Green Stormwater Infrastructure

GUIDANCE MANUAL

Ada County Highway District | June 2014

ACHD

Ada County Highway District

Green Stormwater Infrastructure Guidance Manual

June 2014

Statement of Need

Ada County Highway District (ACHD) is responsible for building, operating, maintaining, and improving urban streets, rural roads, alleys, and public rights-of-way in the cities of Boise, Eagle, Garden City, Kuna, Meridian, and Star, and in unincorporated areas of Ada County. Stormwater conveyances and best management practices (BMPs) associated with the right-of-way are operated by ACHD with the exception of those routes and stormwater facilities operated by the Idaho Transportation Department (ITD). ACHD's right-of-way contains the street, sidewalk, bike lanes, utilities, stormwater management infrastructure, and landscape systems.

ACHD has developed this Green Stormwater Infrastructure (GSI) Guidance Manual (guidance manual) in response to the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit #IDS-027561 requirement (referred to hereafter as the Permit) to implement GSI as a method of stormwater management. The Permit became effective on February 1, 2013.

Development of this manual was fully grant-funded by the ITD, KN #13819.

The Permit requires ACHD to implement and enforce a program to control stormwater runoff from all new development and redevelopment projects resulting in land disturbance, including asphalt removal or regrading, of 5,000 square feet (ft^2) or more. Use of GSI can meet this Permit requirement by providing onsite stormwater management. Pilot studies are required by the Permit to validate the efficiency and to identify local limitations associated with GSI in the Treasure Valley.

While other GSI facilities are available for consideration within the Treasure Valley, this manual provides guidance on determining the feasibility of tree systems, bioretention, permeable pavers, and bio-swales. This is a planning-level guidance manual that includes a general GSI design process and stormwater design criteria to be evaluated at all stages of project development. It does not include design methodologies or sizing details.

RELEVANT PERMIT REQUIREMENTS

- Identify incentives for increased use of GSI facilities in private- and public-sector development projects within the Ada County jurisdiction
- Complete an effectiveness evaluation of at least three pilot projects, prior to the expiration date of the Permit (January 30, 2018)
- Identify barriers to GSI implementation (e.g., funding, conflicting regulations, need for technical information and training, nascent market, and maintenance issues) and opportunities for implementation
- Evaluate feasibility of incorporating GSI facilities when repair work is performed on ACHD-owned or managed streets that involve land disturbance, including asphalt removal or regrading, of 5,000 square feet or more
- Ensure that all stormwater management projects undertaken after the effective date of the Permit are designed and implemented to prevent adverse impacts to water quality
- Evaluate retrofit opportunities of existing stormwater control devices to provide additional pollutant removal from collected stormwater
- Retain and treat the first 0.6 inch of the water quality capture volume from the 24-hour storm event

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Chapter 1

Green Stormwater Infrastructure

This guidance manual is intended to help ACHD staff evaluate the feasibility of GSI for both new development and redevelopment projects.

The primary purpose of this guidance manual is to provide users (planners, project managers, and engineers) a tool to identify and realize GSI opportunities that meet both the Permit requirements and ACHD goals effectively. This document refers to this user group of planners, project managers, and engineers as the designer.

Guidance Manual Summary

This guidance manual includes an introduction to GSI design techniques, a general GSI design (or evaluation) process, and an overview of four GSI practices with key design criteria to consider. The ACHD Policy Manual (Policy Manual, Section 8000) defines the requirement for stormwater systems within ACHD's jurisdiction. The Stormwater Design Manual and Approved BMPs (Design Manual, Section 8200) contains standards and guidance for selecting and sizing permanent stormwater BMPs. This guidance manual is intended to be supplementary to the above-mentioned sections of the Policy Manual. It is understood that the existing Policy Manual will be updated to include these four GSI practices as approved BMPs and will include design methodologies and sizing details.

GSI is an alternative design technique that meets ACHD policy requirements. The evaluation process identified in Chapter 2 is similar to the existing conventional design process (Policy Manual, Section 8000) employed by ACHD. The difference is that stormwater is treated as an asset to be retained on site, considered throughout the design process, and integrated into the site design features.

