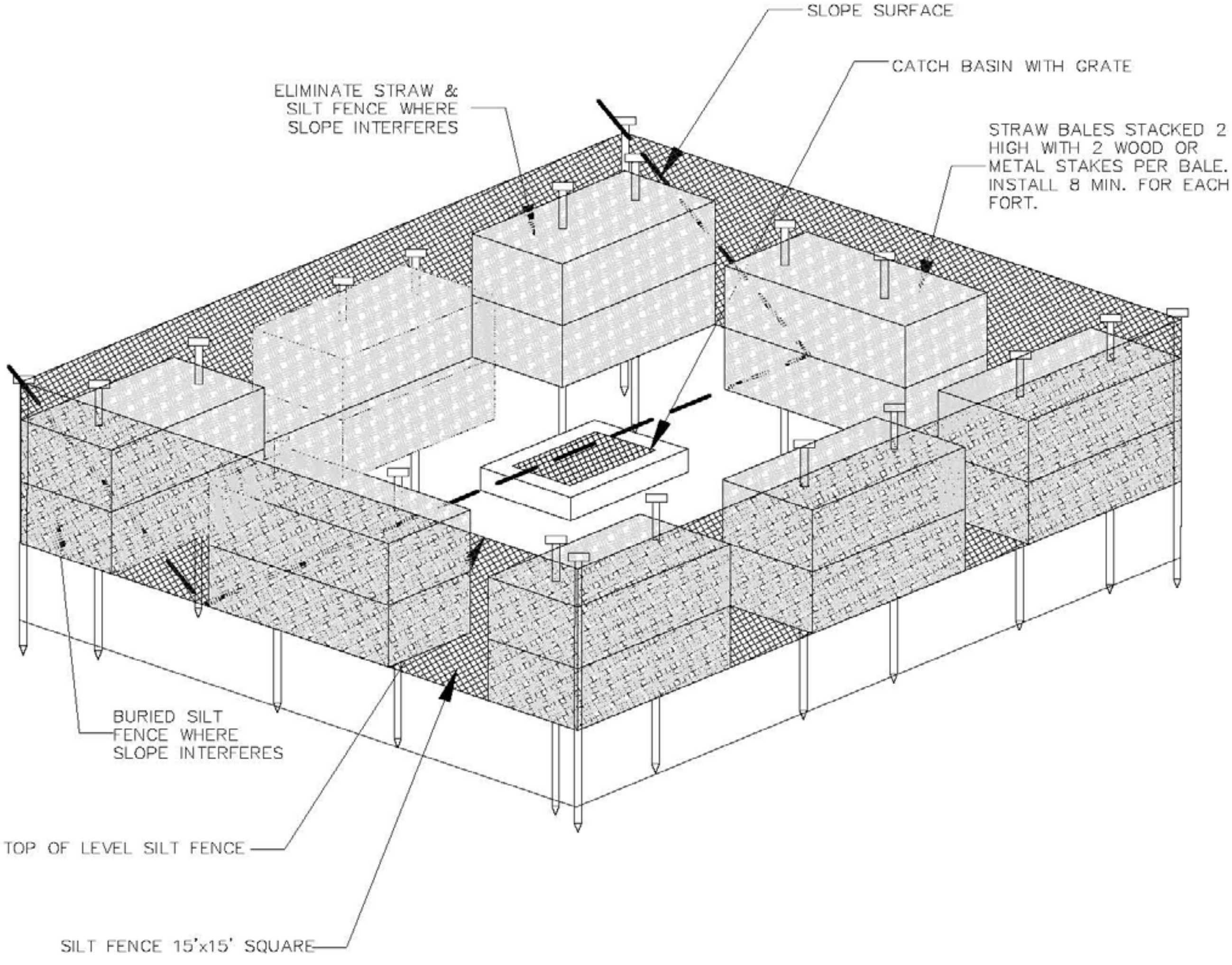
Don't. *Allow sediment laden runoff to enter the storm drain system unimpeded.*



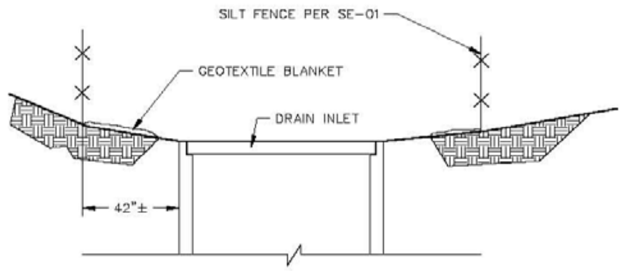




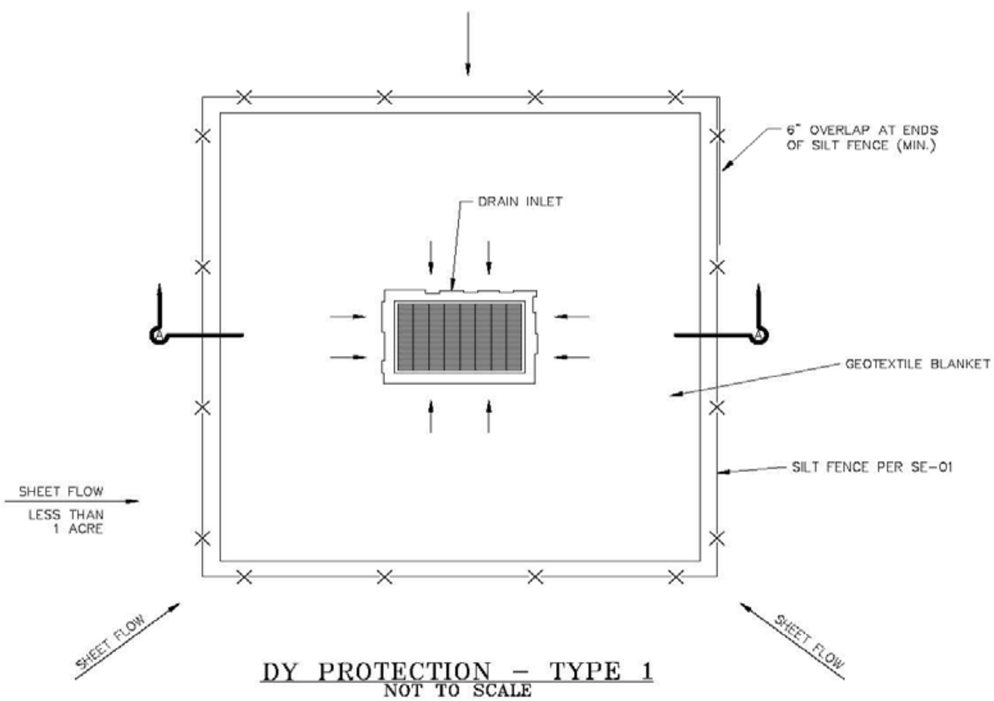
DESILTING FORT



STORM DRAIN INLET PROTECTION



SECTION A-A
NOT TO SCALE

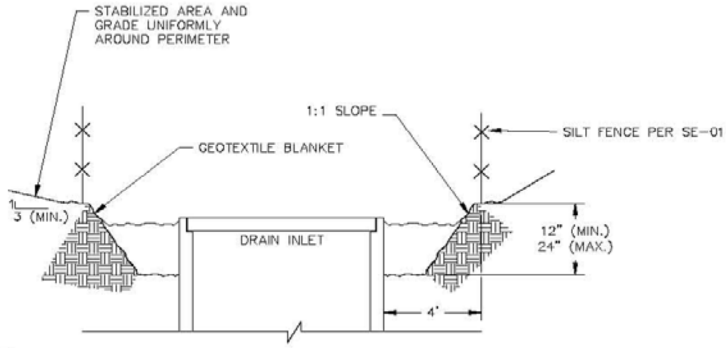


DY PROTECTION – TYPE 1
NOT TO SCALE

NOTES:

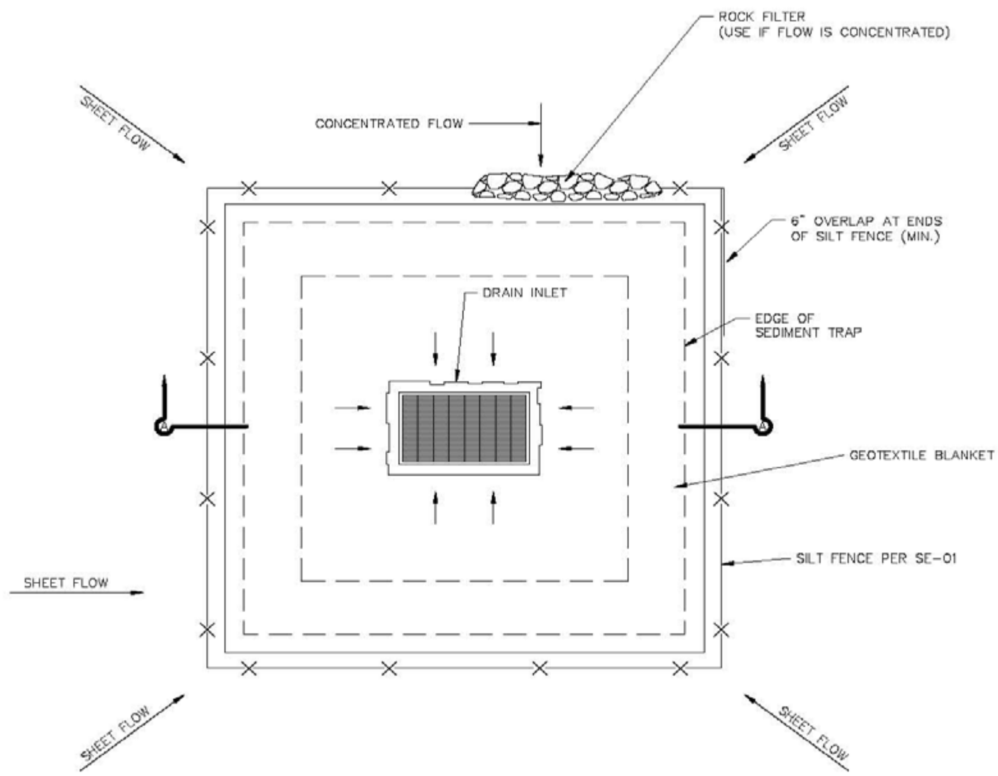
1. FOR USE IN AREAS WHERE GRADING HAS BEEN COMPLETED AND FINAL SOIL STABILIZATION AND SEEDING ARE PENDING.
2. NOT APPLICABLE IN PAVED AREAS.
3. NOT APPLICABLE WITH CONCENTRATED FLOWS.

STORM DRAIN INLET PROTECTION



NOTE:
REMOVE SEDIMENT BEFORE
REACHING ONE THIRD FULL

SECTION A-A
NOT TO SCALE

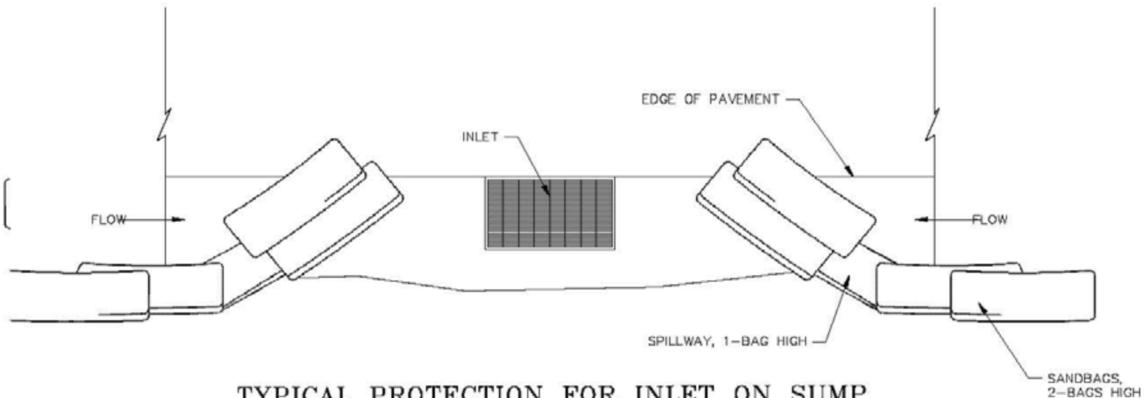


DI PROTECTION - TYPE 2
NOT TO SCALE

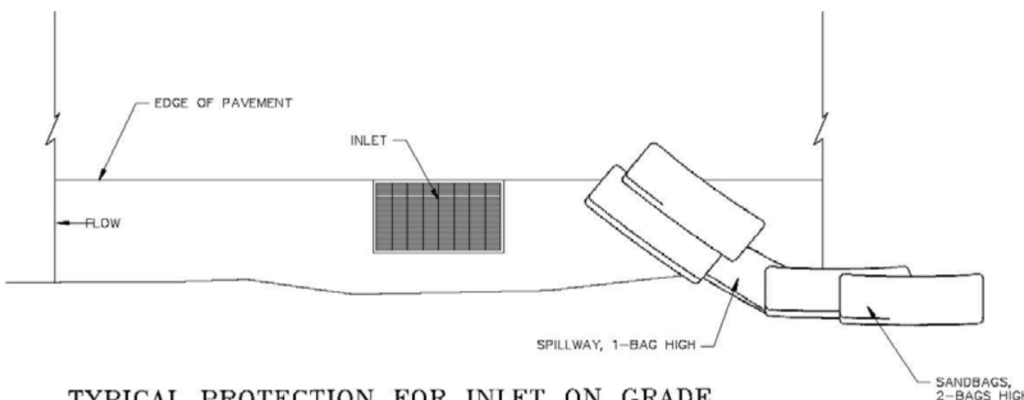
NOTES:

1. FOR USE IN CLEARED, GRUBBED, AND GRADED AREAS
2. SLOPE BASIN SO THAT LONGEST INFLOW AREA FACES LONGEST LENGTH OF TRAP.
3. FOR CONCENTRATED FLOWS, SHAPE BASIN IN 2:1 RATIO WITH LENGTH ORIENTED TOWARDS DIRECTION OF FLOW.

STORM DRAIN INLET PROTECTION



TYPICAL PROTECTION FOR INLET ON SUMP
NOT TO SCALE

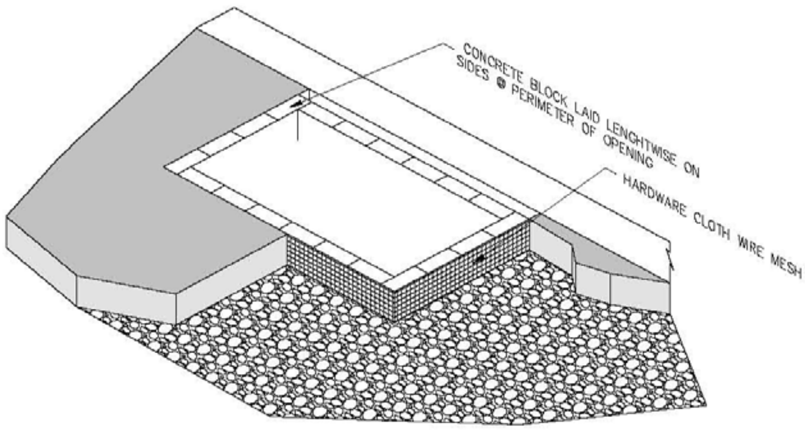


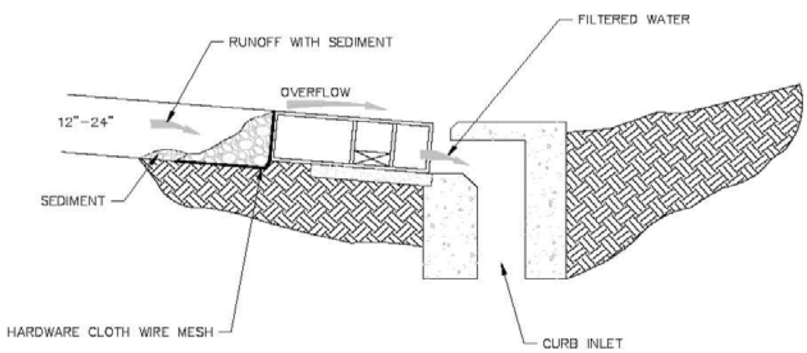
TYPICAL PROTECTION FOR INLET ON GRADE
NOT TO SCALE

NOTES:
1. INTENDED FOR SHORT TERM USE.
2. USE TO INHIBIT SON STORM-WATER FLOW.
3. ALLOW FOR PROPER MAINTENANCE AND CLEANUP.
4. BAGS MUST BE REMOVED AFTER ADJACENT OPERATION IS COMPLETED.
5. NOT APPLICABLE IN AREAS WITH HIGH SILTS AND CLAYS WITHOUT FILTER FABRIC.

TYPICAL DI PROTECTION – TYPE 3

STORM DRAIN INLET PROTECTION





DI PROTECTION TYPE 4
NOT TO SCALE

RR: Rip Rap

Description & Purpose

An arranged layer of rock placed over the soil surface on slopes and at or below storm drain outfalls or temporary dikes. Rip rap used as slope protection against erosion and dissipates the energy of runoff or surface water flow.

Suitable Applications

Rip Rap may be suitable in the following situations:

- Use rip rap on slope greater than 4:1 (H:V)
- In channels where the velocity and water surface elevation occurring during the 100-year storm event has the possibility of damaging the channel banks and/or flowline.
- Around structures that require protection during storm events (i.e., Bridges, Culvert inlets)

Limitations

- The minimum particle size of the rock must be sized for the maximum expected velocity of flow of the outlet and the soil conditions where the outlet will be located.

Objectives

SC Sediment Control

Potential Alternatives

None

Implementation

Design

Riprap should be installed as follows:

- Grade the bank to a maximum slope of two feet of horizontal distance for one foot of vertical rise.
- Place a highly permeable and appropriately sized geotextile filter fabric on the prepared slope following the manufacturer's recommendations. Take care not to tear the filter fabric during installation.
- Place a layer (six inch minimum) of gravel or small rock on the geotextile filter fabric. The underlayer stone needs to be sized appropriately so it will not wash through any gaps between the riprap stones.
- Place the layer of riprap, 1.5 times the thickness of the largest stone, on top of the gravel. The heaviest rocks should be placed along the bottom of the bank. Riprap should be placed onto position, not dumped over the bank edge.
- Entrench the bottom row of stone into the stream bed to prevent undercutting.
- Extend the revetment beyond the area of erosion to prevent erosion behind the ends of the structure.
- The rip rap should be sized according to the following table:

Velocity of Stream	Size Range Largest Diameter of Rock
2 - 6 feet/second	4" - 12"; average 6"
6 - 8 feet/second	6" - 18"; average 12"
8 - 10 feet/second	12" - 24"; average 18"
10 - 12 feet/second	18" - 30"; average 24"
12 - 15 feet/second	24" - 42"; average 36"

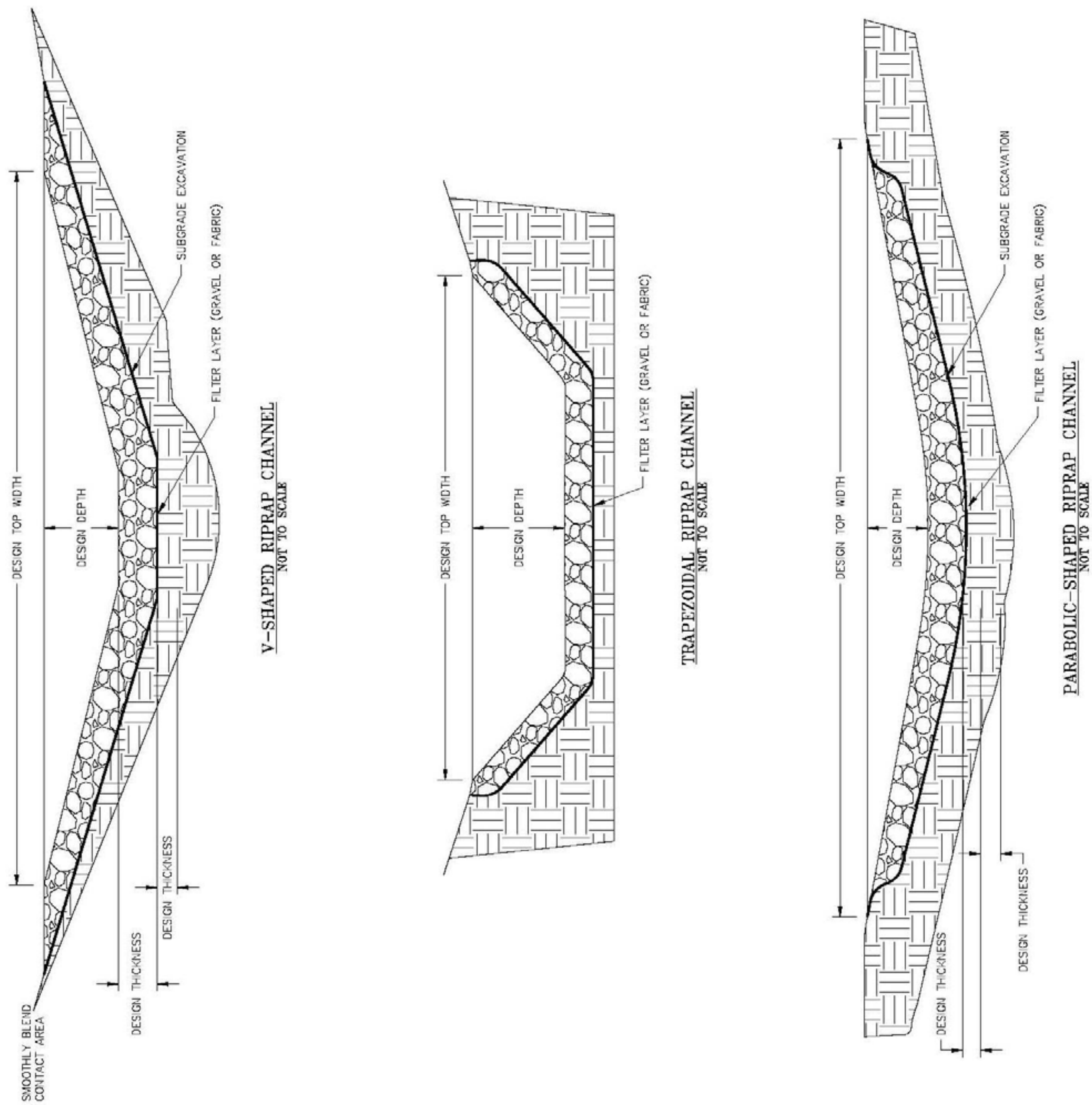
Inspection and Maintenance

- Rip rap must be inspected every two weeks during the construction phase of the project.
- Rip rap must be inspected quarterly after the construction phase of the project is finished.
- Rip Rap must be inspected after all storm events producing a significant amount of runoff.
- Any rocks displaced during storm events must be replaced immediately after the storm event has ended.

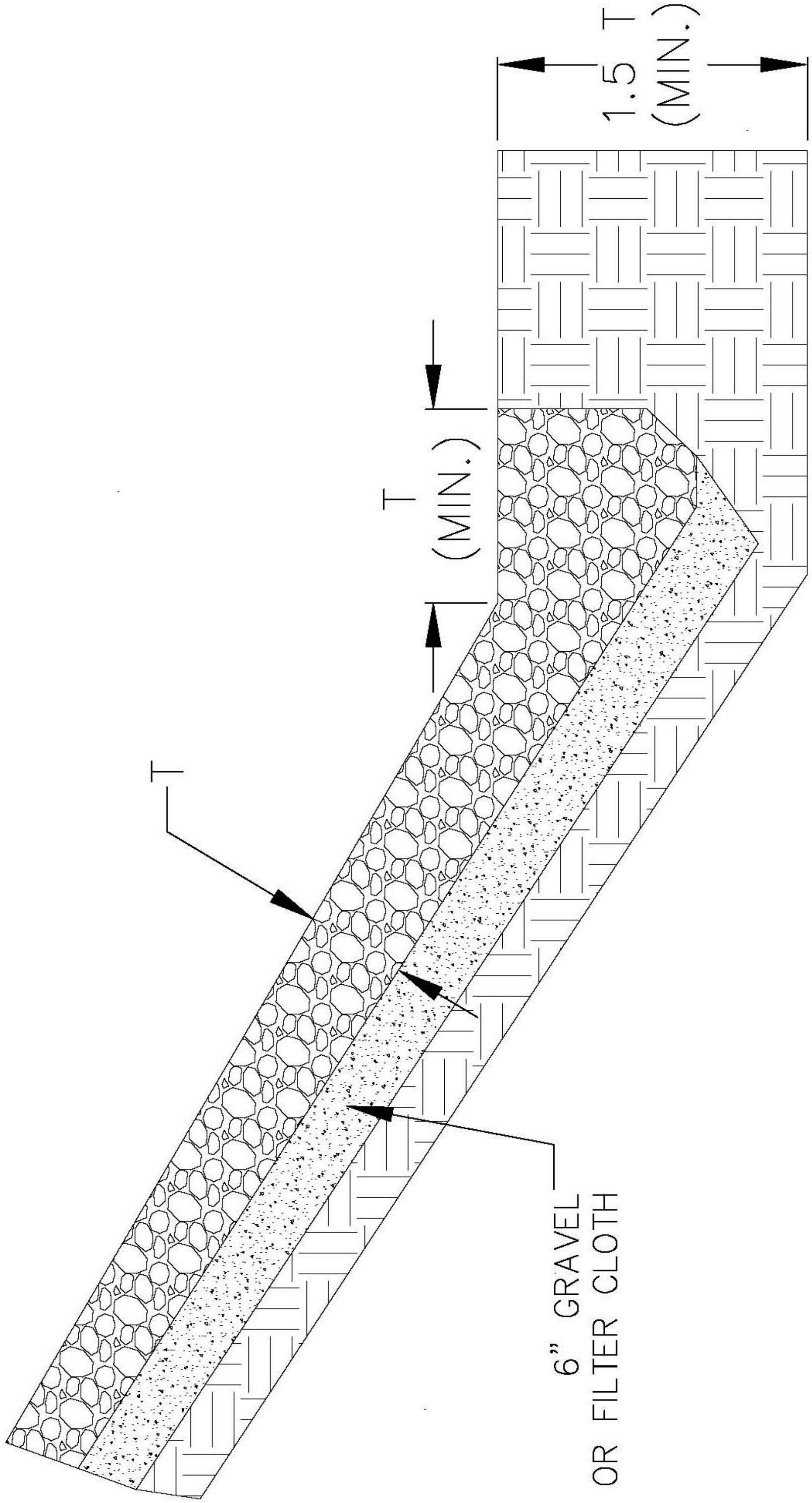
Do. Install rip rap lined channels where erodible channels are constructed or altered.

Don't. *Use concrete rubble as rip rap material.*

RIP RAP


SUBGRADE EXCAVATION
FILTER LAYER (GRAVEL OR FABRIC)
DESIGN TOP WIDTH
DESIGN DEPTH
DESIGN THICKNESS
DESIGN THICKNESS
SMOOTHLY BLEND CONTACT AREA
V-SHAPED RIPRAP CHANNEL
NOT TO SCALE
DESIGN TOP WIDTH
DESIGN DEPTH
FILTER LAYER (GRAVEL OR FABRIC)
TRAPEZOIDAL RIPRAP CHANNEL
NOT TO SCALE
SUBGRADE EXCAVATION
FILTER LAYER (GRAVEL OR FABRIC)
DESIGN TOP WIDTH
DESIGN DEPTH
DESIGN THICKNESS
DESIGN THICKNESS
PARABOLIC-SHAPED RIPRAP CHANNEL
NOT TO SCALE

RIP RAP



CW: Concrete Washout

Description & Purpose

Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout offsite, performing onsite washout in a designated area, and training employee and subcontractors.

Suitable Applications

Concrete Washout may be suitable in the following situations:

- Wherever concrete, slurries, or asphalt concrete will be used on a construction site.

Limitations

- Offsite washout of concrete wastes may not always be possible.
- Onsite concrete washout sites must be maintained to remain effective.

Objectives

WM Waste Management

Potential Alternatives

None

Implementation

The following steps will help reduce stormwater from concrete wastes:

- Discuss the concrete management techniques described in this BMP (such as handling of concrete waste and washout) with the ready-mix concrete supplier before deliveries are made.
- Incorporate requirements for concrete washouts into material supplier and subcontractor agreements.
- Avoid mixing/ordering excess amounts of fresh concrete.
- Perform washout of concrete trucks offsite or in designated areas only.
- Do not wash out concrete trucks into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped onsite, except in designated areas.
- For onsite washout
  - Locate washout area at least 50 feet from storm drains, open ditches, or water bodies. Do not allow runoff from this area by constructing a temporary pit or bermed area large enough for liquid and solid waste.
  - Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed properly.
- Avoid creating runoff by draining water to a bermed or level area when washing concrete to remove fine particles and exposed aggregate.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile or dispose of properly.

Onsite Temporary Concrete Washout Facility

- Temporary concrete washout facilities should be located a minimum of 50 feet from storm drain inlets, open drainages, and watercourses. Each facility should be located away from construction traffic or access areas to prevent disturbance or tracking.
- A sign should be installed adjacent to each washout facility to inform concrete equipment operators to utilize the proper facilities.
- Temporary concrete washout facilities should be constructed above grade or below grade at the option of the contractor. Temporary concrete washout facilities should be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.
- Temporary washout facilities should have a temporary pit or bermed areas sufficient volume to completely contain all liquid and waste concrete materials generated during washout procedures.
- Washout of concrete trucks should be performed in designated areas only.
- Only concrete from mixer truck chutes should be washed into concrete washout.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated washout area or properly disposed of offsite.
- Once concrete wastes are washed into the designated area and allowed to harden, the concrete should be broken up, removed, and disposed of. Dispose of hardened concrete on a regular basis.
- Temporary Concrete Washout Facility (Type Above Grade)
  - Temporary concrete washout facility (type above grade) should be constructed as shown on the details at the end of this BMP, with a recommended minimum length and minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
  - Straw bales, wood stakes, and sandbag materials should conform to the provisions stated in the Straw Bale Barrier BMP.
  - Plastic lining material should be a minimum of 10 mil in polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.
- Temporary Concrete Washout Facility (Type Above Grade)
  - Temporary concrete washout facility (type below grade) should be constructed as shown on the details at the end of this BMP, with a recommended minimum length and minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
  - Lath and flagging should be commercial type.
  - Plastic lining material should be a minimum of 10 mil in polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.

Removal of Temporary Concrete Washout Facilities

- When temporary concrete washout facilities are no longer required for the work, the hardened concrete should be removed and disposed of. Materials used to construct temporary concrete washout facilities should be removed from the site of the work and disposed of.
- Holes, depressions, or other ground disturbance caused by the removal of the temporary concrete washout facilities should be backfilled and repaired.

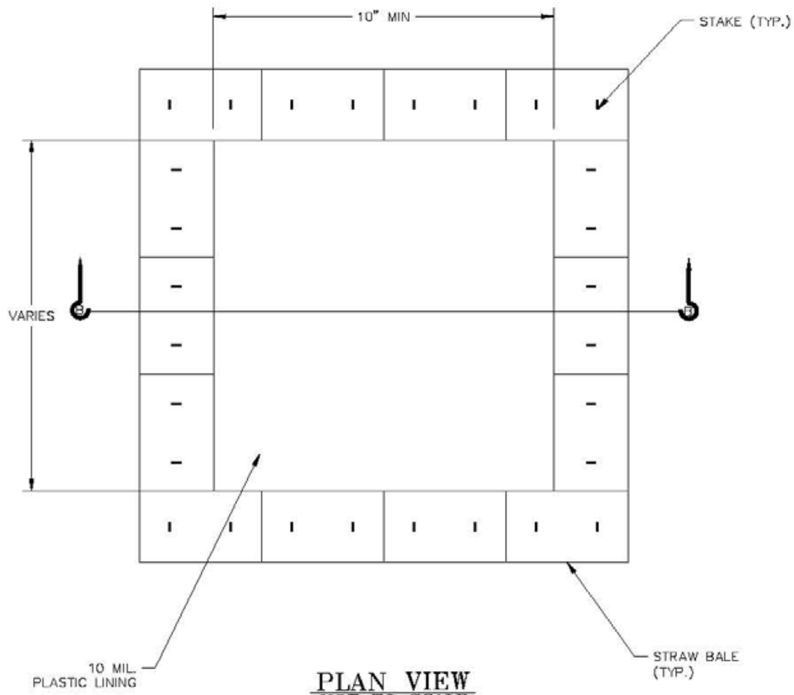
Do. Post signs directing mix trucks to centralized concrete washout facilities.

Don't. Allow concrete mix trucks to dump the excess concrete on the ground. The cleanup is more expensive and difficult to perform.

Inspection and Maintenance

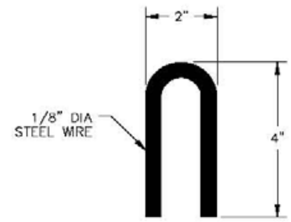
- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and of two-week intervals in the non-rainy season to verify continues BMP implementation.
- Temporary concrete washout facilities should be maintained to provide adequate holding capacity with a minimum freeboard of 4 in. for above grade facilities and 12 in. for below grade facilities. Maintaining temporary concrete washout facilities should include removing and disposing of hardened concrete and returning the facilities to a functional condition. Hardened concrete materials should be removed and disposed of.
- Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.

CONCRETE WASTE MANAGEMENT



PLAN VIEW
NOT TO SCALE

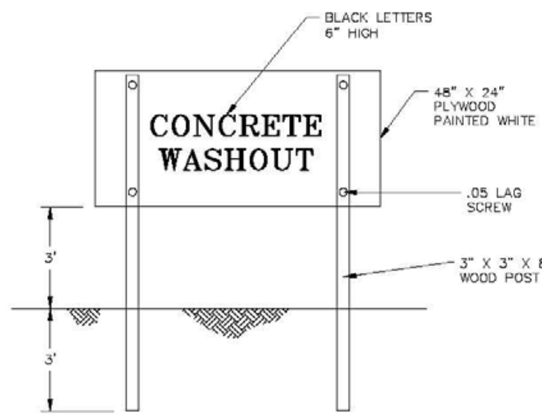
TYPE: "ABOVE GRADE"
(WITH STRAW BALES)



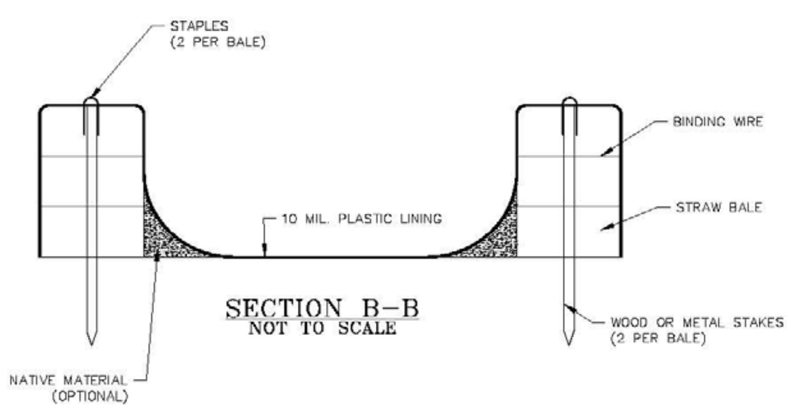
STAPLE DETAIL
NOT TO SCALE

NOTES:

1. ACTUAL LAYOUT DETERMINED IN THE FIELD
2. THE CONCRETE WASHOUT SIGN SHALL BE INSTALLED WITHIN 30 FT. OF THE TEMPORARY CONCRETE WASHOUT FACILITY

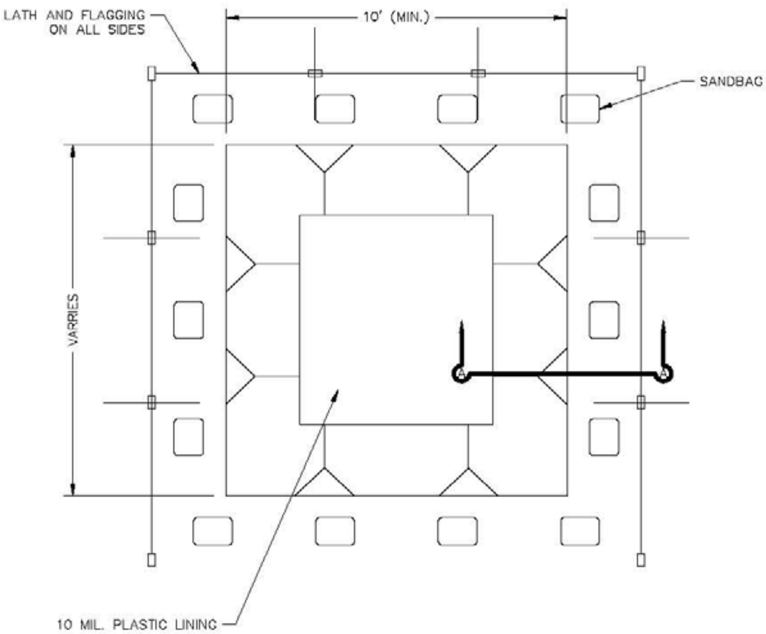


CONCRETE WASHOUT
SIGN DETAIL
OR EQUIVALENT

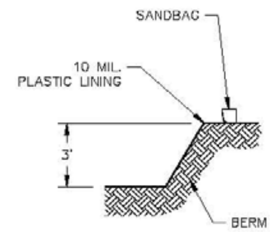


SECTION B–B
NOT TO SCALE

CONCRETE WASTE MANAGEMENT

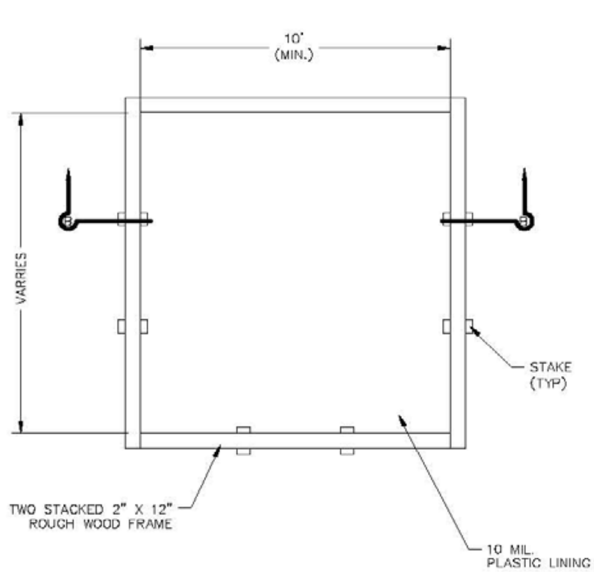


PLAN VIEW
NOT TO SCALE
TYPE: " BELOW GRADE"

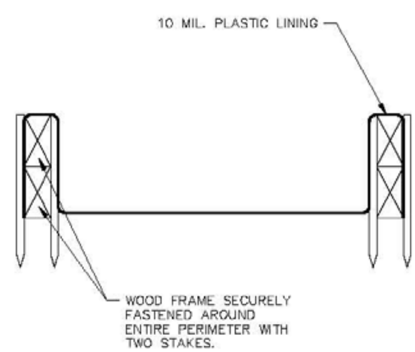


SECTION B–B
NOT TO SCALE

NOTES:
1. ACTUAL LAYOUT DETERMINED IN THE FIELD
2. THE CONCRETE WASHOUT SIGN SHALL BE INSTALLED WITHIN 30 FT. OF THE TEMPORARY CONCRETE WASHOUT FACILITY



PLAN VIEW
NOT TO SCALE
TYPE: " ABOVE GRADE"



SECTION B–B
NOT TO SCALE

SSA: Stabilized Staging Area

Description & Purpose

Provides an onsite location where equipment, deliveries, and project parking can be centralized to reduce mud collection on vehicle tires thus helping to reduce the amount of mud tracking onto adjacent streets.

Objectives

TC Tracking Control

Potential Alternatives

None

Suitable Applications

Stabilized Staging Areas may be suitable in the following situations:

- Wherever an onsite construction management office is located.
- Wherever construction vehicles park on a job site.
- Wherever equipment or supplies are to be stored prior to installation.

Limitations

- Adequate space may not be available on very small sites. Stabilized Staging Areas may be incorporated in this situation by enlarging the Stabilized Construction Entrance to a size sufficient to be utilized as a staging area.
- Onsite stabilized staging areas sites must be maintained to remain effective.

Implementation

General

A stabilized staging area is a pad of aggregate underlain with filter cloth located at any point where vehicles will be parked, equipment or material are stored, and where construction management offices are maintained. The purpose of a stabilized staging area is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets. Reducing tracking of sediments and other pollutants onto paved roads helps prevent deposition of sediments into local storm drains and production of airborne dust.

NPDES permits require that appropriate measures be implemented to prevent tracking of sediments onto paved roadways, where a significant source of sediments is derived from mud and dirt carried out from unpaved roads and construction sites.

Stabilized staging areas are moderately effective at preventing the collection of mud onto the tires of vehicles on a construction site when used in conjunction with stabilized construction entrance/exits and stabilized construction roads. The staging area should be built on level ground and should be connected to the main street by either the stabilized entrance or stabilized road or a combination of both. Advantages of the stabilized staging area are that it does prevent some sediment from equipment and serves to channel construction traffic in and out of the site to specified locations.

Design and Layout

- Construct on level ground where possible.
- Select 3 to 6 in. diameter stones
- Use minimum depth of stones of 12 in. or as recommended by soils engineer.
- Construct length of 50 ft minimum, and 30 ft minimum width.
- Provide ample turning radii as part of the staging area.
- Limit speed of vehicles to control dust.
- Properly grade each staging area to prevent runoff from damaging the staging area.
- Connect staging area to the entrance/exit location of the site by utilizing a stabilized construction roadway.
- Select construction access stabilization (aggregate, asphaltic concrete, concrete) based on longevity, required performance, and site conditions. Do not use asphaltic concrete (AC) grindings for stabilized staging area.
- If aggregate is selected, place crushed aggregate over geotextile fabric to at least 12 in. depth, or place aggregate to a depth recommended by a geotechnical engineer. A crushed aggregate greater than 3 in. but smaller than 6 in. should be used.
- Require that all employees, subcontractors, and suppliers utilize the stabilized staging area.
- Implement removal and replacement of aggregate as needed.
- All staging area locations intended to be used for more than a two-week period should have stabilized staging area BMPs.

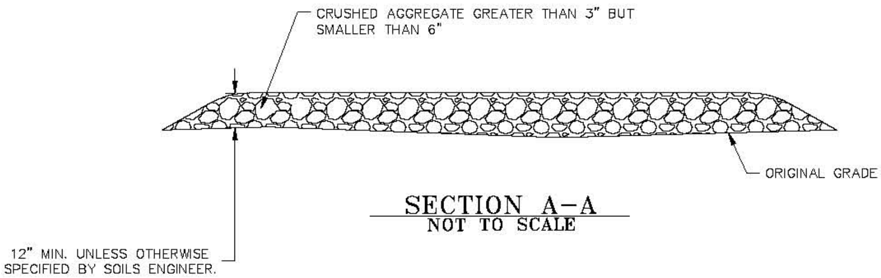
Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMPs are under way, inspect weekly during rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Remove aggregate, separate, and dispose of sediment if staging area is clogged with sediment.
- Keep all temporary ditches clear.
- Check for damage and repair as needed.
- Replace gravel material when surface voids are visible.
- Remove gravel and filter fabric at completion of construction.

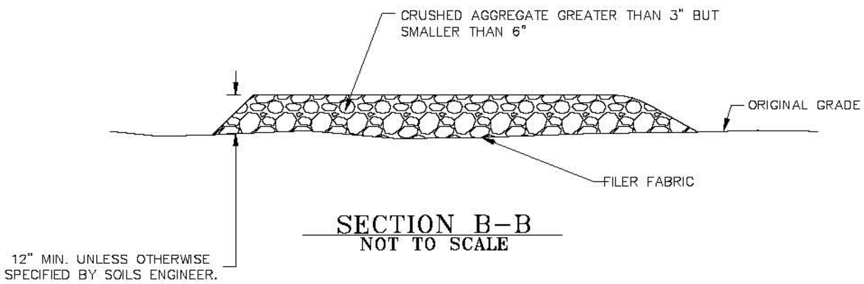
Do.
Construct a stabilized staging area next to an onsite construction manage-ment office.

Don't.
Allow staging to spread over the entire construction site.

STABILIZED STAGING AREA



SECTION A–A
NOT TO SCALE



SECTION B–B
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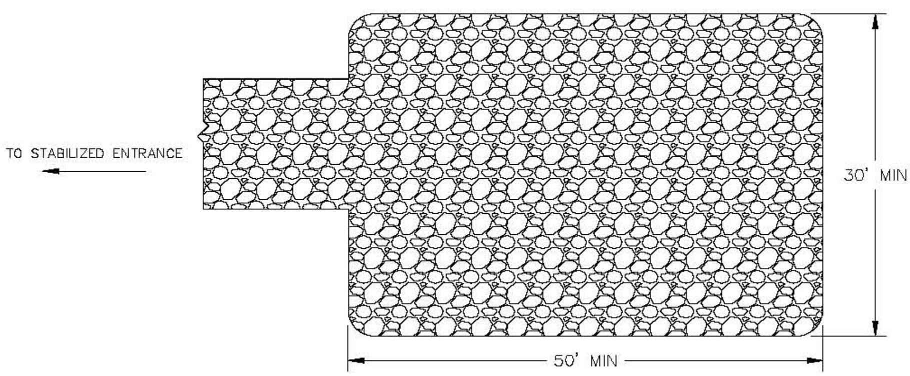


TYPICAL STAGING AREA
NOT TO SCALE

Appendix D:
Grading Permit

WASHINGTON CITY GRADING PREMIT

APPLICANT INFORMATION

Applicant	E-mail address

Organization	Phone

Address City State Zip-code

PROJECT INFORMATION

DISTURBANCE GREATER THAN ONE ACRE OR LRSS MUST INCLUDE THE FOLLOWING TO PROCESS THIS PERMIT:
Check the boxes appropriately for the project.

- ❒ **Required Construction Drawings**
- ❒ **Required Grading Drawings (Pre-Interim-Post Plan)**
- ❒ **Grading Report & Checklist (See grading manual appendix for examples)**
- ❒ **Drainage Report & Checklist (Not required for off site utility installation)**
- ❒ **Soil Report**
- ❒ **Restoration Bond (10% of the Engineer's Estimate)**
- ❒ **Singed Stormwater Management Agreement & Exhibit C** ❒ **Stormwater Management Plan & Maintenance Exhibit**
- ❒ **Grading Permit Application** ❒ **LID Report** ❒ **Under Ground Utility Installation** ❒ **Traffic Control Plan**

Project Name	Project Location

Grading Manager	Phone
Contractor	Phone

Project Engineering Firm

Project Engineer	Phone

Project Description

Applicant agrees to comply with all requirements of the Washington City Grading manual.