The goal of this guidance manual is to familiarize ACHD staff with GSI principles so that they consider GSI implementation in new development and redevelopment projects. This will in turn help meet both the relevant Permit requirements and ACHD goals.

ACHD GSI PROGRAM GOALS

- Identify and integrate GSI into ACHD processes and projects as a drainage option, where appropriate (e.g., repair of streets, community projects, design projects, capital projects, etc.)
- Use GSI practices as a subdivision development drainage control option for meeting existing onsite requirements
- Develop design standards for GSI practices
- Implement, demonstrate, and evaluate new GSI practices through pilot projects
- Use GSI retrofits to disconnect hard surfaces and/or treat runoff in older developed areas with existing storm drain systems
- Incorporate GSI design techniques and practices into streetscape standards for newly developing areas
- Use offsite mitigation mechanisms to incorporate GSI practices into newly developed areas where use of traditional stormwater controls is limited by site conditions such as high groundwater levels

What is in this Manual?

This chapter describes the need for GSI applications in response to Permit requirements, introduces GSI design techniques and criteria, and provides an overview of benefits of GSI and unique considerations in Ada County as they relate to successful implementation of GSI practices. The GSI design criteria are demonstrated with a set of icons that are used throughout the document to illustrate how these criteria must be considered at various stages of the project development process.

The following provides a summary of what is included in the remaining chapters of the guidance manual:

- Chapter 2 includes a description of each of the GSI evaluation process steps and the design criteria identified in each of the steps.
- Chapter 3 includes a brief introduction to different street profiles and types in ACHD and the four GSI practices—tree systems, bioretention, permeable pavers, and bio-swales—that ACHD believes are the most applicable to future projects based on its specific jurisdictional responsibilities and site constraints. These overviews of the four GSI practices are also included in the attachment as fact sheets.
- Chapter 4 illustrates the different applications of GSI practices to different street types described in Chapter 3. For each of the practices, this chapter also includes a demonstration of the GSI design process and the design criteria that must be evaluated for each site.
- Chapter 5 includes a description of various implementation strategies that can be used to overcome barriers that may affect the program outcome.

Pre-Developed Condition

In a natural landscape that is undisturbed by development and has minimal impervious surfaces, precipitation is absorbed and intercepted by the tree canopy, soil, and vegetation, minimizing runoff. Existing vegetation promotes the process of evapotranspiration and slows down the surface runoff so it takes many hours, days, or weeks to reach receiving waters. The total volume of runoff and associated pollutant load reaching surface waters is small, maintaining relatively clean surface water quality.