Applicant's Signature: ________________________________ Date_____________________

WASHINGTON CITY USE ONLY

Permit #____________________ Permit Fee Anount $_________________10% Restoration Bond Anount $______________

❒ Permit Fee Paid (Date) ________________ ❒ Renewal Fee Paid (Date) ________________

Signature: ____Date:______________________

Appendix E:
Fiscal Security Letter Form

Financial institute

To: Washington City
Honorable Mayor and City Council
111 North 100 East
Washington City, UT 84780

Date Issued
Letter of Credit No:

RE: *Project*

To whom it may concern:

We hereby establish an irrevocable letter of credit for the benefit of Washington City in the amount of $____________________ which reflects 110% of the total cost associated with the restoration of disturbed land as determined by Washington City.

The undersigned hereby agrees that the foregoing sum shall be used exclusively for the purpose of paying the cost of any repairs in workmanship and material for the restoration of disturbed land as deemed necessary by the city for a period of twelve (12) months. The undersigned further agrees that the money held in the escrow account shall be paid out to Washington City upon written request by an authorized officer of Washington City for the necessary repairs as required ordinance.

Appendix F:
Washington County Flood Control Authority
Hydrology Manual

WASHINGTON COUNTY FLOOD CONTROL AUTHORITY

STORM DRAINAGE SYSTEMS DESIGN AND MANAGEMENT MANUAL

VERSION 1

TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

SECTION 1
PURPOSE

This manual was prepared as a collaborative effort between the Washington County Flood Control Authority (WCFCA/Authority) and Bowen, Collins and Associates (BC&A). WCFCA plans to continue to make revisions to this manual on an as needed basis.

This manual has been prepared to document the approval process, design standards, regulations, and hydrologic and hydraulic computation methods for evaluating and designing storm drain and flood control facilities in the WCFCA jurisdiction. This manual will provide the standards and requirements that should be used when planning and designing storm drain facilities. Following these standards and requirements should ensure that storm drain improvements are designed and constructed in a manner that is consistent with each municipality within the WCFCA jurisdiction. The developer and/or storm drain engineer shall be responsible to ensure that their construction projects also conform to the requirements of the specific municipality's Storm Drain Master Plan. All storm drain construction projects shall conform to requirements in this Storm Drainage System Design and Management Manual, the governing agency's Storm Drain Master Plan, and shall be approved by the governing agency's Public Works Director, or his designee.

This manual is organized into the following sections:

Section 1 – Purpose

Section 1 describes the purpose of this manual.

Section 2 – Design Submittal Requirements

Section 2 describes the design approval process and procedures for new storm drain facilities in the WCFCA jurisdiction. The process requires that a developer or land owner prepare and submit calculations, reports and drawings for review and approval. The specific requirements for various types of development are provided in this section.

Section 3 – Design Criteria for Storm Drain Facilities

Section 3 outlines the general guidelines that should be followed with respect to grading and drainage, when a property is developed. It also contains detailed and specific criteria that shall be followed when designing typical storm drain facilities, including: pipes, inlets (catch basins), streets, manholes, outlet structures, open channels, detention and retention facilities, and culverts. Development in and near floodplains is also discussed.

Section 4 – Hydrologic Analysis

Section 4 describes the hydrologic methods and parameters that should be used when performing runoff calculations, including: design storm, drainage basin characterization, runoff computational methods and model calibration.

SECTION 2
DRAINAGE SUBMITTAL REQUIREMENTS

2.1 INTRODUCTION

Site grading and drainage plans for parcels of any size must be reviewed in conjunction with the governing agency's development review process. Every property owner or developer that wishes to obtain building permit approval from the governing municipality shall submit data as required in this Section. Every development can be categorized into one of the following development types:

1. Single residential lot
2. Single commercial or industrial lot (less than 1 acre)
3. Multi-lot subdivision

Depending on the size and type of development, a single commercial or industrial lot development could be required to meet the submittal requirements of a multi-lot subdivision. Additionally, if offsite drainage enters the site from outside of the lot, a single commercial or industrial lot could be required to meet multi-lot subdivision requirements. The governing agency's Public Works Director, or his designee, shall determine which drainage criteria must be followed during the planning and design process.

The remainder of this section defines the data required to be submitted for each type of development listed above.

2.2 SINGLE RESIDENTIAL LOT SUBMITTAL REQUIREMENTS

A Lot Grading Plan shall be submitted to the Public Works Director, or his designee, for single residential lot developments. The submittal shall include a drawing that shall contain the information indicated on the checklist (see Appendix A for the checklist and an example of a Lot Grading Plan). The Public Works Director, or his designee, may request a soils letter.

2.3 SINGLE COMMERCIAL OR INDUSTRIAL LOT SUBMITTAL REQUIREMENTS

A Storm Drainage Report and Management Plan shall be submitted to the Public Works Director, or his designee, for single commercial or industrial lot developments and shall be prepared by a professional civil engineer registered in the State of Utah. The submittal shall contain a report and drawing(s) that shall contain the information indicated on the checklist (see Appendix A).

2.4 MULTI-LOT SUBDIVISION STORM SUBMITTAL REQUIREMENTS

A Storm Drainage Report and Management Plan shall be submitted to the Public Works Director, or his designee, for all multi-lot subdivisions and shall be prepared by a professional civil engineer registered in the State of Utah. The submittal shall contain a report and drawing(s) that shall contain the information indicated on the checklist (see Appendix A).

2.5 FLOODPLAIN PERMIT

A Floodplain Development Permit must be obtained from the Governing Agencies Development Department for all developments that are located in a floodplain as defined on a current FEMA Flood Insurance Rate Map. The permit application must address activities that may include, but are not limited to: modifying the existing ground in or near the floodplain (i.e. cutting or filling), adding a culvert or bridge in the floodplain, or constructing a structure or fence in the floodplain.

SECTION 3
DESIGN CRITERIA FOR STORM DRAIN FACILITIES

Correct design of storm drain facilities is critical to the performance of the facilities during runoff events. The purpose of this section is to provide approved design criteria for projects within the WCFCA jurisdiction to ensure that drainage master planning and facility design efforts for developments within the WCFCA jurisdiction are consistent. Design engineers should follow the criteria within this section unless specific waivers are given by the governing agency's Public Works Director, or his designee.

3.1 GENERAL GRADING AND DRAINAGE

Proper management of storm water runoff is essential to fulfill grading and drainage objectives, which are:

1. Reduce flood damage, including life and property, from storm water runoff events.

2. Minimize any increase in storm water runoff from new developments.

3. Reduce soil erosion and sedimentation from development and construction projects.

4. Assure the adequacy of existing and proposed storm drainage facilities.

3.2 CONDUITS

Design Flow – Storm drain pipelines shall be designed to convey the computed design storm runoff (see Section 4.1 for design storm parameters) under full pipe capacity, but with no surcharging. Backwater from receiving streams and full detention/retention basins shall be accounted for in the design.

Minimum Pipe Size – The minimum allowable trunk line pipe diameter is 18 inches for mainline storm drain pipes.

Pipe Material – Storm drain pipelines material shall be reinforced concrete, corrugated smooth-wall and high-density polyethylene, or Governing Agencies approved materials. Ductile iron pipe may be approved by the Public Works Director, or his designee, in certain situations to minimize the pipeline profile.

Minimum Cover – Minimum two feet of cover or as approved by the Public Works Director, or his designee.

Minimum Slope / Velocity – The slope of the pipe is controlled by the velocity of storm water discharge. The pipeline minimum slope shall be designed such that the velocity of the design discharge is greater than three feet per second as approved by the Public Works Director, or his designee.

Location – Storm drain pipelines shall be located within the street right-of-way. All storm drain facilities not located in the street right-of-way shall have a dedicated maintenance access. The minimum width of the easement shall be calculated using the equations below.

1. Single pipe in the Easement

$$W_{easement} = B_c + 2H + 3$$

Where:

$W_{easement}$ = Easement Width (in feet)
B_c = Diameter of the outside wall of the pipe (in feet)
H = Depth from top of pipe to final grade (in feet)

$W_{easement}$ shall be rounded up to the next highest five-foot increment and a minimum width of 20 feet.

2. Multiple pipes in the easement, shall be calculated as a special case as approved by the Public Works Director, or his designee.

3. Open Channel/Swale

Q100 < 20 cfs	$W_{easement}$ = 15 feet minimum
Q100 < 100 cfs	$W_{easement}$ = 25 feet minimum
Q100 > 100 cfs	Easement to be determined with maintenance requirements from coordination with Public Works Director, or his designee

3.3 MANHOLES

Location – A manhole or cleanout structure shall be located at the upstream end of a storm drain conduit and at all changes in pipe size, horizontal alignment, slope, and material of the storm drain. In general, manholes shall be located within the road right-of-way. The edge of the concrete collar must be located at least 3 feet away from the edge of asphalt or gutter to allow for paving between the manhole and edge of pavement.

Spacing – Unless otherwise approved by the Public Works Director, or his designee, the maximum horizontal distance between manholes is 500 feet.

Size – The minimum manhole size is 48-inches in diameter and shall be sized to meet manufactures recommendations based on pipe penetration size and configuration.

Configuration – Either cast-in-place or precast concrete manhole structures or cleanouts can be used as junction structures. These structures shall have concrete troughs to reduce hydraulic losses. For mainline pipes that are 48-inches in diameter or larger, a precast tee manhole may be used as a cleanout structure if approved by the Public Works Director, or his designee.

3.4 INLETS

Location – Storm drain catch basins or inlets shall generally be located on both sides of the street and in road sag locations. As provided in the FHA Urban Drainage Manual, there are a number of locations where inlets may be necessary with little regard to contributing drainage area. These locations should be marked on the plans prior to any computations regarding discharge, water spread, inlet capacity, or flow bypass. Examples of these locations are as follows:

- At all low points in the gutter grade
- Immediately upstream of median break, entrance/exit ramp gores, cross walks, and street intersections (i.e., at any location where water could flow onto the travelway)
- Immediately upgrade of bridges (to prevent pavement drainage from flowing onto bridge decks)
- Immediately downstream of bridges (to intercept bridge deck drainage)
- Immediately upgrade of cross slope reversals
- Immediately upgrade from pedestrian cross walks
- At the end of channels in cut sections
- On side streets immediately upgrade from intersections
- Behind curbs, shoulders or sidewalks to drain low areas

In addition to the areas identified above, runoff from areas draining towards the roadway pavement should be intercepted by roadside channels or inlets before it reaches the roadway. This applies to drainage from cut slopes, side streets, and other areas alongside the pavement.

Configuration – All inlets shall have a curb-back opening and bicycle safe grate with a 6-inch minimum sump depth.

Road Sags – At a minimum, double inlets shall be installed in road sag locations and flanking inlets provided should the low point inlet become clogged or if the design spread is exceeded. See Section 3.5 for 100-year flow conveyance requirements.

Spacing – Inlet spacing and configuration shall be designed to meet the design spread requirements as shown in Table 3-1. As a general rule, inlets should be installed at intervals not to exceed 500 feet. Inlet spacing shall be calculated assuming the grate is 50% plugged.

Table 3-1
Allowable Gutter Spread for Design of Streets

Street Classification	Design Gutter Spread
Design Storm Event (10-Year)	
Local and Sag Point	No curb overtopping. Flow may spread to crown of Street.
Collector	No curb overtopping. Flow spread must leave at least one 10-foot lane free of water (i.e. 5-feet either side of the street crown).

Street Classification	Design Gutter Spread
Arterial	No curb overtopping. Flow spread must leave at least two 10-foot lanes free of water (i.e. 10-feet each side of the street crown of median).
Major Storm Event (100-Year)	
Local, Collector, and Sag Points	Residential dwellings, public, commercial, and industrial buildings shall not be inundated. The depth of water at the gutter flowline shall not exceed 12-inches and must not encroach onto private land, whichever is more restrictive.
Arterial	Residential dwellings, public, commercial, and industrial buildings shall not be inundated. To allow for emergency vehicles, the depth of water shall not exceed 6-inches at the street crown, 12-inches at the gutter flowline, and must not encroach onto private land whichever is more restrictive.

3.5 HYDRAULIC CAPACITY OF STREETS

Design Spread – Storm drain facilities in streets shall be designed to meet the design gutter spread indicated in section 3.4.

100-Year Flow Conveyance – Drainage facilities and streets, if applicable, shall be designed to safely convey runoff from a 100-year design storm (see Section 4.1 for design storm parameters) to adequate downstream conveyance facilities. The 100-year design storm runoff in streets should be contained within street right-of-way. Provisions shall be made, such as flood easements, to allow runoff within the street to enter downstream detention basins, to allow runoff to be conveyed out of road sags or other similar situations.

Cul-De-Sacs and Dead-End Streets – Downhill-sloping cul-de-sacs and dead ends will not be allowed unless specifically approved by the Public Works Director, or his designee. If they are allowed, means to safely convey runoff from design storm events across the site must be provided with appropriate drainage easements.

Tee Intersections – Special consideration, such as higher curbs, additional inlets or flood easements, shall be given to downhill tee intersections to ensure that flooding will not occur outside of the right-of-way during a storm event. Also, an evaluation shall be provided to address where flood water will go if the storm drain facilities plug or become overwhelmed. The governing agency may consider obtaining a flood water easement on the adjacent properties to allow for drainage.

3.6 OUTLET STRUCTURES FROM CLOSED CONDUIT TO OPEN SYSTEM

Location – An outlet structure shall be installed on the downstream end of all closed conduits at the point where the storm water will be discharged into an open channel. The structure shall be designed to minimize erosion within the receiving drainage.

Grating – The outlet structure shall have vertical bars only with an opening spacing of 4 inches and shall be hinged at the top.

Rip Rap Design – Rip rap shall be designed for outlet structures based on discharge velocity and receiving drainage. The minimum thickness of rip rap shall be 2.0 X D_{50}. Riprap design calculations shall be submitted to the Public Works Director, or his designee for review.

Stream Alteration and Corps of Engineers Permits – A State of Utah Stream Alteration permit may be required if the project is to alter the bed or banks of a natural stream. Contact the Division of Water Right (DWR) office to find out if your proposed project will require a stream alteration permit. Be aware that there is a fee and review period associated with the application. A joint or separate US Army Corps of Engineers (ACOE) permit may also be required. Contact the local ACOE office to find out if your proposed project will require an ACOE permit.

3.7 OPEN CHANNELS

The use of open channels to convey storm water runoff must be approved by the Public Works Director, or his designee. If the use of an open channel is approved, the open channel shall be designed to meeting the following criteria:

Velocity – Open channel design shall be dictated by the maximum permissible velocity of the channel material/lining. Table 3-2 shows the maximum permissible velocity for the most common channel material/lining. Provisions shall be made to irrigate naturally lined channels until vegetation is established.

Table 3-2
Maximum Permissible Mean Channel Velocities
(From the Clark County Hydrologic Criteria and Drainage Design Manual)

Material/Lining	Maximum Permissible Mean Channel Velocity (feet per second)
Natural and Improved Unlined Channels	
Fine Sand, Colloidal	1.5
Fine Gravel	2.5
Coarse Gravel, Noncolloidal	4.0
Cobbles	5.0
Fully Lined Channels	
Unreinforced Vegetation	5.0
Loose Riprap	10.0
Grouted Riprap	15.0

Longitudinal Channel Slope – Channel slope is dictated by maximum permissible velocity requirements. Where the natural topography is steeper than desirable, drop structures shall be utilized to limit design velocities.

Easements – Easements shall be finalized and recorded prior to approval.

Channel Cross Section – Channels shall be constructed with a trapezoidal shape. Unless otherwise approved, channel side slopes shall not be designed steeper than 3 horizontal to 1 vertical. Channels with 2 horizontal to 1 vertical side slopes may be allowed provided the lining materials and velocities are reasonable. Other cross section types should be reviewed and approved on an individual basis by the Public Works Director, or his designee.

Maintenance – Channels shall be designed to be low maintenance and to minimize erosion potential. All open channels shall be accessible by City vehicles for maintenance.

Freeboard – The open channel shall have a minimum of 1 foot of freeboard above the design flow water surface elevations.

Depth – Unless otherwise approved, the maximum allowable design depth of flow is 4 feet.

Bottom Width – Unless otherwise approved, the minimum bottom width shall be 4 feet.

Low Flow Channel – All grass lined channels shall be constructed with a low flow channel. The low flow channel shall be lined with concrete or other material approved by the Public Works Director, or his designee.

Levees – Levees or berms along the channel will only be allowed to meet freeboard requirements. Levees or berms shall not be designed to impound storm water.

Channel Transitions and Bends – All channel transitions and horizontal bends in the alignment shall be designed to be gradual enough so as to not induce erosion or have adequate bank stabilization measures installed.

Non-FEMA Floodplains – In general, all building floor levels should be constructed two feet above the 100-year flood elevation. Encroachments into the 100-year floodplain on natural water courses will not be allowed unless otherwise permitted by the City. All natural drainages, washes, and waterways that convey a 100-year flow of greater than 150 cfs in future, full build-out conditions will be left open unless otherwise approved. Developments located adjacent to or in floodplains may be required to stabilize the continual degradation and erosion of the channel by installing grade control structures and/or by other effective means. No alteration that will affect the floodplain will be permitted unless the proposed use can be shown to have no significant negative influence on the flood conveyance, the floodplain, and the alteration itself.

In the layout and design of new developments, adequate access to flood conveyance facilities and erosion protection shall be provided. It is preferred that streets be positioned between the flood conveyance facilities and structures. Where that is not possible or feasible, additional structural setbacks will be required.

Hydrologic, hydraulic, erosion, and geomorpholigic studies will be required of developments adjacent to floodplains.

3.8 DETENTION BASINS

All detention basins serving a development shall be designed according to the criteria listed below and the criteria from the governing agency, whichever is more conservative. In general all local detention basins shall be maintained and operated by a Home Owners Association or similar entity. Design criteria for regional detention basins, or detention facilities that receive storm water runoff from multiple developments, shall be defined by the Public Works Director, or his designee on a case by case basis.

Release Rate – The post-construction release rate shall be equal to or less than the preconstruction discharge.

Volume – Detention facilities shall be designed to prevent local increases in the 10-year and 100-year storms, for the 3 hour and 24 hour durations, whichever case requires the largest volume (see Section 4.1 for design storm parameters). The volume requirements shall not be reduced based on evaporation or infiltration due to percolation. The analysis of multiple design storms is required to mimic pre-development peak runoff for various storms.

Emergency Outlet and Spillway Freeboard – An outlet shall be designed to safely discharge runoff from the maximum storm event. The minimum spillway freeboard shall be 1 foot for a design discharge of twice the 100-year design storm discharge, or as approved by the Public Works Director, or his designee.

Detention Time – The detention time should be as short as possible; typically limited to a maximum of 18 hours.

Water Depth – The maximum water depth shall not exceed 3 feet for a detention basin in a landscaped area and 1 foot in a parking lot.

Side Slope – Detention basin side slopes shall be3H:1V or flatter unless otherwise approved.

Inlet Design – A concrete apron must be installed at entrance and exit structures to minimize erosion and accommodate maintenance.

Outlet Design – All detention basins shall have an outlet to the governing agency's storm drain system. A trash rack shall be installed at the outlet(s) to prevent debris from entering the storm drain system. The orifice restriction should be designed to minimize clogging from debris. The minimum area of the discharge orifice is 6 square inches.

Dewatering – Detention basins shall include provisions for a concrete low flow channel and/or a perforated pipe under-drain system to ensure positive dewatering of the basin.

Location – Detention basins should be located in a manner to minimize their impact on the site and to ensure public safety. Detention basins shall be located at least 40 feet from any structure with a foundation. All detention basins shall have vehicular access for maintenance. All public detention basins shall be accessible from a public right-of-way or a dedicated easement.

Ownership and Maintenance – If the detention basin is privately owned, the Home Owners Association shall own and maintain the detention facility, including landscaping. No alterations to the pond shall be permitted without the approval of the Public Works Director, or his designee.

Landscape – All facilities shall be landscaped in accordance with the governing agency's Standards.

3.9 RETENTION FACILITY

Retention facilities will not be allowed unless approved by the Public Works Director, or his designee.

3.10 CULVERTS

Culverts are conduits that convey runoff in an open channel under or across a road or parcel.

Location – Culverts shall be sized to convey the computed design storm runoff (see Section 4.1 for design storm parameters) without runoff overtopping the road or leaving the channel. The minimum allowable culvert diameter is 24 inches or as approved by the Public Works Director, or his designee.

Design Load – The existing and future street design shall be used to develop the design load and minimum cover. HS-20 loading shall be used if no other loading information is available.

Headwall – Improvements should be installed at entrance and exit structures to minimize erosion and accommodate maintenance. Typically, culverts shall have a headwall with wing walls.

Debris – A culvert blockage factor of 50 percent shall be used for culverts placed in drainages with upstream debris producing potential as determined by the governing agency.

Backwater – Backwater surface computations upstream of culverts shall be performed and shown to be non-damaging to upstream properties.

Configuration – Where possible, culverts shall be designed to have a single opening. Multiple side-by-side culverts are susceptible to clogging.

3.11 DEVELOPMENT ADJACENT TO STEEP SLOPES

Development adjacent to steep slopes should conform to the governing agencies grading and erosion requirements. If development is located adjacent to a hill (slope greater than 10%) provisions shall be made to stabilize the disturbed hillside and to safely convey sediment around or through the development. Access with associated easements shall be provided to accommodate long term maintenance.

SECTION 4
HYDROLOGIC ANALYSIS

4.1 DESIGN STORM

Rainfall Depth and Intensity – Rainfall depth and intensity shall be obtained from the National Weather Service's Precipitation Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html) using the annual maximum time series option. Appendix B contains depth-duration-frequency and intensity-duration-frequency tables for St. George City for example. The storm water engineer shall refer to the website to determine site specific data for their area of development.

Distribution and Duration – Cloudburst rainfall events in southwestern Utah typically have durations ranging from a few minutes to three hours. Storms producing general rainfall over longer periods of time are rare, and are typically associated with slow-moving tropical storm remnants. The following recommended design storms and duration shall be used for sizing drainage and storm water facilities.

- 10-year, 3-hour synthetic storm duration shall be used to evaluate and design storm drain conveyance facilities (i.e. pipes, culverts).
- 100-year, 3-hour synthetic storm duration shall be used to evaluate and design major conveyance facilities such as bridges, culverts, channels, and facilities where public health and safety are a concern.
- 100-year, 3-hour and 100-year, 24-hour storm duration shall be used for all detention facilities' volume design. The maximum peak volume from these two storm durations shall be used to evaluate the design the storage facilities

Storm distributions for the recommended 3- and 24-hour storms are provided in Appendix C. Upon approval from the Governing Agency, the SCS Type II 24-hour storm distribution may be used as a substitution to the above recommended 10-year, 3 hour distributions.

Frequency - Storm drain facilities shall be designed to include major and minor conveyance facilities. Minor system facilities generally include storm drain pipes and culverts. Minor system facilities shall be designed to collect and convey storm water runoff from a storm with a return frequency of 10 years.

Major system facilities generally include streets, culverts, detention basins and streams. Major system facilities shall be designed to collect and convey storm water runoff from a storm with a return frequency of 100 years. Streets shall be designed to convey the 100-year discharge from upstream to downstream (i.e. avoid local street sags or low points).

4.2 DRAINAGE BASIN CHARACTERIZATION

Soil Classification – Soil classification shall be estimated from site specific analysis or from a soil survey, such as the NRCS soil survey data. The NRCS soil survey data and reports are available at http://websoilsurvey.nrcs.usda.gov and http://datagateway.nrcs.usda.gov/.

It should be noted that a “Badlands” designation is not necessarily associated with a Type D Hydrologic Soil group. Further investigation will be required for soil classifications of Badlands. This investigation will need to be completed using Infiltrometer Testing Procedure as outlined in ASTM 3385-88 “Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer”. Tests should be performed in an undisturbed “native soils” location at existing grade. Infiltration rates at each test location should be compaired to Table 7-1 from the “NRCS Part 630 Hydrology National Engineering Handbook” to designated and document the soil classification to be used in the drainage study.

Land Use – Existing land use shall be obtained from site survey or analysis of current aerial photography. Future land use shall be estimated based on proposed development or from the governing agency’s General Plan if future development plans are unknown.

Physical Parameters – Physical parameters such as drainage basin area, length and slope shall be obtained using a current topographic map and existing storm drain facilities.

4.3 RUNOFF COMPUTATIONAL METHODS

Acceptable Methods – There are three acceptable standard methods for estimating the peak runoff: the Rational Method, TR-55 and HEC-HMS. These three methods are described below. TR-55 and HEC-HMS can also be used to estimate runoff volume for storage facility sizing. See Section 3 for design criteria.

Other methods for estimating peak runoff and runoff volume must first be approved by the Public Works Director, or his designee. Table 4-1 indicates the applicable total drainage area for each modelling approach.

Table 4-1
Drainage Models and Applicable Total Drainage Area

Drainage Model	Maximum Drainage Area
Rational Method	< 1 Acre
TR-55	< 2000 Acres for Urban Areas
HEC-HMS	Any

Rational Method

i. **Runoff Equation –** Q = CiA where,
Q – Instantaneous Peak Runoff
C – Runoff Coefficient (see Table 4.2)
i – Intensity (inches/hour)
A – Area (acres)

ii. **Time of Concentration –** Time of concentration shall be calculated using the method found in SCS Technical Release 55 (SCS, 1986). Appendix D contains a sample worksheet (Worksheet 3) from that publication, which can be used to calculate the time of concentration.

iii. **Rainfall Intensity –** The rainfall intensity shall be selected from the intensify-duration-frequency curve in Appendix B. The duration is assumed to equal the time of concentration. The design storm frequency can be obtained from Section 4.1.

iv. **Runoff Coefficient –** Table 4-2 shall be used to estimate the runoff coefficient.

Table 4-2
Rational Method Runoff Coefficients[1]

Type of Drainage Area	Runoff Coefficient, C*	Type of Drainage Area	Runoff Coefficient, C*
Business:		Railroad yard areas	0.20 – 0.35
Downtown areas	0.70 – 0.95	Unimproved areas	0.10 – 0.30
Neighborhood areas	0.50 – 0.70	Lawns, sandy soil:	
Residential:		Flat, 2%	0.05 - 0.10
Single-family areas	0.30 - 0.50	Average, 2 – 7%	0.10 – 0.15
Multi-units, detached	0.40 - 0.60	Steep, 7%	0.15 – 0.20
Multi-units, attached	0.60 – 0.75	Lawns, heavy soil:	
Suburban	0.25 – 0.40	Flat, 2%	0.13 – 0.17
Apartment dwelling areas	0.50 – 0.70	Average, 2 – 7%	0.18 – 0.22
Industrial:		Steep, 7%	0.25 – 0.35
Light areas	0.50 – 0.80	Pavement:	
Heavy areas	0.60 – 0.90	Asphaltic and Concrete	0.70 – 0.95
Parks, cemeteries	0.10 - 0.25	Brick	0.75 – 0.85
Playgrounds	0.20 – 0.35	Roofs	0.75 – 0.95

*Higher values are usually appropriate for steeply sloped areas and longer return periods because infiltration and other losses have a proportionally smaller effect on runoff in these cases.

v. **Runoff Computations.** Runoff computations for directly connected impervious areas shall be performed separately from areas that have pervious surfaces.

SCS TR-55

- The 24-hour SCS Type II storm distribution shall be used (see Appendix C) if the TR-55 method is used.
- The storm depths shall be selected from the depth-duration-frequency curve in Appendix B (see Section 4.1).

- Table 2-2a-d in TR-55 shall be used to estimate the runoff Curve Number (CN). Table 2-2a-d and associated information is located in Appendix D. See below for note regarding modeling impervious area.

Note: A composite SCS curve number may be used to estimate runoff from areas with pervious surfaces. These composite curve numbers represent all of the different soil groups and land use combinations (such as lawn and xeriscaping) within the subbasin for the PERVIOUS areas only. When modeling a developed subbasin to estimate storm water runoff, the pervious and impervious areas must be modelled using separate subbasins. Some methods, including TR-55, suggest that a composite can be selected that will account for impervious area. However, those methods tend to underestimate the runoff potential for the impervious areas and should not be used.

TR-55 Worksheet 3: Time of Concentration, and TR-55 Worksheet 4: Graphical Peak Discharge Method, are included in Appendix D.

HEC-HMS

There are four main input categories in HEC-HMS which are: design storm, loss method, transform method and routing method. The design storms shall be obtained using the procedure described below. For the loss, transform and routing methods, there are multiple options within HEC-RAS than can be used. Below is a description of the preferred method. Other methods may be allowed, but must first be approved by the Public Works Director, or his designee.

i. **Design Storm -**The design storm shall be developed in accordance with Section 4.1.

ii. **Loss Method –** The SCS Curve Number loss method shall be used. The primary input parameter for this method is the Curve Number. As described below, for developed areas, the percent impervious is also entered. The initial abstraction is typically left blank. The program will calculate the initial abstraction based on the Curve Number using the equation documented in TR-55.

a. **Curve Number –** Table2-2a-d in TR-55 shall be used to estimate the pervious runoff Curve Number (CN). Table 2-2a-d and associated information is located in Appendix D. The categories most often used to estimate the pervious CN are highlighted.

b. **Soil Classification –** In order to estimate the CN, the hydrologic soil group classification for the drainage basin must be determined. The hydrologic soil groups shall be obtained as defined in Section 4.2.

c. **Modeling Impervious Areas –** The directly connected impervious area (DCIA) should be used when modeling developed areas. The DCIA should be measured from aerials for existing developments, or should be obtained from the design plans for a proposed development.

iii. **Transform Method –** The SCS Unit Hydrograph transform method shall be used. This method requires the input of a single variable: lag time.

a. **Lag Time for Natural Watersheds -** The Corps of Engineers version of Snyder's equation shall be used to calculate the lag time for natural watersheds (USBR, 1989) as shown below:

$$\text{Lag Time} = C_t \left(\frac{LL_{ca}}{S^{0.5}}\right)^{0.33}$$

Where:

C_t = 26 x average basin Manning's 'n' (Kn). 1.1 is typical for Washington County
L = Length, in miles, of the longest watercourse
L_{ca} = Length, in miles, along L to the centred of the drainage basin
S = Overall drainage basin slope, in feet/mile.

b. **Lag Time of Urban Areas -** The lag time for small urban areas is assumed to be equal the time of concentration. Appendix D contains a sample worksheet (Worksheet 3) from TR-55 that can be used to calculate the time of concentration.

iv. **Routing Method -** The Muskingum-Cunge method shall be used for routing runoff hydrographs. This method uses "reaches" to connect subbasins. Examples of reaches in the real world include open channels and pipes. The method requires that the follow parameters be input:

Length – Total length of the reach element.

Slope – Average slope for the entire reach.

Invert – Optional. Typically not used.

Cross Section Shape – Multiple cross sections are available to select from. Depending on the cross section chosen, additional information is required (i.e. diameter, side slope).

Manning's "n" – Average value for the entire reach. Typical values for Manning's "n" used for storm drain conveyance facilities area shown in Table 4-3.

Table 4-3
Values of Manning's Coefficient (n) for Channels and Pipes

Conduit Material	Manning's n*
Plastic pipe	0.011 – 0.015
Steel/cast iron pipe	0.012 – 0.015
Concrete pipe	0.013 – 0.015
Corrugated metal pipe	0.012 – 0.026
Concrete-lined channel	0.013 – 0.020
Excavated or Dredge Channels	
Earth channel – straight and uniform	0.020 – 0.030
Earth channel – winding, fairly uniform	0.025 – 0.040
Rock	0.030 – 0.045
Unmaintained	0.050 – 0.140
Natural Channel	
Fairly regular section	0.030 – 0.070
Irregular section with pools	0.040 – 0.100

*Lower values are usually for well-constructed and maintained (smoother) pipes and channels.

Other Models

Other computer programs can be used to model the rainfall-runoff process that use similar hydrologic modeling methods, but care should be taken to make sure modeling methods are used correctly. Examples of similar programs include StormCAD, SWMM-5 and StormNET. The Public Works Director, or his designee, must approve the use of all computer programs and methods that are not described above.

4.4 SEDIMENT/DEBRIS BULKING

Discharge estimates developed using rainfall-runoff methods typically do not account for the presence of sediment or debris in the runoff. Sediment loads entrained in the runoff water can increase the peak clear-water discharge as well as total runoff volume. This situation is typically referred to as sediment bulking. Bulking due to mud, suspended sediment, and other debris may affect flow characteristics and can be a major consideration in the hydraulic design of drainage structures particularly for facilities within mountainous watersheds, in arid regions, or near the vicinity of alluvial fans.

Bulking Factors

As described above, bulking is the increase in flow rate and volume due to the presence of sediment/debris in the runoff. A bulking factor (BF) is generally applied to the clear-water runoff hydrographs to obtain a bulked peak flow and volume for hydraulic design purposes.

For an undeveloped watershed, the bulked peak discharge is defined as follows:

$$Q_b = BF * Q_w$$

Where:

Q_b = Bulked Peak Discharge

BF = Bulking Factor

Q_w = Peak Clear-Water Discharge

In the case of a partially developed watershed the bulking factor can be applied on a proportional basis. The relationship between total sediment concentrations and bulking and the bulking factor is presented in Figure 4-1.

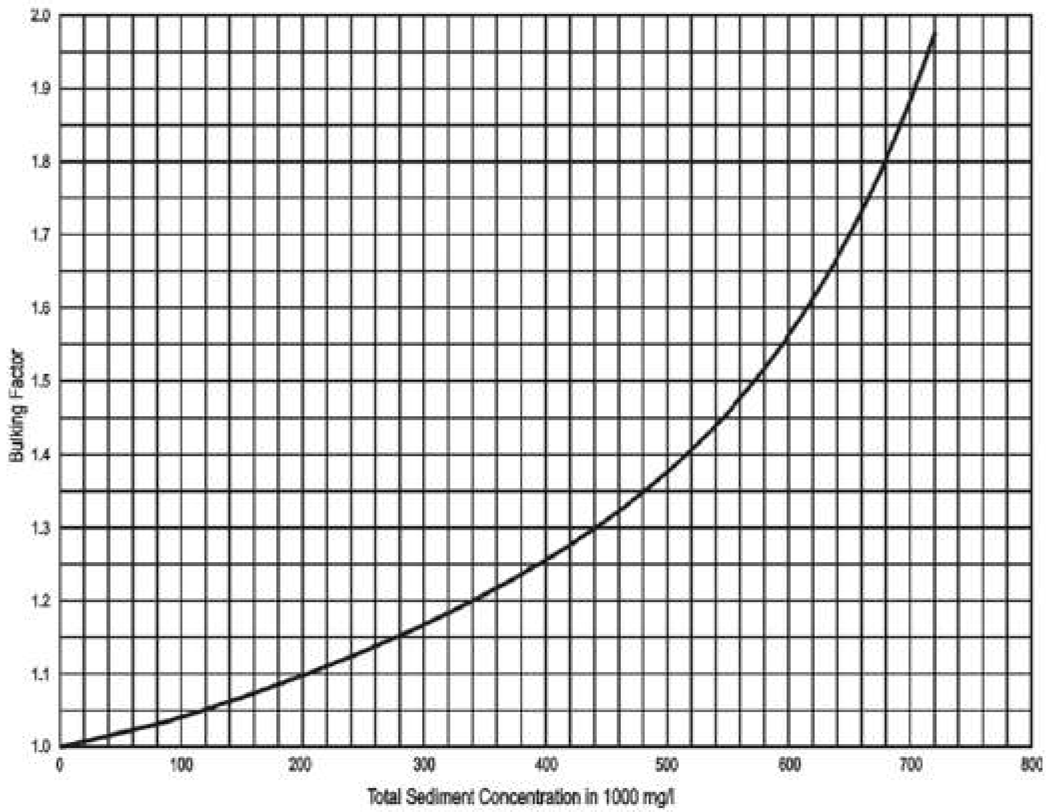


Figure 4-1. Sediment Concentration vs. Bulking Factor (Maricopa County, 2003)

In the absence of measured or calculated sediment concentration, a standard bulking factor of 1.25, depending on the watershed conditions (area, slope, vegetation, etc.), shall be applied. The required bulking factor shall be coordinated with the Public Works Director or his designee prior to completing design calculations.

Locations for Bulking

A bulking factor shall be applied to the peak discharges for collection and conveyance facilities from the point of collection to the termination, which will be transporting runoff from a natural watershed. Conveyance facilities downstream of a debris/detention basin, properly sized for bulking, may be designed for the clear-water peak discharges. Bulking factors are not required for watersheds where peak discharges are developed using flood frequency statistical analysis from stream gauge data. It is also noted that the above reference bulking factors apply to a normal watershed conditions and does not account for a post-fire burned watershed. Additional studies and analysis will be required for calculating peak discharges on a post-fire watershed.

4.5 MODEL CALIBRATION

Peak runoff records are typically not available for local drainage studies. Research should be performed to ensure that rainfall runoff analysis results for local drainage studies are consistent and compatible with the governing agency's Storm Drain Master Plan and other pertinent local drainage studies.

It should be noted that the term "calibration" in this context refers to the process of adjusting parameters to achieve results consistent with available reference information, rather than adjusting for actual stream flow observations from the study area. Multiple hydrologic methods should be evaluated and compared to identify reasonable runoff computation results. These methods may include the Rational Formula, the SCS Curve Number Method, the SCS Pervious CN Method, and the Constant and Initial Loss Method. Regional regression equations may also be used to evaluate results depending on the basin size.

Calibration for Natural Watersheds

Results from hydrologic models should be compared to:

- Actual flow records for modeled drainage channels
- Stream flow records from hydrologically similar drainages in the vicinity of the study
- Regional stream flow data (in the event that stream flow records for the local area are not available).

Calibration for Urban Areas

For small urban (developed) areas, the USGS published regression equations than can be used to "calibrate" hydrologic models (see Peak-flow Characteristics of Small Urban Drainages Along the Wasatch Front, Utah). The range of basin characteristics used to develop the regression equations are shown in Table 4-4.

Table 4-4
Range of Basin Characteristics Used
To Develop Regression Equations for Small Urban Drainages

Basin Characteristic	Unit	Range in Values
Drainage Area (DA)	mi^2	0.085 – 0.87
Basin Slope (BS)	Percent	0.3 – 15
Effective Impervious Area (EIA)	Percent	22 – 57

The equations shown in Table 4-5 are only applicable to drainage basins that meet the range of values shown above.

Table 4-5
Regression Equations for Peak Flows
For Small Urban Drainages

Design Storm Recurrence Interval (Years)	Equations	Average Standard Error of Estimate (Percent)
10	$Q_{10} = 0.575\ DA^{0.285}\ BS^{0.410}\ EIA^{1.29}$	32
25	$Q_{25} = 66.1\ DA^{0.093}\ BS^{0.243}$	33
100	$Q_{100} = 120\ DA^{0.158}\ BS^{0.194}$	29

The unit peak runoff varies depending on slope and the drainage basin percent impervious. In general, the 10-year event for small urban drainages should be between 0.3 cfs/acre and 1.0 cfs/acre. Modification to input parameters should be considered if simulated runoff results are not within this range.

REFERENCES

1. American Society of Civil Engineers, New York, p. 332, 1969, Design and Construction of Sanitary and Storm Sewers.

2. Farmer, E.E., and J.E. Fletcher, February 1972,Rainfall Intensity-Duration-Frequency Relations for the Wasatch Mountains of Northern Utah, Water Resources Research, Vol.8, No. 1.

3. Federal Highway Administration, August 2001, Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, Second Edition.

4. Los Angeles County Department of Public Works, July 2015, Sedimentation Manual, 2nd Edition.

5. Maricopa County of Arizona, August 2013, Drainage Design Manual.

6. National Oceanic and Atmospheric Administration, 2006, NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, Volume I, Version 4, Semiarid Southwest.

7. Rosenberg Associates, October 2014. Washington City Storm Water Capital Facilities Master Plan Update, Washington City, Utah.

8. Thomas, B.E., H.W. Hjalmarson and S.D. Waltemeyer, 1994, Methods for Estimating the Magnitude and Frequency of Floods in the Southwestern United States, U.S. Geological Survey, Open File Report 93-419.

9. U.S. Army Corps of Engineers, December 1979, Project Cloudburst, Salt Lake County, Utah, Internal File Report.

10. U.S. Department of Agriculture, Natural Resources Conservation Service, January 2009. Part 630 – Hydrology National Engineering Handbook, 210-VI-NEH.

11. U.S. Department of Agriculture, Soil Conservation Service, June 1986, Urban Hydrology for Small Watersheds, Technical Release 55.

12. U.S. Department of the Interior, Bureau of Reclamation, 1989, Flood Hydrology Manual.

13. U.S. Department of the Interior, Geological Survey, March 1982. Interagency Advisory Committee on Water Data, Office of Water Data Coordination, Hydrology Subcommittee, Bulletin No. 17B.

14. WEST Consultants, Inc., June 2011, Sediment/Debris Bulking Factors and Post-Fire Hydrology for Ventura County, Final Report.

15. WRC Engineering, Inc., October 1990. Hydrologic Criteria and Drainage Design Manual, Clark County Regional Flood Control District, Las Vegas, Nevada.

APPENDIX A

CHECKLISTS

SINGLE RESIDENTIAL LOTS

Owner: ________________________________

Project: ________________________________ Date __________

Engineer: ________________________________ Review # __________

DRAWING REQUIREMENT

- ❑ Scale, north arrow, legend, title block showing project name, date and preparer's name.
- ❑ Existing and proposed property lines, rights-of-way and easements.
- ❑ Addressed any subdivision or lot specific requirements. For example; geologic hazards, steep slopes or sensitive lands, high water table area, existing drainage or other features, setbacks, etc.
- ❑ Flow arrows that represent the intended flow patterns of finish grade
- ❑ Elevations of the top of curb, flow line of gutter, building and driveway, as necessary, to depict intentions of grading
    - Proposed Final Elevations showing the following:
    - Minimum 12 inch rise from flow line of gutter to a spot on the driveway
    - Lowest habitable floor elevation relative to the top back of curb
    - Lot drainage is addressed within individual lot boundaries
        - o Drain as much of the lot as possible to the street
        - o Remaining drainage to be absorbed by own landscape
- ❑ Complied with municipality Notice of Intent (NOI) requirement
- ❑ Identify any requirements (stabilization, sediment conveyance, maintenance access) associated with hillside development.

Reviewed By:______________________________

SINGLE COMMERCIAL OR INDUSTRIAL LOT

Owner: ________________________________

Project: ________________________________ Date __________

Engineer: ________________________________ Review # __________

REPORT REQUIREMENTS

- ❑ Description of the lot location (township, range, section, subdivision and lot).
- ❑ General description of the property, area, existing site conditions including all existing onsite drainage facilities such as ditches, canals, washes, swales, structures, storm drains, springs, detention and retention basins, and any proposed modifications to drainage facilities.
- ❑ General description of off-site drainage features and characteristics upstream and downstream of the site and any known drainage problems and plan to mitigate problems.
- ❑ General description of the proposed storm water facilities that will be used to manage onsite and offsite runoff discharging onto the parcel.
- ❑ General description of master planned drainage facilities on or adjacent to the lot and proposed drainage features and how the development and proposed drainage facilities conform to the storm water master plan.
- ❑ Detailed runoff calculations for the design storm. See Section 3 for design criteria.
- ❑ Described if a FEMA floodplain or Erosion Hazard Zone is on or adjacent to the lot. It must be noted if there are plans to modify the ground surface (cut or fill) in a FEMA floodplain or Erosion Hazard Zone.
- ❑ Identify any requirements (stabilization, sediment conveyance, maintenance access) associated with hillside development.
- ❑ Provided the elevation of the lowest habitable floor space. A separate groundwater report will be required to recommend an appropriate elevation for structures in some areas (see Section 2.2).
- ❑ A list of all other applicable permits that may need to be obtained, including: Grading Permit, Floodplain Permit and/or Stream Alteration Permit.
- ❑ Statement that BMPs for Storm Water Pollution Prevention will be utilized to comply with the governing agency's erosion control requirements.
- ❑ SWPPP Narrative (see governing agency's erosion and sediment control requirements).
- ❑ Described existing and proposed structures and any structures that may be demolished.

Reviewed By:____________________________

SINGLE COMMERCIAL OR INDUSTRIAL LOT

- ❑ Complied with municipality Notice of Intent (NOI) requirements.

REPORT REQUIREMENTS (Continued)

- ❑ Contains stamped statement

  “This report for the drainage design of [NAME OF DEVELOPMENT] was prepared by me (or under my direct supervision) in accordance with the provisions of Washington County Flood Control Authority (WCFCA) Storm Drainage Systems Design and Management Manual, and was designed to comply with the provisions thereof. I understand that [NAME OF LOCAL MUNICIPALITY] and WCFCA do not and will not assume liability for drainage facilities design.

DRAWING REQUIREMENT

- ❑ Scale, north arrow, legend, title block showing project name, date, preparers name, engineer’s seal and signature on 11”x17” electronic format set up to print on 11”x17” or 24”x36” paper.
- ❑ Existing and proposed property lines, rights-of-way and easements.
- ❑ Location of required drainage easements. A maintenance easement access shall be provided to all storm drain facilities.
- ❑ Existing and proposed topography (2-foot maximum contour interval) extending at least 50 feet beyond the lot boundaries.
- ❑ Existing improvements on or within 15 feet of the property.
- ❑ Existing drainage and irrigation facilities.
- ❑ Existing drainage patterns and runoff flow paths.
- ❑ Design details of proposed storm drain facilities, including storm drain inlets. Include separate maintenance and monitoring plan for any proposed storm water detention, retention, or water quality facility.
- ❑ FEMA floodway and floodplain boundaries and elevations and Erosion Hazard Zone.
- ❑ Proposed drainage patterns and runoff flow paths.
- ❑ Location of any proposed storm water management facilities including: storm drain pipes, inlets, manholes, cleanouts, swales, channels, and retention and detention facilities.
- ❑ Other relevant drainage features.
- ❑ Showed existing and proposed structures and indicate structures that may be demolished.

Reviewed By:______________________________

MULTI-LOT SUBDIVISION

Owner: ________________________________

Project: ________________________________ Date __________

Engineer: ________________________________ Review # __________

Report Requirements

- ❑ Title page showing project name, date, preparer's name, seal and signature.
- ❑ Description of the development, including location (township, range, section, subdivision and lot).
- ❑ Description of property, area, existing site conditions including all existing drainage facilities such as ditches, canals, washes, swales structures, storm drains, springs, detention and retention basins.
- ❑ Description of off-site drainage features and characteristics upstream and downstream of the site and any known drainage problems and plan to mitigate problems.
- ❑ Description of proposed facilities that will be used to manage on-site and off-site storm water runoff associated with the development, including calculations used to estimate runoff and size storm water facilities. See Section 3 for design criteria and Section 4 for approved rainfall-runoff computation methods.
- ❑ Description of master planned drainage facilities on or adjacent to the development and how the development and proposed drainage facilities conform to the storm water master plan.
- ❑ Description of existing downstream facilities that will receive storm water runoff from the development and appropriate analyses and discussion to determine if those facilities have capacity available to receive runoff from the site. Include calculations.
- ❑ Description of other drainage studies that affect the site.
- ❑ Description of FEMA floodway and floodplain boundaries and associated elevations on or adjacent to the property.
- ❑ Design calculations to support inlet spacing and sizing of storm water conveyance facilities. Include a description of drainage facility design computations. See Section 3 for facility design criteria.
- ❑ Description of how development activities will comply with applicable flood control requirements and FEMA requirements, if applicable.
- ❑ Indicated if an Erosion Hazard Zone is on or adjacent to the lot. It must be noted if there are plans to modify the ground surface (cut or fill) in an Erosion Hazard Zone.

MULTI-LOT SUBDIVISION

Report Requirements (Continued)

- ❑ Identify any requirements (stabilization, sediment conveyance, maintenance access) associated with hillside development.
- ❑ Identified any needed drainage easements or rights-of-way. A maintenance easement access shall be provided to all storm drain facilities.
- ❑ Preliminary drawings of proposed drainage facilities that also show existing storm drain facilities on or adjacent to the site.
- ❑ Summary of design runoff computations. See Section 4 for approved rainfall-runoff computation methods.
- ❑ Provided the elevation of the lowest habitable floor space. A separate groundwater report will be required to recommend an appropriate elevation for structures in some areas (see Section 2.2).
- ❑ Appendices showing all applicable reference information.
- ❑ A list of all other applicable permits that may need to be obtained, including: Grading Permit, Floodplain Permit and/or Stream Alteration Permit.
- ❑ Conclusions and statements that indicate that proposed improvements associated with the development will comply with City drainage requirements that proposed storm drain facilities will be effective, and that the computations were performed using the current standard of care. See Section 3 for design criteria.
- ❑ Statement that BMPs for Storm Water Pollution Prevention will be utilized to comply with the governing agency's erosion control requirements.
- ❑ Described existing and proposed structures and any structures that may be demolished.
- ❑ Complied with municipality Notice of Intent (NOI) requirements.
- ❑ Discussed, or submitted under separate cover, grading plan, Storm Water Pollution Prevention Plan and geotechnical report
- ❑ Contains stamped statement

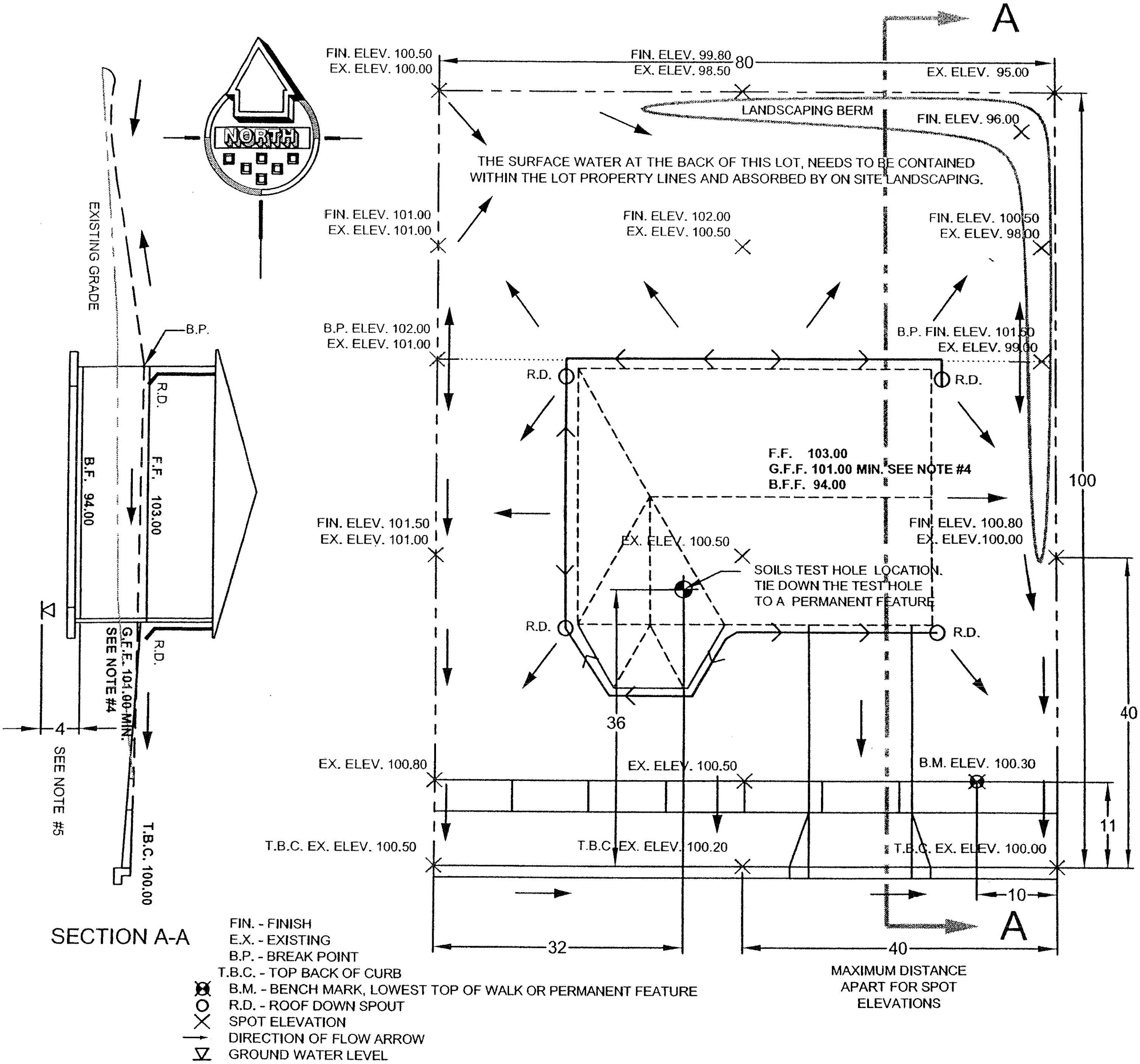
  "This report for the drainage design of [NAME OF DEVELOPMENT] was prepared by me (or under my direct supervision) in accordance with the provisions of Washington County Flood Control Authority (WCFCA) Storm Drainage Systems Design and Management Manual, and was designed to comply with the provisions thereof. I understand that [NAME OF LOCAL MUNICIPALITY] and WCFCA do not and will not assume liability for drainage facilities design.

MULTI-LOT SUBDIVISION

DRAWING REQUIREMENTS

- ❑ Drawings shall be submitted in electronic format set up to be printed on 11”x17” or 24”x36” paper.
- ❑ Existing and proposed property lines.
- ❑ Existing and proposed topography (2-foot maximum contour interval) extending at least 100 feet beyond the site.
- ❑ Existing and proposed streets, easements, and rights-of-way.
- ❑ Location of required drainage easements. A maintenance easement access shall be provided to all storm drain facilities.
- ❑ Existing drainage and irrigation facilities.
- ❑ FEMA floodway and floodplain boundaries and elevations.
- ❑ Required setbacks for structures from the center line of stream channels, if applicable.
- ❑ Drainage basin boundaries and subbasin boundaries on a topographical map.
- ❑ Existing drainage patterns and runoff flow paths.
- ❑ Proposed drainage patterns and runoff flow paths.
- ❑ Location and size of proposed storm water management facilities including: storm drain pipes, inlets, manholes, cleanouts, swales, channels, and retention and detention basins. Include spot elevations of proposed grade, flow line and top, back of curb.
- ❑ Design details of proposed storm drain facilities, including storm drain inlets. Include separate maintenance and monitoring plan for any proposed storm water detention, retention, or water quality facility.
- ❑ Design details of proposed improvements to existing irrigation facilities and any facilities to be used to manage high groundwater conditions on the site.
- ❑ Hydraulic grade line on major trunk lines and backbone pipelines shown on a profile drawing indicating backwater affects from receiving streams and full detention/retention basins.
- ❑ Other relevant drainage features.
- ❑ Scale, north arrow, legend, title block showing project name, date, preparers name, seal and signature.
- ❑ Showed existing and proposed structures and indicate structures that may be demolished.
- ❑ Showed proposed land to be disturbed (show “do not disturb” line).

LOT GRADING PLAN



APPENDIX B

NOAA ATLAS 14 INFORMATION

APPENDIX B

Below is the depth-duration-frequency and intensity-duration-frequency data for St. George City gaging station.

NOAA Atlas 14, Volume 1, Version 5

ST GEORGE
Station ID: 42-7516
Location name: St. George, Utah, US*
Latitude: 37.1061°, Longitude: -113.5672°
Elevation:
Elevation (station metadata): 2770 ft*

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PRECIPITATION FREQUENCY ESTIMATES (inches)								
by duration for ARI:	1	2	5	10	25	50	100	500
5-min:	0.13	0.16	0.22	0.27	0.34	0.41	0.48	0.69
10-min:	0.2	0.25	0.33	0.41	0.52	0.62	0.73	1.05
15-min:	0.24	0.31	0.41	0.5	0.64	0.77	0.91	1.3
30-min:	0.33	0.42	0.56	0.68	0.87	1.03	1.22	1.75
60-min:	0.4	0.51	0.69	0.84	1.07	1.27	1.51	2.16
2-hr:	0.49	0.6	0.78	0.94	1.18	1.38	1.6	2.23
3-hr:	0.54	0.67	0.85	1.01	1.24	1.43	1.64	2.24
6-hr:	0.67	0.83	1.05	1.23	1.5	1.73	1.96	2.6
12-hr:	0.81	1.01	1.26	1.48	1.76	1.98	2.22	2.8
24-hr:	0.93	1.16	1.46	1.69	2.01	2.26	2.51	3.11
2-day:	1.02	1.27	1.59	1.85	2.19	2.46	2.73	3.39
3-day:	1.08	1.35	1.7	1.96	2.32	2.61	2.9	3.58
4-day:	1.15	1.44	1.8	2.08	2.46	2.76	3.06	3.78
7-day:	1.31	1.64	2.04	2.35	2.78	3.1	3.42	4.17
10-day:	1.45	1.82	2.27	2.62	3.08	3.43	3.77	4.57
20-day:	1.82	2.28	2.82	3.22	3.71	4.06	4.39	5.1
30-day:	2.16	2.71	3.36	3.84	4.46	4.89	5.32	6.23
45-day:	2.59	3.25	4.06	4.66	5.43	5.99	6.54	7.71
60-day:	2.94	3.69	4.61	5.28	6.13	6.73	7.32	8.57

APPENDIX C

STORM DISTRIBUTIONS

APPENDIX C
STORM DISTRIBUTIONS

Below are the unit storm distributions for the 3- and 24-hour storm durations. To use these storm distributions multiply the incremental precipitation values by the total precipitation (see Appendix B for storm depth). The Farmer-Fletcher 3-hour modified storm distribution is the one exception to this rule. Below is an explanation of how that storm distribution was developed.

The modified version of the Farmer-Fletcher distribution was developed by nesting the one-hour (quartile 1) Farmer-Fletcher storm distribution, within the three hour period. The difference between the three-hour and the one-hour rainfall depths is divided equally and is distributed over the first 30 minutes of the storm and from hour 1.5 to 3.0 (see Table C-1).

Table C-1
Farmer-Fletcher Modified 3-Hour
Storm Distribution

Time (min)	Precipitation (Inches)
0	0.000
5	X
10	X
15	X
20	X
25	X
30	X
35	0.285*Y
40	0.225*Y
45	0.157*Y
50	0.100*Y
55	0.060*Y
60	0.046*Y
65	0.034*Y
70	0.026*Y
75	0.020*Y
80	0.018*Y
85	0.016*Y
90	0.013*Y

Time (min)	Precipitation (Inches)
95	X
100	X
105	X
110	X
115	X
120	X
125	X
130	X
135	X
140	X
145	X
150	X
155	X
160	X
165	X
170	X
175	X
180	X

Where:

X = (3-Hour Storm Total – 1-Hour Storm Total)/24
Y = 1-Hour Storm Total

Table C-2
SCS Type II 24-Hour
Storm Distribution

Time (hours)	Precipitation (Inches)	Time (hours)	Precipitation (Inches)
0	0.000	12.5	0.072
0.5	0.005	13.0	0.037
1.0	0.006	13.5	0.027
1.5	0.006	14.0	0.021
2.0	0.006	14.5	0.018
2.5	0.006	15.0	0.016
3.0	0.006	15.5	0.014
3.5	0.007	16.0	0.013
4.0	0.007	16.5	0.011
4.5	0.007	17.0	0.011
5.0	0.008	17.5	0.010
5.5	0.008	18.0	0.009
6.0	0.008	18.5	0.009
6.5	0.009	19.0	0.008
7.0	0.010	19.5	0.007
7.5	0.011	20.0	0.007
8.0	0.011	20.5	0.007
8.5	0.013	21.0	0.007
9.0	0.014	21.5	0.006
9.5	0.016	22.0	0.006
10.0	0.018	22.5	0.006
10.5	0.023	23.0	0.006
11.0	0.031	23.5	0.006
11.5	0.048	24.0	0.005
12	0.380	Total:	1.00

APPENDIX D

TR-55 INFORMATION

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1/]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2/]	A [3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected impervious areas — An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into the drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN vales were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a 1/2-acre lot in HSG B, with assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected impervious areas — Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a 1/2-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

U.S. Department of Agriculture
Natural Resources Conservation Service

FL-ENG-21B
06/04

TR 55 Worksheet 3: Time of Concentration (T_c) or Travel Time (T_t)

Project: ______________________ Designed By: ______________ Date: ________

Location: ______________________ Checked By: ______________ Date: ________

Check one: ☐ Present ☐ Developed

Check one: ☐ T_c ☐ T_t ☐ through subarea ______________________

NOTES: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

<u>Sheet Flow</u> (Applicable to T_c only)

	Segment ID			
1. Surface description (Table 3-1)				
2. Manning's roughness coeff., n (Table 3-1)				
3. Flow length, L (total L $\leq$ 100 ft) .... ft				
4. Two-year 24-hour rainfall, P_2.. in				
5. Land slope, s .... ft/ft				
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t .... hr		+		=

<u>Shallow Concetrated Flow</u>

	Segment ID			
7. Surface description (paved or unpaved)				
8. Flow length, L .... ft				
9. Watercourse slope, s .... ft/ft				
10. Average velocity, V (Figure 3-1) .... ft/s				
11. $T_t = \frac{L}{3600\,V}$ Compute T_t .... hr		+		=

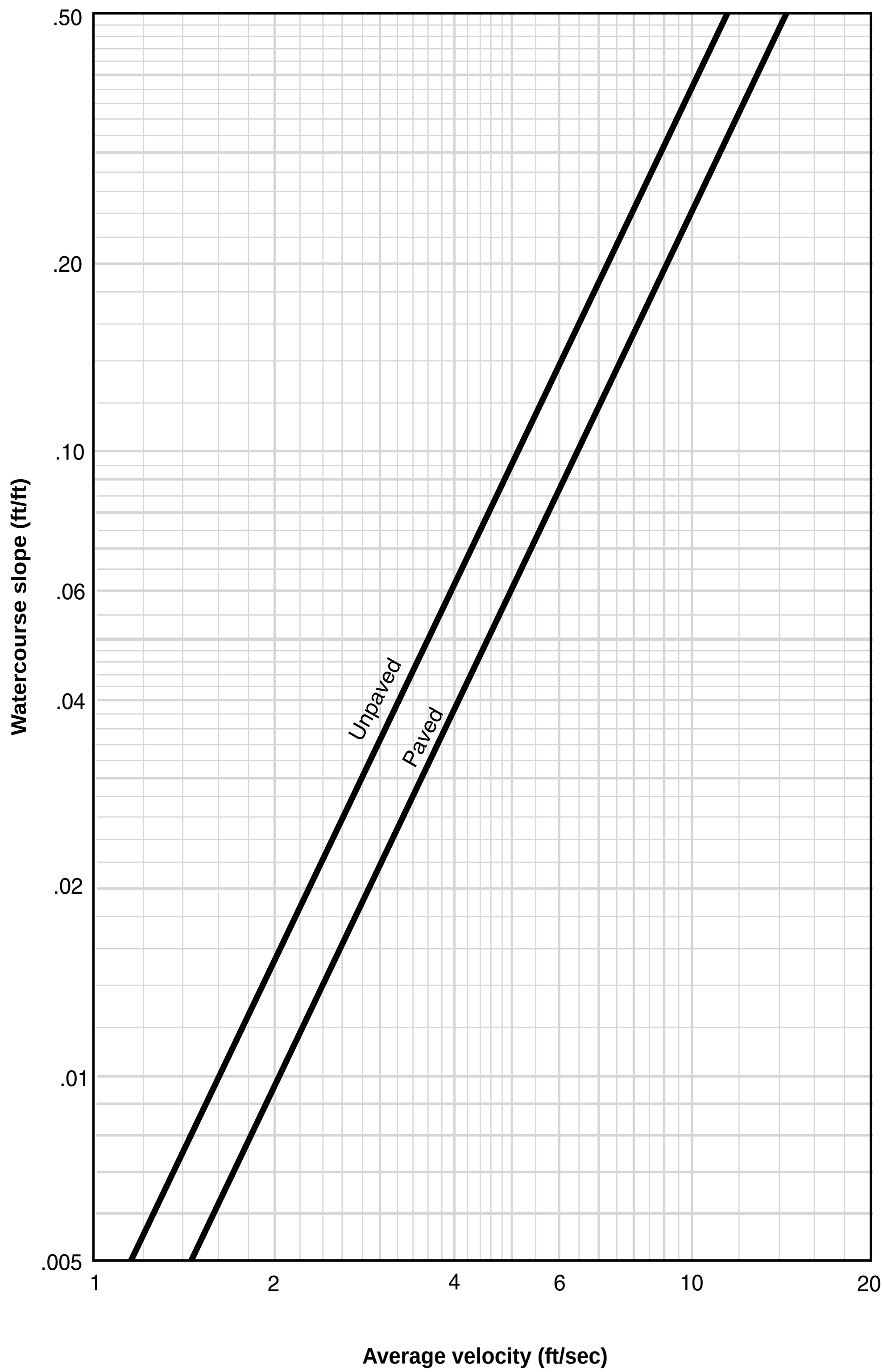
<u>Channel Flow</u>

	Segment ID			
12. Cross sectional flow area, a .... ft^2				
13. Wetted perimeter, P_w .... ft				
14. Hydraulic radius, $r = \frac{a}{P_w}$ Compute r .... ft				
15. Channel Slope, s .... ft/ft				
16. Manning's Roughness Coeff., n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V .... ft/s				
18. Flow length, L .... ft				
19. $T_t = \frac{L}{3600\,V}$ Compute T_t.................................. hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19 .... hr ☐

Print Form | Reset Form | Save Form

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Tr 55 Worksheet 4: Graphical Peak Discharge Method

Project: ____________ Designed By: ____________ Date: ________

Location: ____________ Checked By: ____________ Date: ________

Check one: ____ Present ____ Developed

1. Data:

Drainage area .... A_m = ________ mi^2 (acres/640)

Runoff curve number .... CN = ________ (From Worksheet 2)

Time of concentration ..... T_c = ________ hr (From Worksheet 3)

Rainfall distribution type ...... = ________ (II, III, DMVIII)

Pond and swamp areas spread throughout watershed .... = ________ percent of A_m (________ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency...	yr			
3. Rainfall, P (24-hour)..................................	in			
4. Initial abstraction, I_a................................... (Use CN with Table 4-1.)	in			
5. Compute I_a/P..				
6. Unit peak discharge, q_u.......................... (Use T_c and I_a/P with exhibit 4- 10)	csm/in			
7. Runoff, Q .... (From Worksheet 2)	in			
8. Pond and swamp adjustment factor, F_p........ (Use percent pond and swamp area with Table 4-2. Factor is 1.0 for zero percent pond and swamp area.)	in			
9. Peak discharge, q_p.................................... (Where $q_p = q_u A_m Q F_p$)	cfs			

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Appendix G:
Dixie Stormwater Coalition Low Impact Development Guidance Manual

GREEN INFRASTRUCTURE AND LOW-IMPACT DEVELOPMENT
APPLICATION GUIDANCE
FOR
WASHINGTON COUNTY, UTAH

To be used in partial fulfillment of the requirements associated with Small Municipal Separate Storm Sewer System (MS4) General Permit

Updated:
June 12, 2020

Dixie Storm Water Coalition

St. George, Washington, Ivins, Santa Clara

Contributors

Sponsoring Agency: Dixie Storm Water Coalition

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JE Fuller would like to extend thanks and appreciation to the Dixie Storm Water Coalition members, agency staff, and local consultants who provided documents, insight, review and direction in the preparation of this Guidance Documents and the Matrix enclosed herein.

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Glossary of Acronyms

BMP(s)	Best Management Practices
CFR	Code of Federal Regulations
CGP	Construction General Permit
CWA	Clean Water Act
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
GI	Green Infrastructure
GIS	Geographical Information System
IDDE	Illicit Discharge Detection and Elimination
LID	Low Impact Development
MCM	Minimum Control Measures
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer Systems
MSGP	Multi-Sector General Permit (non-mining)
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollution Discharge Elimination System
O&M	Operations and Maintenance Plan
SWMP	Storm Water Management Program
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
UPDES	Utah Pollution Discharge Elimination System
WQRV	Water Quality Retention Volume

Glossary of Commonly Used Terms

Best Management Practices (BMPs): Methods, measures or practices to prevent or reduce storm water runoff and includes both structural and nonstructural controls and operation and maintenance procedures. These controls and procedures serve to project water resources, minimize fugitive dust, manage waste and mitigate erosion.

Detention: The process of temporarily collecting and storing surface water runoff such that the peak discharge is reduced below a specified threshold. Typically, a predevelopment value.

Disturbance: The result of altering soil from its native or stabilized condition thereby rendering it subject to movement or erosion by water to potentially become or becoming a pollutant in site storm water runoff; also means soil disturbance.

Erosion: The wearing away of land surface by water or wind, which occurs from weather or runoff, but is often intensified by human activity.

Evapotranspiration: The loss of water from the soil both by evaporation from the soil surface and be vegetative transpiration.

Facility: Any “point source” or any land, building, installation, structure, equipment, device, conveyance, area, source, activity or practice from which there is, or with reasonable probability may be, the introduction of storm water to the County MS4 or Storm Drainage Systems connected to the MS4 such that it is subject to regulation under the UPDES/NPDES program.

Green Infrastructure (GI): The range of measures that use plant or soil systems, permeable pavement or other permeable surface or substrates, storm water harvest or reuse, or landscaping to store, infiltrate, or evapotranspirate storm water and reduce flows to the sewer systems or to surface waters.

Low Impact Development (LID): Systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of storm water in order to protect water quality and associated aquatic habitat.

Multi-Sector General Permit (MSGP): Permit that authorizes the discharge of storm water from facilities associated with any one of twenty-nine (29) industrial activities into a Municipal Separate Storm Sewer System that leads to a surface water or directly into a surface water.

Municipal Operations: Any facility that is owned, operated or maintained by the governing entity.

Municipal Separate Storm Sewer System (MS4s): a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains) that are owned and operated by public entity, having jurisdiction to discharge into waters of the United States, and are designed or used for collecting or conveying storm water, but are not part of a combined sewer system and are not part of a publicly-owned treatment works (POTW).

Non-Storm Water Drainage: Any drainage that is not composed entirely of storm water.

Operator: A party or parties that either individually or taken together have operational control over the site specifications, including the ability to make modifications in specifications and they have day-to-day operational control of activities at the site necessary to ensure compliance with plan requirements and permit conditions.

Owner: The person, persons, or entity whose name appears on the title or deed to the subject property or properties.

Outfall: Any location within a project site where storm water runoff or a non-storm water discharge exits the site.

Operation and Maintenance Plan: A legally recorded document or section within a legally recorded document that specifies the processes, procedures and actions that will be implemented to ensure the long-term operation and maintenance of the post-construction storm water BMP's. The plan, which is to be reviewed and accepted by the permitting agency, will delegate to a party or entity that is tied to the property (e.g. Homeowner's Association, Neighborhood Association, Community Association, Property Managing Company or Condominium Association) the responsibilities of implementation of the plan in perpetuity with the understanding that failure to perform the duties specified in the plan can lead to fines and civil penalties to be assessed to the owners of the property.

Point Source: Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collections system, vessel or other floating craft from which pollutants are or maybe discharged, excluding return flows from irrigated agriculture or agriculture storm water runoff.

Pollutant: Sediment, fluids, toxic waste, dredged spoil, solid waste, substances and chemicals, pesticides, herbicides, fertilizers, and other agricultural chemicals, incinerator residue, sewage, garbage, sewage sludge, munitions, petroleum products, equipment, rock, sand cellar dirt (e.g. overburden material) and mining, industrial, municipal and agricultural waste or any other liquid, solid, gaseous or hazardous substance which has the capacity to degrade water quality.

Retention: The process of collecting and indefinitely storing storm water runoff with the sole intent of infiltrating, evaporating, transpiring and/or reusing. For the purposes of this manual, retention systems should be expanded to include systems that temporarily detain storm water, filtering it through a soil medium and discharging through an underdrain and outfall at a rate and quality that does not adversely affect the downstream receiving waters.

Sediment: Small particles of loose, unconsolidated organic and inorganic material that is broken down by processes of decay, weathering or erosion and can be subsequently transported by wind or water.

Storm water: Any surface flow, runoff, and drainage consisting entirely of water from any form of natural precipitation and resulting from such precipitation.

Structural Best Management Practices: Any physical means of controlling, capturing, diverting or conveying runoff or a point source for the purpose of reducing, to the maximum extent practicable, pollutants from exiting a site.

Urbanized Area: A portion of the County that has a population density of at least one thousand (1,000) people per square mile and/or meets other criteria set by the U.S. Bureau of Census in the latest Decennial Census. Or a densely settled core of census tracts and/or census blocks that have population of at least 50,000, along with adjacent territory containing non-residential urban land uses as well as territory with low population density included to link outlying densely settled territory with the densely settled core. It is a calculation used by the Bureau of the Census to determine the geographic boundaries of the most heavily developed and dense urban areas.

Waters of the U.S.: As defined in 33 CFR 328.3(a) and 40 CFR 230.3(s).

Introduction and Background

In December 2018, the Utah Department of Environmental Quality Division of Water Quality (UT DWQ) prepared a manual intended to serve as a reference and guide for incorporating Low Impact Development (LID) approaches into new development and redevelopment projects in Utah. The manual was intended to provide guidance for planners and designers as well as small Municipal Separate Storm Sewer System (MS4) storm water managers in selecting appropriate practices for their communities.

To meet the requirements of the State Permit, MS4 municipalities require that LID practices be discussed and analyzed at the initial stages of development prior to the approval of the concept plans, development plans or preliminary plats.

UT DWQ guidance was provided to reduce to the maximum extent practicable pollutants transported in untreated storm water to the waters of the United States by using key Low Impact Development (LID) principles such as; mimicking natural processes, promoting infiltration/ evapotranspiration/ harvesting/ reuse, and managing storm water with distributed systems close to the source. Additional LID requirements are expected for permitted MS4's, to develop a LID approach for retention of storm water, from the 80th percentile storm event for all new development and redevelopment projects that are greater than 1 acre or equal to or part of a common plan of development. In so doing, the UT DWQ guidance is designed to increase the use of LID practices and specific applications.

While the UT DWQ manual provided a fairly comprehensive approach to LID applications to storm water management, concerns existed with the applicability, feasibility, and associated costs (long-term) of the LID practices presented within the manual as it related to the Dixie Metropolitan Area within Washington County, Utah.

- ## Code Requirements

  Starting with the enactment of the Federal Clean Water Act in the 1970s and subsequently the initiation of the National Pollution Discharge Elimination System (NPDES), there has been a concerted effort to protect the nations waterways from storm water borne contamination. As recent as the 2010's, it is understood that the EPA began developing new rules to encourage the use of LID practices. In this context, more of an emphasis was placed on low-tech retention-based strategies as a proxy for contaminant reduction. Accordingly, the Utah Department of Water Quality (UT DWQ) has established MS4 permit minimum performance measures and requirements within its permit that, as part of long-term storm water management for new development and re-development, requires the establishment of a retention-based criteria for new and redevelopment. An anticipated update to the permit requirement which became effective March 1, 2020 (based on the December 24, 2019 draft) is summarized below:

  1. New Development (> 1-acre disturbance): Retention of the 80th percentile rainfall event or to limit offsite discharges to a pre-developed hydrologic condition, whichever is less.

2. Redevelopment (> 1 acres): If the redevelopment increases the impervious surfaces by more than 10%, then the site design should prevent the discharge of (retain) the net increase in volume associated with all precipitation events up to the 80th percentile rainfall event.

The guidance further clarifies that these objectives must be accomplished by methods designed, constructed and maintained to infiltrate, evapotranspire and/or harvest and reuse the rainwater (UPDES, 2019). The permit also requires the evaluation of LID retention strategies to meet the storm water quality objectives to the maximum extent feasible. Feasibility or infeasibility as specified in the permit will require the developer to document and quantify how infiltration, evapotranspiration, and rainwater harvesting have been used to the maximum extent possible or provide documentation to explain why implementation of LID measures is not possible.

- ### Purpose

As part of the requirements associated with operating an MS4, Coalition Member Cities have prepared this Applicability Matrix in order to:

1. Provide regional context for application of LID based storm water management.
2. Provide minimum criteria for the regional use of UT DWQ LID practices.
3. Provide an understanding of relative costs associated with standard LID practice implementation.

This document addresses the initial screening of recommended practices and will aid as a decision-making-tool for planners, developers and engineers in the Dixie Metropolitan Area. It is not intended to replace or supersede any existing Local, Regional, State or Federal guidance nor is it intended to be used as a prescriptive tool. Each site should be evaluated independently to determine the best LID based storm water management practice.

- ### Urbanized Area - Geographical Limits

This manual is intended for regulated cities within Washington County, Utah, defined as the Dixie Metropolitan Area which includes the City of St. George, Washington City, Santa Clara City and Ivins City. This area is also referred to as the Dixie Storm Water Coalition Region. Guidance found in this manual could be applied to other arid regions. However, such use is beyond the intent of this document and is therefore cautioned.

- ### Receiving Waters

The receiving waters, often referred to as waters of the United States and/or navigable waters associated with Dixie Metropolitan Area of Washington County Utah are the Santa Clara River and the Virgin River.

Regional Constraints

Regional soils are known to be problematic for water retention or detention adjacent to infrastructure. While LID practices may have benefits, common concerns exist regarding the applicability of various LID practices with regard to the long-term maintenance and viability of these features in the Dixie Metropolitan Area. The following sections provide an overview of the geological and soil conditions that exist in the region. Maps that can be used to help determine applicability are provided at the end of this document.

- ## Soils & Geology

An understanding of the various geology and soils within the project area will aid in informing the user regarding the applicability of various Utah standard LID practices. As an overview, United States Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Survey data was used to evaluate soil data within each of the metropolitan areas. Estimates are expressed as percentages of the total area in Table 1.

Table 1: Prevalence of Regional Soil Parameters

CITY	HYDROLOGIC SOIL GROUP (%)				Bedrock within 5 feet from surface (%)
	A+ B	C	D	Other	
Washington City	43.7	12	27.6	16.7	34.9
Saint George	44.5	20.7	6.8	28	18.9
Santa Clara	29.9	8.7	35.9	25.5	39.8
Ivins City	58.6	12.4	23	6	12.5

Regional data indicates a significant range of infiltration rates from about 0.16 to 4.0 inch/hour. Hydrologic Soil Group (HSG) ratings are somewhat indicative of the infiltration rates and can be useful for selecting LID BMPs. HSG A is characterized by a high infiltration capacity while HSG Type D soils typically shows very low infiltration capacity. Note that HSG type D soils cover approximately 23 percent of the Dixie Storm Water Coalition Region.

Regional data also suggests that near surface soils are predominantly of eolian or alluvial deposits. However, there are also residual soils derived from bedrock weathering/decomposition processes. The eolian deposits are characterized by relatively low plasticity, low density, and relatively high porosity. They exhibit collapse potential upon saturation, which may be as high as 10 percent. The alluvial deposits include a wide range of soils that are both plastic and non-plastic. They may exhibit expansion or collapse potential of slight to moderate magnitude. Properties of the residual soils derived from bedrock (sometimes referred to as “colluvium”) depend on the parent material type. Claystone derived soils, as well as weathered claystone, may exhibit expansion potential with sometimes high-expansive pressures. Additionally, gypsum and gyspsiferous soils are commonly found in the Dixie Storm Water Coalition Region. Hydration of these soils can dissolve the gypsum and cause severe complications for infrastructure. Special attention must be given when these conditions are concealed.

To aid in the planning stages of a proposed project and to inform the user regarding potential hazards that may affect their project several maps are provided. These maps **are not** a replacement for detailed geotechnical evaluation for a specific project but are provided as a guide for planning purposes only.

- ## Climatology

  Utah contains a wide range of climatological variability, Washington County alone contains three distinct climate regions; the Colorado Plateau Region (to the east and northeast), the Great Basin Region (to the northwest), and the Mojave Desert Region (which encompasses the Dixie Storm Water Coalition Region). Located in an arid desert region of southwest Utah, the Dixie Storm Water Coalition Region is characterized by hot summers (average high temperature in June, July and August is near or over 100 degrees Fahrenheit) and infrequent precipitation, generally less than an inch per month. With an annual precipitation of just over 8 inches and with some of the lowest elevations in Washington County there is little permanent vegetal ground cover and high sediment yields indicating an additional consideration for application of selected LID BMPs. Infrequent precipitation and climate variability should be considered in the selection of any LID BMP especially those that depend on the establishment of permanent vegetation. In accordance with UT DWQ gage analysis procedures the 80th percentile depth for the Dixie Storm Water Coalition Region is 0.44-inches.

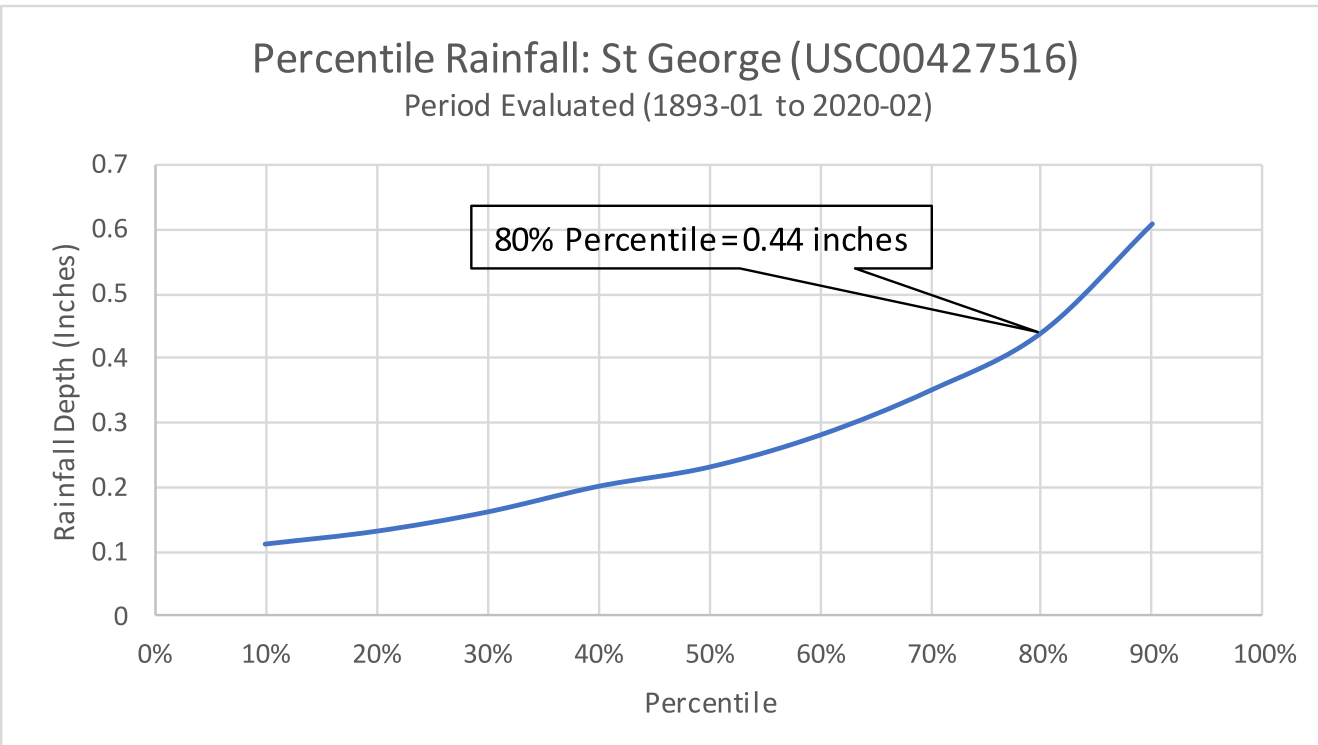


Figure 1 Percentile Rainfall Chart

Retention Volume

The Utah DWQ LID manual provides examples on how to calculate the Water Quality Retention Volume (WQRV) for compliance with the permit. In general, the form of the WQRV equation is as listed below:

$$WQRV = \frac{P_{80\%} * R_{new} * A}{12}, \qquad \text{EQ 1}$$

Where,

WQRV = Water Quality Retention Volume, in ac-ft,

$P_{80\%}$ = 80^{th} percentile precipitation value (excluding snowfall, from gage analysis, in inches),

R_{new} = Storm Water Runoff Coefficient associated with the proposed new development, and

R_{new} = 1.14 (Imp) -0.371 when imp ≥ 55%

R_{new} = .225 (Imp) +-0.05 when imp ≤ 55%

A = Area, in Acres.

Imp = decimal percentage of impervious surface in the contributing watershed

For new development greater than 1-acre, and areas smaller than 1 acre but are part of a common plan of development, the permit specifies prevention of runoff from all events less than the 80^{th} percentile rainfall or a predeveloped hydrologic condition, whichever is less.

For redevelopment greater than 1-acre, the current permit allows the retention from the increases only as shown in the Equation below:

$$WQRV = \frac{P_{80\%} * (R_{new} - R_{pre}) * A}{12}, \qquad \text{EQ 2}$$

Where,

WQRV = Water Quality Retention Volume required to maintain existing conditions, in ac-ft,

$P_{80\%}$ = 80^{th} percentile precipitation value (excluding snowfall, from gage analysis, in inches),

R_{pre} = Storm Water Volumetric Runoff Coefficient for existing conditions

R_{new} = Storm Water Volumetric Runoff Coefficient for proposed conditions

$R_{pre/new}$ = Storm Water Volumetric Runoff Coefficient Equation (UDOT, 2018)

$R_{pre/new}$ = 1.14 (Imp) -0.371 when imp ≥ 55%

$R_{pre/new}$ = .225 (Imp) +-0.05 when imp ≤ 55%

A = Area, in Acres.

Imp = decimal percentage of impervious surface in the contributing watershed

Occasionally, it may be necessary to maintain consistency across differing hydrologic methods such as the SCS Method and the Rational Method. In general, the runoff coefficient is defined as the ratio of runoff to rainfall. Accordingly, Dr. Ron Rossmiller's Equation has historically been used for conversion of SCS Curve Number to a Runoff Coefficient (Rossmiller, 1980). However, special care must be used to understand the slight variance between a traditional Runoff Coefficient and the Utah Storm Water Volumetric Runoff Coefficient ($R_{pre/new}$). The Utah Storm Water Volumetric Runoff Coefficient is generally lower than the traditional runoff coefficient found in table (UDOT, 2018). Therefore, the Rossmiller Equation result should be considered an upper limit.

$$R_{pre/new} = 7.2 * (10)^{-7} * CN^3 * RI^3 * ((0.01 * CN)^{0.6})^{-S^{0.2}} * (0.01 * CN^{1.48})^{0.15-0.1(I)} * \left(\frac{(IMP+1)}{2}\right)^{0.7},$$

EQ 3

Where,

CN	=	SCS/NRCS Curve Number,
RI	=	Recurrence Interval (years),
IMP	=	Impervious coverage (decimal form, i.e. for a 30% impervious, IMP=0.3),
R_{pre}	=	Existing Condition Storm Water Runoff Coefficient
S	=	Average land slope (whole number percent, i.e. for a 4% slope S=4)
I	=	Rainfall Intensity calculated using methodologies consistent with local jurisdiction (inches/hour)

Importantly, the minimum requirement within the Dixie Storm Water Coalition Region is to disconnect impervious areas. The designer may use procedures as proposed by Bowen Collins & Associates (Bowen Collins & Associates, 2020) to establish a credit for disconnected impervious to be applied to the WQRV. Additionally, the Bowen Collins procedure can also be applied to LID BMPs such as Bio-swales (BR-3), Vegetative Strips (BR-4), or Pervious Surfaces (PS-1) where a clear volumetric quantity cannot be determined from BMP geometry. The Bowen Collins procedure is attached to this guidance document.

Due to the operation and maintenance efforts in addition to the need for irrigation water Green Roofs (BR-6) are not recommended within the Dixie Storm Water Coalition Region (arid or semi-arid settings). However, in the rare instance this LID BMP is selected. Green roof WQRV should be provided within the void space of the drainage layer and the growing media. Designer will need to provide evidence that this volume is sufficient to accept the additional runoff. Guidance for this application within the arid and semi-arid west is provided by the US EPA (Tolderlund, 2010).

Applicability

The Utah DWQ LID manual provides standard practices and applications intended for statewide use. As a part of its broad attempt to provide a comprehensive manual, UT DWQ provided three flow charts to be used in the selection of a LID BMPs from a list of twelve that were considered by UT DWQ to be most applicable for the State of Utah (Table 2).

For areas like the Dixie Storm Water Coalition Region, which contain the aforementioned regional constraints, additional criteria needed to be applied to the selection process, to ensure that a region-specific LID BMP can be implemented. The BMPs that the Dixie Storm Water Coalition considers region appropriate are highlighted in the table.

Table 2: Utah DWQ LID BMP

BR-1	Rain Garden
BR-2	Bioretention Cell
BR-3	Bioswale
BR-4	Vegetated Strip
BR-5	Tree Box Filter
BR-6	Green Roof
PS-1	Pervious Surfaces
ID-1	Infiltration Basin
ID-2	Infiltration Trench
ID-3	Dry Well
ID-4	Underground Infiltration Galleries
HR-1	Harvest and reuse

- ## BMP Selection Tools

  To aid the evaluation and selection process to following tools and guidance are provided:

  - ### Decision Making Flow Chart

    In similar fashion to the UTAH DWQ LID Manual, the decision-making process is summarized in a flow chart (Figure 2).

  - ### Region Applicability Matrix

    To further assist in the binary progression through the flowchart, a criteria matrix has been provided that summarizes how the uniqueness of the region effects the applicability of a given BMP (Table 3).

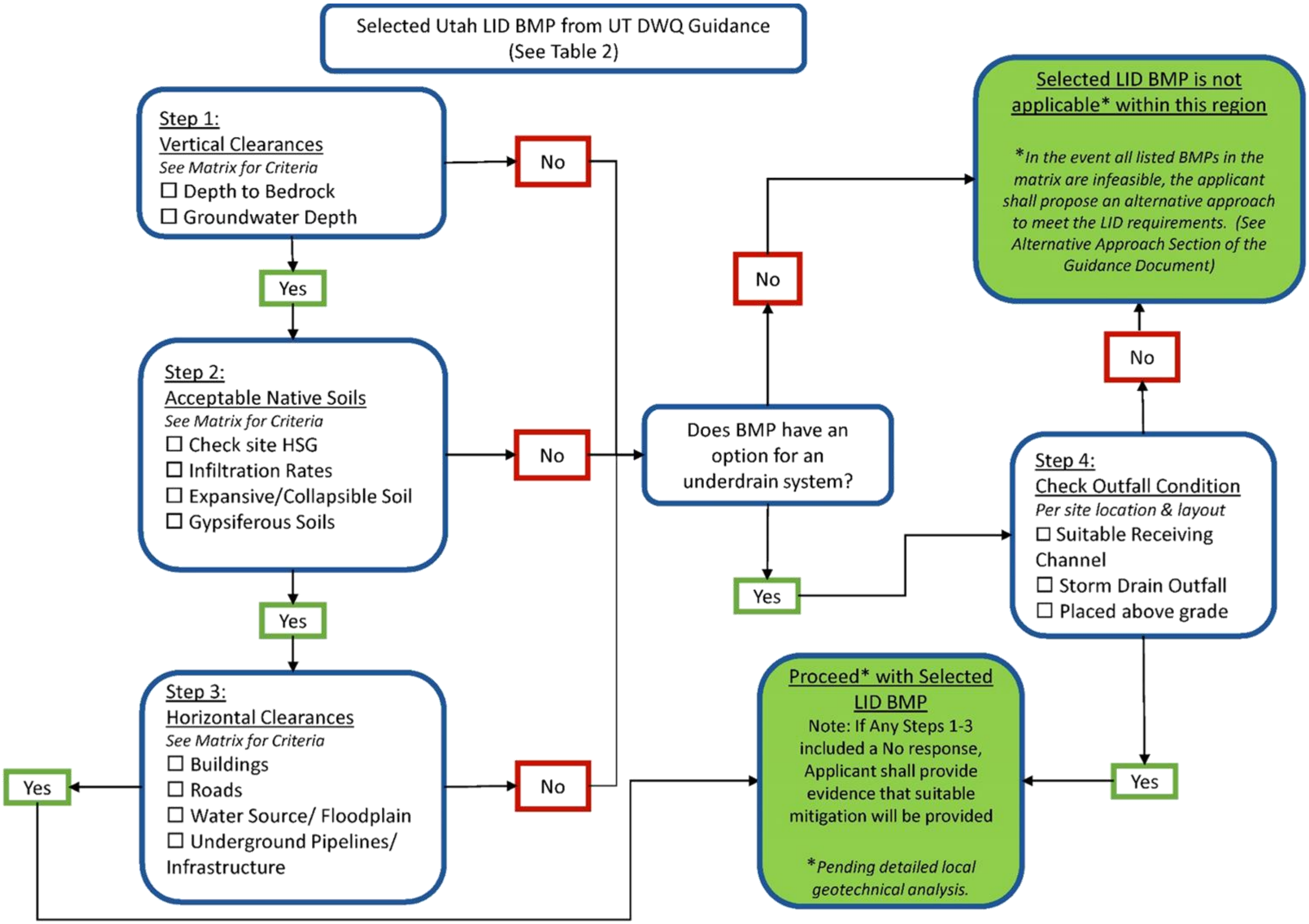


Figure 2 Applicability Matrix Flow Chart

Table 3: Region Applicability Matrix

UPDATED: 6/15/2020

Utah LID BMP		Step 1: Min. Acceptable Vertical Clearances		Step 2: Minimum Acceptable Native/ In-Situ Soil Parameters*					Step 3: Minimum Acceptable Horizontal Clearances***			
		Groundwater	Bedrock	HSG	Infiltration Rates**	Expansive/Collapse Risk	Gypsiferous Soils	Liquefaction Risk	Buildings (w/ basement)	Roads	Floodplains or Water Source	Underground Pipeline Infrastructure
BR-1	Rain Garden	> 10 ft	> 5 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	5 ft	Any	Any
BR-2	Bioretention Cell	Any	Any	Any	NA	Any	< 3%	Any	10 ft. (50 ft)	5 ft	Any	20 ft
BR-3	Bioswale	> 10 ft	> 5 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	5 ft	Any	Any
BR-4	Vegetated Strip	> 10 ft	> 5 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	Any	Any	Any
BR-5	Tree Box Filter	Any	Any	Any	NA	Any	< 3%	Any	Any	Any	Any	Any
BR-6	Green Roof	NA	NA	Any	NA	Any	NA	Any	Any	Any	NA	NA
PS-1	Pervious Surfaces	> 10 ft	> 5 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	Any	Any	20 ft
ID-1	Infiltration Basin	> 10 ft	> 10 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	5 ft	25 ft	20 ft
ID-2	Infiltration Trench	> 10 ft	> 5 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	10 ft. (50 ft)	5 ft	25 ft	20 ft
ID-3	Dry Well	> 10 ft	No Bedrock	A, B or C	NA	Low to Moderate	< 3%	Any	20 ft. (100 ft)	20 ft	100 ft	20 ft
ID-4	Underground Infiltration Galleries	> 10 ft	> 10 ft	A or B	0.5 in/hr.	Low to Moderate	< 3%	Low to Moderate	20 ft. (100 ft)	50 ft	50 ft	20 ft
HR-1	Harvest and reuse	NA	NA	Any	NA	Any	NA	Any	NA	NA	Any	NA

*Native soil values only. Per site specific geotechnical report. Engineered soil fills and liners may be required at additional costs if minimum recommended parameters are not met.
**Minimum State Requirement is 0.25 in/hr. This should be considered after aging.
***Geotechnical Analysis required to document safe horizontal setback per site conditions.
NOTE: This Matrix should be considered a living document. User's shall coordinate with local agency staff to verify most current version.