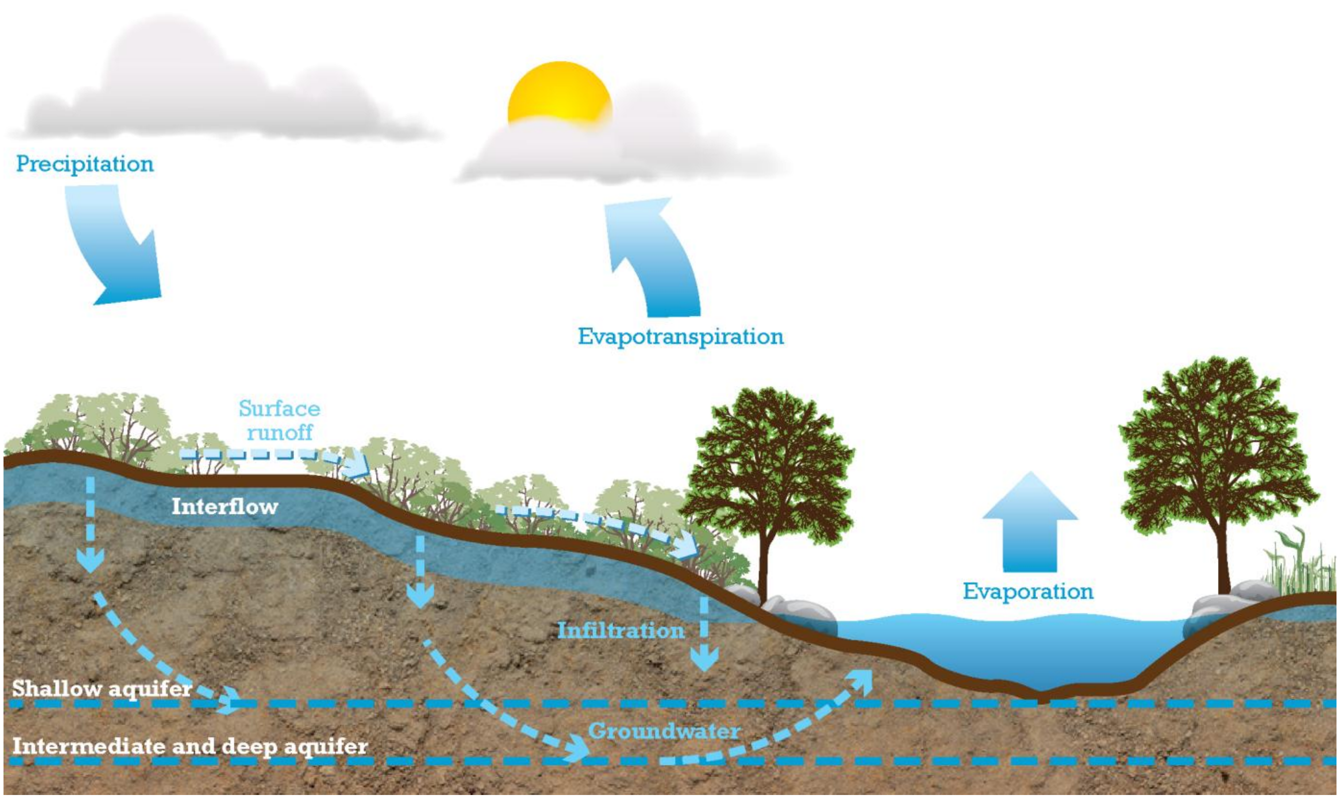

FIGURE 1-1
Water budget for the pre-developed condition in the Treasure Valley.

Impacts of Urbanization

As a community develops, the amount of surface area covered by roadways, parking lots, roads, and rooftops increases. These developments reduce, disrupt, or entirely eliminate native vegetation, upper soil layers, and natural drainage patterns. This results in an increase in the total volume of runoff.

Stormwater runoff often contains pollutants such as oil, grease, bacteria, heavy metals, sediments, hydrocarbons, and some nutrients that eventually get discharged to surface waters. These pollutants degrade surface water quality.

Urbanization in Ada County has affected the quantity and quality of stormwater runoff from rainfall and snowmelt by replacing the sites' natural hydrologic function with gray stormwater infrastructure that concentrates, collects, and conveys runoff offsite before receiving treatment. Green infrastructure was created to mimic pre-development processes by retaining more runoff on site.

FIGURE 1-2
This traditional stormwater inlet has been used in combination with the curb to concentrate and quickly convey runoff away from the pavement.