- ## Guidance

  Both tools along with the information presented below provides additional context for decision makers specific to the Dixie Storm Water Coalition Communities. Both the flowchart and applicability matrix, which has been provided within the appendix of this document, should be consulted during the planning stages of a future project to guide regional limitations and use of LID BMPs. In the event that a proposed retention-based LID Practice is not applicable to the site, the minimum requirement within the Dixie Storm Water Coalition Region is to disconnect impervious areas. If the WQRV is not met by disconnecting impervious areas, an alternative approach to LID that meets the water quality objectives shall be considered.

  - ### <u>Step 1:</u> Check Acceptable Minimum Vertical Clearances

    Minimum vertical clearances are important to the function of the selected LID BMPs in terms of ensuring proper installation and performance. The two most relevant categories for vertical clearances are related to the presence of groundwater and bedrock or impermeable lenses. Per the Matrix, each LID BMP is listed with the corresponding minimum acceptable vertical clearance. If the selected BMP does not meet the criteria, proceed to Step 4. If the selected LID BMP does meet the criteria for vertical clearances, the user shall proceed to Step 2.

  - ### <u>Step 2:</u> Check Acceptable Minimum Native/ In-Situ Soil Parameters

    Step 2 is intended to verify that the surrounding native soils have the capability and capacity to absorb additional storm water without negatively affecting surrounding infrastructure. This includes the Hydrologic Soil Group, Infiltration Rates, Expansive/Collapse Risk Potential, and Presence of Gysiferious Soils. For convenience, a collection of Maps (Figures 3-8) have been provided at the end of this document to aid in planning level efforts. Each of these categories/maps are intended to inform the user of the surrounding soil conditions and may require soil modification which may be cost prohibitive to mitigate. It should also be noted that the presence of a sloping impervious lens or obscured soils may further complicate the use of LID BMPs as it pertains to the risk to downstream properties. It is vital that a comprehensive site analysis be conducted so as to certify that proposed design features do not pose a negative risk to downstream owners.

    Using the Matrix, if the selected LID BMP does not meet the criteria for each of the native soil parameters, proceed to Step 4. If the selected LID BMP does meet the criteria for native soil parameters, the user shall proceed to Step 3.

- **<u>Step 3:</u> Check Acceptable Minimum Horizontal Clearances**

  Step 3 is to check is the horizontal distance or setback from relevant infrastructure such that water that has been infiltrated does not cause an adverse condition. While the guidance within the Matrix has been developed as a guide, the user is ultimately responsible for ensuring that adverse conditions are not created that impact existing adjacent infrastructure. Using the Matrix, the user must determine if adequate horizontal clearances exist. If the selected LID BMP does not meet the criteria, proceed to Step 4. If the selected LID BMP does meet the criteria for minimum horizontal clearances, the user also proceeds to Step 4 with selected LID BMP pending a detailed site-specific geotechnical analysis and cost-benefit analysis.

- **<u>Step 4:</u> Check for Logical Downstream Outfall Conditions**

  Some of the limitations for the use of LID BMPs in the Dixie Storm Water Coalition region can be mitigated with the use of impermeable liners in combination with a connection to an appropriate downstream storm water conveyance outfall system. Therefore, Step 4 in determining if a selected LID BMP or practice is applicable as shown on the matrix is whether the connection to a downstream outfall exists.

  Following the Matrix, if a suitable downstream condition exists, like a storm-drain or downstream channel, the use of a liner and underdrain system to contain, detain, treat and discharge to the acceptable downstream outfall is permissible. This may be used in conjunction with any detention or retention requirements for new or redeveloped parcels.

  If an acceptable downstream outfall does not exist and other limitations cannot be mitigated (pending detailed site-specific geotechnical analysis and design), or is cost infeasible, the selected BMP is not applicable for use within the Dixie Storm Water Coalition Region and an alternative approach may be requested.

- ### Alternative Approach

  If the user identifies that the available LID BMPs that meet the intent of the UT DWQ permit do not meet the criteria presented within the Matrix, a request for Alternative Approach shall be sought. In applying for an Alternative Approach, either for use of a non-regional approach LID BMP or an alternative approach, a site-specific engineering study that demonstrates the ability to meet the intent of the UPDES MS4 general permit will be required. The alternative will be submitted to the local jurisdiction for approval.

  In accordance with the UT DWQ permit, alternate approaches from the retention requirement will only be allowed with a site-specific engineering study that demonstrates infeasibility based on insurmountable constraints and may be permitted on a case-by-case basis. Any alternate approach will require that retention and LID BMPs are incorporated to the maximum extent feasible which includes disconnecting impervious areas, per the permit. This may include a reduction in the required retention volume permitted, as long as verifiable documentation can be provided to adequately show that the proposed plan will "protect water quality and reduce the discharge of pollutants to the MS4" (UT DWQ).

Costs

Costs have historically been a driving factor in the use or exclusion of LID practices from a proposed project. One key factor to consider when evaluating costs or cost-benefits of LID infrastructure is how to monetize social or environmental benefits, especially in arid regions. These social and environmental benefits are not discussed within this document but should be considered by the developer as part of any cost-benefit assessment.

- ### Implementation Cost

  Initial investments or capital costs are often the primary economic considerations for implementation of a specific BMP. Recently greater attention has been provided to understanding both life-cycle costs of specific BMP features as well as environmental or social benefits which can be difficult to monetize. While information in this area is growing, special consideration must be considered in arid regions. Specifically, when it comes to selection of vegetation and various BMP types. Relative initial and operation and maintenance costs for a respective BMP is presented in Table 4.

Table 4: Relative Costs of UT DWQ LID BMPs

Utah LID BMP		Costs[1, 2]	
		Initial	Operation & Maintenance
BR-1	Rain Garden	$	$
BR-2	Bioretention Cell	$$	$
BR-3	Bioswale	$	$
BR-4	Vegetated Strip	$	$
BR-5	Tree Box Filter	$$	$
BR-6	Green Roof	$$$	$$
PS-1	Pervious Surfaces	$$$	$$
ID-1	Infiltration Basin	$$$	$$
ID-2	Infiltration Trench	$$$	$
ID-3	Dry Well	$$	$$
ID-4	Underground Infiltration Galleries	$$$	$$
HR-1	Harvest and reuse	$	$$

[1] as adapted from Impact Infrastructure, LLC. & Stantec, 2014 for arid regions

[2] as adapted from Mateleska, K. 2016

- ### Inspections & Maintenance

  Long-term inspection and maintenance plans are key to ensuring successful implementation of LID Practices. Typical of any storm water management element, LID BMPs will require ongoing inspection and maintenance. As a part of the development approval, it is incumbent upon the developer/engineer to provide an operations and maintenance plan. The plan shall include responsibility for inspecting and maintaining, frequency of inspections and estimated upkeep or replacement costs. The plan should be submitted for approval to the local jurisdiction. If the operations and maintenance is to be provided by the local jurisdiction, a storm water fee may be assessed in accordance with local codes and ordinances.

Infeasibility

The U.S. Environmental Protection Agency (EPA) has documented that implementing well-chosen LID techniques designed to reduce runoff of water and pollutants into rivers and groundwater saves money while protecting and restoring water quality. There is much literature and documentation that is supportive that an overall LID Approach enhances property values by creating aesthetic amenities and improves the overall quality of life within a community.

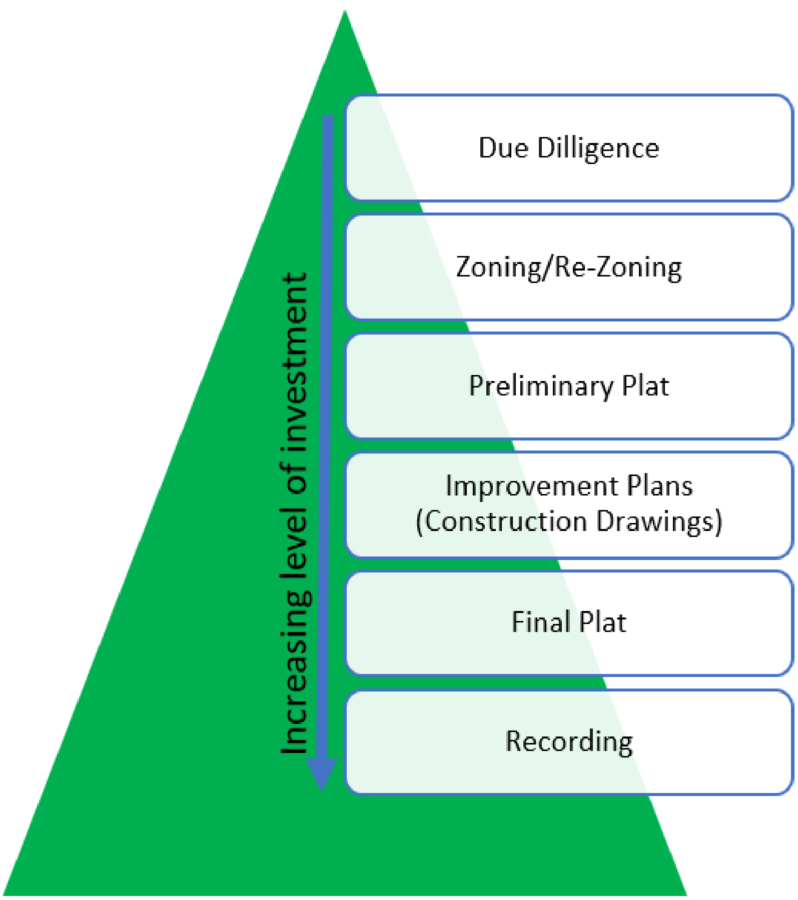
- **Technical Infeasibility**

  This guidance document and matrix are intended to assist the user to work through feasibility of the UT DWQ LID BMPs for use within the Dixie Storm Water Coalition Region. According to the UPDES permit, infeasibility which would be considered technical are listed as:

  - High groundwater,
  - Drinking Water Source protection,
  - Soil Conditions,
  - Slopes, or
  - Others.

- **Cost Infeasibility**

  The Small MS4 General UPDES Permit describes "excessive cost" as a constraint contributing to infeasibility of the retention standards outlined in the General Permit for Discharges from Small Municipal Separate Storm Sewer Systems.



The following factors, not conclusive, would be considered by the entity when determining whether cost could be used as an infeasibility factor in meeting the retention requirement on-site. Other factors could be considered as appropriate:

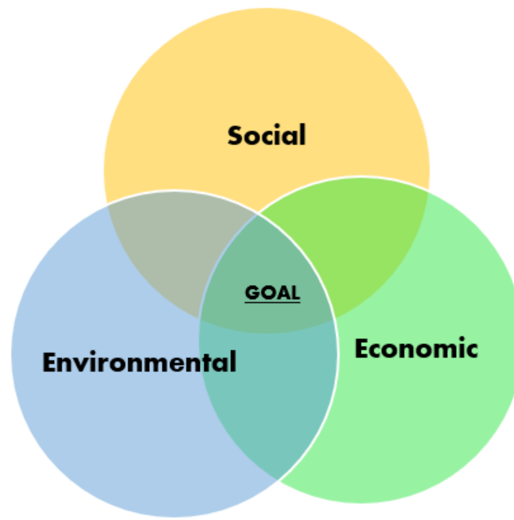
- Cost infeasibility must be addressed early on in the approval process such as prior to preliminary plat, PD Zone Change, or the conceptual site plan phase of the approval process. Infeasibility due to cost would not be considered valid if only considered late in the approval process such as during final plan preparation.
- Consideration should be given to life-cycle vs initial installation cost.
- Where low maintenance non-structural BMP's incorporate existing landscape features (washes, rock outcrops, steep hillsides, open space, etc.) vs structural BMP's that require on-going long-term maintenance by the owner, HOA, or local agency.

- The cost of non-storm water required elements, such as drainage/flood control improvements, erosion protection, ground stabilization, detention requirements, that would be required regardless of the retention requirement, would generally not be included in the cost infeasibility analysis. However, these improvements may be considered in the overall LID Approach.
- Whether there is an impact and/or cost to downstream rivers and property due to releasing untreated runoff.

The above factors with accompanying documentation will be considered by the permitting agency on a case-by-case basis to determine if the retention requirement could be waived due to cost considerations.

All cost-based analyses, or cost-benefit scenarios are required to provide full considerations of the Social, Environmental, and Economic costs. The approach must provide an objective, defensible and repeatable approach to the cost-benefit of a particular LID BMP.

While there are several online tools to assist with this type of evaluation, it is essential that the selected tool includes cost tables associated with arid regions of the Southwestern United States. The following elements were identified within a recent study for the City of Phoenix and should be considered as a part of any TBL-CBA analysis (Autocase, Watershed Management Group, et. al., 2018).



1. Financial Costs and Benefits;
2. Carbon emissions and air pollution;
3. Heat island impacts;
4. Water quality improvement;
5. Flood risk reduction; and
6. Property value increases.

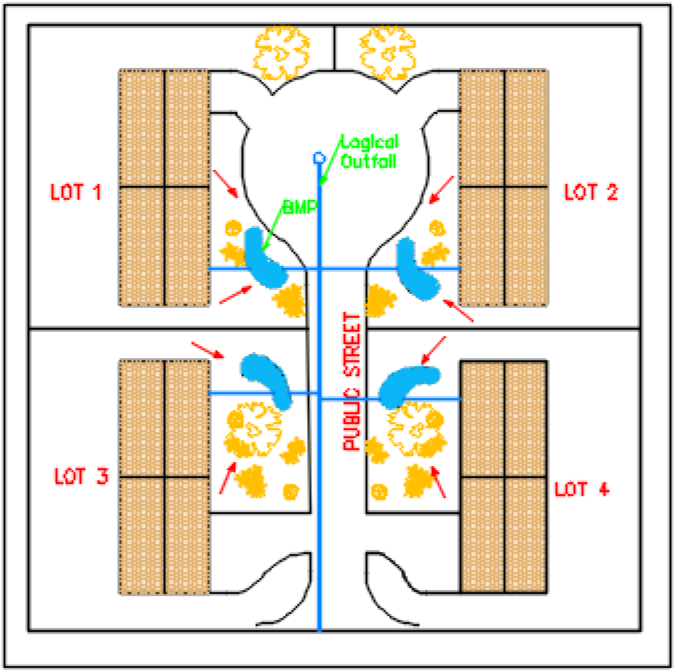
Example Application

Not every LID BMP is appropriate in every situation. The following worked example can serve as a guide for use of this Guidance Matrix and the Utah DWQ Guidance Manual. Note that the objective of this approach is the meet the requirements within the Utah DWQ Storm Water Permit. To the extent that meeting the conditions of that permit are not technically feasible, this manual can be used to support the case for a reduced (feasible) level of storm water retention based on satisfying the other constraints by walking through the Matrix.

Example – Subdivision Development

LID BMP Selection

An investor is considering a new 4-lot-per-acre single-family residential subdivision. During the due diligence phase concept planning efforts consider the potential for Lot Harvest & Reuse to meet the new state WQRV requirements.



Givens:

Logical downstream outfall condition exists.
Preliminary geotechnical engineering percolation test completed indicated infiltration rate of 0.51-inches.

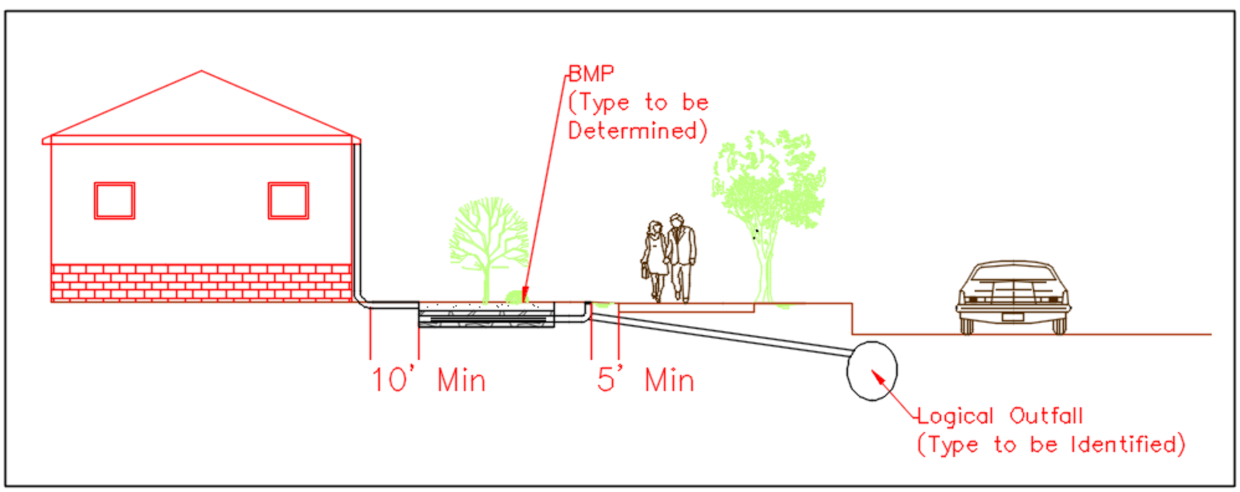
No existing conditions to hinder percolation (P_{80} = 0.44-inches).

Estimate retention volume for each acre of development
Area = 1 acre
Impervious cover = 35%

Storm Water Volume (Page 5):

$$R_{new} = 0.225\,(Imp)+0.05 = 0.225*0.35+0.05 = 0.129$$

$$WQRV = (1)(0.129)(0.44)/(12)*43{,}560 = \underline{206\ \text{cu-ft.}}$$



The 206 cu-ft is the amount of runoff that needs to be collected to meet the storm water quality requirements for each acre of development. On a per house basis this equates to 51.5 cu-ft. The total volume supplied by the selected BMPs must be equal to or greater than exceed that calculated or (Vbmp > WQRV).

Option 1 - Bio Retention Cell (BR-2)

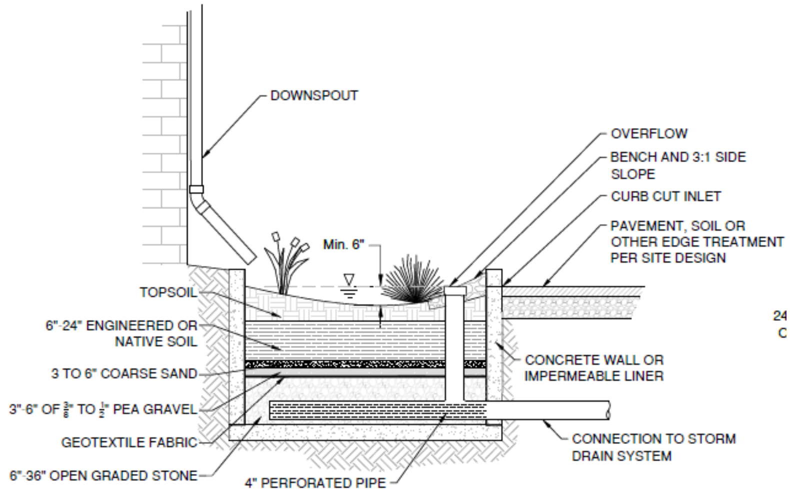
$V_{br} = 1.2(V_{dep} + V_{ts} + V_{es} + V_{cs} + V_{pg} + V_{gl})$

Where,

V_{br} = Volume of Bio Retention Cell (cu-ft)
V_{dep} = Volume of Top Depression (cu-ft)
V_{cs} = Volume of Coarse Sand (cu-ft)
V_{ts} = Volume of Topsoil (cu-ft)
V_{pg} = Volume of pea gravel (cu-ft)
V_{es} = Volume of Engineered Soil (cu-ft)
V_{gl} = Volume of Gravel (cu-ft)

$V = A_{surface} \times T_{Layer} \times V_{Ratio}$.

$A_{surface}$ = Surface Area (ft)
T_{layer} = Thickness of Media (ft)
V_{ratio} = Void Ratio expressed as a decimal



The void ratio will be provided by a geotechnical engineer. No void ratio will be applied to the depression. The depression depth cannot exceed 6".

Option 2 - Tree Box (BR-5)

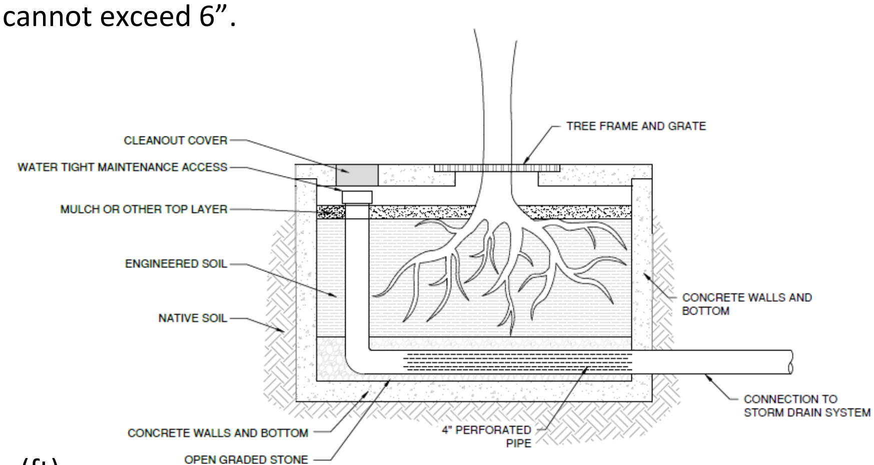
$V_{tb} = 1.2(V_{gl})$

Where,

V_{tb} = Volume of Tree Box
V_{gl} = Volume of Gravel (cu-ft)

$V = A_{surface} \times T_{Layer} \times V_{Ratio}$.

$A_{surface}$ = Surface Area (ft)
T_{layer} = Thickness of Media (ft)
V_{Ratio} = Void Ratio expressed as a decimal



TREE BOX FILTERS
NTS

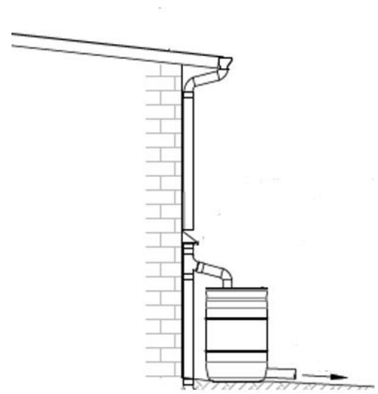
The void ratio will be provided by a geotechnical engineer. No void ratio will be applied to the depression. The depression depth cannot exceed 6".

Option 3 - Bio Swale[1] (BR-4)

$V_{bs} = 1.2(½(W_{top} + W_{Bottom})DL)$

Option 4 - Roof Cisterns (HR-1)

V_{cs} = will vary by manufacturer.



The size of the cistern cannot exceed the amount allowed be the State of Utah Code section 73-3-1.5. Should the volume of the cistern be less than WQRV then additional measures will be necessary to make up the deficiency.

Region Applicability Matrix

Step 1: Vertical Clearances

Applicability Matrix Step 1 Check:	
Step → / **Options**	**1 - Vertical Clearances**
1- Bio Retention Cell (BR-2)	Fully contained units have no vertical clearance limitations.
2- Tree Box (BR-5)	Fully contained units have no vertical clearance limitations.
3- Bio Swale (BR-4)	BR-4 requires more than 10-ft to groundwater and more than 5-ft to bedrock to be applicable
4- Roof Cisterns (HR-1)	Fully contained units have no vertical clearance limitations.

Step 2: Native/ In-Situ Soil Parameters

Applicability Matrix Step 2 Check:	
Step → / **Options**	**2 - *Native/ In-Situ Soil Parameters***
1- Bio Retention Cell (BR-2)	Fully contained units have engineered soil infill, no native soils.
2- Tree Box (BR-5)	Fully contained units have engineered soil infill, no native soils.
3- Bio Swale (BR-4)	Must have HSG Type A or B soils, infiltration rate of at least 0.5 in/hr., low to moderate risk of expansives/collapse and less than 3% gypsiferous soils.
4- Roof Cisterns (HR-1)	Generally comprised of above ground hollow cells, native materials must support bearing capacity only.

[1] Note: In-situ infiltration rate is equal to at least 0.5 in/hr.

Step 3: Horizontal Clearances

Applicability Matrix Step 3 Check:	
Step → / **Options**	**3 - *Horizontal Clearances***
1- Bio Retention Cell (BR-2)	Must be at least 10-ft from buildings (50-ft if basement), 5-ft from public road, and 20-ft from any pipeline infrastructure (gas, water, sewer, etc.)
2- Tree Box (BR-5)	Self-contained units can be placed without restriction
3- Bio Swale (BR-4)	Must be at least 10-ft from buildings (50-ft if basement), 5-ft from public roads.
4- Roof Cisterns (HR-1)	Self-contained units can be placed without restriction

Step 4: Downstream Outfall Conditions

Applicability Matrix Step 4 Check:	
Step → / **Options**	**4 - *Downstream Outfall Conditions***
1- Bio Retention Cell (BR-2)	Underground units require a downstream storm-drain or drywell (if applicable).
2- Tree Box (BR-5)	Underground Tree box filters require a downstream storm-drain or drywell (if applicable).
3- Bio Swale (BR-4)	Bio-swale can maintain a positive slope with positive outflow
4- Roof Cisterns (HR-1)	Above ground unit can overflow to yard as surface flow.

Summary of Region Applicability Matrix

Based on the example provided above, the table below provides a summary of the applicability of the selected options.

Applicability Matrix Check (Applicable - Y/N)				
Step → / **Options**	**1, Vertical Clearances**	**2, *Native/ In-Situ Soil Parameters***	**3, *Horizontal Clearances***	**4, *Downstream Outfall Conditions***
1- Bio Retention Cell (BR-2)	Y	Y	Y	Y
2- Tree Box (BR-5)	Y	Y	Y	Y
3- Bio Swale (BR-4)	Y	Y	Y	Y
4- Roof Cisterns (HR-1)	Y	Y	Y	Y

In addition to providing guidance on the selection of BMP and meeting the requirements set forth by UT DWQ, the Dixie Storm Water Coalition has provided a Storm Water Quality Report Template (Attachment 1). The Storm Water Quality Report Template shall be completed and submitted for review as part of the compliance process.

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Maps

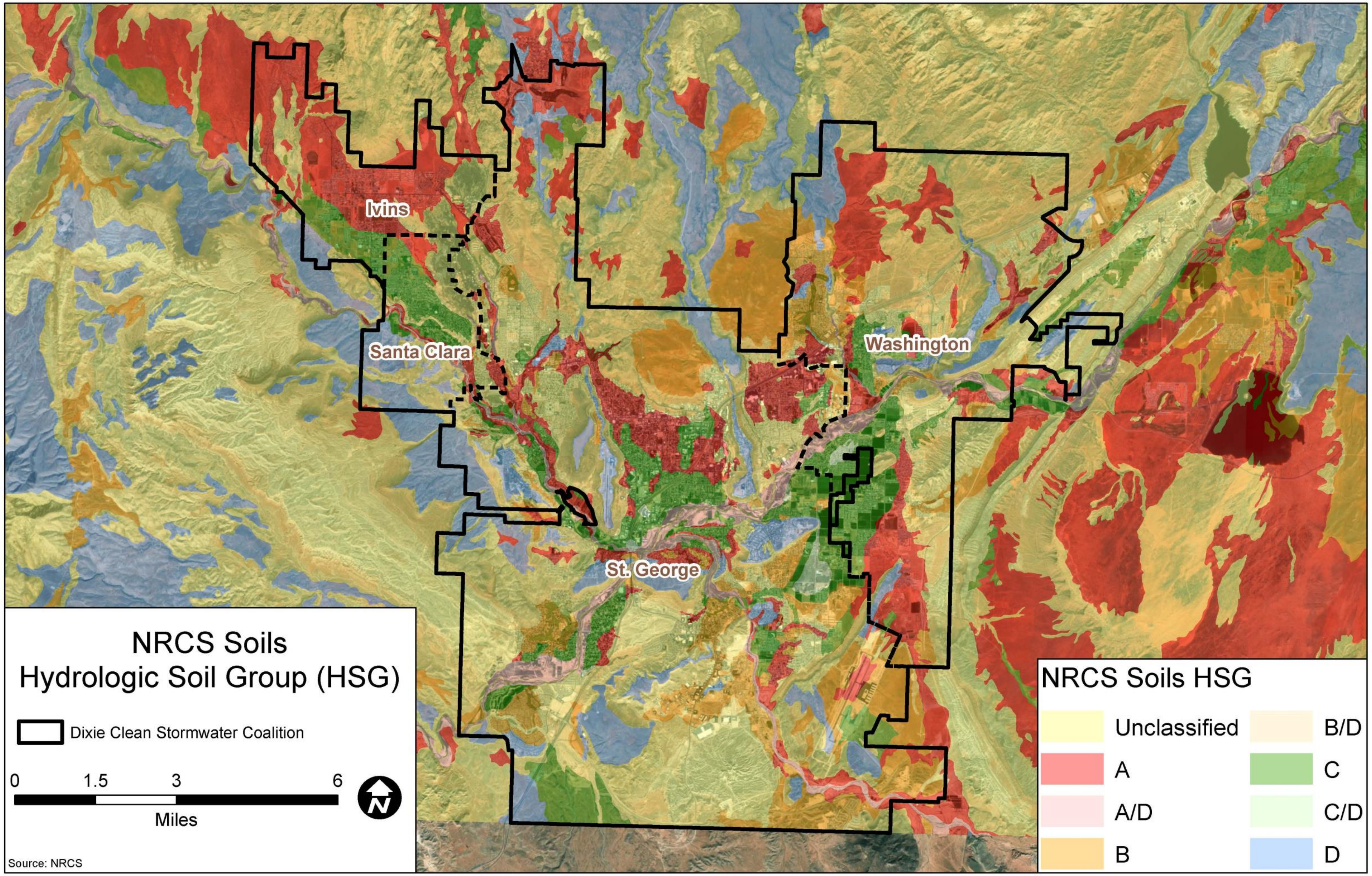


Figure 3 **Hydrologic Soil Group Map**

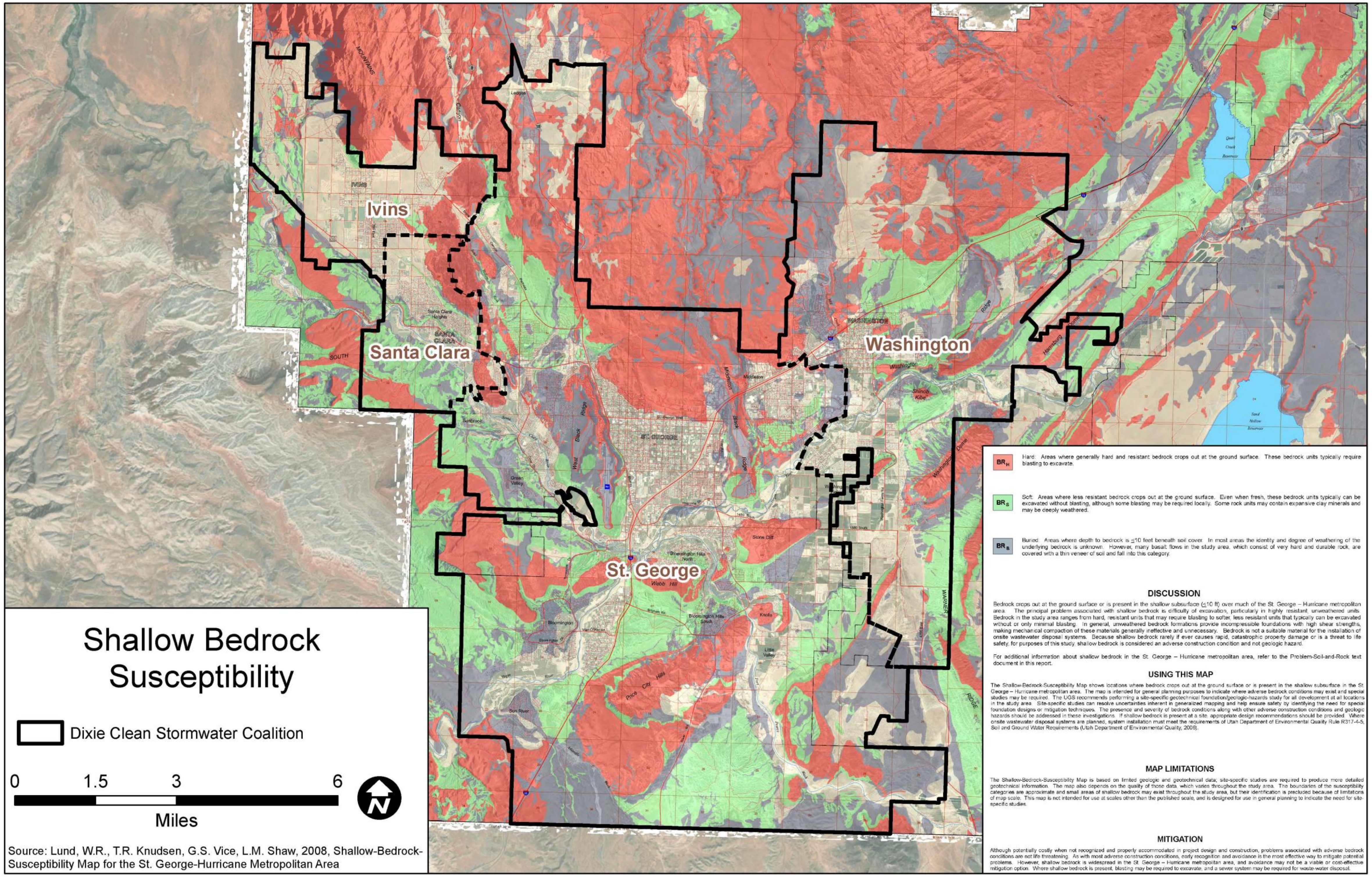


Figure 4 Shallow Bedrock Map

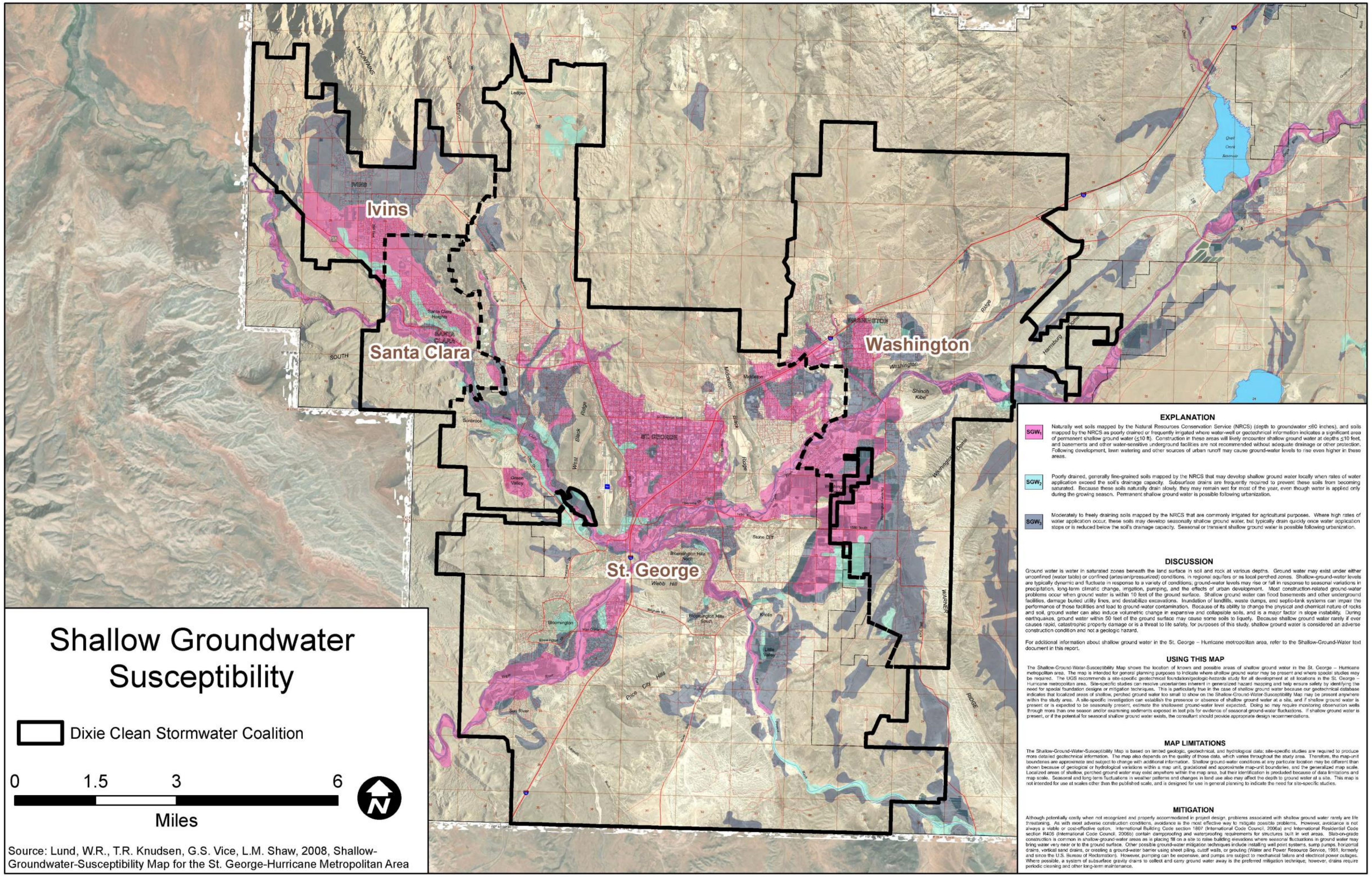


Figure 5 High/Shallow Groundwater Map

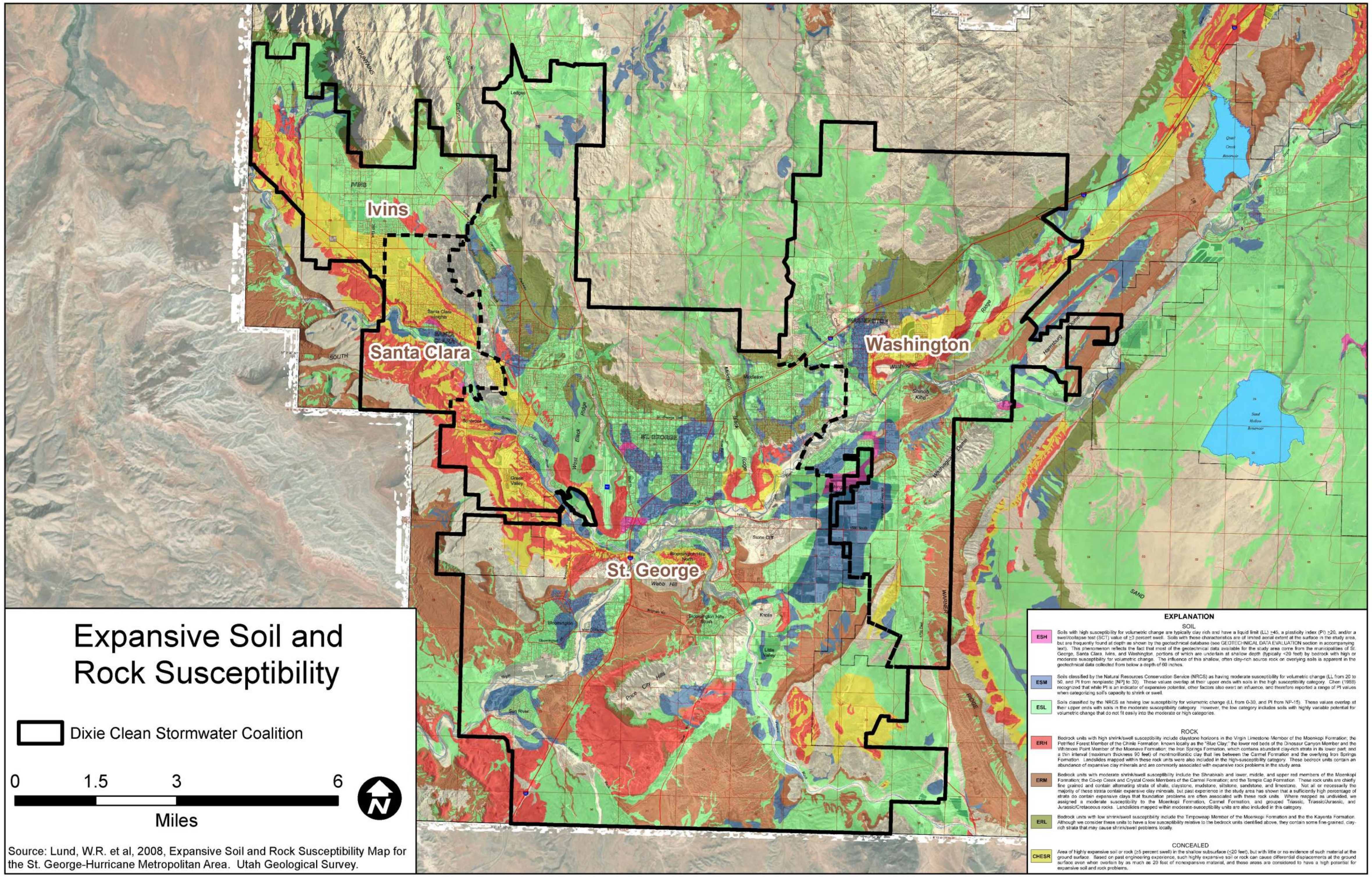


Figure 6 Expansive Soil & Rock Map

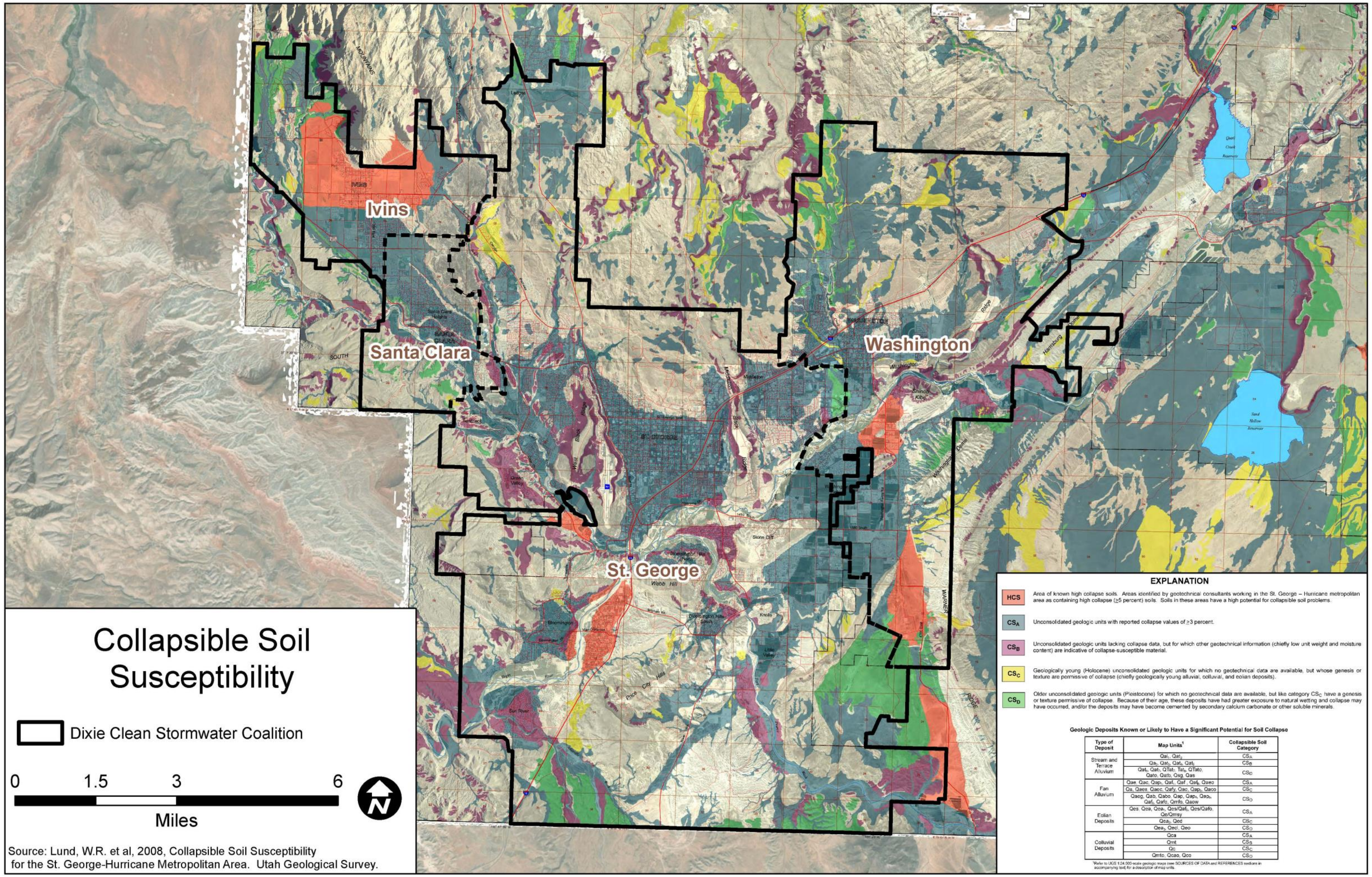


Figure 7 **Collapsible Soil Map**

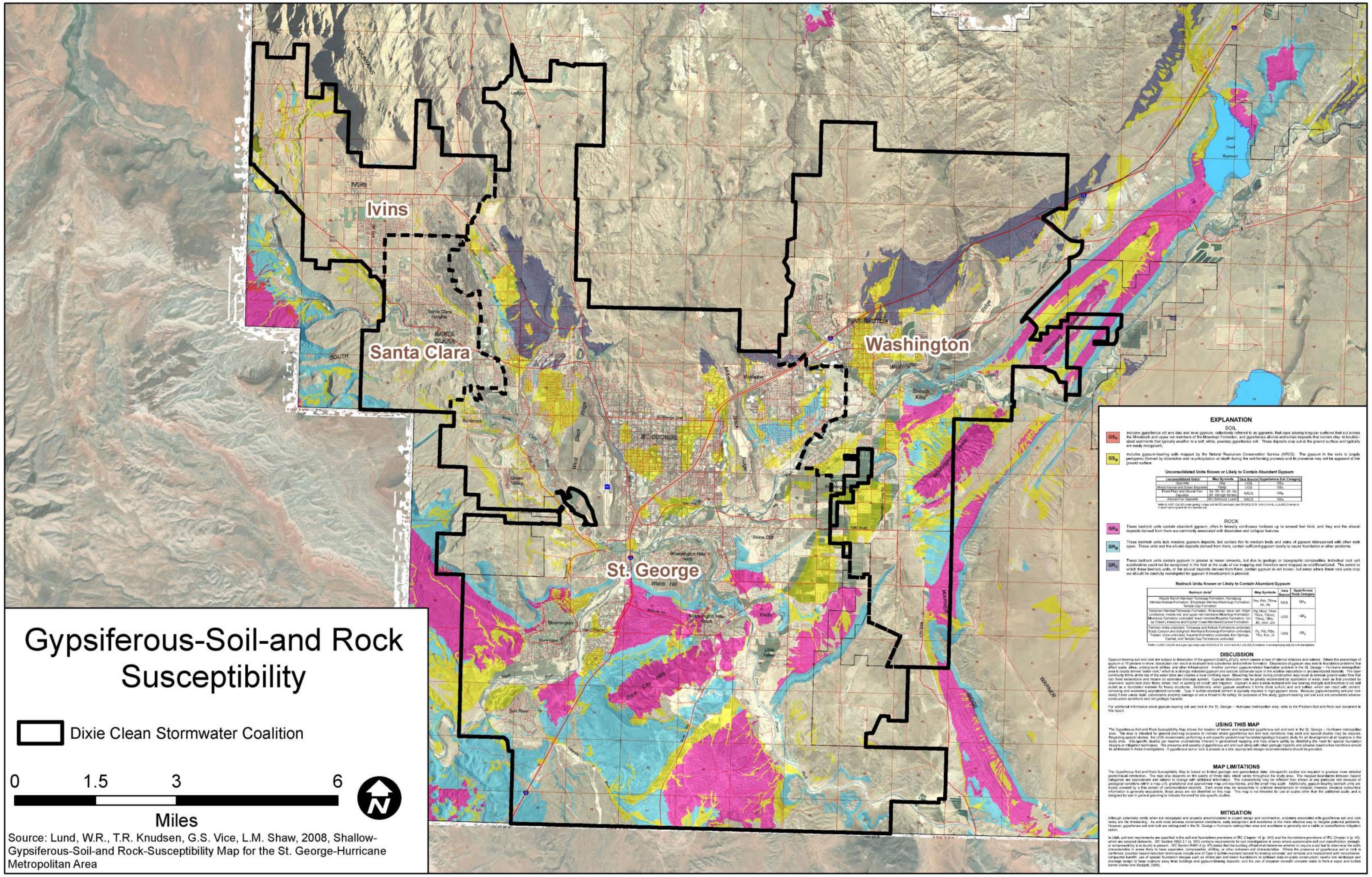


Figure 8 Gypsiferous Soils Map

Attachment 1 – Storm Water Quality Report - Template

Dixie Storm Water Coalition
St. George, Washington, Ivins, Santa Clara

Storm Water Quality Report – Template

Date: ______________________________

Project Name: ________________________

Project ID: ___________________________

Design Engineer: ______________________

Is the project within a watershed that is 303(d) listed? _____________

If yes:

Name of receiving water(s): ____________________

Listed Impairment(s): ____________________

Does the watershed have an approved TMDL? _____________

If yes:

Approved TMDL(s): ____________________

I have reviewed the storm water quality design and find this report to be complete, accurate, and current.

____

[name], Project Manager

____

[name], Designate Storm Water Coordinator

____

[name], Head of Maintenance

[stamp required at final design phase]

____

[name], Landscape Architect or Equivalent

Dixie Storm Water Coalition
St. George, Washington, Ivins, Santa Clara

Project Information

Type of Project (New Development, Redevelopment): ____________________

Area of Land Disturbance (ac): _______

Project Impervious Area (ac): ________

Project Imperviousness (%): _________

Project Volumetric Runoff Coefficient, R_V: ___________

80th Storm Depth (in): __________

Project 80th Percentile Volume, V_{goal} (cf): ______

Subsurface Information

Groundwater

Depth to Groundwater (ft): ______

Historical High Depth to Groundwater if known (ft): _______

Source: _____________________________

Groundwater Contamination at Site: ______________

Soil Information

Infiltration Rate (in/hr): ___________

Hydrologic Soil Group: ______________

Source: __________________________

Soil Contamination at Site: ___________

Drinking Water

Within Drinking Water Source Area Protection: _________

Additional Relevant Site Information

____

____

____

Dixie Storm Water Coalition
St. George, Washington, Ivins, Santa Clara

LID Drainage Areas

Add additional rows as needed.

Contributing Drainage Area	Area (ac)	Impervious Area (ac)	Imperviousness (%)	Volumetric Runoff Coefficient, R_V	Water Quality Volume, WQV (cf)
CDA 1					
CDA 2					
CDA 3					
CDA 4					
				Total WQV (cf)	

LID BMP Design

Add additional rows as needed.

Contributing Drainage Area	LID BMP Type	Water Quality Volume, WQV (cf)	Runoff Retained (cf)	Percent of Runoff Captured (%)
CDA1				
CDA 2				
CDA 3				
CDA 4				
		Total Volume Retained (cf)		

Percent of V_{goal} captured by LID BMPs: _____%

If 100% of V_{goal} is not captured, document and provide narrative of technical infeasibilities and/or alternate compliance measures below:

Describe additional storm water quality measures incorporated into the site:

Attachment 2 – Bowen Collins Procedure

TECHNICAL MEMORANDUM

TO:	Melinda Gibson Dixie Clean Storm Water Coalition Chair Ivins City Public Works 55 N Main Ivins, UT 84738
COPIES:	Lester Dalton – Washington City Public Works Todd Olsen – BC&A File
FROM:	Clinton Merrell, P.E., CFM 20 North Main, Suite No. 107 St. George, Utah 84770
DATE:	May 27, 2020
SUBJECT:	Disconnecting Impervious Areas to Increase On-site Infiltration and Reuse
JOB NO.:	446-20-01

BACKGROUND/PURPOSE

On February 26, 2020, the Utah Department of Environmental Quality (DEQ) General Permit for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) was modified. This permit (Permit No. UTR090000) establishes the requirements most MS4s in the state of Utah must meet in order to discharge stormwater runoff to downstream surface waters under the Utah Pollutant Discharge Elimination System (UPDES). Section 4.2.5.1.2 of the permit states:

> *Retention Requirement. The Permittee must develop and define a specific hydrologic method or methods for calculating runoff volumes and flow rates to ensure consistent sizing of structural BMPs* [Best Management Practices] *in their jurisdiction and to facilitate plan review.*
>
> *By July 1, 2020, new development projects that disturb land greater than or equal to one acre, including projects that are part of a larger common plan of development or sale which collectively disturbs land greater than or equal to one acre must manage rainfall on-site, and prevent the off-site discharge of the precipitation from all rainfall events less than or equal to the 80th percentile rainfall event or a predevelopment hydrologic condition, whichever is less. This objective must be accomplished by the use of practices that are designed, constructed, and maintained to infiltrate, evapotranspire and/or harvest and reuse rainwater. The 80th percentile rainfall event is the event whose precipitation total is greater than or equal to 80 percent of all storm events over a given period of record.*

Washington City, a member of the Dixie Clean Storm Water coalition, asked Bowen Collins and Associates (BC&A) to determine how to quantify the increase in on-site infiltration and reuse of stormwater resulting from decreasing the amount of directly connected impervious area (DCIA) on a site. Specifically, BC&A evaluated the practice of disconnecting residential building rooftop drains (rain gutters) from downstream directly connected impervious areas (driveways, sidewalks, etc). This Technical Memorandum (TM) will provide background on the hydrologic analysis of both directly-connected and unconnected impervious areas, demonstrate how to apply these hydrologic methods to residential development in Washington County, and provide recommendations for implementing the practice of disconnecting directly connected impervious areas as a storm water Best Management Practice (BMP).

ESTIMATING RUNOFF FROM DIRECTLY CONNECTED IMPERVIOUS AREAS

Many different hydrologic methods exist for estimating the magnitude of runoff from any given site. The “SCS Curve Number” method described in the National Resource Conservation Service’s (NRCS) National Engineering Handbook, Part 630 (NEH-630) and NRCS Technical Release 55, Urban Hydrology for Small Watersheds (TR-55) is a popular method due to its relative simplicity and ease of use. The method requires the user determine a “curve number,” or CN, for the subject drainage area based on the combination of land cover and underlying soil type. This curve number is then used to determine the estimated volume of runoff that can be expected to result from a given volume of rainfall.

In addition to land use and soil type, the curve number for a given drainage area is dependent on the presence of impervious areas. The effects of impervious areas are more significant when the impervious areas are “directly connected.” According to NEH-630.0901(c)(1):

> *“An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as shallow concentrated flow that runs over a pervious area and then into a drainage system.”*

TR-55 and NEH-630 provide several tables with typical CN values for various land cover and soil type combinations. Often engineers choose curve numbers directly from the TR-55 tables for their subject study areas. These table include descriptions for areas which include both pervious and impervious areas such as “Residential districts by average lot size.” For these areas, the CN values listed include assumptions about the total percent impervious, directly connected impervious areas, and the hydrologic condition of pervious areas. If the subject area has different characteristics from those assumed to develop the CN values in the table, those values should not be applied to the subject area. Instead, NEH-630 provides additional equations and figures to determine the CN value representative of the subject area.

Another typically employed practice is to compute a composite CN value for a subject area based on an area weighted average of various land uses-soil type combinations present withing the subject area. While this approach is typically valid, special care should be taken in urban area hydrology where impervious areas are present in the drainage area. Per the limitations outlined in TR-55 page 1-4:

> *“The user should understand the assumption reflected in the initial abstraction term (Ia) and should ascertain that the assumption applies to the situation. Ia, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place.”*

Where directly connected impervious areas are present, the New Jersey Stormwater Best Management Practices Manual (NJ SWBMP 2004) recommends using a weighted average volume method instead of the traditional weighted average curve number technique. With the weighted average volume method, the runoff for pervious and impervious areas in a subject drainage area are calculated separately and added together. Example 5-2 of the NJ SWBMP manual illustrates the difference in runoff volume between the two approaches. In the example, 1.25 inches of rainfall on a 3-acre development site, with 1 acre of connected impervious area (CN 98) and 2 acres of lawn and woods (CN 65) results in the following runoff volumes:

Weighted Average Curve Number Method: **1089 cu. ft.**

Weighted Average Volume Method: 3775 cu. ft. (impervious area) + 36 cu. ft. (pervious area) for a total of **3811 cu. ft.**

In this example, the weighted average volume method predicts approximately 3.5 times more runoff than the weighted average curve number method. Please refer to the excerpts of chapter 5 of the NJ SWBMP manual in Attachment A for the complete example.

It should be noted that when the commonly used hydrologic modeling software HEC-HMS is used to compute runoff volumes for drainage areas with impervious areas, the software uses an approach like the weighted average volume method recommended by the NJ SWBMP manual. HEC-HMS computes runoff volumes for the impervious areas and pervious areas separately if a percent impervious value is supplied for a sub basin element; however, for the impervious area, instead of using a curve number value of 98, the software assumes there are no losses for the impervious areas (i.e. CN 100) and all rainfall on those areas becomes runoff. If HEC-HMS were used for the Example above, the estimated volume would be:

HEC-HMS with % impervious: 4537 cu. ft (impervious area) + 36 cu. ft. (pervious area) for a total of **4573 cu. ft.**

The HEC-HMS estimate is the most conservative, predicting approximately 4.2 times the total runoff volume of the weighted average curve number method.

Based on these examples, a review of relevant hydrologic texts and experience, BC&A recommends using either the weighted average volume method or HEC-HMS with percent impervious for estimating runoff volumes from drainage areas with directly connected impervious areas.

ESTIMATING RUNOFF FROM UNCONNECTED IMPERVIOUS AREAS

When impervious areas are not directly connected to the downstream storm drain system, the areas are considered "unconnected." According to NEH-630:

> *"If runoff from impervious areas occurs over a pervious area as sheet flow prior to entering the drainage system, the impervious area is unconnected."*

NEH-630 provides a separate figure (NEH-630 Figure 9-4) or an equation (NEH-630 Figure 9-4) to determine a composite curve number for drainage areas with unconnected impervious areas; however, according to NEH-630, when more than 30 percent of the total drainage area is impervious area the absorptive capacity of the remaining pervious areas will not significantly affect runoff, and the unconnected impervious areas should be treated as directly connected.

All sites considered in this study have total percent impervious values greater than 30%, therefore another method for determining the runoff volume from unconnected impervious areas was needed. The NJ SWBMP provides a two-step runoff estimation technique for drainage areas with unconnected impervious areas. When using this approach, runoff from the upstream unconnected impervious areas is computed, then added as an additional rainfall depth on the downstream pervious area it sheet flows onto. Example 5-3 of the NJ SWBMP manual demonstrates this method for a 1.25-inch storm on a 3-acre drainage area with 1 acre of unconnected impervious area (CN 98) and 2 acres of lawn and woods (CN 65). The results of this example are summarized below, additional details are provided in the excerpts of the NJ SWBMP provided in Attachment A.

Unconnected Impervious Area runoff volume: 3775 cu. ft.

Impervious area runoff spread over 2 acres of downstream pervious area:

(3775 cu. ft.) / (2 acres) x (43,560 sq. ft. per acre) = 0.52 inches

Total effective rainfall on downstream pervious areas: 1.25 + 0.52 = 1.77 inches

Total site runoff off (1.77 inches over 2-acre downstream pervious area: **581 cu. ft.**

The parameters of examples 5-2 and 5-3 (rainfall, total area, impervious area, etc.) are constant with the only difference being, the 1 acre of impervious area is directly connected in example 5-2 and unconnected in example 5-3. It is interesting to note the reduction in runoff volume between the two examples:

Example 5-2, one acre of directly connected impervious area: 3811 cu. ft.

Example 5-3, one acre of unconnected impervious area: 581 cu. ft.

Reduction from "disconnecting" one acre of impervious area: **3230 cu. ft.** (85% reduction)

APPLICATION TO RESIDENTIAL DEVELOPMENTS IN WASHINGTON COUNTY

A primary goal of this study was to determine how to quantify the increase in on-site infiltration and reuse of stormwater resulting from decreasing the amount of DCIA on a site. Specifically, BC&A evaluated the practice of disconnecting building rooftop drains (rain gutters) from downstream DCIAs. Thirteen sites were selected from recent development projects in Washington City. Nine sites from two developments in residential, ¼ acre zoning areas, three sites from a development in a residential 1/8-acre zoning area, and a single site of townhomes in a Planned Unit Development (PUD) were selected. Although these sites were all within Washington City, they were qualitatively compared to other recent developments throughout Washington County and are similar enough that results from the analysis of the selected sites can reasonably be applied to similar new developments throughout the county, based on sound engineering judgement.

For each site, the curve number method described previously was used to estimate runoff volume for several scenarios. The hydrologic parameters for each scenario were developed as described below.

Rainfall

The UPDES permit for MS4s as cited previously requires each permittee to "*prevent the off-site discharge of the precipitation from all rainfall events less than or equal to the 80th percentile rainfall event or a predevelopment hydrologic condition, whichever is less.*" The Utah DEQ Division of Water Quality (DWQ) published a guidance document titled "A Guide to Low Impact Development within Utah" (DWQ 2018) which includes guidance on how to determine the 90th percentile storm for a given location from historical daily rainfall data. Rainfall daily summaries were obtained from the National Oceanic and Atmospheric Administration (NOAA) website for St. George, Utah. Details regarding the weather station used can be downloaded from:

https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00427516/detail

Following the procedure in the DWQ document, the 80th percentile rainfall depth for St. George, Utah was determined to be **0.44 inches**. This rainfall depth was used for all runoff estimates performed for this study.

Land Cover

For each selected site, 3-inch resolution, 2018 aerial imagery provided by Washington County was used to create polygons representing each of the following land cover types: directly connected impervious areas (driveways and public sidewalks), unconnected impervious areas (detached sheds and private sidewalks/concrete pads), roofs and lawns. The remaining portion of each lot was typically artificial desert landscaping and rock mulch with pervious weed barrier. The extent of each selected site was determined based on existing perimeter walls and extended to the top back of curb at the public roadway. For the purposes of this study, it was assumed that retention of runoff from the public roadways would be accounted for and treated separately from each individual lot in a subdivision. Site number one is shown in Figure 1. Figures for each site are provided in the detailed calculations in Attachment B.

Figure 1. Land cover map for Study Site 1.

Soil Type

Because all four hydrologic soil types are found throughout Washington County, each site was analyzed four times, once for each soil type. This approach facilitates the application of the results to other similar sites throughout the county.

Curve Number Selection and Runoff Estimates

For each site, curve numbers were selected, and runoff volume estimates were created for the following scenarios:

1. Undeveloped – using TR-55 Table 2-2d CN value for desert in fair hydrologic condition (30-70% ground cover).
2. Developed (Composite Curve Number) – using the weighted average (composite) curve number method. Composite curve numbers for each site were computed using the typical

values from TR-55 shown in Table 1. This scenario was analyzed for comparison with the more conservative weighted average volume method.

Table 1
Curve Numbers Selected from TR-55

Land Cover Description	Curve Numbers for Soil Type			
	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98

3. Roof Connected (Weighted Average Volume) – This scenario is the same as the developed condition analysis, except the analysis was performed using the weighted average volume method described previously and in the NJ SWBMP manual. For this scenario, the roof of the main residence was assumed to be **directly connected** via rain gutters and yard drains to the downstream driveways, public sidewalks, and roadway storm drain system.
4. Roof Disconnected (Two-step Runoff Method) – This scenario is the same as the "Roof Connected" scenario, except that the roof of the main residence was assumed to be **disconnected** from the downstream driveways, public sidewalks, and roadway storm drain system. Specific guidelines for ensuring the rain gutters are adequately disconnected from downstream impervious areas will be provided later in this TM.

The difference between the volumes computed in the "Roof Connected" and "Roof Disconnected" scenarios is the reduction in runoff achieved by disconnecting a site's roof from the downstream impervious areas. A summary of the results of the runoff volume calculations for each studied site is included in Table 2 below. Detailed calculations for each site are provided in Attachment B. For specific details and step-by-step examples of the weighted average volume and two-step runoff methods, please refer to chapter 5 of the NJ SWMP manual.

Table 2
Summary of Runoff Volume Estimates

Site Parameters													
Site Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Zoning Type	Residential 1/4 Acre									Residential 1/8 Acre			Townhomes
Zoning Code	R-1-10									R-1-6			PUD
Total Area (acres)	0.23	0.24	0.19	0.19	0.19	0.29	0.23	0.21	0.26	0.12	0.14	0.12	12.77
Impervious Area (acres)	0.15	0.11	0.12	0.09	0.11	0.10	0.15	0.12	0.16	0.08	0.08	0.07	7.11
Total Percent Impervious	64%	49%	63%	46%	57%	34%	64%	57%	63%	64%	57%	57%	56%
Overall Average % Impervious	56%												
Runoff Volumes from the 80th Percentile Storm (0.46 in)													
Soil Type A													
Undeveloped (Desert, Fair) (Cu. Ft,)	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed (Weighted Curve Number) (Cu. Ft,)	67	53	73	33	57	27	66	47	59	35	32	27	4756
Roofs Connected (Weighted Average Volume) (Cu. Ft,)	141	110	117	84	105	94	140	113	156	74	77	65	6813
Roofs Disconnected (Two-Step Runoff Method) (Cu. Ft,)	20	24	35	14	19	22	61	31	78	16	15	16	3538
Total Reduction in Runoff by Disconnecting Roofs (Cu. Ft,)	121	86	82	70	86	72	79	82	78	58	62	49	3275
Total Reduction in Runoff by Disconnecting Roofs (Gal.)	910	640	610	520	640	540	590	610	580	430	460	370	24500
Percent Reduction in Runoff by Disconnecting Roofs	86%	78%	70%	83%	82%	77%	56%	73%	50%	78%	81%	75%	52%
Average Reduction	74%												See Note 1
Soil Type B													
Undeveloped (Desert, Fair) (Cu. Ft,)	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed (Weighted Curve Number) (Cu. Ft,)	67	53	73	33	57	27	66	47	59	35	32	27	4756
Roofs Connected (Weighted Average Volume) (Cu. Ft,)	141	110	117	84	105	94	140	113	156	74	77	65	6813
Roofs Disconnected (Two-Step Runoff Method) (Cu. Ft,)	20	24	36	14	19	22	61	31	78	16	15	16	3538
Total Reduction in Runoff by Disconnecting Roofs (Cu. Ft,)	121	86	81	70	86	72	79	82	78	58	62	49	3275
Total Reduction in Runoff by Disconnecting Roofs (Gal.)	910	640	610	520	640	540	590	610	580	430	460	370	24500
Percent Reduction in Runoff by Disconnecting Roofs	86%	78%	69%	83%	82%	77%	56%	73%	50%	78%	81%	75%	48%
Average Reduction	74%												See Note 1
Soil Type C													
Undeveloped (Desert, Fair) (Cu. Ft,)	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed (Weighted Curve Number) (Cu. Ft,)	67	53	73	33	57	27	66	47	59	35	32	27	4756
Roofs Connected (Weighted Average Volume) (Cu. Ft,)	141	110	117	84	106	94	140	113	156	74	77	65	6850
Roofs Disconnected (Two-Step Runoff Method) (Cu. Ft,)	30	32	48	20	31	24	67	37	79	23	19	20	4002
Total Reduction in Runoff by Disconnecting Roofs (Cu. Ft,)	111	78	69	64	75	70	73	76	77	51	58	45	2848
Total Reduction in Runoff by Disconnecting Roofs (Gal.)	830	580	520	480	560	520	550	570	580	380	430	340	21300
Percent Reduction in Runoff by Disconnecting Roofs	79%	71%	59%	76%	71%	74%	52%	67%	49%	69%	75%	69%	42%
Average Reduction	68%												See Note 1
Soil Type D													
Undeveloped (Desert, Fair) (Cu. Ft,)	6	6	5	5	5	8	6	6	7	3	4	3	348
Developed (Weighted Curve Number) (Cu. Ft,)	67	53	73	33	57	27	66	47	59	35	32	27	4756
Roofs Connected (Weighted Average Volume) (Cu. Ft,)	141	113	120	87	109	97	141	114	156	75	78	66	7189
Roofs Disconnected (Two-Step Runoff Method) (Cu. Ft,)	43	47	63	32	47	35	79	49	88	31	29	27	4839
Total Reduction in Runoff by Disconnecting Roofs (Cu. Ft,)	98	66	57	55	62	62	62	65	68	44	49	39	2350
Total Reduction in Runoff by Disconnecting Roofs (Gal.)	730	490	430	410	460	460	460	490	510	330	370	290	17580
Percent Reduction in Runoff by Disconnecting Roofs	70%	58%	48%	63%	57%	64%	44%	57%	44%	59%	63%	59%	33%
Average Reduction	57%												See Note 1
Notes:													

1. Site 13 was the only townhome site analyzed, therefore there is insufficient data to make solid recommendations for similar developments. Such developments should have a site-specific analysis performed to determine the estimated reduction runoff by disconnecting roofs.

Based on the results shown in Table 2 above, a number of observations can be made:

- The average total percent impervious across all sites is 56-percent, with values ranging from 34% to 64%. The typical residential development curve numbers in Table 2-2a of TR-55 assume a total percent impervious of 38% for 1/4-acre residential development and 65% for 1/8 acre or less residential developments. This reinforces the fact that engineers should exercise caution when using curve numbers for urban areas directly from Table 2-2a.
- For all soil types and all sites, there is a large difference in runoff volume predicted by the weighted average curve number and the weighted average volume methods. The weighted average volume method is about 200% of the weighted average curve number method for all sites except for the townhome subdivision, where the difference is about 150%.
- For all sites and soil types, there is a minimum 55% average reduction in estimated runoff when roofs are disconnected from downstream impervious areas.
- For soil types A and B at all sites (except site 13) when roofs are disconnected, the remaining downstream pervious area can absorb all the rainfall falling on the pervious area as well as all runoff from the rooftop. The only runoff from these sites is the runoff from rain fall on the remaining directly connected impervious areas (driveways and public sidewalks).

RECOMMENDATIONS

The DWQ low impact development (LID) guidance document (DWQ 2018) mentions the practice of disconnecting impervious areas as a recommended LID site design practice; however, no details are provided for quantifying the potential runoff reduction of the practice. The designer can use a site-specific analysis or approximate method as described in the following sections to refine post-development runoff volume estimates to account for disconnecting roofs from downstream impervious areas .

The reader should note that reducing runoff from a site by disconnecting rooftop drains as described in this TM will increase the amount of infiltration, retention, and evapotranspiration on a site. This TM provides guidelines and recommendations for determining the magnitude of this increase in infiltration. The potential geotechnical concerns which may arise from increasing retention and infiltration in the vicinity of structures is beyond the scope of this study. In evaluating the implementation of disconnected impervious areas as described herein, engineers, developers, and reviewers should exercise caution and consider all potential impacts of increased infiltration on a proposed site.

Site-Specific Analysis

A site-specific analysis can be conducted as follows:

1. <u>Identify the 80th percentile rainfall depth</u>
2. <u>Determine the hydrologic soil type for the site</u> – Sites with more than one soil type were not addressed in this TM but similar methods can be used to develop composite CN values for site pervious areas.
3. <u>Determine undeveloped runoff volume</u> – Calculate the estimated runoff for the site in the undeveloped condition using a weighted average for the undeveloped land cover. (Typically desert in Washington County)
4. <u>Determine developed land cover areas</u> –For the developed condition, delineate and measure the areas of land cover types present within a site, including but not limited to: directly connected impervious areas (driveways and public sidewalks), unconnected impervious

areas (detached sheds and private sidewalks/concrete pads), roofs and lawns, and other pervious areas (planters, gravel with pervious weed barrier).

5. Determine developed runoff volume with roofs connected – Use the weighted average volume method. Include the area of building rooftops in the value for DCIA. (See Example 5-2 of the NJ SWMP)
6. Determine developed runoff with roofs disconnected - Use the two-step runoff method (See NJ SWBMP Example 5-3)
    a. Calculate the runoff from building rooftops (using a CN of 98), then convert that volume to an equivalent rainfall depth over the area of the downstream unconnected pervious areas using the equations below:

$$P_{roofs} = \frac{V_{roofs}}{A_{per}} x\ 12$$

Where:
V_{roofs} = *Volume of runoff from roofs, cubic feet*
A_{per} = *Area of downstream, unconnected pervious areas where roof drains will discharge, square feet*
P_{roofs} = *Runoff from roofs as additional precipitation depth to be applied on downstream pervious areas, inches*

And:

$$P_{eqv} = P_{80} + P_{roofs}$$

Where:
P_{80} = *Precipitation depth of 80th percentile storm (0.44 inches in Washington County)*
P_{eqv} = *Total equivalent precipitation depth to be applied on downstream pervious areas, inches*

    b. Calculate the estimated runoff from the remaining pervious and connected impervious areas, using the weighted average volume method. For pervious areas, use the total equivalent precipitation depth (P_{eqv}) as calculated in 6a above. For remaining impervious areas, use the 80th percentile rainfall depth (P_{80}).
7. Determine volume reduction obtained by disconnecting roofs - Subtract the result of 6 from 5 above.
8. Compare undeveloped and developed runoff volumes – Subtract the result of 6 from 3 above. If the resulting difference in volume is greater than zero, additional BMPs can be implemented as feasible to further reduce post-development runoff volume to the maximum extent practical (MEP) as required by the general MS4 permit.

Approximate Method

Based on the results of the analysis conducted for sites 1 through 12, approximate reduction factors were selected to quickly approximate the runoff volume reduction achievable by disconnecting rooftops from downstream impervious areas. An approximate method analysis is conducted in the same manner as the site-specific analysis outlined above, however, the developed runoff volume with roofs disconnected (Step 6) can be approximated as follows:

6. Determine developed runoff volume with roofs disconnected – For a given site soil type, multiply the calculated volume by the appropriate factor from Table 3 below to obtain the runoff volume for the site when roofs are disconnected:

Table 3
Factors for Converting Runoff Volumes from Sites with Roofs Connected to Roofs Disconnected Condition

Soil Type	Reduction Factor[1]
A or B	0.35
C	0.45
D	0.55

Notes:
1. Reduction factor is the average ratio of disconnected to connected runoff with an additional factor for the uncertainty of site-specific conditions

This simplified method should be used only if the subject site meets the following conditions:

- The site is a single residential lot with land covers similar in type and proportion to the sites used in this study (see Attachment B for details).
- Total percent impervious is less than 65%.
- Pervious areas must include at least 20% lawn in good condition.

Additional Limitations

For any impervious area to be considered unconnected, the following conditions must be met:

1. All runoff from the unconnected impervious area must be sheet flow.
2. Upon entering the downstream pervious area, all runoff must remain as sheet flow.
3. Flow from the impervious surface must enter the downstream pervious area as sheet flow or, in the case of roofs, from downspouts equipped with splash pads, level spreaders, or dispersion trenches that reduce flow velocity and induce sheet flow in the downstream pervious area.
4. All discharges onto the downstream pervious surfaces must be stable and nonerosive.
5. The shape, slope, and vegetated cover in the downstream pervious area must be sufficient to maintain sheet flow throughout its length. Maximum slope of the downstream pervious area is 8 percent.
6. The maximum roof area that can be drained by a single downspout is 600 square feet.

In addition, downstream unconnected pervious areas must meet the following conditions:

1. The minimum sheet flow length across the downstream pervious area is 25 feet.
2. The maximum sheet flow length across the unconnected impervious area is 100 feet.
3. While the total flow length area may be greater, the maximum sheet flow length across the downstream pervious area that can be used to compute the total resultant runoff volume is 150 feet.

CONCLUSIONS

Based on the analysis of the residential sites selected for this study, the practice of disconnecting rooftops from downstream impervious areas can be used to reduce the runoff volume from the site by 55 to 74% on average, depending on the soil type. Using a combination of the weighted average volume and two-step runoff volume methods described in this TM, site designers and reviewers can quantify the estimated reduction in runoff volume achieved by disconnecting impervious areas for almost any site. When implementing this practice, designers and reviewers must ensure the proposed design meets the limitations for unconnected impervious and downstream unconnected pervious areas described in this TM.

REFERENCES

Natural Resources Conservation Service, National Engineering Handbook, Part 630, Hydrology.

New Jersey Department of Environmental Protection, April 2004, New Jersey Stormwater Best Management Practices Manual (https://www.njstormwater.org/bmp_manual2.htm).

U.S. Department of Agriculture, Soil Conservation Service, June 1986, Urban Hydrology for Small Watersheds, Technical Release 55.

Utah Department of Environmental Quality, Division of Water Quality, December 2018, A Guide to Low Impact Development within Utah.

Utah Department of Environmental Quality, Division of Water Quality, February 2020, General Permit for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s), UPDES Permit Number UTR09000.

Attachment A – Excerpts from Chapter 5 of New Jersey Storm Water Best Management Practices Manual (2004)

Example 5-2: Site With Pervious and Directly Connected Impervious Cover
Runoff Volume Computation Using NRCS Methodology

Description: A 3-acre development site is comprised of 1 acre of impervious surface and 2 acres of lawn and woods with an NRCS Curve Number (CN) of 65. The entire impervious surface is directly connected to the site's drainage system. Compute the site's total runoff volume for the 1.25-inch stormwater quality design storm using the Weighted Average CN technique. Compare the results with the Weighted Average Volume technique.

Stormwater Quality Design Storm = P = 1.25 inches

Total drainage area = 3 acres

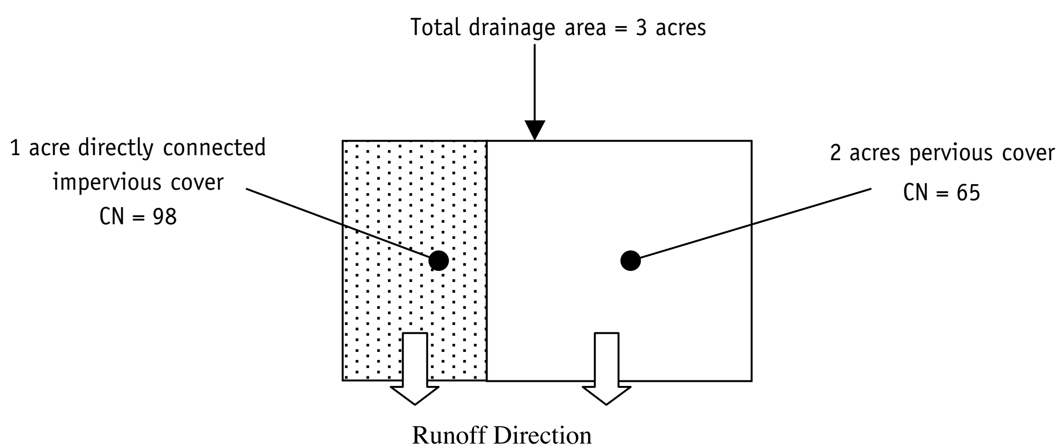
Impervious area = 1 acre (1/3 of total area)

Pervious area = 2 acres (2/3 of total area)

Pervious cover = mixture of lawn and woods   Pervious CN = 65

Impervious cover = asphalt   Impervious CN = 98

Note: All impervious cover is connected to the drainage system



1. Using Weighted Average Curve Number Technique

Weighted CN = (65)(2/3) + (98)(1/3) = 76

$$\text{Average S} = \frac{1000}{CN} - 10 = \frac{1000}{76} - 10 = 3.16 \text{ inches}$$

Average initial abstraction = Ia = 0.2S = (0.2)(3.16) = 0.63 inches

0.8S = (0.8)(3.16) = 2.53 inches

$$\text{Runoff volume} = Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} = \frac{(1.25 - 0.63)^2}{1.25 + 2.53} = 0.10 \text{ inches}$$

Runoff volume = (0.10 inches/12 inches per foot)(3 acres)(43,560 sf per acre)

Total site runoff volume = 1089 cubic feet

2. Using Weighted Average Volume Technique

Impervious Area

$$\text{Impervious area } S = \frac{1000}{CN} - 10 = \frac{1000}{98} - 10 = 0.20 \text{ inches}$$

$$\text{Impervious area initial abstraction} = 0.2S = (0.2)(0.20) = 0.04 \text{ inches}$$

$$0.8S = (0.8)(0.20) = 0.16 \text{ inches}$$

$$\text{Impervious area runoff volume} = Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} = \frac{(1.25 - 0.04)^2}{1.25 + 0.16} = 1.04 \text{ inches}$$

Runoff volume = (1.04 inches/12 inches per foot)(1 acre)(43,560 sf per acre)

Impervious area runoff volume = 3775 cubic feet

Pervious Area

$$\text{Pervious area } S = \frac{1000}{CN} - 10 = \frac{1000}{65} - 10 = 5.38 \text{ inches}$$

$$\text{Pervious area initial abstraction} = 0.2S = (0.2)(5.38) = 1.08 \text{ inches}$$

$$0.8S = (0.8)(5.38) = 4.30 \text{ inches}$$

$$\text{Pervious area runoff volume} = Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} = \frac{(1.25 - 1.08)^2}{1.25 + 4.30} = 0.005 \text{ inches}$$

Runoff volume = (0.005 inches/12 inches per foot)(2 acres)(43,560 sf per acre)

Pervious area runoff volume = 36 cubic feet

Total site runoff volume = 3775 + 36 = 3811 cubic feet
(vs. 1089 cubic feet using weighted average CN)

As can be seen in Example 5-2 above, the weighted average CN technique produced an estimated stormwater quality design storm runoff volume that was less than 30 percent of the volume produced by the weighted average volume technique. Perhaps more significantly, the example also demonstrates how virtually the entire site runoff for the stormwater quality design storm comes from the impervious portion and that very little comes from the pervious portion (i.e., 3775 cubic feet vs. 36 cubic feet). The significant but erroneous initial loss that the NRCS cautions about in TR-55 can also be seen in the 0.63 inch initial abstraction for the entire site (including 1 acre of impervious surface) produced by the weighted average CN technique.

It is important to note that, in computing a weighted average runoff volume from the development site, Example 5-2 does not address the resultant peak discharge or hydrograph from the site. If both the pervious and directly connected impervious site areas will have the same time of concentration, the weighted runoff volume can then be used directly to compute the peak site discharge or hydrograph. However, if these areas will respond to rainfall with different times of concentration, separate hydrographs should be computed for each and then combined to produce the peak site discharge or hydrograph.

their own direct rainfall as well as the "rainfall" flowing from the upstream unconnected impervious areas. The resultant runoff from the downstream pervious areas in response to this combined rainfall can then be computed using the NRCS runoff equation again.

Example 5-3 illustrates this two-step runoff computation technique for unconnected impervious areas. In reviewing the example, it is important to note that the unconnected impervious area runoff depth must be converted to an equivalent uniform rainfall depth over the entire downstream pervious area based on the relative sizes of the unconnected impervious and downstream pervious areas.

Example 5-3: Site With Unconnected Impervious Cover
Runoff Volume Computation Using Two-Step Technique

Description: A 3-acre development site is comprised of 1 acre of impervious surface and 2 acres of lawn and woods with an NRCS Curve Number (CN) of 65. Runoff from the entire impervious surface sheet flows onto to the pervious portion of the site before entering the site's drainage system. Compute the total runoff volume for the 1.25-inch stormwater quality design storm using the NRCS methodology.

Stormwater Quality Design Storm = P = 1.25 inches

Total drainage area = 3 acres

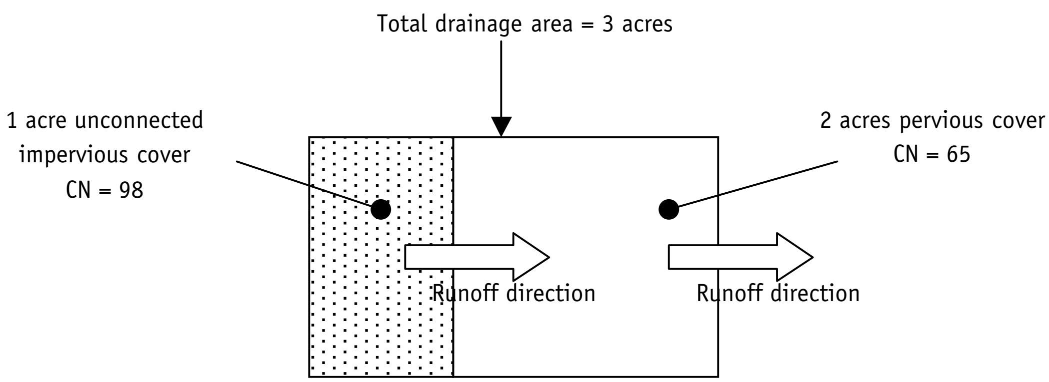
Impervious area = 1 acre (1/3 of total area)

Pervious area = 2 acres (2/3 of total area)

Pervious cover = mixture of lawn and woods pervious CN = 65

Impervious cover = asphalt impervious CN = 98

Note: All impervious area runoff sheet flows onto downstream pervious area



Impervious Area

$$\text{Impervious area } S = \frac{1000}{CN} - 10 = \frac{1000}{98} - 10 = 0.20 \text{ inches}$$

Impervious area initial abstraction = 0.2S = (0.2)(0.20) = 0.04 inches

0.8S = (0.8)(0.20) = 0.16 inches

$$\text{Impervious area runoff volume} = Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} = \frac{(1.25 - 0.04)^2}{1.25 + 0.16} = 1.04 \text{ inches}$$

Runoff volume = (1.04 inches/12 inches per foot)(1 acre)(43,560 sf per acre)

Impervious area runoff volume = 3775 cubic feet

Equivalent rainfall depth on downstream pervious area =

(3775 cubic feet)/(2 acres)(43,560 sf per acre) = 0.043 feet = 0.52 inches

Pervious Area

Total effective rainfall = direct rainfall + unconnected impervious area runoff

= 1.25 inches + 0.52 inches = 1.77 inches total

$$\text{Pervious area } S = \frac{1000}{CN} - 10 = \frac{1000}{65} - 10 = 5.38 \text{ inches}$$

Pervious area initial abstraction = 0.2S = (0.2)(5.38) = 1.08 inches

0.8S = (0.8)(5.38) = 4.30 inches

$$\text{Pervious area runoff volume} = Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} = \frac{(1.77 - 1.08)^2}{1.77 + 4.30} = 0.08 \text{ inches}$$

Runoff volume = (0.08 inches/12 inches per foot)(2 acres)(43,560 sf per acre)
= 581 cubic feet

Pervious area runoff volume = total runoff volume = 581 cubic feet

From the above example, it can be seen that a key parameter in the two-step runoff computation technique for unconnected impervious cover is the effective size of the downstream pervious area. The following three criteria, in conjunction with the seven requirements for all unconnected impervious areas shown above, should be used to determine the effective size of this downstream area:

1. The minimum sheet flow length across the downstream pervious area is 25 feet.
2. The maximum sheet flow length across the unconnected impervious area is 100 feet.
3. While the total flow length area may be greater, the maximum sheet flow length across the downstream pervious area that can be used to compute the total resultant runoff volume is 150 feet.

These criteria are illustrated below in Figures 5-5 and 5-6 for both on-grade and above-grade unconnected impervious areas, respectively. Additional criteria for determining the lower limits of the downstream pervious area are presented in Figure 5-7. When using Figure 5-6 with overlapping pervious areas downstream of roof downspouts, the overlapping areas should be counted only once in the computation of the total pervious area downstream of the roof.

Finally, when computing the peak runoff rate or hydrograph from an area with unconnected impervious cover, the time of concentration of the combined impervious and downstream pervious area should be based upon the Tc of the downstream pervious area only, with the Tc route beginning as sheet flow at the upper end of the pervious area.