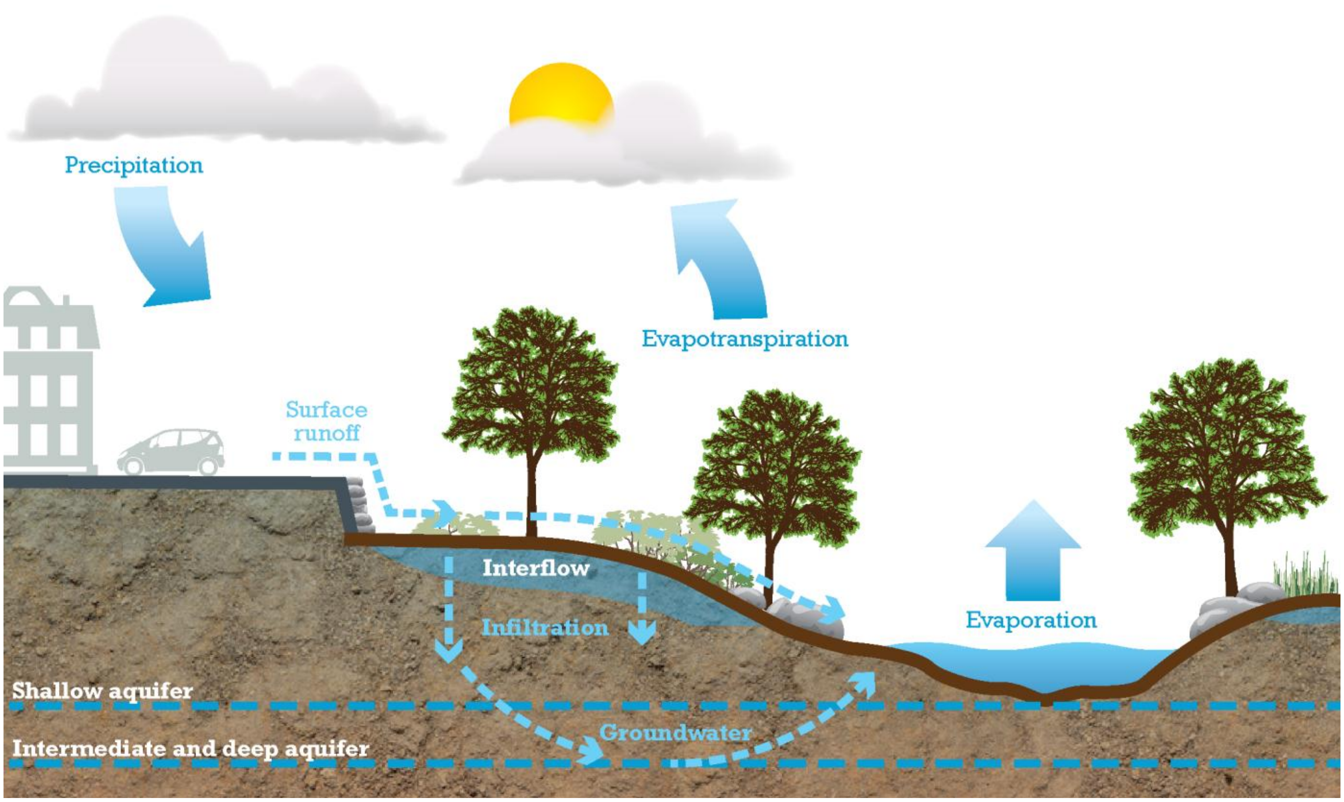

FIGURE 1-3
Water budget for the post-developed condition in the Treasure Valley. Impervious areas block infiltration, thereby generating additional surface runoff volume and pollutant load to receiving waters and degrading surface water quality.

Introduction to GSI Technique

GSI refers to stormwater systems and practices that use or mimic natural processes to infiltrate, evapotranspirate, and/or reuse stormwater runoff on site. The GSI technique addresses both the quantity and quality of stormwater runoff to achieve surface water quality improvement.

GSI is an element of Low Impact Development (LID), an approach to land development that works with nature to manage stormwater as close to its source as possible. LID and GSI both employ principles, such as preserving natural landscape features and minimizing effective imperviousness, to create functional and appealing site drainage features that use stormwater as a resource. GSI design elements manage stormwater at the source allowing rainfall to infiltrate as it lands on site by designing short travel distances to nearby landscaping. The GSI practices identified in this manual are smaller, more integrated techniques that rely on infiltration for stormwater management. These GSI practices include tree systems, bioretention areas, permeable pavers, and bio-swales.

All ACHD projects should consider incorporating GSI techniques. Incorporation of site stormwater management starts at the planning stage of development and continues throughout the design, construction, and maintenance of the project. An overview of the general approach to evaluate these GSI practices is shown in the next section.