Attachment B – Runoff Volume Calculations

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	1
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.229**	acres	9981	sq ft
Roof	0.119	acres	5187	sq ft
Driveway/sidewalk	0.021	acres	928	sq ft
Other Impervious	0.007	acres	288	sq ft
Lawn	0.046	acres	2021	sq ft
Other Pervious	0.036	acres	1556	sq ft

Impervious Areas				
Total Impervious Area	**0.147**	acres	6404	sq ft
	64%			
Directly Connected Impervious Areas				
w/ Roof connected	0.140	acres	6116	sq ft
w/ Roof disconnected	0.021	acres	928	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.007	acres	288	sq ft
w/ Roof disconnected	0.126	acres	5476	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**49**	**68**	**79**	**83**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp}	A_{per}	P_{imp}	R	CN_p	CN_c	S	Ia	Volume			Comments
			(acres)	(acres)	(%)	(%)	-	-	(in)	(in)	(in)	(cu ft)	(gal)	
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.147	0.082	64		83	93	0.75	0.15	0.080	**67**	**500**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.082				49	10.41	2.08	0.000	0	0	
	Impervious Area		0.147					98	0.20	0.04	0.264	141	1055	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**141**	**1055**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.126					98	0.20	0.04	0.264	121	902	
	Equiv. Rain on Downstream Pervious Area (in)	0.40												
	New Total Effective Rainfall Depth (in)	0.84												
	Downstream Pervious Area Runoff			0.082				49	10.41	2.08	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.021					98	0.20	0.04	0.264	20	153	
	Weighted Volume Total											**20**	**153**	
Reduction in Runoff obtained by disconnecting Roof												**121**	**902**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.147	0.082	64		83	93	0.75	0.15	0.080	**67**	**500**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.082				68	4.71	0.94	0.000	0	0	
	Impervious Area		0.147					98	0.20	0.04	0.264	141	1055	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**141**	**1055**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.126					98	0.20	0.04	0.264	121	902	
	Equiv. Rain on Downstream Pervious Area (in)	0.40												
	New Total Effective Rainfall Depth (in)	0.84												
	Downstream Pervious Area Runoff			0.082				68	4.71	0.94	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.021					98	0.20	0.04	0.264	20	153	
	Weighted Volume Total											**20**	**153**	
Reduction in Runoff obtained by disconnecting Roof												**121**	**902**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.147	0.082	64		83	93	0.75	0.15	0.080	**67**	**500**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.082				79	2.66	0.53	0.000	0	0	
	Impervious Area		0.147					98	0.20	0.04	0.264	141	1055	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**141**	**1055**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.126					98	0.20	0.04	0.264	121	902	
	Equiv. Rain on Downstream Pervious Area (in)	0.40												
	New Total Effective Rainfall Depth (in)	0.84												
	Downstream Pervious Area Runoff			0.082				79	2.66	0.53	0.032	10	71	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.021					98	0.20	0.04	0.264	20	153	
	Weighted Volume Total											**30**	**224**	
Reduction in Runoff obtained by disconnecting Roof												**111**	**830**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**6**	**47**	
Developed (Composite Curve Number Approach)			0.147	0.082	64		83	93	0.75	0.15	0.080	**67**	**500**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.082				83	2.05	0.41	0.000	0	1	
	Impervious Area		0.147					98	0.20	0.04	0.264	141	1055	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.265	**141**	**1056**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.126					98	0.20	0.04	0.264	121	902	
	Equiv. Rain on Downstream Pervious Area (in)	0.40												
	New Total Effective Rainfall Depth (in)	0.84												
	Downstream Pervious Area Runoff			0.082				83	2.05	0.41	0.075	22	167	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.021					98	0.20	0.04	0.264	20	153	
	Weighted Volume Total											**43**	**319**	
Reduction in Runoff obtained by disconnecting Roof												**98**	**736**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	2
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.235**	acres	10255	sq ft
Roof	0.085	acres	3718	sq ft
Driveway/sidewalk	0.025	acres	1100	sq ft
Other Impervious	0.004	acres	170	sq ft
Lawn	0.030	acres	1289	sq ft
Other Pervious	0.091	acres	3978	sq ft

Impervious Areas				
Total Impervious Area	**0.115**	acres	4988	sq ft
	49%			
Directly Connected Impervious Areas				
w/ Roof connected	0.111	acres	4818	sq ft
w/ Roof disconnected	0.025	acres	1100	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.004	acres	170	sq ft
w/ Roof disconnected	0.089	acres	3888	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**57**	**73**	**82**	**86**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.115	0.121	49		86	92	0.87	0.17	0.062	**53**	**399**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.121				57	7.54	1.51	0.000	0	0	
	Impervious Area		0.115					98	0.20	0.04	0.264	110	821	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**110**	**821**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.089					98	0.20	0.04	0.264	86	640	
	Equiv. Rain on Downstream Pervious Area (in)	0.20												
	New Total Effective Rainfall Depth (in)	0.64												
	Downstream Pervious Area Runoff			0.121				57	7.54	1.51	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.025					98	0.20	0.04	0.264	24	181	
	Weighted Volume Total											**24**	**181**	
Reduction in Runoff obtained by disconnecting Roof												**86**	**640**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.115	0.121	49		86	92	0.87	0.17	0.062	**53**	**399**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.121				73	3.70	0.74	0.000	0	0	
	Impervious Area		0.115					98	0.20	0.04	0.264	110	821	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**110**	**821**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.089					98	0.20	0.04	0.264	86	640	
	Equiv. Rain on Downstream Pervious Area (in)	0.20												
	New Total Effective Rainfall Depth (in)	0.64												
	Downstream Pervious Area Runoff			0.121				73	3.70	0.74	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.025					98	0.20	0.04	0.264	24	181	
	Weighted Volume Total											**24**	**181**	
Reduction in Runoff obtained by disconnecting Roof												**86**	**640**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.115	0.121	49		86	92	0.87	0.17	0.062	**53**	**399**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.121				82	2.20	0.44	0.000	0	0	
	Impervious Area		0.115					98	0.20	0.04	0.264	110	821	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**110**	**821**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.089					98	0.20	0.04	0.264	86	640	
	Equiv. Rain on Downstream Pervious Area (in)	0.20												
	New Total Effective Rainfall Depth (in)	0.64												
	Downstream Pervious Area Runoff			0.121				82	2.20	0.44	0.017	7	55	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.025					98	0.20	0.04	0.264	24	181	
	Weighted Volume Total											**32**	**236**	
Reduction in Runoff obtained by disconnecting Roof												**78**	**585**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**6**	**48**	
Developed (Composite Curve Number Approach)			0.115	0.121	49		86	92	0.87	0.17	0.062	**53**	**399**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.121				86	1.63	0.33	0.008	3	25	
	Impervious Area		0.115					98	0.20	0.04	0.264	110	821	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.272	**113**	**846**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.089					98	0.20	0.04	0.264	86	640	
	Equiv. Rain on Downstream Pervious Area (in)	0.20												
	New Total Effective Rainfall Depth (in)	0.64												
	Downstream Pervious Area Runoff			0.121				86	1.63	0.33	0.051	22	167	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.025					98	0.20	0.04	0.264	24	181	
	Weighted Volume Total											**47**	**348**	
Reduction in Runoff obtained by disconnecting Roof												**67**	**498**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	3
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

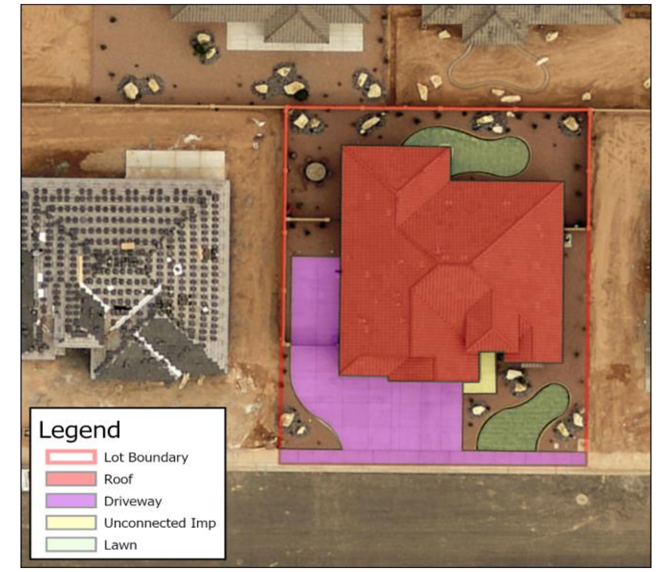
80th Percentile Storm Depth	**0.44**	in

Total Area	**0.195**	acres	8486	sq ft
Roof	0.083	acres	3624	sq ft
Driveway/sidewalk	0.037	acres	1613	sq ft
Other Impervious	0.002	acres	71	sq ft
Lawn	0.013	acres	563	sq ft
Other Pervious	0.060	acres	2615	sq ft

Impervious Areas				
Total Impervious Area	**0.122**	acres	5308	sq ft
	63%			
Directly Connected Impervious Areas				
w/ Roof connected	0.120	acres	5237	sq ft
w/ Roof disconnected	0.037	acres	1613	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.002	acres	71	sq ft
w/ Roof disconnected	0.085	acres	3695	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**59**	**74**	**83**	**87**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches



Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.122	0.073	63		87	94	0.64	0.13	0.103	**73**	**543**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.073				59	6.95	1.39	0.000	0	0	
	Impervious Area		0.122					98	0.20	0.04	0.264	117	874	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**117**	**874**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	81	609	
	Equiv. Rain on Downstream Pervious Area (in)	0.31												
	New Total Effective Rainfall Depth (in)	0.75												
	Downstream Pervious Area Runoff			0.073				59	6.95	1.39	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.037					98	0.20	0.04	0.264	35	266	
	Weighted Volume Total											**35**	**266**	
Reduction in Runoff obtained by disconnecting Roof												**81**	**609**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.122	0.073	63		87	94	0.64	0.13	0.103	**73**	**543**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.073				74	3.51	0.70	0.000	0	0	
	Impervious Area		0.122					98	0.20	0.04	0.264	117	874	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**117**	**874**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	81	609	
	Equiv. Rain on Downstream Pervious Area (in)	0.31												
	New Total Effective Rainfall Depth (in)	0.75												
	Downstream Pervious Area Runoff			0.073				74	3.51	0.70	0.001	0	1	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.037					98	0.20	0.04	0.264	35	266	
	Weighted Volume Total											**36**	**267**	
Reduction in Runoff obtained by disconnecting Roof												**81**	**607**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.122	0.073	63		87	94	0.64	0.13	0.103	**73**	**543**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.073				83	2.05	0.41	0.000	0	1	
	Impervious Area		0.122					98	0.20	0.04	0.264	117	874	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.265	**117**	**875**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	81	609	
	Equiv. Rain on Downstream Pervious Area (in)	0.31												
	New Total Effective Rainfall Depth (in)	0.75												
	Downstream Pervious Area Runoff			0.073				83	2.05	0.41	0.049	13	96	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.037					98	0.20	0.04	0.264	35	266	
	Weighted Volume Total											**48**	**362**	
Reduction in Runoff obtained by disconnecting Roof												**69**	**513**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**5**	**40**	
Developed (Composite Curve Number Approach)			0.122	0.073	63		87	94	0.64	0.13	0.103	**73**	**543**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.073				87	1.49	0.30	0.012	3	24	
	Impervious Area		0.122					98	0.20	0.04	0.264	117	874	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.276	**120**	**898**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	81	609	
	Equiv. Rain on Downstream Pervious Area (in)	0.31												
	New Total Effective Rainfall Depth (in)	0.75												
	Downstream Pervious Area Runoff			0.073				87	1.49	0.30	0.105	28	207	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.037					98	0.20	0.04	0.264	35	266	
	Weighted Volume Total											**63**	**473**	
Reduction in Runoff obtained by disconnecting Roof												**57**	**425**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	4
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	0.44	in

Total Area	0.193	acres	8394	sq ft
Roof	0.069	acres	3027	sq ft
Driveway/sidewalk	0.015	acres	638	sq ft
Other Impervious	0.004	acres	170	sq ft
Lawn	0.027	acres	1166	sq ft
Other Pervious	0.078	acres	3393	sq ft

Impervious Areas				
Total Impervious Area	0.088	acres	3834	sq ft
	46%			
Directly Connected Impervious Areas				
w/ Roof connected	0.084	acres	3664	sq ft
w/ Roof disconnected	0.015	acres	638	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.004	acres	170	sq ft
w/ Roof disconnected	0.073	acres	3197	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**57**	**73**	**82**	**86**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.088	0.105	46		86	91	0.99	0.20	0.048	**33**	**249**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.105				57	7.54	1.51	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.088					98	0.20	0.04	0.264	84	631	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**84**	**631**	
	Runoff from Disconnected Imp Area		0.073					98	0.20	0.04	0.264	70	526	
	Equiv. Rain on Downstream Pervious Area (in)	0.19												
	New Total Effective Rainfall Depth (in)	0.63												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.105				57	7.54	1.51	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.015					98	0.20	0.04	0.264	14	105	
	Weighted Volume Total											**14**	**105**	
Reduction in Runoff obtained by disconnecting Roof												**70**	**526**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.088	0.105	46		86	91	0.99	0.20	0.048	**33**	**249**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.105				73	3.70	0.74	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.088					98	0.20	0.04	0.264	84	631	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**84**	**631**	
	Runoff from Disconnected Imp Area		0.073					98	0.20	0.04	0.264	70	526	
	Equiv. Rain on Downstream Pervious Area (in)	0.19												
	New Total Effective Rainfall Depth (in)	0.63												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.105				73	3.70	0.74	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.015					98	0.20	0.04	0.264	14	105	
	Weighted Volume Total											**14**	**105**	
Reduction in Runoff obtained by disconnecting Roof												**70**	**526**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.088	0.105	46		86	91	0.99	0.20	0.048	**33**	**249**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.105				82	2.20	0.44	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.088					98	0.20	0.04	0.264	84	631	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**84**	**631**	
	Runoff from Disconnected Imp Area		0.073					98	0.20	0.04	0.264	70	526	
	Equiv. Rain on Downstream Pervious Area (in)	0.19												
	New Total Effective Rainfall Depth (in)	0.63												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.105				82	2.20	0.44	0.015	6	43	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.015					98	0.20	0.04	0.264	14	105	
	Weighted Volume Total											**20**	**148**	
Reduction in Runoff obtained by disconnecting Roof												**65**	**483**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**5**	**39**	
Developed (Composite Curve Number Approach)			0.088	0.105	46		86	91	0.99	0.20	0.048	**33**	**249**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.105				86	1.63	0.33	0.008	3	21	
Roof Connected - Weighted Average Volume	Impervious Area		0.088					98	0.20	0.04	0.264	84	631	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.272	**87**	**653**	
	Runoff from Disconnected Imp Area		0.073					98	0.20	0.04	0.264	70	526	
	Equiv. Rain on Downstream Pervious Area (in)	0.19												
	New Total Effective Rainfall Depth (in)	0.63												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.105				86	1.63	0.33	0.048	18	136	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.015					98	0.20	0.04	0.264	14	105	
	Weighted Volume Total											**32**	**241**	
Reduction in Runoff obtained by disconnecting Roof												**55**	**411**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	5
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.195**	acres	8474	sq ft
Roof	0.088	acres	3812	sq ft
Driveway/sidewalk	0.020	acres	855	sq ft
Other Impervious	0.003	acres	123	sq ft
Lawn	0.016	acres	684	sq ft
Other Pervious	0.069	acres	2999	sq ft

Impervious Areas				
Total Impervious Area	**0.110**	acres	4791	sq ft
	57%			
Directly Connected Impervious Areas				
w/ Roof connected	0.107	acres	4667	sq ft
w/ Roof disconnected	0.020	acres	855	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.003	acres	123	sq ft
w/ Roof disconnected	0.090	acres	3935	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**59**	**74**	**83**	**87**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.110	0.085	57		87	93	0.75	0.15	0.080	**57**	**425**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.085				59	6.95	1.39	0.000	0	0	
	Impervious Area		0.110					98	0.20	0.04	0.264	105	789	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**105**	**789**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.090					98	0.20	0.04	0.264	87	648	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.085				59	6.95	1.39	0.000	0	0	
	Downstream Impervious Area Runoff		0.020					98	0.20	0.04	0.264	19	141	
	Weighted Volume Total											**19**	**141**	
Reduction in Runoff obtained by disconnecting Roof												**87**	**648**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.110	0.085	57		87	93	0.75	0.15	0.080	**57**	**425**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.085				74	3.51	0.70	0.000	0	0	
	Impervious Area		0.110					98	0.20	0.04	0.264	105	789	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**105**	**789**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.090					98	0.20	0.04	0.264	87	648	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.085				74	3.51	0.70	0.000	0	0	
	Downstream Impervious Area Runoff		0.020					98	0.20	0.04	0.264	19	141	
	Weighted Volume Total											**19**	**141**	
Reduction in Runoff obtained by disconnecting Roof												**87**	**648**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.110	0.085	57		87	93	0.75	0.15	0.080	**57**	**425**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.085				83	2.05	0.41	0.000	0	1	
	Impervious Area		0.110					98	0.20	0.04	0.264	105	789	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.265	**106**	**790**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.090					98	0.20	0.04	0.264	87	648	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.085				83	2.05	0.41	0.041	13	94	
	Downstream Impervious Area Runoff		0.020					98	0.20	0.04	0.264	19	141	
	Weighted Volume Total											**31**	**235**	
Reduction in Runoff obtained by disconnecting Roof												**74**	**555**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**5**	**40**	
Developed (Composite Curve Number Approach)			0.110	0.085	57		87	93	0.75	0.15	0.080	**57**	**425**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.085				87	1.49	0.30	0.012	4	28	
	Impervious Area		0.110					98	0.20	0.04	0.264	105	789	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.276	**109**	**817**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.090					98	0.20	0.04	0.264	87	648	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.085				87	1.49	0.30	0.093	28	213	
	Downstream Impervious Area Runoff		0.020					98	0.20	0.04	0.264	19	141	
	Weighted Volume Total											**47**	**353**	
Reduction in Runoff obtained by disconnecting Roof												**62**	**463**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	6
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	0.44	in

Total Area	0.286	acres	12450	sq ft
Roof	0.062	acres	2696	sq ft
Driveway/sidewalk	0.023	acres	992	sq ft
Other Impervious	0.013	acres	580	sq ft
Lawn	0.063	acres	2744	sq ft
Other Pervious	0.125	acres	5438	sq ft

Impervious Areas				
Total Impervious Area	0.098	acres	4268	sq ft
	34%			
Directly Connected Impervious Areas				
w/ Roof connected	0.085	acres	3688	sq ft
w/ Roof disconnected	0.023	acres	992	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.013	acres	580	sq ft
w/ Roof disconnected	0.075	acres	3276	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**55**	**72**	**81**	**85**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.098	0.188	34		85	89	1.24	0.25	0.026	**27**	**202**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.188				55	8.18	1.64	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.098					98	0.20	0.04	0.264	94	703	
	Weighted Volume Total										0.264	**94**	**703**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.075					98	0.20	0.04	0.264	72	539	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.11												
	New Total Effective Rainfall Depth (in)	0.55												
	Downstream Pervious Area Runoff			0.188				55	8.18	1.64	0.000	0	0	
	Downstream Impervious Area Runoff		0.023					98	0.20	0.04	0.264	22	163	
	Weighted Volume Total											**22**	**163**	
Reduction in Runoff obtained by disconnecting Roof												**72**	**539**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.098	0.188	34		85	89	1.24	0.25	0.026	**27**	**202**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.188				72	3.89	0.78	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.098					98	0.20	0.04	0.264	94	703	
	Weighted Volume Total										0.264	**94**	**703**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.075					98	0.20	0.04	0.264	72	539	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.11												
	New Total Effective Rainfall Depth (in)	0.55												
	Downstream Pervious Area Runoff			0.188				72	3.89	0.78	0.000	0	0	
	Downstream Impervious Area Runoff		0.023					98	0.20	0.04	0.264	22	163	
	Weighted Volume Total											**22**	**163**	
Reduction in Runoff obtained by disconnecting Roof												**72**	**539**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.098	0.188	34		85	89	1.24	0.25	0.026	**27**	**202**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.188				81	2.35	0.47	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.098					98	0.20	0.04	0.264	94	703	
	Weighted Volume Total										0.264	**94**	**703**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.075					98	0.20	0.04	0.264	72	539	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.11												
	New Total Effective Rainfall Depth (in)	0.55												
	Downstream Pervious Area Runoff			0.188				81	2.35	0.47	0.003	2	14	
	Downstream Impervious Area Runoff		0.023					98	0.20	0.04	0.264	22	163	
	Weighted Volume Total											**24**	**177**	
Reduction in Runoff obtained by disconnecting Roof												**70**	**526**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**8**	**58**	
Developed (Composite Curve Number Approach)			0.098	0.188	34		85	89	1.24	0.25	0.026	**27**	**202**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.188				85	1.76	0.35	0.004	3	21	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.098					98	0.20	0.04	0.264	94	703	
	Weighted Volume Total										0.268	**97**	**724**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.075					98	0.20	0.04	0.264	72	539	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.11												
	New Total Effective Rainfall Depth (in)	0.55												
	Downstream Pervious Area Runoff			0.188				85	1.76	0.35	0.020	13	101	
	Downstream Impervious Area Runoff		0.023					98	0.20	0.04	0.264	22	163	
	Weighted Volume Total											**35**	**264**	
Reduction in Runoff obtained by disconnecting Roof												**61**	**459**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	7
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.227**	acres	9881	sq ft
Roof	0.077	acres	3345	sq ft
Driveway/sidewalk	0.063	acres	2764	sq ft
Other Impervious	0.006	acres	240	sq ft
Lawn	0.032	acres	1400	sq ft
Other Pervious	0.049	acres	2132	sq ft

Impervious Areas				
Total Impervious Area	**0.146**	acres	6349	sq ft
	64%			
Directly Connected Impervious Areas				
w/ Roof connected	0.140	acres	6109	sq ft
w/ Roof disconnected	0.063	acres	2764	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.006	acres	240	sq ft
w/ Roof disconnected	0.082	acres	3585	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**53**	**71**	**81**	**85**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.146	0.081	64		85	93	0.75	0.15	0.080	**66**	**495**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.081				53	8.87	1.77	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.146					98	0.20	0.04	0.264	140	1045	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**140**	**1045**	
	Runoff from Disconnected Imp Area		0.082					98	0.20	0.04	0.264	79	590	
	Equiv. Rain on Downstream Pervious Area (in)	0.27												
	New Total Effective Rainfall Depth (in)	0.71												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.081				53	8.87	1.77	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.063					98	0.20	0.04	0.264	61	455	
	Weighted Volume Total											**61**	**455**	
Reduction in Runoff obtained by disconnecting Roof												**79**	**590**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.146	0.081	64		85	93	0.75	0.15	0.080	**66**	**495**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.081				71	4.08	0.82	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.146					98	0.20	0.04	0.264	140	1045	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**140**	**1045**	
	Runoff from Disconnected Imp Area		0.082					98	0.20	0.04	0.264	79	590	
	Equiv. Rain on Downstream Pervious Area (in)	0.27												
	New Total Effective Rainfall Depth (in)	0.71												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.081				71	4.08	0.82	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.063					98	0.20	0.04	0.264	61	455	
	Weighted Volume Total											**61**	**455**	
Reduction in Runoff obtained by disconnecting Roof												**79**	**590**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.146	0.081	64		85	93	0.75	0.15	0.080	**66**	**495**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.081				81	2.35	0.47	0.000	0	0	
Roof Connected - Weighted Average Volume	Impervious Area		0.146					98	0.20	0.04	0.264	140	1045	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**140**	**1045**	
	Runoff from Disconnected Imp Area		0.082					98	0.20	0.04	0.264	79	590	
	Equiv. Rain on Downstream Pervious Area (in)	0.27												
	New Total Effective Rainfall Depth (in)	0.71												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.081				81	2.35	0.47	0.022	7	49	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.063					98	0.20	0.04	0.264	61	455	
	Weighted Volume Total											**67**	**504**	
Reduction in Runoff obtained by disconnecting Roof												**72**	**541**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**6**	**46**	
Developed (Composite Curve Number Approach)			0.146	0.081	64		85	93	0.75	0.15	0.080	**66**	**495**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
	Pervious Area			0.081				85	1.76	0.35	0.004	1	9	
Roof Connected - Weighted Average Volume	Impervious Area		0.146					98	0.20	0.04	0.264	140	1045	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.268	**141**	**1055**	
	Runoff from Disconnected Imp Area		0.082					98	0.20	0.04	0.264	79	590	
	Equiv. Rain on Downstream Pervious Area (in)	0.27												
	New Total Effective Rainfall Depth (in)	0.71												
Roof Disconnected - Two-Step Runoff Method	Downstream Pervious Area Runoff			0.081				85	1.76	0.35	0.060	18	132	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.063					98	0.20	0.04	0.264	61	455	
	Weighted Volume Total											**79**	**587**	
Reduction in Runoff obtained by disconnecting Roof												**62**	**467**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	8
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	0.44	in

Total Area	0.206	acres	8976	sq ft
Roof	0.075	acres	3255	sq ft
Driveway/sidewalk	0.033	acres	1417	sq ft
Other Impervious	0.010	acres	456	sq ft
Lawn	0.033	acres	1454	sq ft
Other Pervious	0.055	acres	2394	sq ft

Impervious Areas				
Total Impervious Area	0.118	acres	5128	sq ft
	57%			
Directly Connected Impervious Areas				
w/ Roof connected	0.107	acres	4672	sq ft
w/ Roof disconnected	0.033	acres	1417	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.010	acres	456	sq ft
w/ Roof disconnected	0.085	acres	3711	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**54**	**71**	**81**	**85**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.118	0.088	57		85	92	0.87	0.17	0.062	**47**	**349**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.088				54	8.52	1.70	0.000	0	0	
	Impervious Area		0.118					98	0.20	0.04	0.264	113	844	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**113**	**844**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	82	611	
	Equiv. Rain on Downstream Pervious Area (in)	0.25												
	New Total Effective Rainfall Depth (in)	0.69												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.088				54	8.52	1.70	0.000	0	0	
	Downstream Impervious Area Runoff		0.033					98	0.20	0.04	0.264	31	233	
	Weighted Volume Total											**31**	**233**	
Reduction in Runoff obtained by disconnecting Roof												**82**	**611**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.118	0.088	57		85	92	0.87	0.17	0.062	**47**	**349**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.088				71	4.08	0.82	0.000	0	0	
	Impervious Area		0.118					98	0.20	0.04	0.264	113	844	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**113**	**844**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	82	611	
	Equiv. Rain on Downstream Pervious Area (in)	0.25												
	New Total Effective Rainfall Depth (in)	0.69												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.088				71	4.08	0.82	0.000	0	0	
	Downstream Impervious Area Runoff		0.033					98	0.20	0.04	0.264	31	233	
	Weighted Volume Total											**31**	**233**	
Reduction in Runoff obtained by disconnecting Roof												**82**	**611**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.118	0.088	57		85	92	0.87	0.17	0.062	**47**	**349**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.088				81	2.35	0.47	0.000	0	0	
	Impervious Area		0.118					98	0.20	0.04	0.264	113	844	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**113**	**844**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	82	611	
	Equiv. Rain on Downstream Pervious Area (in)	0.25												
	New Total Effective Rainfall Depth (in)	0.69												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.088				81	2.35	0.47	0.019	6	46	
	Downstream Impervious Area Runoff		0.033					98	0.20	0.04	0.264	31	233	
	Weighted Volume Total											**37**	**279**	
Reduction in Runoff obtained by disconnecting Roof												**76**	**565**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**6**	**42**	
Developed (Composite Curve Number Approach)			0.118	0.088	57		85	92	0.87	0.17	0.062	**47**	**349**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.088				85	1.76	0.35	0.004	1	10	
	Impervious Area		0.118					98	0.20	0.04	0.264	113	844	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.268	**114**	**854**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.085					98	0.20	0.04	0.264	82	611	
	Equiv. Rain on Downstream Pervious Area (in)	0.25												
	New Total Effective Rainfall Depth (in)	0.69												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.088				85	1.76	0.35	0.054	17	130	
	Downstream Impervious Area Runoff		0.033					98	0.20	0.04	0.264	31	233	
	Weighted Volume Total											**49**	**363**	
Reduction in Runoff obtained by disconnecting Roof												**66**	**491**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	9
Zoning Type	Residential 1/4 Acre
Zoning ID	R-1-10

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.260**	acres	11320	sq ft
Roof	0.072	acres	3147	sq ft
Driveway/sidewalk	0.081	acres	3548	sq ft
Other Impervious	0.009	acres	380	sq ft
Lawn	0.059	acres	2550	sq ft
Other Pervious	0.039	acres	1695	sq ft

Impervious Areas				
Total Impervious Area	**0.162**	acres	7075	sq ft
	63%			
Directly Connected Impervious Areas				
w/ Roof connected	0.154	acres	6695	sq ft
w/ Roof disconnected	0.081	acres	3548	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.009	acres	380	sq ft
w/ Roof disconnected	0.081	acres	3527	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**49**	**67**	**78**	**83**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.162	0.097	63		83	92	0.87	0.17	0.062	**59**	**440**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.097				49	10.41	2.08	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.162					98	0.20	0.04	0.264	156	1165	
	Weighted Volume Total										0.264	**156**	**1165**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.081					98	0.20	0.04	0.264	78	581	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.22												
	New Total Effective Rainfall Depth (in)	0.66												
	Downstream Pervious Area Runoff			0.097				49	10.41	2.08	0.000	0	0	
	Downstream Impervious Area Runoff		0.081					98	0.20	0.04	0.264	78	584	
	Weighted Volume Total											**78**	**584**	
Reduction in Runoff obtained by disconnecting Roof												**78**	**581**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.162	0.097	63		83	92	0.87	0.17	0.062	**59**	**440**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.097				67	4.93	0.99	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.162					98	0.20	0.04	0.264	156	1165	
	Weighted Volume Total										0.264	**156**	**1165**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.081					98	0.20	0.04	0.264	78	581	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.22												
	New Total Effective Rainfall Depth (in)	0.66												
	Downstream Pervious Area Runoff			0.097				67	4.93	0.99	0.000	0	0	
	Downstream Impervious Area Runoff		0.081					98	0.20	0.04	0.264	78	584	
	Weighted Volume Total											**78**	**584**	
Reduction in Runoff obtained by disconnecting Roof												**78**	**581**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.162	0.097	63		83	92	0.87	0.17	0.062	**59**	**440**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.097				78	2.82	0.56	0.000	0	0	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.162					98	0.20	0.04	0.264	156	1165	
	Weighted Volume Total										0.264	**156**	**1165**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.081					98	0.20	0.04	0.264	78	581	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.22												
	New Total Effective Rainfall Depth (in)	0.66												
	Downstream Pervious Area Runoff			0.097				78	2.82	0.56	0.003	1	8	
	Downstream Impervious Area Runoff		0.081					98	0.20	0.04	0.264	78	584	
	Weighted Volume Total											**79**	**593**	
Reduction in Runoff obtained by disconnecting Roof												**77**	**572**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**7**	**53**	
Developed (Composite Curve Number Approach)			0.162	0.097	63		83	92	0.87	0.17	0.062	**59**	**440**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.097				83	2.05	0.41	0.000	0	1	Calculates runoff from impervious area and pervious areas separately.
	Impervious Area		0.162					98	0.20	0.04	0.264	156	1165	
	Weighted Volume Total										0.265	**156**	**1166**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.081					98	0.20	0.04	0.264	78	581	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.22												
	New Total Effective Rainfall Depth (in)	0.66												
	Downstream Pervious Area Runoff			0.097				83	2.05	0.41	0.027	10	72	
	Downstream Impervious Area Runoff		0.081					98	0.20	0.04	0.264	78	584	
	Weighted Volume Total											**88**	**656**	
Reduction in Runoff obtained by disconnecting Roof												**68**	**510**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	10	
Zoning Type	Residential 1/8 Acre	
Zoning ID	R-1-6	

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.120**	acres	5225	sq ft
Roof	0.049	acres	2155	sq ft
Driveway/sidewalk	0.017	acres	722	sq ft
Other Impervious	0.011	acres	479	sq ft
Lawn	0.017	acres	762	sq ft
Other Pervious	0.025	acres	1107	sq ft

Impervious Areas				
Total Impervious Area	**0.077**	acres	3356	sq ft
	64%			
Directly Connected Impervious Areas				
w/ Roof connected	0.066	acres	2878	sq ft
w/ Roof disconnected	0.017	acres	722	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.011	acres	479	sq ft
w/ Roof disconnected	0.060	acres	2634	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**53**	**70**	**81**	**85**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp}	A_{per}	P_{imp}	R	CN_p	CN_c	S	Ia	Volume			Comments
			(acres)	(acres)	(%)	(%)	-	-	(in)	(in)	(in)	(cu ft)	(gal)	
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.077	0.043	64		85	93	0.75	0.15	0.080	**35**	**262**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.043				53	8.87	1.77	0.000	0	0	
	Impervious Area		0.077					98	0.20	0.04	0.264	74	553	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**74**	**553**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.060					98	0.20	0.04	0.264	58	434	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.37												
	New Total Effective Rainfall Depth (in)	0.81												
	Downstream Pervious Area Runoff			0.043				53	8.87	1.77	0.000	0	0	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	119	
	Weighted Volume Total											**16**	**119**	
Reduction in Runoff obtained by disconnecting Roof												**58**	**434**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.077	0.043	64		85	93	0.75	0.15	0.080	**35**	**262**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.043				70	4.29	0.86	0.000	0	0	
	Impervious Area		0.077					98	0.20	0.04	0.264	74	553	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**74**	**553**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.060					98	0.20	0.04	0.264	58	434	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.37												
	New Total Effective Rainfall Depth (in)	0.81												
	Downstream Pervious Area Runoff			0.043				70	4.29	0.86	0.000	0	0	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	119	
	Weighted Volume Total											**16**	**119**	
Reduction in Runoff obtained by disconnecting Roof												**58**	**434**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.077	0.043	64		85	93	0.75	0.15	0.080	**35**	**262**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.043				81	2.35	0.47	0.000	0	0	
	Impervious Area		0.077					98	0.20	0.04	0.264	74	553	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**74**	**553**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.060					98	0.20	0.04	0.264	58	434	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.37												
	New Total Effective Rainfall Depth (in)	0.81												
	Downstream Pervious Area Runoff			0.043				81	2.35	0.47	0.043	7	50	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	119	
	Weighted Volume Total											**23**	**169**	
Reduction in Runoff obtained by disconnecting Roof												**51**	**383**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**3**	**24**	
Developed (Composite Curve Number Approach)			0.077	0.043	64		85	93	0.75	0.15	0.080	**35**	**262**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.043				85	1.76	0.35	0.004	1	5	
	Impervious Area		0.077					98	0.20	0.04	0.264	74	553	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.268	**75**	**557**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.060					98	0.20	0.04	0.264	58	434	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Equiv. Rain on Downstream Pervious Area (in)	0.37												
	New Total Effective Rainfall Depth (in)	0.81												
	Downstream Pervious Area Runoff			0.043				85	1.76	0.35	0.094	15	110	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	119	
	Weighted Volume Total											**31**	**228**	
Reduction in Runoff obtained by disconnecting Roof												**44**	**329**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	11
Zoning Type	Residential 1/8 Acre
Zoning ID	R-1-6

80th Percentile Storm Depth	**0.44**	in

Total Area	**0.142**	acres	6166	sq ft
Roof	0.054	acres	2333	sq ft
Driveway/sidewalk	0.016	acres	699	sq ft
Other Impervious	0.011	acres	475	sq ft
Lawn	0.025	acres	1093	sq ft
Other Pervious	0.036	acres	1566	sq ft

Impervious Areas				
Total Impervious Area	**0.081**	acres	3507	sq ft
	57%			
Directly Connected Impervious Areas				
w/ Roof connected	0.070	acres	3032	sq ft
w/ Roof disconnected	0.016	acres	699	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.011	acres	475	sq ft
w/ Roof disconnected	0.064	acres	2808	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**53**	**70**	**80**	**85**

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.081	0.061	57		85	92	0.87	0.17	0.062	**32**	**240**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.061				53	8.87	1.77	0.000	0	0	
	Impervious Area		0.081					98	0.20	0.04	0.264	77	577	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**77**	**577**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.064					98	0.20	0.04	0.264	62	462	
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.061				53	8.87	1.77	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.016					98	0.20	0.04	0.264	15	115	
	Weighted Volume Total											**15**	**115**	
Reduction in Runoff obtained by disconnecting Roof												**62**	**462**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.081	0.061	57		85	92	0.87	0.17	0.062	**32**	**240**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.061				70	4.29	0.86	0.000	0	0	
	Impervious Area		0.081					98	0.20	0.04	0.264	77	577	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**77**	**577**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.064					98	0.20	0.04	0.264	62	462	
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.061				70	4.29	0.86	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.016					98	0.20	0.04	0.264	15	115	
	Weighted Volume Total											**15**	**115**	
Reduction in Runoff obtained by disconnecting Roof												**62**	**462**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.081	0.061	57		85	92	0.87	0.17	0.062	**32**	**240**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.061				80	2.50	0.50	0.000	0	0	
	Impervious Area		0.081					98	0.20	0.04	0.264	77	577	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**77**	**577**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.064					98	0.20	0.04	0.264	62	462	
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.061				80	2.50	0.50	0.018	4	30	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.016					98	0.20	0.04	0.264	15	115	
	Weighted Volume Total											**19**	**145**	
Reduction in Runoff obtained by disconnecting Roof												**58**	**433**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**4**	**29**	
Developed (Composite Curve Number Approach)			0.081	0.061	57		85	92	0.87	0.17	0.062	**32**	**240**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.061				85	1.76	0.35	0.004	1	7	
	Impervious Area		0.081					98	0.20	0.04	0.264	77	577	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.268	**78**	**584**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.064					98	0.20	0.04	0.264	62	462	
	Equiv. Rain on Downstream Pervious Area (in)	0.28												
	New Total Effective Rainfall Depth (in)	0.72												
	Downstream Pervious Area Runoff			0.061				85	1.76	0.35	0.063	14	105	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		0.016					98	0.20	0.04	0.264	15	115	
	Weighted Volume Total											**29**	**220**	
Reduction in Runoff obtained by disconnecting Roof												**49**	**364**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	12
Zoning Type	Residential 1/8 Acre
Zoning ID	R-1-6

80th Percentile Storm Depth	0.44	in

Total Area	**0.120**	acres	5219	sq ft
Roof	0.048	acres	2097	sq ft
Driveway/sidewalk	0.017	acres	750	sq ft
Other Impervious	0.002	acres	104	sq ft
Lawn	0.019	acres	806	sq ft
Other Pervious	0.034	acres	1463	sq ft

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

Impervious Areas				
Total Impervious Area	**0.068**	acres	2951	sq ft
	57%			
Directly Connected Impervious Areas				
w/ Roof connected	0.065	acres	2847	sq ft
w/ Roof disconnected	0.017	acres	750	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.002	acres	104	sq ft
w/ Roof disconnected	0.051	acres	2201	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**54**	**71**	**81**	**85**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.068	0.052	57		85	92	0.87	0.17	0.062	**27**	**203**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.052				54	8.52	1.70	0.000	0	0	
	Impervious Area		0.068					98	0.20	0.04	0.264	65	486	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**65**	**486**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.051					98	0.20	0.04	0.264	48	362	
	Equiv. Rain on Downstream Pervious Area (in)	0.26												
	New Total Effective Rainfall Depth (in)	0.70												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.052				54	8.52	1.70	0.000	0	0	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	123	
	Weighted Volume Total											**16**	**123**	
Reduction in Runoff obtained by disconnecting Roof												**48**	**362**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.068	0.052	57		85	92	0.87	0.17	0.062	**27**	**203**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.052				71	4.08	0.82	0.000	0	0	
	Impervious Area		0.068					98	0.20	0.04	0.264	65	486	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**65**	**486**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.051					98	0.20	0.04	0.264	48	362	
	Equiv. Rain on Downstream Pervious Area (in)	0.26												
	New Total Effective Rainfall Depth (in)	0.70												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.052				71	4.08	0.82	0.000	0	0	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	123	
	Weighted Volume Total											**16**	**123**	
Reduction in Runoff obtained by disconnecting Roof												**48**	**362**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			0.068	0.052	57		85	92	0.87	0.17	0.062	**27**	**203**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.052				81	2.35	0.47	0.000	0	0	
	Impervious Area		0.068					98	0.20	0.04	0.264	65	486	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**65**	**486**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.051					98	0.20	0.04	0.264	48	362	
	Equiv. Rain on Downstream Pervious Area (in)	0.26												
	New Total Effective Rainfall Depth (in)	0.70												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.052				81	2.35	0.47	0.021	4	29	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	123	
	Weighted Volume Total											**20**	**153**	
Reduction in Runoff obtained by disconnecting Roof												**45**	**333**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**3**	**24**	
Developed (Composite Curve Number Approach)			0.068	0.052	57		85	92	0.87	0.17	0.062	**27**	**203**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			0.052				85	1.76	0.35	0.004	1	6	
	Impervious Area		0.068					98	0.20	0.04	0.264	65	486	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.268	**66**	**492**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		0.051					98	0.20	0.04	0.264	48	362	
	Equiv. Rain on Downstream Pervious Area (in)	0.26												
	New Total Effective Rainfall Depth (in)	0.70												Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Pervious Area Runoff			0.052				85	1.76	0.35	0.057	11	81	
	Downstream Impervious Area Runoff		0.017					98	0.20	0.04	0.264	16	123	
	Weighted Volume Total											**27**	**204**	
Reduction in Runoff obtained by disconnecting Roof												**38**	**288**	

Sample Site Data and Calculations are Provided FOR INFORMATION ONLY

Example Number	13
Zoning Type	Townhomes
Zoning ID	PUD

Variable Abbreviations	
A_{imp}	Impervious Area, acres
A_{per}	Pervious Area, acres
P_{imp}	Percent Impervious, %
CN_p	Pervious Area Curve Number
CN_c	Composite Curve Number
S	Maxiumum Potential Retention, inches
Ia	Initial Abstraction, inches

80th Percentile Storm Depth	**0.44**	in

Total Area	**12.767**	acres	556120	sq ft
Roof	2.817	acres	122706	sq ft
Driveway/sidewalk	3.689	acres	160710	sq ft
Other Impervious	0.599	acres	26108	sq ft
Lawn	0.325	acres	14151	sq ft
Other Pervious	5.336	acres	232444	sq ft

Impervious Areas				
Total Impervious Area	**7.106**	acres	309525	sq ft
	56%			
Directly Connected Impervious Areas				
w/ Roof connected	6.506	acres	283416	sq ft
w/ Roof disconnected	3.689	acres	160710	sq ft
Unconnnected Impervious Areas				
w/ Roof connected	0.599	acres	26108	sq ft
w/ Roof disconnected	3.416	acres	148815	sq ft

Curve numbers				
Soil Type	A	B	C	D
Undeveloped (Desert, Fair)	55	72	81	86
Natural Desert Landscaping	63	77	85	88
Lawn	39	61	74	80
Impervious Areas	98	98	98	98
Composite Pervious Numbers for this lot	**62**	**76**	**84**	**88**

Volume NEH 630/TR-55 Method

Scenario Description			A_{imp} (acres)	A_{per} (acres)	P_{imp} (%)	R (%)	CN_p -	CN_c -	S (in)	Ia (in)	Volume (in)	Volume (cu ft)	Volume (gal)	Comments
Soil Type A														
Undeveloped (Desert, Fair)					0	0	55	55	8.18	1.64	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			7.106	5.661	56		88	94	0.64	0.13	0.103	**4756**	**35576**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			5.661				62	6.13	1.23	0.000	0	0	
	Impervious Area		7.106					98	0.20	0.04	0.264	6813	50966	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**6813**	**50966**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		3.416					98	0.20	0.04	0.264	3276	24504	
	Equiv. Rain on Downstream Pervious Area (in)	0.16												
	New Total Effective Rainfall Depth (in)	0.60												
	Downstream Pervious Area Runoff			5.661				62	6.13	1.23	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		3.689					98	0.20	0.04	0.264	3538	26463	
	Weighted Volume Total											**3538**	**26463**	
Reduction in Runoff obtained by disconnecting Roof												**3276**	**24504**	
Soil Type B														
Undeveloped (Desert, Fair)					0	0	72	72	3.89	0.78	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			7.106	5.661	56		88	94	0.64	0.13	0.103	**4756**	**35576**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			5.661				76	3.16	0.63	0.000	0	0	
	Impervious Area		7.106					98	0.20	0.04	0.264	6813	50966	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.264	**6813**	**50966**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		3.416					98	0.20	0.04	0.264	3276	24504	
	Equiv. Rain on Downstream Pervious Area (in)	0.16												
	New Total Effective Rainfall Depth (in)	0.60												
	Downstream Pervious Area Runoff			5.661				76	3.16	0.63	0.000	0	0	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		3.689					98	0.20	0.04	0.264	3538	26463	
	Weighted Volume Total											**3538**	**26463**	
Reduction in Runoff obtained by disconnecting Roof												**3276**	**24504**	
Soil Type C														
Undeveloped (Desert, Fair)					0	0	81	81	2.35	0.47	0.000	**0**	**0**	
Developed (Composite Curve Number Approach)			7.106	5.661	56		88	94	0.64	0.13	0.103	**4756**	**35576**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			5.661				84	1.90	0.38	0.002	36	273	
	Impervious Area		7.106					98	0.20	0.04	0.264	6813	50966	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.266	**6850**	**51239**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		3.416					98	0.20	0.04	0.264	3276	24504	
	Equiv. Rain on Downstream Pervious Area (in)	0.16												
	New Total Effective Rainfall Depth (in)	0.60												
	Downstream Pervious Area Runoff			5.661				84	1.90	0.38	0.023	464	3473	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		3.689					98	0.20	0.04	0.264	3538	26463	
	Weighted Volume Total											**4002**	**29935**	
Reduction in Runoff obtained by disconnecting Roof												**2848**	**21304**	
Soil Type D														
Undeveloped (Desert, Fair)					0	0	86	86	1.63	0.33	0.008	**348**	**2605**	
Developed (Composite Curve Number Approach)			7.106	5.661	56		88	94	0.64	0.13	0.103	**4756**	**35576**	Typical Method - Underestimates runoff for areas with directly connected impervious surfaces.
Roof Connected - Weighted Average Volume	Pervious Area			5.661				88	1.36	0.27	0.018	376	2810	
	Impervious Area		7.106					98	0.20	0.04	0.264	6813	50966	Calculates runoff from impervious area and pervious areas separately.
	Weighted Volume Total										0.282	**7189**	**53776**	
Roof Disconnected - Two-Step Runoff Method	Runoff from Disconnected Imp Area		3.416					98	0.20	0.04	0.264	3276	24504	
	Equiv. Rain on Downstream Pervious Area (in)	0.16												
	New Total Effective Rainfall Depth (in)	0.60												
	Downstream Pervious Area Runoff			5.661				88	1.36	0.27	0.063	1302	9737	Calculates runoff from roof, then applies that runoff as "rainfall" to the remaining downstream pervious areas.
	Downstream Impervious Area Runoff		3.689					98	0.20	0.04	0.264	3538	26463	
	Weighted Volume Total											**4839**	**36200**	
Reduction in Runoff obtained by disconnecting Roof												**2350**	**17576**	

Appendix H:
Noxious Weed Field Guide

NOXIOUS WEED FIELD GUIDE FOR UTAH



EXTENSION

UtahStateUniversity

4th Edition

Authors: Brenda Jarvis Lowry, Corey V. Ransom, Ralph E. Whitesides, and Heather Olsen

Edited by: Brenda Jarvis Lowry

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Graphics and design by: Mike Wernert

This handbook is valid as to its list of noxious weeds as of the date of publication. However, the list is subject to change. Please contact the Utah Department of Agriculture and Food, or go to ag.utah.gov/plants-pests.html to ensure you have the most up-to-date information.

The authors gratefully acknowledge the contributions of the authors of previous editions: Nathan Belliston, Ralph Whitesides, Steven Dewey, Joel Merritt, and Stephen Burningham.

ON THE COVER

Left to Right: *Musk Thistle – pg. 72, Camelthorn – pg. 10, Purple Loosestrife – pg. 48, Cogongrass – pg. 92*

CONTENTS

INTRODUCTION

Noxious Weeds a Biological Wildfire

Invasive noxious weeds have been described as a raging biological wildfire – out of control, spreading rapidly, and causing enormous economic losses. Millions of acres in North America have been invaded or are at risk of being invaded by weeds, including cropland, pastures, rangelands, forests, wilderness areas, national parks, recreation sites, wildlife management areas, transportation corridors, waterways, wetlands, parks, golf courses, even yards and gardens. Noxious weeds are capable of spreading at rates of up to 60% annually (Smith et al. 1999).

Devastation caused by noxious weeds is enormous. Economic losses from weeds exceed $30 billion (Pimentel et al. 2005) annually in the United States, and the cost continues to grow. Weeds often reduce crop yields, and can damage watersheds, increase soil erosion, negatively impact wildland plant and animal communities, and adversely affect outdoor recreation. Ecological damage from uncontrolled noxious weed infestations can be permanent, leaving lands unable to return naturally to their pre-invasion condition.

The weeds included in this guide are legally denoted as noxious according to Utah state law (Code 4-17). Through a structured decision-making process, and with the use of a prioritization tool to help guide the process, the current noxious weed list was determined. The process was biased toward weed species that currently have limited state-wide distribution, and also included those that have not yet been identified as occurring within the state. Because weed management focused on newly invading species, it holds the most promise for effective management.

Prevention, preserving, and protecting lands not presently infested is the first line of defense against aggressive noxious weeds. Prevention requires awareness and action by land managers as well as the general public, to recognize, report, and control new infestations before they have a chance to expand and spread.

Effective April 2016, the Utah Noxious Weed Act was also amended to allow for an updated categorization of weeds based on preventive or management measures. The categories are as follows:

Class IA Early Detection Rapid Response (EDRR)/Watch List: Plants not known to be in Utah, but thought to be present in neighboring states. If found in the state, swift eradication of any plants in this category is a very high priority.

Class IB Early Detection (ED): Plants that occur in Utah at very low levels. It is a high priority to eradicate all known populations, and prevent new ones.

Class II Control: Plants that have a reasonable distribution in Utah, but do not occur everywhere. These should be given a high priority for control.

Class III Contain: Plants widely distributed in Utah. The current populations of these plants should be contained to halt their spread. These plants should not enter commercial channels.

Class IV Prohibited: Plants that are present in Utah, appear to be arriving in nursery stock/seed, and are being sold as ornamentals. This is now illegal.

USING THIS BOOK

This publication is designed to help you identify some of the common noxious and invasive weed species that are currently threatening Utah and have been identified on Utah's state weed list. If you are an outdoor enthusiast or other concerned citizen, this booklet will help you recognize these invasive weeds so you can report them to proper authorities before significant spread and damage can occur. If you are an agriculturalist or public land manager, this booklet will help you more accurately identify the invasive weeds in the area of your stewardship — a critical step in choosing the most effective control strategy.

This book is divided into five color-coded sections that reflect the categories and weed rankings from a statewide perspective. Individual counties may add county-declared noxious weeds to the list and rank the state-listed weeds in different categories, but cannot delete state-listed weeds.

Except for Class IA weeds, each of the noxious weeds in this book occupies one full spread of the publication, with written information on the left side and photos of the weed on the right. Class IA weeds are given minimal treatment, appearing four to a spread (two per page). Weeds are listed in alphabetical order by common name within the designated noxious classifications. Scientific names are listed directly underneath the main common names.

COMMON NAME

The most widely accepted name used by the Weed Science Society of America (WSSA) and found in the book *Weeds of the West*.

SCIENTIFIC NAME

The officially accepted scientific name used by WSSA and found in the book *Weeds of the West*, plus common synonyms.

For each weed, given underneath the names are the following:

BACKGROUND

The plant's origin, habitat preferences, and reasons for noxious designation.

OTHER COMMON NAMES

Local or historical names.

DESCRIPTION

Life cycle, distinguishing characteristics, and methods of reproduction.

CONTROL

General effective control methods.

DISTRIBUTION MAPS

The known county distribution in Utah, from EDDmapS (see references), current as of December 2016.

Class IA Weeds
(Early Detection Rapid Response Watch List)

African Rue *Peganum harmala*

DESCRIPTION: A succulent, highly-branched herbaceous perennial, which grows 1-1 ½ feet tall and 3-4 feet wide. Leaves are very narrow and are divided into fine segments. When crushed, stems and leaves have an unpleasant smell. Five-petaled white flowers yield segmented seed pods.

(UGA5078008)

Common Crupina
Crupina vulgaris

DESCRIPTION: A winter annual. Common crupina grows 1-4 feet tall on a spiny stem that branches widely at the top, bearing up to 40 flower heads. Leaves have spiny margins and are increasingly lobed toward the top of the stems, with upper leaves threadlike. Flower heads are pinkish purple with a swollen base.

(UGA1459128)

Malta Starthistle

Centaurea melitensis

OTHER COMMON NAME: Malta thistle

DESCRIPTION: An annual or biennial plant that grows 1-2 feet tall on stiff, branching stems. Leaves are grayish green with stiff hairs, and dotted with resin. Leaf bases extend down the stem and cause the stem to look winged. Sharp purplish spines occur below the yellow flower head.

Mediterranean Sage

Salvia aethiopis

OTHER COMMON NAME: Ethiopian sage

DESCRIPTION: A shrubby biennial plant that can grow 2-3 feet tall and 2-3 feet wide. Rosette leaves are grayish-green, and triangular. The mature plant has multiple square stems covered with fine hairs and woolly leaves. Flowers are yellowish-white. It becomes a tumbleweed when mature.

(UGA0021072)

Plumeless Thistle

Carduus acanthoides

DESCRIPTION: A winter annual or biennial. Plumeless thistle can grow over 5 feet tall on spiny-winged stems. Rosette leaves are wavy, with white margins. Leaves are hairy underneath and spiny at the margins. Purple flower heads are borne in clusters at the spiny stem tips throughout the summer.

(UGA5290084)

Small Bugloss

Anchusa arvensis

OTHER COMMON NAME: Annual bugloss

DESCRIPTION: Small bugloss is a branching, leafy annual covered with stiff hairs that grow 1-3 feet tall. Leaves are lance-shaped and wavy. Flowers are funnel-shaped and blue with a white center, and have five petals.

Contact your state or county weed specialist for specific, updated control information.

Spring Milletgrass

Milium vernale

OTHER COMMON NAME: Spring millet

DESCRIPTION: Spring milletgrass is an annual that grows 2 ½ feet tall, with drooping, upright or spreading stems. Stems are hollow with swollen joints that are sometimes purple. Stems each produce one cluster of flowers in the spring.

Syrian Beancaper

Zygophyllum fabago

DESCRIPTION: A rhizomatous woody perennial that grows up to 3 feet tall on multiple branches. The oblong leaves are smooth and waxy. Flowers are five-petaled, white with orange markings, and have orange filaments protruding beyond the petals. Seed pods are fleshy and cylindrical.

Contact your state or county weed specialist for specific, updated control information.

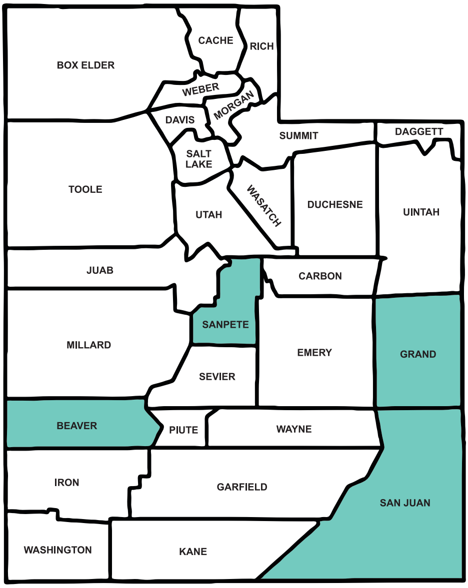
(UGA5078001)

Class IB Weeds
(Early Detection)

Camelthorn *Alhagi maurorum*

BACKGROUND: Native to Eurasia, camelthorn is a weed of rangeland, cropland, scrub wasteland, and waterways. It grows in dry or moist environments, tolerates poor soils, and can form dense stands. The plant is unpalatable and potentially harmful to livestock. It can also become a contaminant in alfalfa seed.

DESCRIPTION: A rhizomatous, thorny, highly branched herbaceous perennial that grows up to 4 feet tall. Pea-like flowers are pink to red and borne on spines that branch off the stems. Spine tips are dry and yellowed. Rhizomes penetrate deeply and spread aggressively, with new plants



regenerating easily from rhizome fragments. Seeds are borne in reddish-brown capsules, retain viability for several years, and are dispersed by animals or water.

CONTROL: Mowing and cultivation of mature plants encourage new growth, and should be avoided. Herbicides can be effective, if used long-term. Contact your state or county weed specialist for specific, updated information.

Camelthorn stand

Single plant

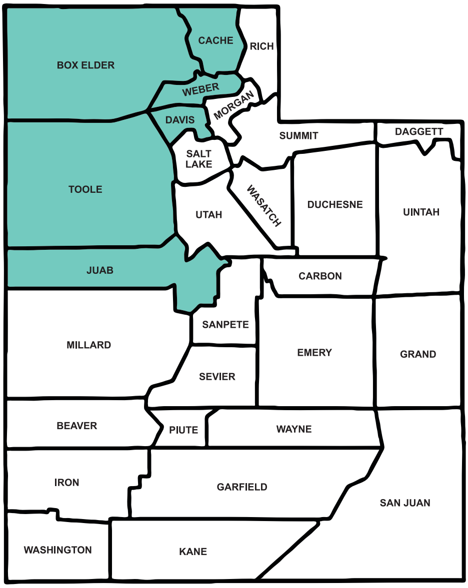
Pea-like flowers and dry spine tips

Common St. Johnswort *Hypericum perforatum*

BACKGROUND: St. Johnswort was introduced from Europe. It invades areas with sandy or gravelly soils. Reproduction is by seeds and short runners. It contains a substance that is toxic (but rarely fatal) to white-haired animals causing them to develop skin irritations and often lose weight when exposed to sunlight. It is also a key ingredient of some popular dietary supplements.

DESCRIPTION: This herbaceous perennial grows 1 to 3 feet tall. Stems are rust colored and woody at the base. Leaves are characterized by prominent veins and transparent dots, visible when held up to light. The flowers are bright yellow with five petals.

CONTROL: Several biocontrol agents are available and can offer good to excellent control. Herbicides can offer good control when applied to actively growing plants between rosette and pre-bloom stages. Contact your state or county weed specialist for specific, updated information.



Transparent dots on leaves

Bright yellow flowers

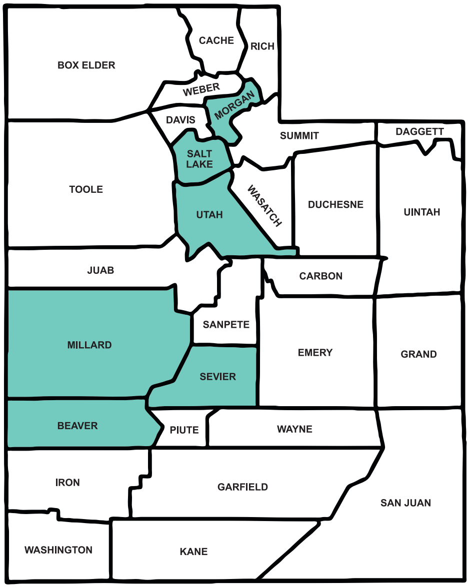
Stand of common St. Johnswort

Cutleaf Vipergrass *Scorzonera laciniata*

BACKGROUND: Native to Eurasia and Africa, cutleaf vipergrass is found in disturbed sites, in open or fallow fields, and on roadsides. It is reportedly edible, and sometimes grown as a crop. The plant is known to serve as a food source for clover cutworms (Anarta trifolii), which also feed on and damage a wide variety of food crops.

DESCRIPTION: An herbaceous, taprooted biennial or short-lived perennial, with hollow, branching stems, that grows about 1 1/2 feet tall. Rosette leaves are 2-8 inches long. Leaves can sometimes appear grass-like, due to deep dissections into narrow lobes. Each stem has one bright yellow composite ray flower head at the top, open a few hours daily. The plant flowers throughout the summer, and produces seed heads 1 to 2 inches in diameter, made up of many parachute-like seed pods.

CONTROL: Do not grow this plant. Contact your state or county weed specialist for specific, updated information.




Taproot


Rosette


Seedhead


Bright yellow composite ray flower head


Infested field


Closed bracts

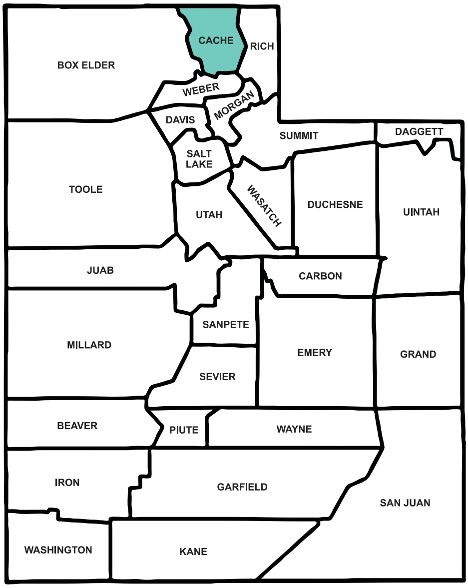

Plant with flowers and fruit in various stages

Elongated Mustard *Brassica elongata*

BACKGROUND: Native to Eurasia, elongated mustard is a weed of disturbed sites and roadsides. It tolerates a wide variety of growing conditions, and thrives in desert settings.

DESCRIPTION: Elongated mustard can be a biennial, winter annual, or short-lived perennial. Branched at the base, the plant grows to 3 feet tall. Lower leaves are shaped like flattened circles with slightly toothed margins, stem leaves are oblong and smaller. Bright yellow, fragrant four-petaled flowers are borne in clusters along stems in mid-summer. Seedpods grow upright and have a tapered tip. The plant produces abundant seed. Seeds are dispersed by wind, and become sticky when wet.

CONTROL: Hand-pulling and digging of seedlings and older plants before seed set is recommended. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Elongated mustard in a typical setting

Four-petaled flowers

Basal leaves

Seedpods

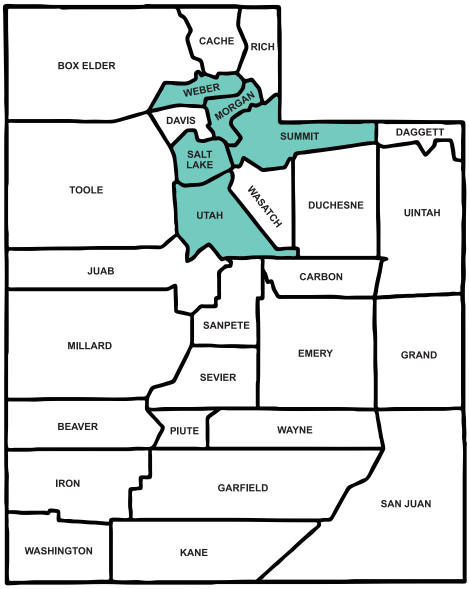
Single plant

Garlic Mustard *Alliaria petiolata*

BACKGROUND: This native to Europe is found in deciduous forests and wetlands, along roadsides, and in disturbed areas. It thrives in shady sites, and can form dense stands. Garlic mustard is suspected of chemically inhibiting the growth of other nearby plants, and is toxic to some native butterflies.

DESCRIPTION: Garlic mustard is a biennial that grows up to 4 feet tall. Rosette leaves have a rounded kidney shape, and mature leaves are arrow shaped with unevenly toothed margins. Injured plant parts smell like garlic. Branch tips produce clusters of four-petaled white flowers, and narrow seed pods grow upright from the stalk. Seeds are sticky when wet, and can remain viable for 5 years in the soil.

CONTROL: Hand-pull or dig before seed production, completely remove roots, and destroy plants with seedpods. Cutting stems at ground level prevents seed production. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Mature plants with seedpods

Flowering plants

Narrow seedpods and four-petaled flowers

Seedling plant

Rounded rosette leaves

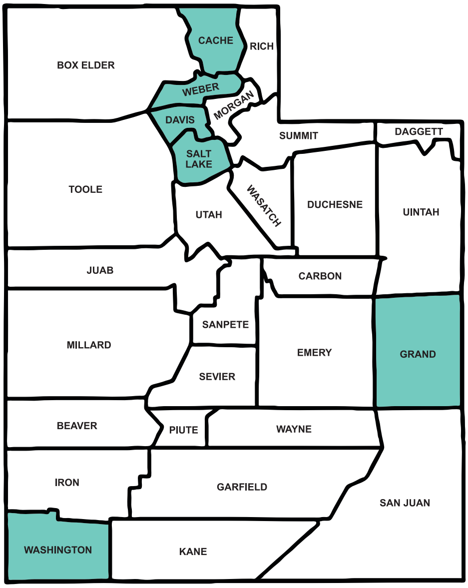
Giant Reed *Arundo donax*

BACKGROUND: Native to Eurasia, giant reed is a weed in waterways and wetlands, disturbed sites, and garden edges. Its aggressive habit allows it to displace native riparian vegetation. It can also be a fire hazard. It is sold as an ornamental and farmed for its canes.

OTHER COMMON NAME: Giant cane

DESCRIPTION: A perennial, creeping rhizomatous grass with hollow stems that grows 6-30 feet tall. The plant can regenerate easily from rhizome fragments. Rough-edged leaves grow up to 1-2 feet in length. Tightly packed cream to purplish-brown flowers form plumes that occur from early summer to early fall. Commonly mistaken for the related grass, phragmites, flower-bearing giant reed stems are hairless, whereas those of phragmites have silky hairs.

CONTROL: Do not buy giant reed at nurseries. Mowing and tilling encourage new growth and should be avoided. Chemical control can be effective. Contact your state or county weed specialist for specific, updated information.



Giant reed seedlings

A stand of giant reed

Rough-edged leaf

Rhizomes

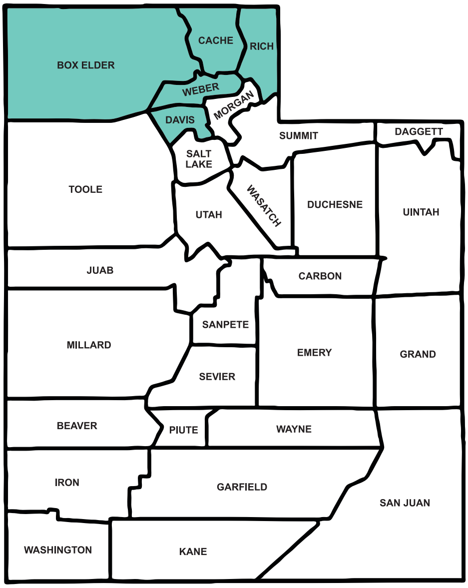
Flower plume

Goatsrue *Galega officinalis*

BACKGROUND: Native to Europe, goatsrue is found in wetlands, along waterways and roads, in pastures, and cropland. It is unpalatable and highly toxic to livestock, and can form dense stands. Goatsrue is a designated federal noxious weed.

DESCRIPTION: A tap-rooted herbaceous perennial with hollow stems that grows up to 5 feet tall. Compound leaves branch off the stems, having 9-15 leaflets each. Light purplish-white, pea-like flowers are borne in clusters at stem tips. Flowers bloom throughout the summer and produce tiny, narrow, elongated seed capsules. Each plant can produce up to 135,000 seeds. Seeds are dispersed in waterways, as a contaminant in seed, and on farm or construction equipment. Seeds can remain viable for up to 10 years.

CONTROL: Crop rotation, deep tilling, and digging are recommended for control. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



In typical setting

Flowering plant

Narrow, elongated seedpods

Compound leaves on young growth

Single plant

Pea-like flowers

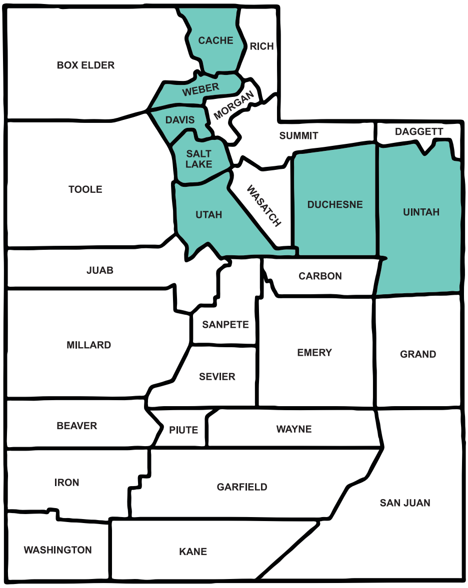
Japanese Knotweed *Polygonum cuspidatum*

Synonym: ***Fallopia japonica***

BACKGROUND: Native to Asia, Japanese knotweed is an escaped ornamental found along roadsides and waterways, in waste areas, and pastures. It forms thick stands and is also shade tolerant. Dormant plants can be a fire hazard.

DESCRIPTION: A creeping herbaceous perennial with hollow, reddish-brown, jointed stems. The plant grows 2.5-5 feet tall. Leaves are oval to heart-shaped. Tiny cream-colored flowers are borne in loose, branching clusters. Rhizomes can grow 30 feet long and form dense tangles. New plants can also regenerate from rhizome fragments.

CONTROL: When digging, the entire rhizome must be removed. Repeated mowing over a period of several years depletes the rhizomes. Japanese knotweed has been shown to have medicinal properties, for which it could potentially be harvested. Some herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Stand of Japanese knotweed

Heart-shaped leaves and fruit

Early growth

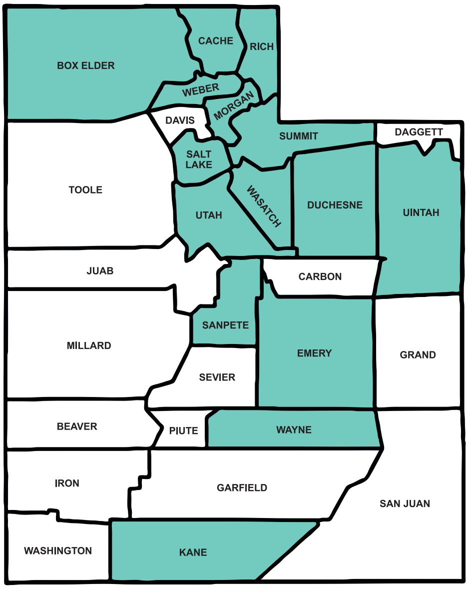
Reddish-brown stems and branching flower clusters (UGA1539051)

Oxeye Daisy *Leucanthemum vulgare*

BACKGROUND: This native of Europe survives in a wide range of environments. It is prevalent on poor soils, tolerates cold conditions, and survives drought well. Often found in meadows, roadsides, waste areas, grasslands, or overgrazed pastures.

DESCRIPTION: This creeping perennial, rhizomatous herb grows 1 to 3 feet tall. Leaves are lance-shaped with coarse teeth. Flowers range 1- 2.2 inches in diameter, and usually appear from June to August. The plant has a disagreeable odor if crushed. Although not toxic, it can give milk an off-flavor if consumed by dairy cattle. It grows in patches, and spreads vegetatively and by seed. Oxeye daisy's coarse toothed-leaf margins differentiate it from members of the Aster genus, with which it is often confused.

CONTROL: Cultivation is effective. Maintaining a dense crop canopy is effective in preventing establishment. Several herbicides give good control. Contact your state or county weed specialist for specific, updated information.



Patchy growth

Upper leaf lobes

Leaves with coarse teeth (UGA1459136)

Flowering plant

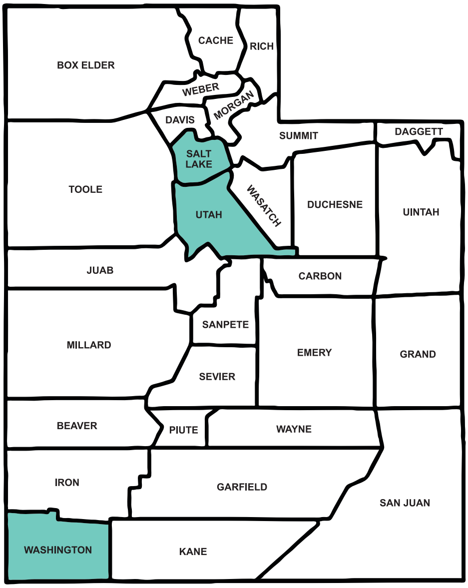
Young plant (1553166)

Purple Starthistle *Centaurea calcitrapa*

BACKGROUND: Native to Eurasia. Purple starthistle is a weed in rangeland, grassland, fields, disturbed areas, and along roadsides. It is unpalatable to livestock, is tolerant to many different soil types, and can form dense stands.

DESCRIPTION: A tap-rooted biennial with branching stems up to 3 feet tall. Rosette leaves are deeply lobed, and the rosette has a spiny center. Young stems and leaves are covered with long, soft, fine hairs. Stem leaves are narrow, not lobed, and have resinous dots on the surface. Flower heads are purple with long, yellow spines below. Purple starthistle blooms throughout the summer. Seeds are dispersed by water, vehicles, animals, and people. Seeds can retain viability for 3 years.

CONTROL: Small infestations can be controlled by digging, especially before seed production. Mowing encourages extra growth of the plant, and should be avoided. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Flowerhead with spines below

Deeply lobed rosette leaves and unlobed stem leaves

Purple starthistle infestation (UGA1459651)

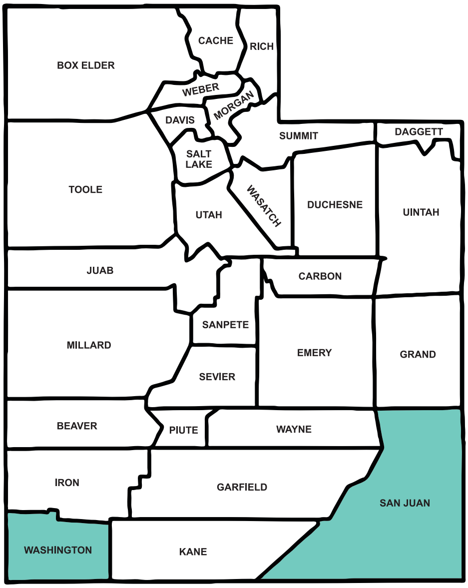
Sahara Mustard *Brassica tournefortii*

BACKGROUND: Native to northern Africa, the Middle East, and southern Europe, Sahara mustard is drought tolerant and thrives in poor soils, especially sandy areas, roadsides, unused fields, and even native desert shrublands. It can form dense stands and also be a fire hazard.

OTHER COMMON NAME: African mustard

DESCRIPTION: Sahara mustard is an annual. Rosette leaves are deeply lobed and can reach 12 inches long. Stem leaves are progressively fewer toward the tips. Stems grow up to 2 feet tall and are covered with stinging hairs. Sahara mustard usually flowers and sets seed very early in spring. Small, pale yellow, four-petaled flowers are borne in clusters on the ends of branches. Narrow seed capsules open when mature, releasing small seeds that are sticky when wet and impervious to water. When mature, the plant breaks off at the base and becomes a tumbleweed.

CONTROL: Plants in small infestations can be pulled before seed set. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Flowering plant (5374664)

Rosette (5374667)

Pale, four-petaled flowers

Narrow seed capsules

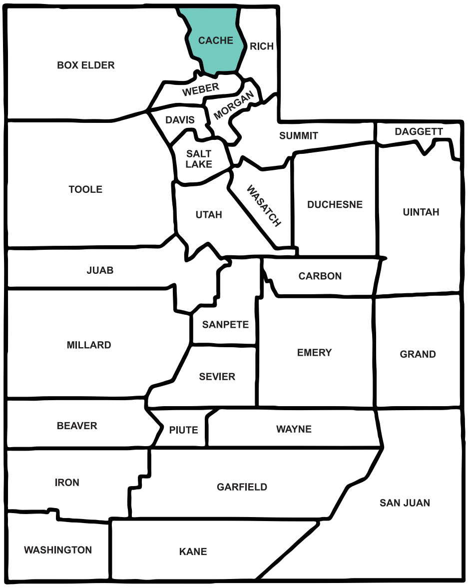
Ventenata *Ventenata dubia*

BACKGROUND: Introduced from Eurasia, ventenata occurs in grain crops, rangeland, and on disturbed sites. The seeds resemble wild oat seeds, with the bent awn. Once the panicles emerge, cattle will not graze it.

OTHER COMMON NAME: North Africa grass

DESCRIPTION: A winter annual grass that grows 6 inches to 2 feet tall. Seedlings have narrow leaves that are folded or rolled inward. Stems have reddish-black joints. Tan seed heads are produced in loose, branching clusters.

CONTROL: Effective control options are limited. Mowing may be effective if performed multiple times throughout the season. Fall applications of herbicides can also be effective. Contact your state or county weed specialist for specific, updated information.



Ventenata

Dark, swollen nodes and membranous ligule of ventenata.

Ventenata florets showing the bent awns.

Ventenata inflorescence

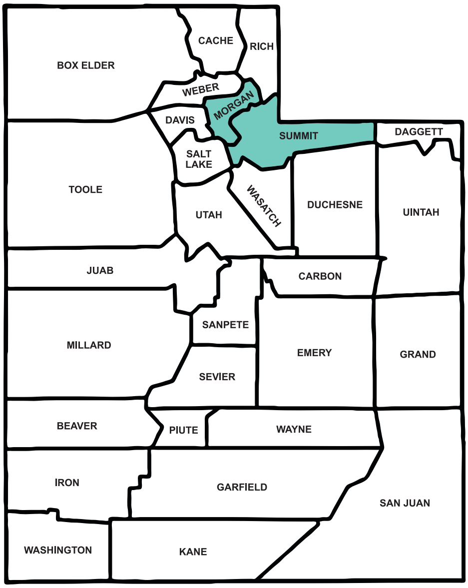
Vipers Bugloss *Echium vulgare*

BACKGROUND: Native to Eurasia, vipers bugloss is found in pastures, along roadsides and waterways, and in disturbed areas. It thrives in poor soil. The plant's stiff hairs can cause skin irritation in humans, and it is toxic and unpalatable to horses and cattle. It is also a known host of several crop diseases.

OTHER COMMON NAME: Blueweed

DESCRIPTION: A deeply taprooted biennial or short-lived perennial that grows 1-3 feet tall. Stems and leaves are rough and hairy. Stems are speckled purple and bear lance-shaped leaves. Flowers are borne on curling clusters that branch off the main stem. Flower buds are pink, but blooming flowers are bright blue and funnel-shaped. Each flower produces four seeds, which are viable up to 3 years.

CONTROL: Maintaining fertile soil and healthy desirable vegetation can reduce the plant's establishment. Pull or dig the plant before seeds set, and remove the tap root. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Rosette

Mature plant

Lance-shaped leaves and curling flower clusters

Hairy, speckled stem

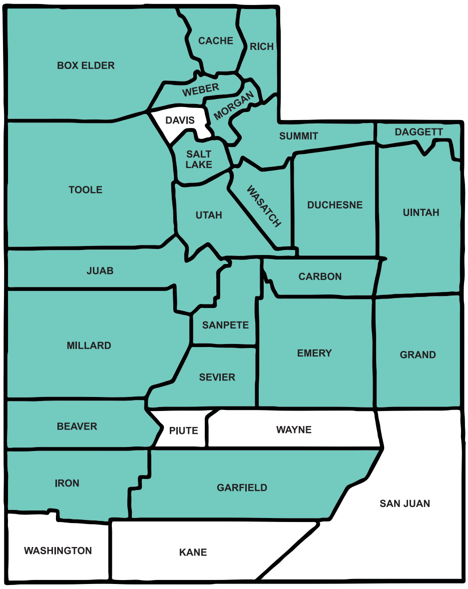
Class II Weeds
(Control)

Black Henbane *Hyoscyamus niger*

BACKGROUND: Black henbane is a native plant of Europe commonly found in waste areas, pastures, along rights-of-way, and fence lines. It is poisonous to both animals and humans; however, it has medical use in controlled circumstances.

DESCRIPTION: As either an annual or biennial, black henbane grows 1 to 3 feet tall. Leaves have pointed lobes and prominent veins. Off-white or greenish flowers with purple centers and veins are 1 to 2 inches wide. Pineapple-shaped fruit is borne in leaf axils. Each fruit has five lobes and contains hundreds of tiny black seeds. Bloom occurs in late spring.

CONTROL: Herbicides can be very effective when applied during rosette to bloom stages. Digging can offer some control. Contact your state or county weed specialist for specific, updated information.



Off-white flowers with purple centers

Rosette, leaves with pointed lobes

Mature flowering plant

Desiccated fruit

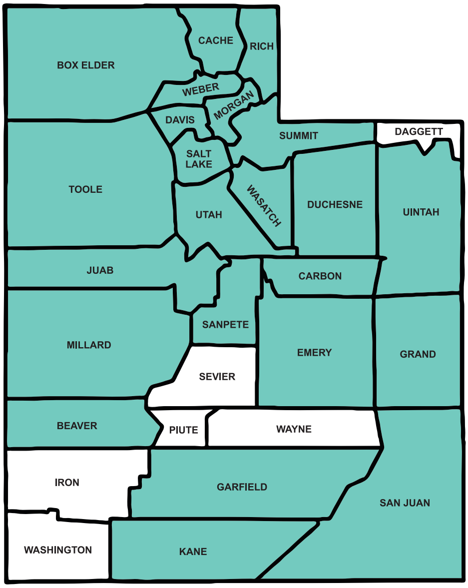
Pineapple-shaped fruit

Dalmatian Toadflax *Linaria dalmatica*

BACKGROUND: Dalmatian toadflax was brought to the United States from Europe, probably for ornamental purposes. It prefers rangeland and roadside habitat with sandy soils. It is very aggressive and hard to control due to deep roots and a thick, waxy leaf cuticle. It reproduces by seed and rootstock.

DESCRIPTION: This creeping herbaceous perennial weed grows from 2 to nearly 4 feet tall. Multiple stems may come from the base. Blue-green leaves alternately line the stem. Leaves are wedge shaped, have a thick, waxy cuticle, and partially clasp the stem. Flowers are yellow and may have white highlights and long tails, similar to snap dragon flowers. Bloom is in late spring into summer. Fruits are two-celled, berry-like capsules containing many seeds.

CONTROL: Biocontrol is available and offers fair control. Select herbicides can offer good control when applied from spring through fall. Contact your state or county weed specialist for specific, updated information.



Dalmatian toadflax patch

Creeping roots

Snapdragon-like flowers

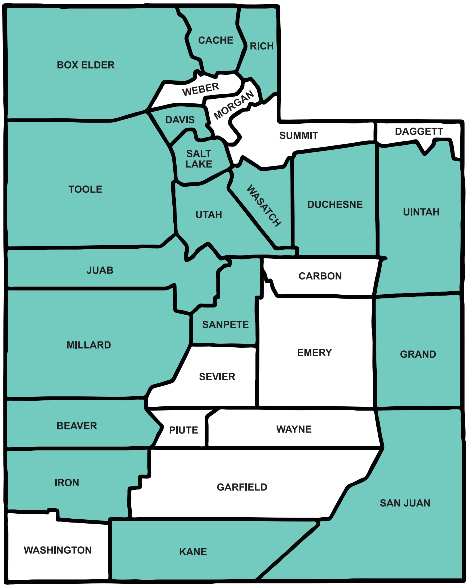
Waxy, wedge-shaped leaves

Diffuse Knapweed *Centaurea diffusa*

BACKGROUND: Native to Eurasia, diffuse knapweed inhabits dry rangeland, roadsides, field edges, and waste areas. Knapweeds release chemical substances into the soil that inhibit the growth of competing vegetation.

DESCRIPTION: It is an annual or a short-lived perennial averaging 1 to 2 feet tall. Leaves have finely divided lobes. Flowers are white to rose in color. Diffuse knapweed differs from squarrose knapweed in that the terminal spine of the toothed flower bracts is straight rather than arched outward. It blooms throughout summer.

CONTROL: Several biocontrol agents are available and provide fair to good control. Select herbicides can offer good to excellent control when applied from rosette to pre-bud stages. Tillage offers good control. Contact your state or county weed specialist for specific, updated information.



Mature flowering plant

White to rose flowers, and straight terminal spine of bracts

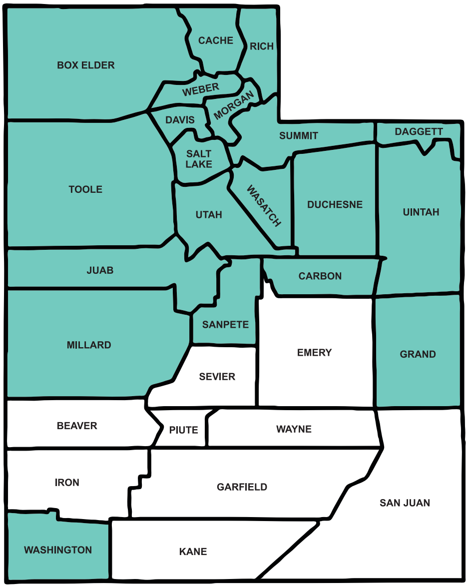
Rosette

Dyers Woad *Isatis tinctoria*

BACKGROUND: Dyers woad was introduced from Europe for production of textile dyes. It thrives in waste areas, gravel pits, road sides, pastures, field edges, and disturbed soils.

DESCRIPTION: Dyers woad may be a winter annual, biennial, or a short-lived perennial. Heights of 1 to 4 feet are common. A thick tap root may penetrate to 5 feet deep. Leaves are blue-green with a whitish midrib. The bright yellow, four-petaled flowers bloom and are highly visible in late spring. Club-shaped seed pods each produce a single seed. As the fruits mature, they turn from green to dark brown or nearly black.

CONTROL: Biocontrol rust fungus is naturally wide spread and other agents are currently undergoing research. Herbicides can offer good to excellent control when applied to rosettes in spring and fall and during pre-bloom. Digging offers good control. Contact your state or county weed specialist for specific, updated information.



Dyers woad infestation

Maturing fruits

Four-petaled flowers

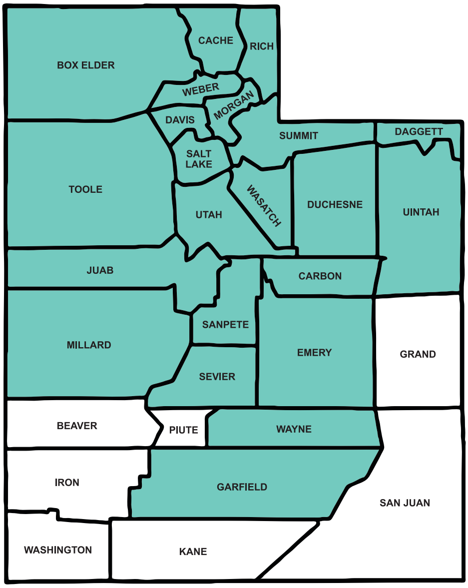
Flowering plant

Leafy Spurge *Euphorbia esula*

BACKGROUND: A native plant of Eurasia, leafy spurge is an aggressive invader of pastures, rangeland, stream banks, and waste areas. It reproduces by seed and rootstock. It is toxic to cattle and may result in their death.

DESCRIPTION: This creeping herbaceous perennial plant grows up to 3 feet tall. The leaves are narrow, and 1 to 4 inches long. In late spring, yellow-green flower bracts appear, which cup tiny, inconspicuous flowers that develop in early summer. Seeds are contained in a three-celled capsule, with one seed per cell. When dry, capsules can shoot seeds up to 15 feet from parent plant. Stems exude a milky fluid when damaged. An extensive root system, up to 20 feet long and more than 14 feet deep, with multiple shoot-producing buds, makes this plant very difficult to control.

CONTROL: Biocontrol is extensive and control is fair to excellent. Herbicides can offer fair to good control, especially when combined with biocontrol. Apply herbicides from spring to the killing frost. Contact your state or county weed specialist for specific, updated information.



Leafy spurge infestation

Flowering plant

Narrow leaves and milky sap

Yellow-green bracts cup tiny flowers

Close-up of flowers

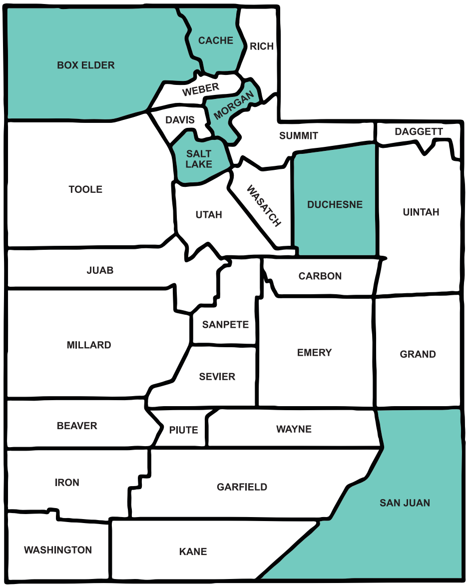
Medusahead *Taeniatherum caput-medusae*

BACKGROUND: Medusahead was brought to the United States from Eurasia. It is extremely competitive, completely displacing other desirable grass species. It spreads by seed, commonly carried by wind, animals, clothing, and vehicles.

OTHER COMMON NAME: Medusahead rye

DESCRIPTION: Medusahead is an annual growing from 6 inches to 2 feet high. Leaf blades are about 1/8 inch wide. Awns of the seedhead are long and become twisted as the seed matures. It is sometimes confused with foxtail barley or squirreltail, but is different in that the seedhead doesn't break apart completely as the seeds mature. Flowering and seed production take place in late spring and early summer.

CONTROL: A combination of burning, herbicide, and reseeding offers the best control. For the best results, this should be done in fall through early winter. Contact your state or county weed specialist for specific, updated information.



Thatch

Medusahead infestation

Seedhead

Seedheads

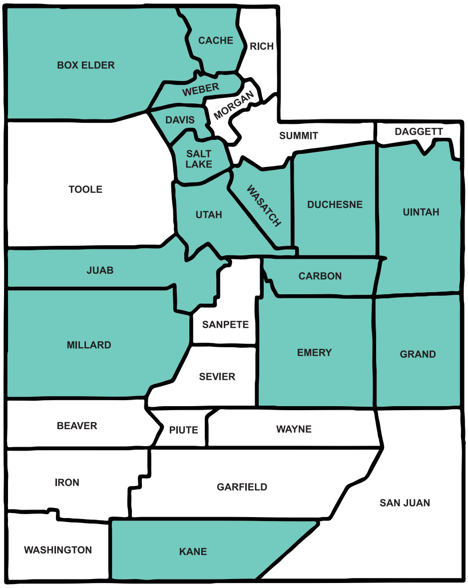
Infesting sagebrush

Purple Loosestrife *Lythrum salicaria*

BACKGROUND: Purple loosestrife is a European plant probably introduced to the United States as an ornamental. It reproduces both by seed and creeping rootstocks. Infestations can impede water flow and replace beneficial plants, and thus displace wildlife. It can be found in shallow, marshy wetland areas and ditches.

DESCRIPTION: Purple loosestrife is a semi-aquatic creeping herbaceous perennial growing 6 to 8 feet tall. There are five to seven petals on rose-purple flowers that appear in columns along the upper end of stems. Leaves are lance shaped with smooth margins up to 5 inches long. Bloom is in midsummer.

CONTROL: Biocontrol is limited in availability but control can be good to excellent. Herbicides with an aquatic label can offer fair to good control. Contact your state or county weed specialist for specific, updated information.



Growing along waterways

Purple flowers with five to seven petals

Lance-shaped leaves

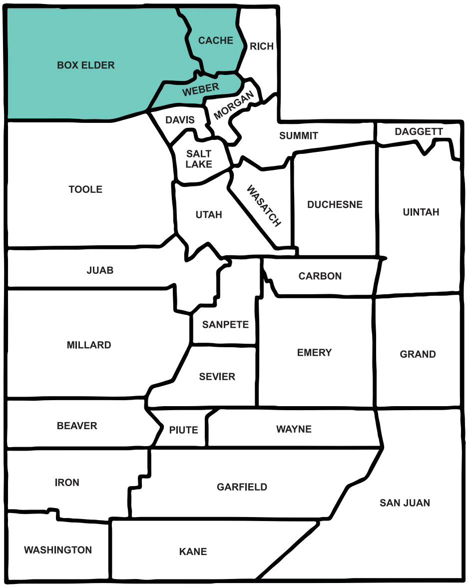
Flowers in columns at stem ends

Rush Skeletonweed *Chondrilla juncea*

BACKGROUND: Native to Eurasia, rush skeletonweed is found in rangeland, cropland, pastures, wasteland, disturbed areas, sagebrush, and along roadsides. It tolerates drought and many different soil types, and also benefits from wildfires.

DESCRIPTION: A deeply tap-rooted creeping perennial with stiff stems that grows up to 4 feet tall. The plant produces a rosette that dies back after stems develop. The lowest few inches of stems are covered in prickly hairs, and stems are nearly leafless. Plant parts exude a milky juice when damaged. Yellow flowers are dispersed irregularly among the branches. Plants do not need fertilization to produce seed, and root fragments can generate new plants, as well. Individual plants can produce 20,000 seeds, each with a small silky parachute. Stems die back in autumn.

CONTROL: Repeated hand-pulling and tilling help control rush skeletonweed. Biocontrol agents may be available. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Flowers and buds

Mature plant

Rosette and prickly, downward pointing hairs on stem

Silky seedhead

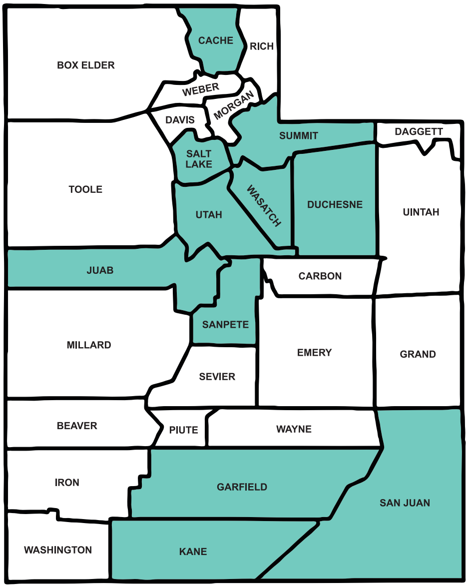
Spotted Knapweed *Centaurea stoebe*

Synonym: ***Centaurea maculosa***

BACKGROUND: Originally found in Eurasia, spotted knapweed infests rangeland, pastures, roadsides, or any disturbed soils. Knapweeds release chemical substances into the soil that inhibit the growth of competing vegetation.

DESCRIPTION: Spotted knapweed is a short-lived, creeping herbaceous perennial that is 1 to 3 feet tall. The rosette leaves are deeply lobed and may be 6 inches in length. The stems are moderately leaved. Flowers are typically pink with black-tipped flower bracts. Bloom is in early summer.

CONTROL: Several biocontrol agents are available and offer fair to good control. Select herbicides can offer good to excellent control when applied between rosette and pre-bud stages. Contact your state or county weed specialist for specific, updated information.



Rosette

Black-tipped flower bracts

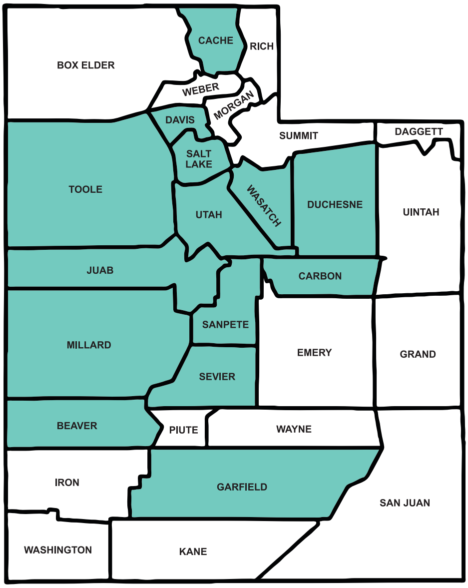
Flowering plant

Squarrose Knapweed *Centaurea virgata*

BACKGROUND: Squarrose knapweed is a native plant of the eastern Mediterranean area. It is very competitive on rangelands. Knapweed releases a chemical substance that reduces competing vegetation.