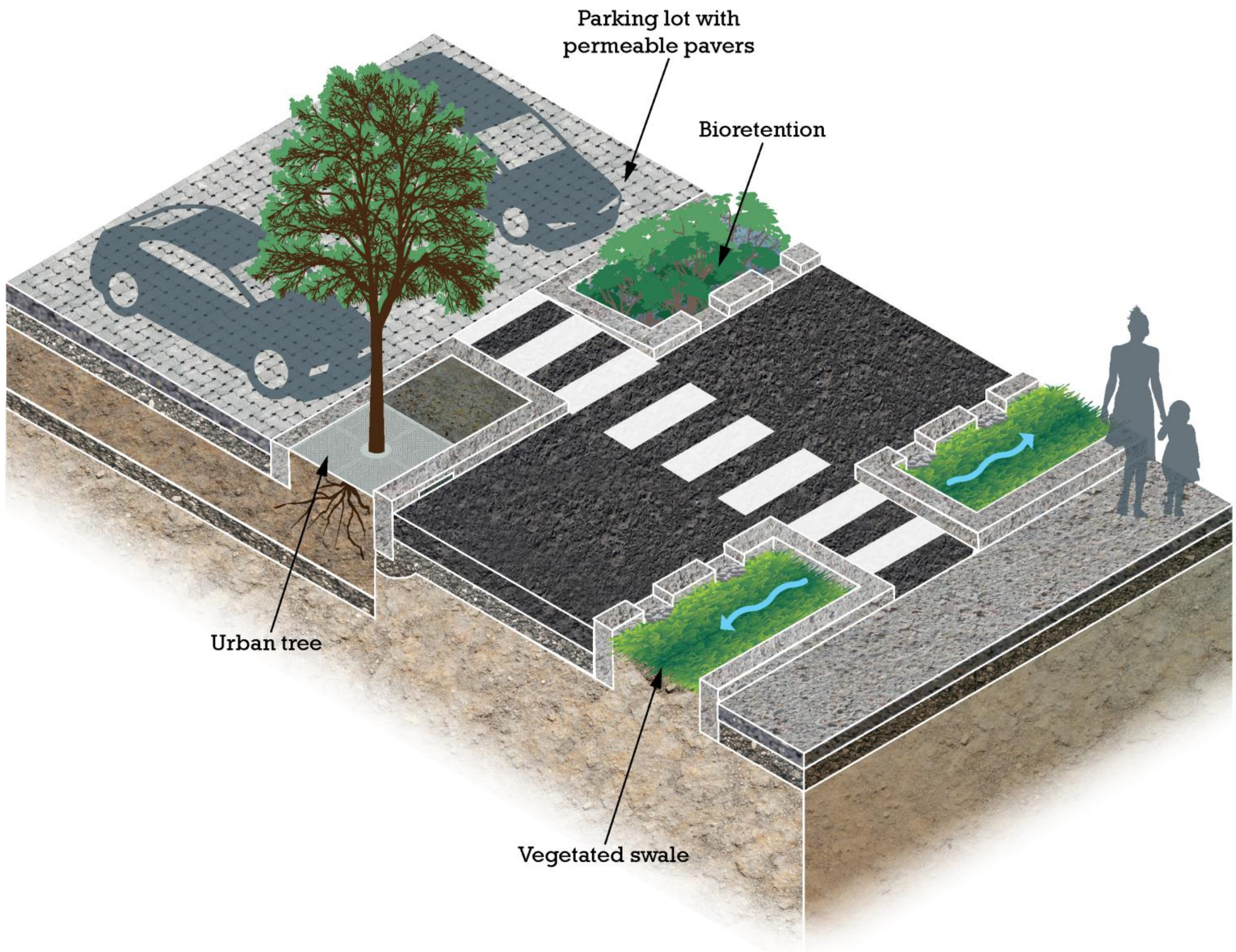

FIGURE 1-4
Various types of GSI practices can be implemented to address both the quantity and quality of stormwater runoff to achieve water quality improvement.

Implementing GSI Practices

All ACHD projects have design criteria that must be evaluated when considering stormwater management on any project, from the planning phase through construction.

During the planning phase, these criteria will not be well known and assumptions will have to be made based on historical data. As the project progresses into the design phase, site-specific investigations will be performed to determine actual site conditions including the depth to groundwater, general soil conditions, long-term infiltration and groundwater mounding potential, and potential interactions with land and water use within the immediate vicinity of the project. An overview to the design criteria is provided below, and further details on design criteria and specific Ada County considerations are presented in Chapters 2 and 4 of this guidance manual.

WATER QUALITY

The overall relationship between the proposed project site and the proximity to both surface and subsurface receiving water bodies (upstream and downstream) must be considered. Any impaired water bodies impacted by the project site must be identified.

HYDROLOGY

The hydrologic characteristics of the project site dictate the amount of runoff that will be generated and where stormwater facilities can be placed. The existing hydrologic characteristics of the project site must be studied early and accommodated as possible.

DRAINAGE AREA

Existing drainage patterns should be maintained. Placing stormwater facilities in strategic locations can minimize piping. The goal is to minimize the impervious surfaces and mimic the natural hydrologic pattern to minimize the amount of runoff that leaves the site.

SOIL AND VEGETATION CONDITIONS

A site evaluation must be completed to identify general soil types and soil permeability to generate the basic information needed for siting practices, slope design, and developing erosion control plans.

GROUNDWATER

Feasibility of infiltration practices is dependent on both the permeability of soil and groundwater elevation. For all projects, depth to groundwater and seasonal variation of the groundwater table must be assessed to validate that minimum groundwater separation requirements are met.

SPACE LIMITATION

Aboveground and underground space limitations of the project must be identified to determine whether enough right-of-way space is available for the GSI facility. If the available right-of-way is not adequate, additional land may need to be acquired.

UTILITIES

The horizontal and vertical location of underground utilities, such as water, sewer, stormwater, and gas, and aboveground utilities, such as power and phone, must be identified. Existing utility vaults can be difficult to accommodate when placing GSI practices and should be identified early in the planning phase.

CONSTRUCTABILITY

Assessing the constructability of a given GSI practice includes reviewing the construction process from start to finish during the preliminary design phase with the goal of identifying any possible hurdles. Adequate space for construction, vehicular access and use, volume of traffic, seasonal considerations, and preserving adequate sight distances should also be considered early in the design process.

Why Use GSI?

GSI design techniques mimic or preserve natural drainage processes to manage stormwater. By implementing GSI design techniques, the landscape responds more like pre-developed lands—despite the ever-expanding number of roads and rooftops.

GSI practices such as bioretention and tree systems capture and retain water on site, allowing time for water to soak into soil where it is then naturally filtered. GSI also improves community aesthetics by minimizing impervious areas and increasing vegetative cover.

Stormwater runoff is considered a resource in GSI design. In addition to preserving natural drainage processes to manage stormwater, GSI design techniques provide the following benefits.

IMPROVED WATER QUALITY

GSI techniques help to minimize the adverse impacts of stormwater runoff on water quality, the biological integrity of receiving waters, and the beneficial uses of water bodies. GSI prevents measurable physical, chemical, and biological degradation of streams, lakes, wetlands, and other natural aquatic systems by retaining runoff on site and allowing stormwater uptake by plants and soil.

Even when site soils are not conducive to infiltration, water quality is still enhanced through pollutant settling, runoff absorption into soil, adsorption of pollutants to active elements in the soil, and runoff uptake by vegetation, which also intercepts and uptakes pollutants from soils and water directly. Stormwater runoff often contains pollutants such as oil, grease, bacteria, heavy metals, sediments, hydrocarbons, and some nutrients from impervious surfaces that eventually get discharged to surface waters.

IMPROVED GROUNDWATER RECHARGE

GSI practices retain more rainfall and runoff on site, allowing it to enter the ground and be filtered by soil as it percolates to the water table. By doing so, GSI practices help recharge the groundwater closer to the source and replenish the local groundwater aquifers.

ENHANCED NEIGHBORHOOD AESTHETICS

GSI practices can broadly increase property values and enhance communities by making them more beautiful and sustainable. Practices including bio-swales and bioretention make the community more "green," increasing the desirability of living in that community. In addition, some practices such as tree systems provide shade and privacy to homeowners and reduce the "heat island" effect.

VOLUME AND FLOW REDUCTION

GSI design techniques are used to manage stormwater runoff as close to the source as possible by using small-scale, distributed hydrologic controls and minimizing impervious surfaces. This helps to reduce the flow rates and volume of stormwater runoff through infiltration. These techniques may use existing site topography for stormwater storage and conveyance.

AIR QUALITY AND MICRO CLIMATE BENEFITS

Plants mitigate local air quality issues. Trees help reduce low-level ozone, settle out particulate matter, and help mitigate the urban "heat island" effect. Light-colored permeable pavement further mitigates the "heat island" effect of paved areas.

Unique Considerations for Ada County

There are unique design considerations related to implementing GSI techniques in Ada County. The following are some of the specific considerations that need to be understood and addressed before implementing GSI practices. For more details on the unique considerations for Ada County please refer to Attachment B.