DESCRIPTION: This long-lived herbaceous weed has a simple taproot and grows 12 to 18 inches tall. The rosette and stems have deeply-lobed leaves. Flowers are rose to pink. It is often confused with diffuse knapweed, but differs in that the terminal spines on the flower bracts are curved outward and are not laterally toothed. Bloom occurs in early to mid-summer.

CONTROL: Several biocontrol agents are available. Herbicides offer good to excellent control. Contact your state or county weed specialist for specific, updated information.



Single plant

Deeply lobed rosette leaves

Bracts with outward curvature

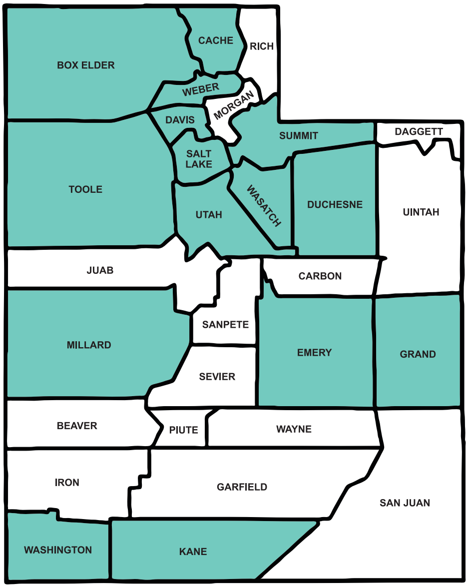
Squarrose knapweed infestation

Yellow Starthistle *Centaurea solstitialis*

BACKGROUND: Yellow starthistle was introduced from Europe. It grows well on dry sites in rangeland, roadsides, and waste areas. It can cause "Chewing disease" in horses that consume it.

DESCRIPTION: Yellow starthistle is a 2 to 3 foot tall winter annual with blue-green coloration. Rosette leaves are deeply lobed and could be confused with dandelion. Stems are winged and sparsely leaved. Flowers are yellow. Cream-colored thorns, 1/4 to 3/4 inch long, protrude from the flowering heads. Bloom is in early summer.

CONTROL: Several biocontrol agents have been tested, but availability is limited. Select herbicides offer fair to good control when applied between rosette and bloom stages. Tillage is effective. Contact your state or county weed specialist for specific, updated information.



Blue-green winged stem

Flower with cream-colored, thorny bracts

Flowering plant

Yellow starthistle infestation

Rosette

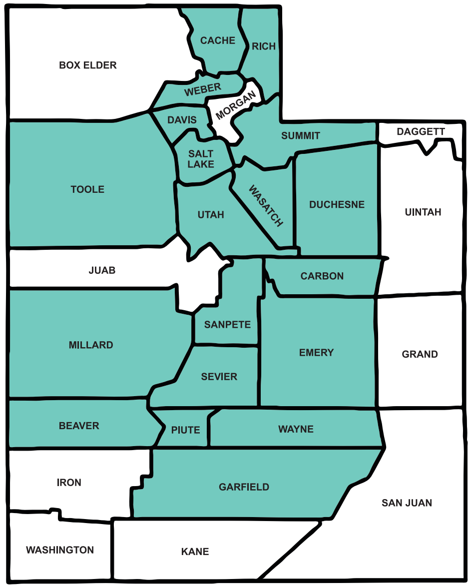
Yellow Toadflax *Linaria vulgaris*

BACKGROUND: Yellow toadflax came from Eurasia. It is an aggressive invader of rangeland, roadsides, field edges, and waste areas. An extensive root system makes this weed difficult to control. It reproduces by seeds and roots.

OTHER COMMON NAME: Butter and eggs

DESCRIPTION: This creeping herbaceous perennial weed grows to 2 feet tall. Leaves are 2.5 inches in length, and are narrow and pointed. Flowers are about 1 inch long, yellow with an orange throat, have long tails, and develop in dense, terminal clusters. They look similar to snap dragon flowers. Bloom is in late spring into summer. Fruits are small, 1/4 inch, two-celled, berry-like capsules containing many seeds.

CONTROL: A few biocontrol agents are available and offer fair control. Herbicides can offer good control. Contact your state or county weed specialist for specific, updated information.



Narrow, pointed leaves

Snapdragon-like flowers

Yellow toadflax infestation

Creeping roots

Class III Weeds
(Contain)

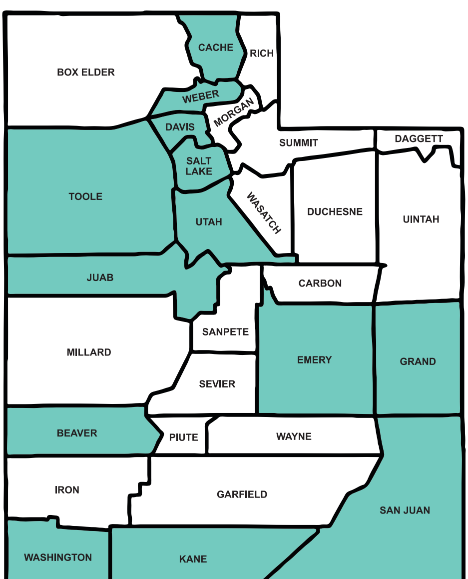
Bermudagrass *Cynodon dactylon*

BACKGROUND: Bermudagrass probably came from Africa. It prefers warmer regions, but it is becoming established in cooler regions as well. It is posing a serious threat to crop production and turf management. It reproduces by seed, rhizomes, and lateral stolons, taking root at any node.

DESCRIPTION: It is a low-growing and sod-forming perennial grass with stolons creeping along the ground and upright stems about 12 inches tall. Seedheads have three to seven terminal spikes, each about 2 inches in length.

CONTROL: Herbicides can offer fair to good control. Tillage should not be used as a control. Contact your state or county weed specialist for specific, updated information.

**Bermudagrass is exempt from noxious weed classification in Washington County.*



Creeping stolons

Patch of bermudagrass

Seedheads have three to seven terminal spikes

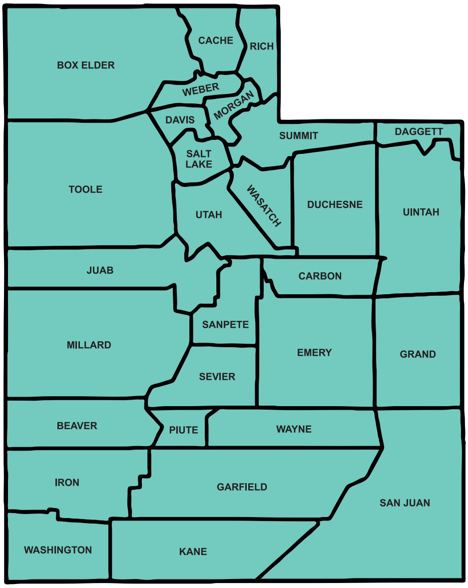
Whole plant

Canada Thistle *Cirsium arvense*

BACKGROUND: A native to southeastern Eurasia, Canada thistle reproduces by seeds and rootstock. It is adaptable to a diverse range of habitats.

DESCRIPTION: Canada thistle is a creeping herbaceous perennial plant usually from 1 to 4 feet tall, in sparse to extremely dense colonies. Leaves have spiny tipped lobes. Flowerheads are light pink to purple and are typically 3/4 inch in diameter. Bracts are softly spined. Bloom occurs in July and August.

CONTROL: Several biocontrol agents are available offering fair control. Herbicides can offer good control when applied to actively growing plants from spring to fall. As with most creeping perennials, digging or tillage is generally not effective. Contact your state or county weed specialist for specific, updated information.



Rosettes

Leaves with spiny-tipped lobes

Canada thistle infestation

Flowerheads and buds with softly spined bracts

Seedheads

Flowering plants (UGA1459760)

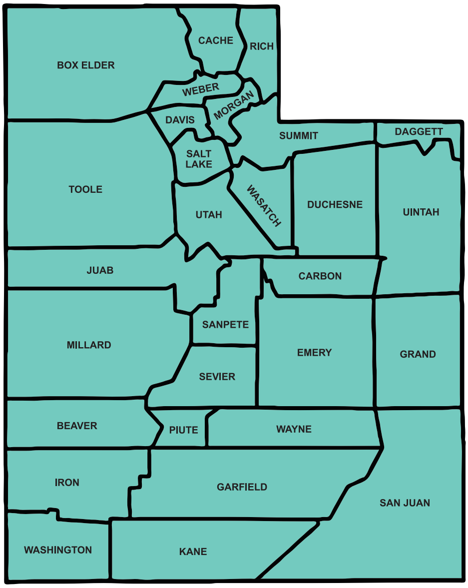
Field Bindweed *Convolvulus arvensis*

BACKGROUND: This European native reproduces from both seed and rootstock. Seeds may remain viable in the soil for up to 50 years. It grows in fields, pastures, gardens, road sides and many other areas. It may be found in areas up to 10,000 feet in elevation.

OTHER COMMON NAME: Wild morningglory

DESCRIPTION: Field bindweed is a creeping herbaceous perennial with twisting stems up to 6 feet long, growing prostrate, or it may climb nearby vegetation. The root system may grow to a depth of 10 feet or more. Arrow-shaped leaves are up to 2 inches long. Flowers are funnel-shaped, white to pink and 1 inch wide. Fruit is teardrop-shaped. Bloom is from June through September.

CONTROL: Biocontrol is available. Several herbicides offer good control when applied from late spring to the killing frost. Contact your state or county weed specialist for specific, updated information.



Twisting stems

Funnel-shaped flowers

Young plant

Arrow-shaped leaves

Teardrop-shaped fruit

Field bindweed infestation

Hoary Cress *Cardaria draba*

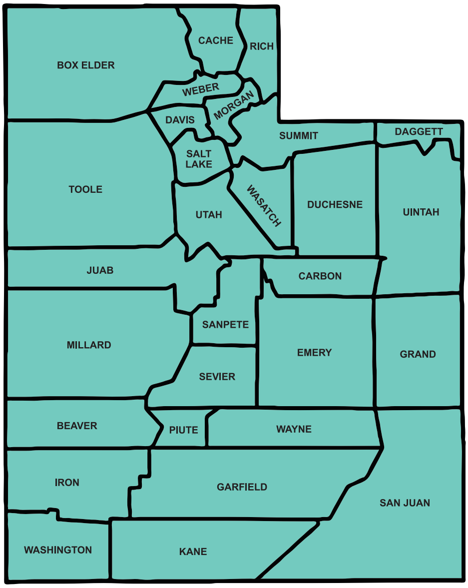
Synonym: ***Lepidium draba***

BACKGROUND: This plant originated in Europe. It reproduces by root segments and seed. It is commonly found on disturbed sites along road ways, field edges, and excavations. It is also a widespread weed of grain fields, cultivated fields, and meadows. It grows particularly well on somewhat salinic soils.

OTHER COMMON NAME: Whitetop

DESCRIPTION: Hoary cress is a perennial plant, commonly 1 to 2 feet tall, with creeping rootstocks. Leaves are finely toothed. Upper leaves clasp the stem. Bloom is in late spring with clusters of white flowers, each flower containing four petals. Seed pods are heart-shaped bladders and contain two brownish seeds.

CONTROL: Biocontrol research is in the early stages. Select herbicides can offer fair to good control when applied from rosette to early bloom stages. Contact your state or county weed specialist for specific, updated information.



Flowering plant

Hoary cress infestation

Creeping rootstocks

Four-petaled flowers

Heart-shaped seedpods

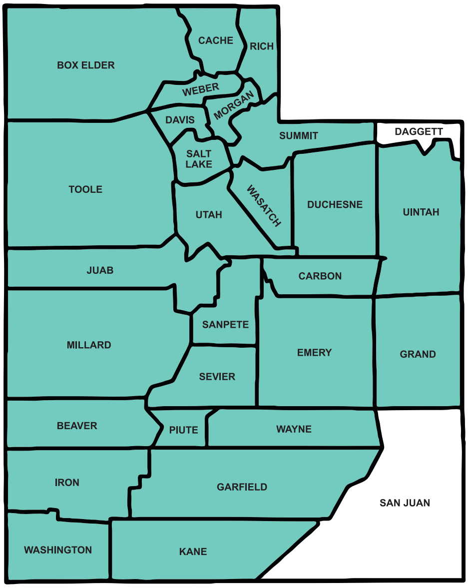
Houndstongue *Cynoglossum officinale*

BACKGROUND: Houndstongue is a native of Europe. It thrives in disturbed soils along roadsides, trails, in pastures, and rangelands. Because of the bur-like seed, it spreads widely along travel corridors as a passenger on clothing or animal fur. It is toxic to livestock.

OTHER COMMON NAME: Gypsy flower

DESCRIPTION: Houndstongue is a 1 to 4 foot tall biennial. Basal leaves are about 3 inches wide with a hairy surface. Upper leaves are narrower, about 1 inch wide and have a curled appearance and partially clasp the stem. Small reddish purple flowers form in the upper portions of the plant along stems borne in leaf axils. Each flower produces four green, bur-like fruits that turn brown as they mature. Bloom is in early summer.

CONTROL: Herbicides can offer good to excellent control when applied between the rosette and bloom stages. Digging before seed development can offer good control. Contact your state or county weed specialist for specific, updated information.



Rosette

Bur-like fruits

Dry plant

Houndstongue patch

Houndstongue with flowers

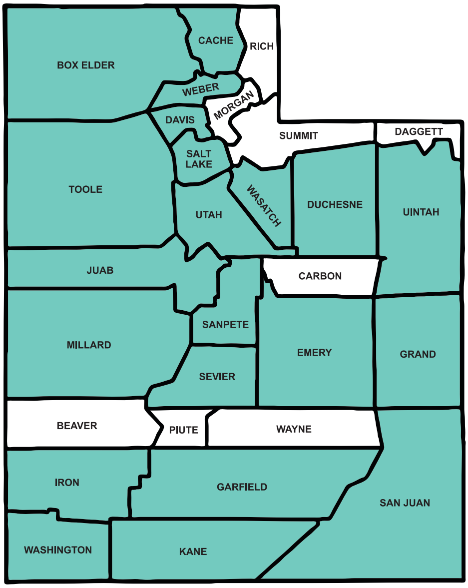
Houndstongue with fruit and flowers

Jointed Goatgrass *Aegilops cylindrica*

BACKGROUND: Native to Eurasia, jointed goatgrass is a weed in rangeland, disturbed areas, fields, pastures, and along roadsides. It is drought tolerant, and is especially troublesome in winter wheat fields, where hybridization of the two can occur. It is also a common contaminant in grain.

DESCRIPTION: A winter annual grass that grows up to 2 1/2 feet tall on hollow stems that branch at the base. Leaves have fine hairs along their margins and surfaces. Seed heads are cylindrical, jointed stacks that shatter into individual pieces when mature. Plants can produce up to 3,000 seeds each. Seeds can be viable up to 5 years.

CONTROL: Rotation cropping is an effective control. Farming equipment should be cleaned after being used in infested fields. Mowing and tilling give good control, especially prior to seed set. No selective herbicides are available for jointed goatgrass in winter wheat or wildland grasses. Contact your state or county weed specialist for specific, updated information.



Spike

Infestation

Separate spikelets

Whole plants

Infestation

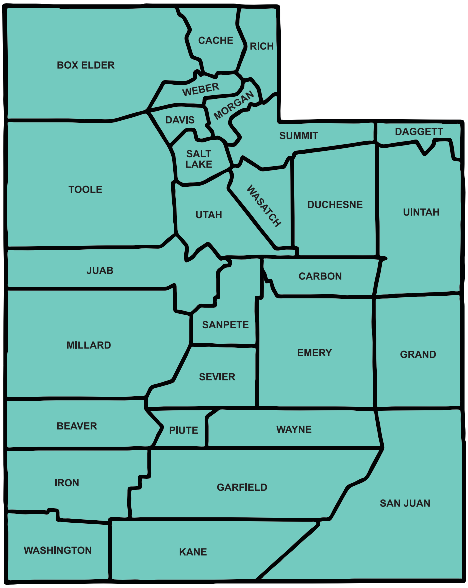
Musk Thistle *Carduus nutans*

BACKGROUND: Native to southern Europe and western Asia, musk thistle thrives in pastures and rangelands, in waste areas, stream banks, and road sides.

OTHER COMMON NAMES: Nodding plumeless thistle

DESCRIPTION: Musk thistle is a biennial or winter annual. Plants 4 to 6 feet tall are common. Deeply lobed spiny leaves are distinguished by a dark green blade with a prominent light green midrib. Stems are spiny and appear winged. Flowers may be violet, purple, or rose colored. Flowers are typically "nodding" or bent over. A tuft of white hairs is attached to each seed, which develops together at maturity and displaces the flowerhead. Bloom is in June and July.

CONTROL: Several biocontrol agents are available and offer good control. Herbicides can offer good to excellent control when applied between rosette and pre-bud stages. Mechanical means can be used for control by chopping the plant off at the ground. Contact your state or county weed specialist for specific, updated information.



Spiny, winged stem

Flowering plant

Deeply lobed rosette leaves

Seedhead

Musk thistle infestation

Nodding flowers at various stages of maturity

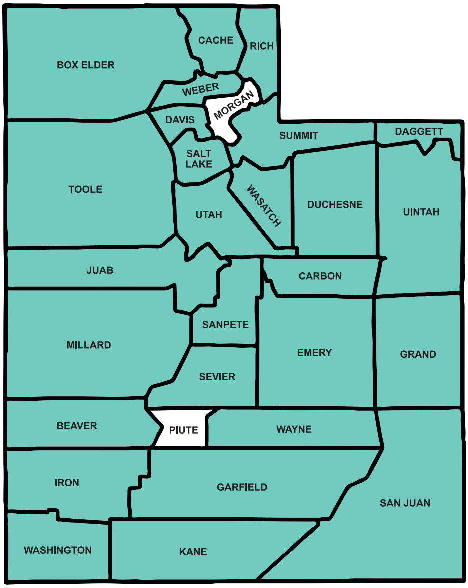
Perennial Pepperweed *Lepidium latifolium*

BACKGROUND: Native to southern Europe and western Asia, perennial pepperweed is commonly found in wet drainage areas of waste areas, ditches, roadsides, and crop lands.

OTHER COMMON NAME: Tall whitetop

DESCRIPTION: Perennial pepperweed grows from 1 to 6 feet tall. It is a creeping perennial and has spreading lateral rootstocks. Leaves have smooth to lightly toothed margins. Stems and leaves are waxy. Four-petaled white flowers form dense clusters at the end of branches. Flowering takes place from summer into early fall. Seeds form in round, flattened two-chambered pods.

CONTROL: Biocontrol research is in early stages. Select herbicides can offer fair to good control when applied to actively growing plants up to pre-bloom. Contact your state or county weed specialist for specific, updated information.



Round, flattened two-chambered seedpods

Flowering plants

Young growth

Four-petaled white flowers

Perennial pepperweed infestation

Perennial Sorghum Species

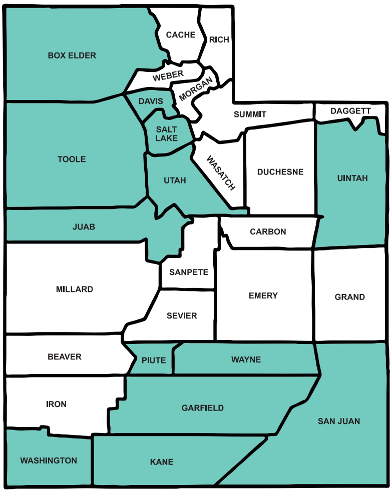
Sorghum grasses include many different variants and can hybridize easily with each other. Johnsongrass and Sorghum-almum are two perennial species with particularly invasive habits.

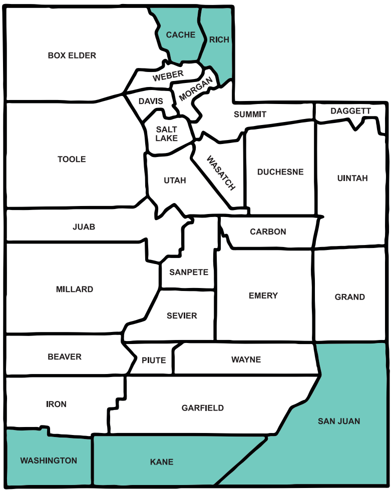
Johnsongrass *Sorghum halepense*

Sorghum-almum *Sorghum almum Parodi*

BACKGROUND: Johnsongrass was introduced from the Mediterranean as a forage grass, but when under frost or moisture stress, it becomes toxic to livestock. It reproduces by seed and lateral root systems. It thrives in rich soils and along waterways. A hybrid between Johnsongrass and grain sorghum (Sorghum bicolor), Sorghum-almum is similar in many ways to Johnsongrass, including toxicity. However, it tolerates drought better than its parent.

DESCRIPTION: Johnsongrass is a hardy creeping perennial grass with large, fleshy rhizomes. Stems grow 2-8 feet tall. Leaf blades are flat, up to 1 inch wide, with a prominent light midvein and prominent nodes. Seedheads



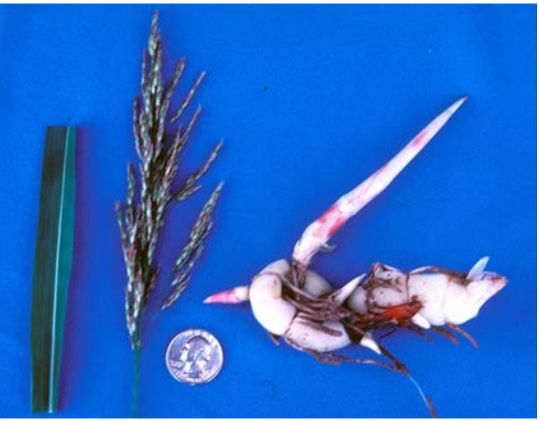


are reddish to purple. Sorghum-almum can grow up to 15 feet tall, with leaves up to 2 inches wide. Its rhizomes are shorter, have a general upward curve, and are not as aggressive as Johnsongrass rhizomes. Its seedheads are also longer and more open.

CONTROL: Plowing gives effective control for Sorghum-almum, but the more aggressive Johnsongrass is better controlled with herbicides. Contact your state or county weed specialist for specific, updated information.

Perennial Sorghum patch

Seedhead



Leaf with prominent light midvein, reddish to purple seedhead, fleshy rhizomes (UGA1459246)

Ligule

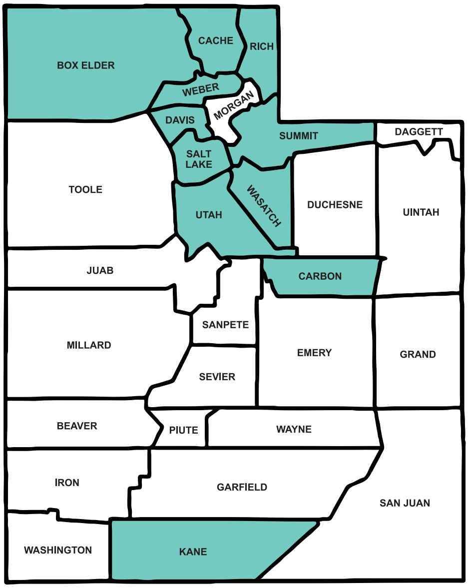
Phragmites *Phragmites australis*

BACKGROUND: Native to North America and Europe, phragmites is a weed in wetlands, marshes, and waterways, where it can form impenetrable stands. It is sold by nurseries, is commonly used in erosion control, and sometimes for livestock grazing. It is tolerant of fire and salinity.

OTHER COMMON NAME: Common reed

DESCRIPTION: A perennial rhizomatous grass, with hollow, sometimes creeping stems. Phragmites grow up to 10 feet tall, with rhizomes as deep as 3 feet, and rough-margined leaves up to 1 ½ feet long. Flowers form in dense, brown, feathery plumes at stem tips. Phragmites is commonly mistaken for giant reed. However, the flower-bearing stems on giant reed are hairless, whereas those of phragmites have silky hairs.

CONTROL: Do not plant phragmites. Because of extensive rhizomes, most mechanical control measures are only partially successful, and some actually encourage its spread. Research on biocontrol agents is ongoing. Systemic herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Phragmites stand

Flower plume

Spreading stems

Creeping stems (1559091)

Rhizomes (5487187)

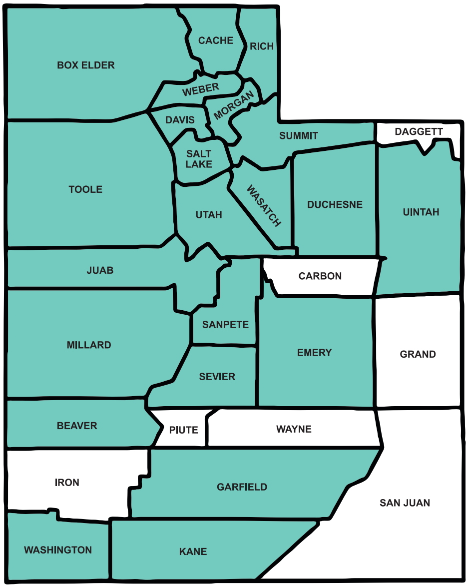
Leaves (5487202)

Poison Hemlock *Conium maculatum*

BACKGROUND: Poison hemlock is a European native, growing 6 to 10 feet tall. It is commonly found along waterways, roadsides, and field edges and tolerates poorly drained soils. It has been mistaken for parsley and wild carrot. All parts of the plant are toxic.

DESCRIPTION: This biennial has a large taproot. The stems have purple spots, especially at the bases. Leaves are finely divided, having a fern-like appearance. Leaf stems clasp the main stem. The tiny flowers are in umbrella-shaped clusters on the ends of individual stalks. Bloom is late spring into early summer.

CONTROL: Biocontrol is available and offers fair to good control. Herbicides can offer excellent control when applied to actively growing plants between rosette and bloom stages. Contact your state or county weed specialist for specific, updated information.




Poison hemlock infestation


Poison hemlock seedling


Fern-like fine leaves


Umbrella-shaped flower clusters


Flowering plant


Purple-spotted stems

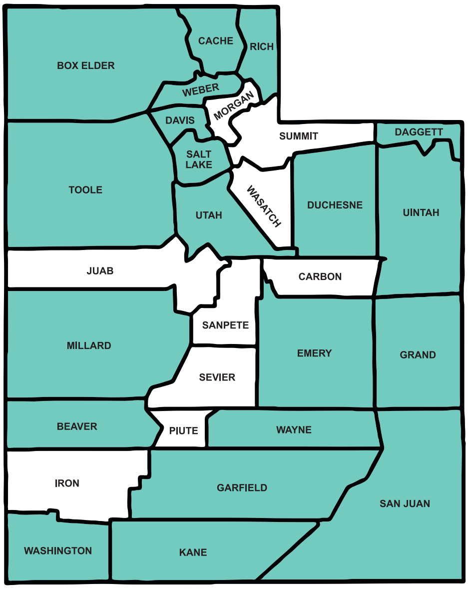
Puncturevine *Tribulus terrestris*

BACKGROUND: Native to Eurasia and Africa puncturevine can be found along roadsides, in cropland, pastures, and waste areas. It tolerates very dry conditions and poor soil. Its spiny fruit can penetrate skin, bicycle tires, and thin vehicle tires, and cause external and internal injury to grazing animals. Puncturevine foliage can also be toxic to livestock.

OTHER COMMON NAMES: Goathead

DESCRIPTION: A mat-forming summer annual with a deep taproot. Leaves consist of four to eight pairs of oval-shaped leaflets. Stems and leaves are covered with tiny hairs. The plant blooms throughout the summer, producing single, bright yellow, five-petaled flowers. The fruit is spiny and resembles a five-rayed cross, which turns brown and woody as it matures. It then splits into five separate, wedge-shaped seedpods.

CONTROL: Puncturevine plants can be controlled before fruit develops by digging, hoeing, tilling, and hand-pulling every few weeks throughout the season. Biocontrol may be available. Herbicides are also effective. Contact your state or county weed specialist for specific, updated information.



Puncturevine infestation

Leaves with flowers

Five-petaled flower and hairy stem

Taproot and leaves with four to eight pairs of leaflets

Spiny, five-rayed fruit

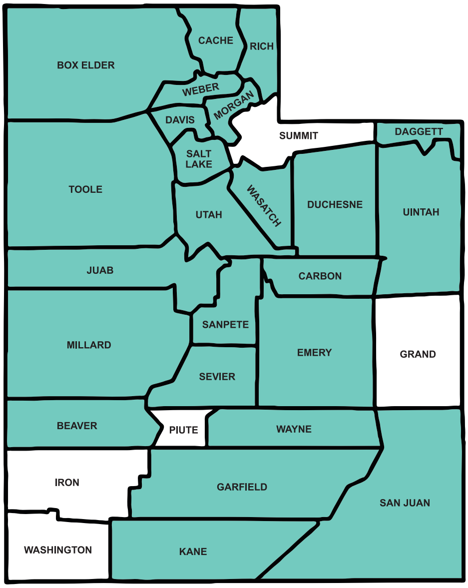
Quackgrass *Elymus repens*

Synonym: ***Agropyron repens, Elytrigia repens***

BACKGROUND: Originally found in the Mediterranean area, quackgrass infests crops, rangeland, pasture, and lawns. It adapts well to moist soils in cool, temperate climates. It reproduces by seed and rhizomes. These rhizomes can penetrate hardened soils and even roots of other plants.

DESCRIPTION: This creeping perennial grass usually grows 1 to 3 feet tall. Rhizomes are creamy colored and pointed. Leaf blades are up to 0.5 inch wide. Near the tip of the leaves a band-like constriction may be present. Seedheads are 3 to 4 inches long and narrow.

CONTROL: Herbicides can offer good control when applied from early spring to winter. Contact your state or county weed specialist for specific, updated information.



Quackgrass infestation

Band-like constriction

Seed-bearing plant

Mature seedheads

Mature seeds

Pointed, creamy-colored rhizomes

Russian Knapweed *Acroptilon repens*

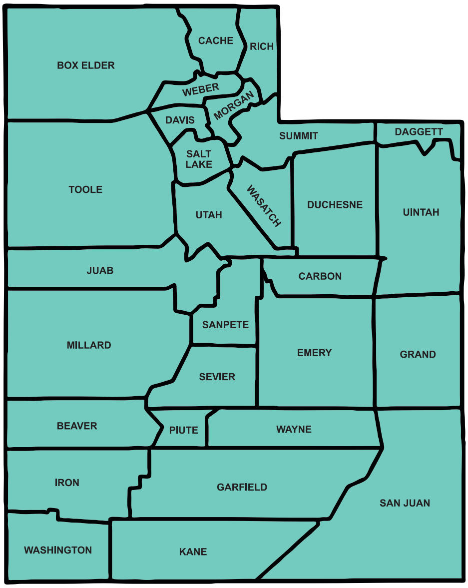
Synonym: ***Centaurea repens, Rhaponticum repens***

BACKGROUND: Russian knapweed is native to Eurasia. It infests rangelands, field edges, pasture, roadsides, and other disturbed soils. Knapweeds release chemical substances into the soil that inhibit the growth of competing vegetation. It can cause "chewing disease" in horses that consume it.

OTHER COMMON NAME: Hard heads

DESCRIPTION: A creeping herbaceous perennial, Russian knapweed grows 2 to 3 feet tall. Roots are black and may go 8 feet deep or more. Basal leaves are lobed and are 2 to 4 inches in length. Flowers are pinkish to purple, and flower bracts have membranous cream-colored tips. Bloom is early summer through late summer.

CONTROL: Biocontrol is available, but limited. Select herbicides can offer good to excellent control when applied between pre-bloom to the killing frost. Contact your state or county weed specialist for specific, updated information.



Russian knapweed infestation

Black root

Lobed leaves

Flowering plants

Membranous bract tips

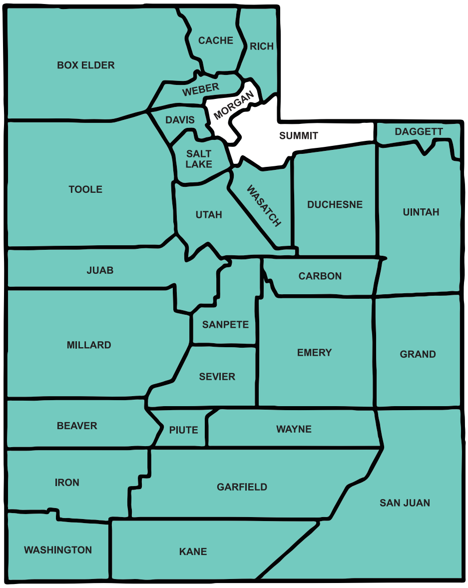
Saltcedar *Tamarix ramosissima*

BACKGROUND: Saltcedar was introduced from Eurasia and is found throughout the United States. It is widely used as an ornamental. It commonly infests lake and stream banks as well as pastures and rangeland. Large plants can transpire 200 gallons of water per plant per day, drying up ponds and streams.

OTHER COMMON NAME: Tamarisk

DESCRIPTION: This woody perennial plant grows 5 to 20 feet tall. Stems are reddish-brown. Leaves are small and scale-like. Branches are long and slender. White to pink flowers have five petals and are borne in finger-like clusters. The root system is extensive. Saltcedar may exhibit either deciduous or evergreen traits.

CONTROL: Biocontrol is available. Select herbicides can offer excellent control when applied in late summer through early fall, especially after cutting or burning. Contact your state or county weed specialist for specific, updated information.



Young growth with reddish-brown stems

Flower clusters

Saltcedar infestation

Scale-like leaves

Flowering plants

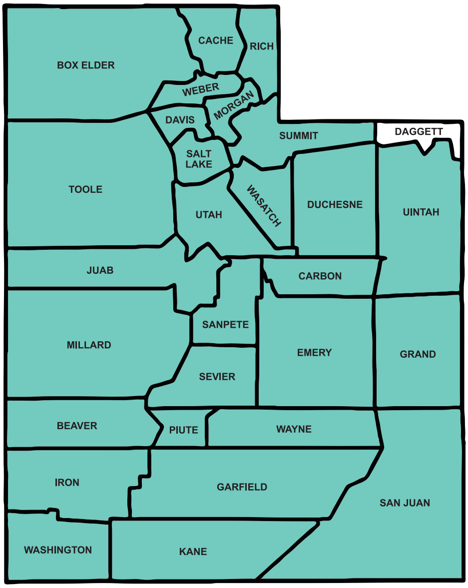
Flowering plants

Scotch Thistle *Onopordum acanthium*

BACKGROUND: Scotch thistle is native to Europe and eastern Asia. It grows well in waste areas, pastures, rangeland, and along canal and stream banks.

DESCRIPTION: This biennial plant commonly grows 3 to 8 feet tall, but it may grow as high as 12 feet. Rosettes may be 4 feet wide. Large, spiny leaves are covered with dense hair, giving a grayish, blue-green coloration. Stems are winged. The flowers are violet to reddish with spine tipped bracts, blooming in mid-summer.

CONTROL: Biocontrol research is currently being conducted. Herbicides can offer good-to-excellent control when applied between rosette and pre-bud stages. Contact your state or county weed specialist for specific, updated information.



Spiny leaves covered with dense hair

Winged stems and flowers with spine-tipped bracts

Flowering plant

Rosette

Scotch thistle infestation

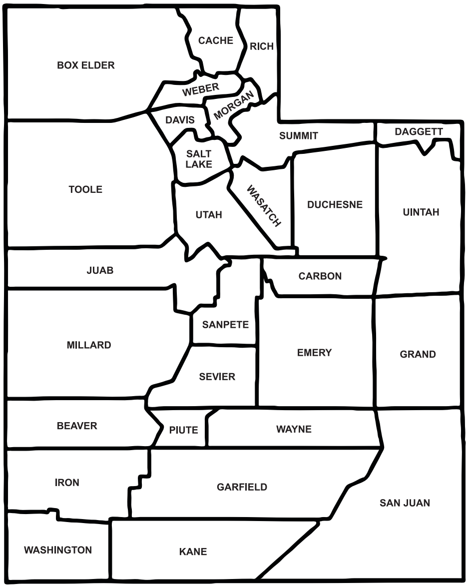
Class IV Weeds
(Prohibited)

Cogongrass *Imperata cylindrica*

BACKGROUND: Native to Asia and Africa, several cultivars of cogongrass are grown as ornamentals. It is an aggressive weed of forests, roadsides, and disturbed areas, and is tolerant of a wide variety of growing conditions. The plant is highly flammable and fire tolerant. Cogongrass is a designated federal noxious weed.

OTHER COMMON NAME: Japanese blood grass

DESCRIPTION: A perennial rhizomatous grass that can grow over 4 feet tall. The plant is yellowish-green, sometimes changing to red in autumn. It grows in dense patches and reproduces by seed and segmented, sharp-tipped, scaly rhizomes. Fragmented rhizomes can easily generate new



plants. Leaves have a dominant off-centered whitish vein. Cogongrass produces silky white flower heads in spring.

CONTROL: This plant is not known to be in Utah outside of ornamental gardens. Do not buy cogongrass from nurseries. Contact your state or county weed specialist for specific, updated information.

Sharp-tipped, scaly rhizomes (UGA2120071)

Cogongrass infestation (UGA1380037)

Silky white flowerhead (UGA2131097)

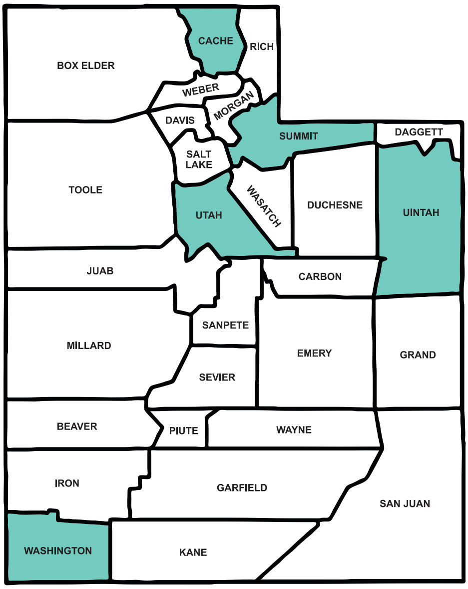
Dominant whitish midvein (UGA5125041)

Damesrocket *Hesperis matronalis*

BACKGROUND: Native to Europe and central Asia. Damesrocket is sold in wildflower seed mixes and is desired for its sweet scent, as a cut flower, for its essential oil, and its attraction to butterflies. Leaves, seeds, and oil are also edible. However, it is highly aggressive and known for invading native landscapes.

DESCRIPTION: A biennial or simple herbaceous perennial. In its second season, the rosette produces 1-4 foot high flowering stalks. Stems and leaves are finely hairy, and leaves are lance-shaped with serrated edges. The four-petaled flowers develop separately on short, equal stalks along the stem. In spring, flowers bloom pink, white or violet, and long, narrow seedpods develop under the flowers.

CONTROL: Do not buy wildflower seed mixes that include damesrocket. Mow plants before flowering to prevent seed production. With flowering plants, pull before seeds mature and remove. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Damesrocket infestation

Rosette (5450182)

Four-petaled flowers

Long, narrow seedpods (5450142)

Lance-shaped leaves with serrated edges (5450175)

Pre-flowering plant (5542024)

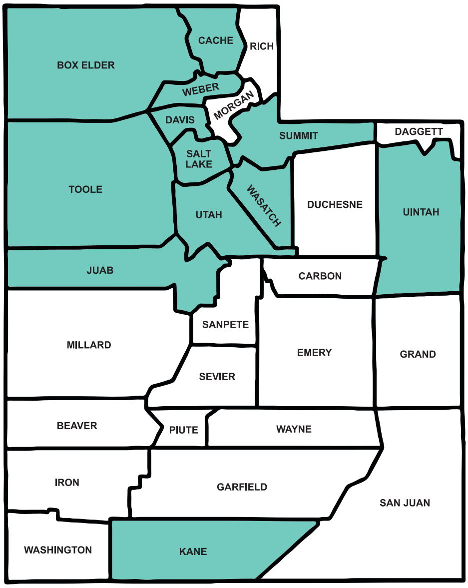
Myrtle Spurge *Euphorbia myrsinites*

BACKGROUND: Native to Eurasia, myrtle spurge is a weed of gardens, dry natural hillsides, waste areas, and public lands. It is drought tolerant and thrives in nutrient poor, sandy, and rocky soils. The plant contains a milky sap toxic to cattle and humans. Myrtle spurge is sold as an ornamental.

OTHER COMMON NAME: Blue spurge

DESCRIPTION: A short-lived, clumping herbaceous perennial with 8-inch tall, fleshy stems that bear thick, waxy, grayish-blue leaves. Stem tips bear yellow-green bracts that cup tiny flowers in umbrella-like clusters. Seeds are ejected up to 15 feet when the seed capsules open. The plants can also regenerate from root fragments.

CONTROL: Do not buy or grow this plant. Seedlings are easily dug or hand-pulled (use gloves, eye and skin protection!), but when digging more mature plants, the entire root must be removed. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Myrtle spurge infestation

Fleshy stems and milky sap

Yellow-green bracts cup tiny flowers

Waxy grayish-blue leaves

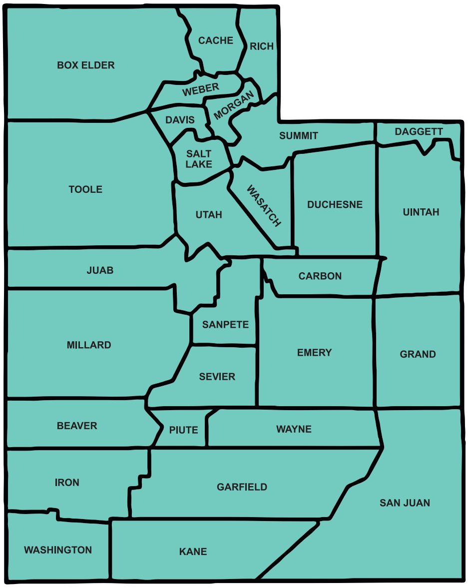
New growth emerging through dead stalks

Russian Olive *Elaeagnus angustifolia*

BACKGROUND: Native to Eurasia. Russian olive is a weed of gardens, roadsides, pastures, waterways, cropland, meadows, and seasonally moist open areas. It can form thickets and be aggressively competitive, even on poor soils. It tolerates flooding, salinity, and drought. It is sold in nurseries.

DESCRIPTION: An open, irregular tree up to 35 feet tall. Young branches are silvery, while older branches are red-brown. Stems and branches bear 1-2 inch thorns. Leaves are narrow and oval-shaped, with silvery-gray undersides. Flowers are small, fragrant, yellow, and funnel-shaped. Fruit is olive-shaped and silvery, and becomes tan with age.

CONTROL: Do not buy or plant this tree. Young plants can be hand-pulled, or tilled or mowed repeatedly. Goat grazing is also helpful. Larger plants must be cut or girdled at or below ground level, and any regrowth should be removed. Herbicides can be effective. Contact your state or county weed specialist for specific, updated information.



Red-brown, thorny branches

Russian olive infestation

Silvery, olive-shaped fruit

Funnel-shaped flowers and narrow leaves

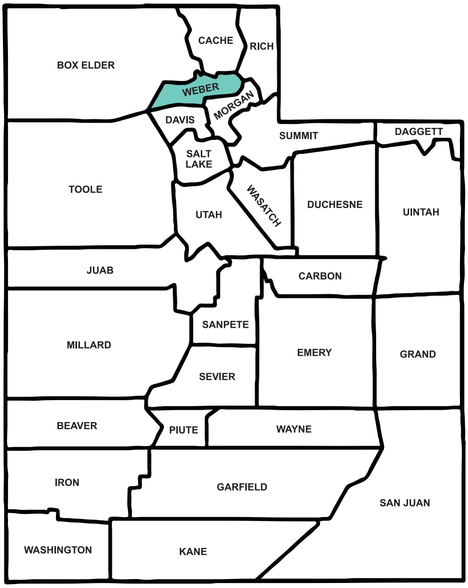
Mature tree

Scotch Broom *Cytisus scoparius*

BACKGROUND: Native to Europe, Scotch broom grows on roadsides, pastures, open areas, and recently disturbed areas. The plant is tolerant of fire, and is toxic to livestock. It also displaces desirable vegetation and forms dense stands. It is sold as an ornamental.

DESCRIPTION: A long-lived, highly branched woody perennial that can grow over 6 feet tall. Scotch broom produces bright yellow, pea-like flowers in early summer. Stems are dark green and sparsely covered with leaves. When young, the stems are ridged and hairy. The plant reproduces by seed. Seed pods are dark brown and have hairy margins. Seeds can remain viable for over 30 years.

CONTROL: Do not buy Scotch broom at nurseries. Plants can be hand pulled, dug, cut, or mowed, all done best before seeds mature. Applying herbicide to cut plants can help prevent regrowth. Some insects are known to provide biocontrol. Contact your state or county weed specialist for specific, updated information.



Pea-like flowers (UGA1459557)

Flowering plant (UGA1459556)

Dark brown seedpods (5447462)

Ridged young stems with sparse leaves (5397124)

Scotch broom infestation (5392106)

LIFE CYCLE DEFINITIONS

Annual—life cycle completed in 1 year or less (seed to seed), reproduce by seed only.

- Winter annuals: germinate in fall or winter, finish in spring or summer.
- Summer annuals: germinate in spring, mature and die by summer or autumn.

Biennial—a plant that lives longer than one season but fewer than 2 years. A rosette is produced the first year (a circular cluster of leaves, usually at soil level). Following a cold period there is floral initiation, fruit set, and death.

Perennial— a plant that lives for more than 2 years, and renews growth year to year from the same root system.

- Woody Perennials—plants such as trees, shrubs, and vines that do not die back during cold winters.
- Simple Herbaceous Perennials—reproduce by seed, usually not vegetative parts. However, a cut piece can regenerate. Above-ground parts usually die back to the ground in a cold winter.
- Creeping Herbaceous Perennials—reproduce by seed and by vegetative parts: roots, stolons, and rhizomes. Above-ground parts usually die back to the ground in a cold winter.

COUNTY WEED CONTROL OFFICES

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STATE AND FEDERAL OFFICES

Utah Dept. of Agriculture and Food
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P.O. Box 146500
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jwilkins@utah.gov

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Fax (801) 975-3310

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Jerry Caldwell, Tooele County Weed Supervisor

K. Mosbruger

Mark Anderson, Box Elder County Weed Supervisor

Nate Bellison, Uintah County Weed Supervisor

Patrick Nelson, Salt Lake City Public Utilities Watershed Manager

Quenton Lewis, Wasatch County Weed Supervisor

Richard (Dick) Jones, Wasatch County

Sage Fitch, Salt Lake County Weed Supervisor

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