SOIL CONDITIONS AND HYDROLOGY

Some areas, particularly in western Ada County, have a hardpan, or duripan, soil layer that can restrict water infiltration and reduce downward movement of water. Restrictive layers can also artificially raise groundwater levels during the irrigation season. While mitigation measures, such as soil amendments and mechanical alteration of restrictive soils, can be applied to promote successful infiltration in restrictive soils, some site conditions may preclude the use of GSI.

The role of infiltration in promoting groundwater recharge warrants consideration. Although this is a benefit in regions where groundwater levels are dropping, it may be undesirable in some situations where there are perched aquifers or groundwater levels are seasonally high. Pipe and canal leakage and over-irrigation of lawns and landscape plantings have already increased infiltration well over the pre-development amount and raised groundwater tables, sometimes to problematic levels. This unnecessary use of irrigation reduces capacity to infiltrate stormwater without further water table rise. The use of infiltration practices will change local subsurface hydrology, and the ramifications of this—good and bad—should be considered prior to their installation.

EXISTING VEGETATION

Ada County has invasive plant species that spread in exposed or disturbed soils. Much of the open spaces are dominated by invasive species that require treatment to reduce or eliminate them. These invasive species make it harder for new vegetation to establish.

Native plants have adapted to a short growing season and may have a long establishment period. Therefore, establishing mature plants will require a longer sustained effort.

Plant selection should consider tolerance for drought conditions, periods of infrequent inundation, extreme heat, and winter conditions including snow cover and freezing. The varied nature of these factors make plant selection and availability important design considerations.

Plant species with low maintenance can reduce long-term cost of GSI applications. Some plants produce large or abundant seeds/seed pods that are released every season. Some plants lose their leaves during fall and winter months. This may produce large amounts of litter that require cleaning maintenance or could reduce the functionality of the treatment application by blocking soil exposure or clogging flow areas or filters.

CURRENT CLIMATE IN ADA COUNTY

The area typically experiences four distinct seasons with substantial variations in temperature and precipitation. National Weather Service (NWS) historical data shows that diurnal temperature fluctuations of 40 degrees or more are fairly common in any season. Winter low temperatures often reach 0°F and lower for short periods of time, but typical average temperatures for the winter months range between 30°F and 37°F degrees Fahrenheit. Summer extremes often exceed 100°F. Summer monthly averages range between 67°F and 75°F.

On average, approximately 75 percent of area precipitation occurs between November and May and can take the form of rain or snow. Average snowfall accumulation is around 20 inches but varies greatly from year to year. Storms during this colder weather period are often widespread, producing steady precipitation. Precipitation during the warmer months is more likely to take the form of frequent, isolated, and intense showers and thunderstorms (Attachment B).

Implementation Considerations

When moving through the GSI design process, barriers to implementation should be continuously considered and accommodated. Continuous consideration and flexibility in design will lead to execution of a comprehensive GSI program. The following are some ways to manage barriers.

PROMOTE COLLABORATION AND COMMUNICATION

Increased communication with all municipalities, designers, neighborhood associations, local experts, and special-interest groups can help alleviate fragmented responsibility and integrate management and implementation of GSI throughout the community.

Lack of proper training in GSI design techniques for designers can lead to GSI facilities that are poorly designed and constructed. Sharing information on historical GSI practices that were both successful and unsuccessful, along with improvements to the design that can increase the likelihood of success, is imperative.

KEEP GSI PROJECTS COSTS LOW

In order for GSI to be a successful low-impact stormwater management approach, project costs must be kept affordable. Construction and maintenance of GSI projects may be able to be funded through a cost-sharing program. Cost savings have been realized through other project phases such as site grading, preparation, and paving and installation of the required stormwater infrastructure.

EMPLOY GSI DESIGN CRITERIA

Site-specific barriers include utility conflicts and infiltration impediments such as rock, poorly draining soil, and high water table. Therefore, it is important to implement the GSI design process and carefully review all available options before a GSI practice is chosen. At the conclusion of pilot study monitoring, GSI design criteria should be developed and included in the Design Manual as approved BMPs.

FIGURE 1-5
Collaboration among different jurisdictions must be incorporated into the GSI implementation process.

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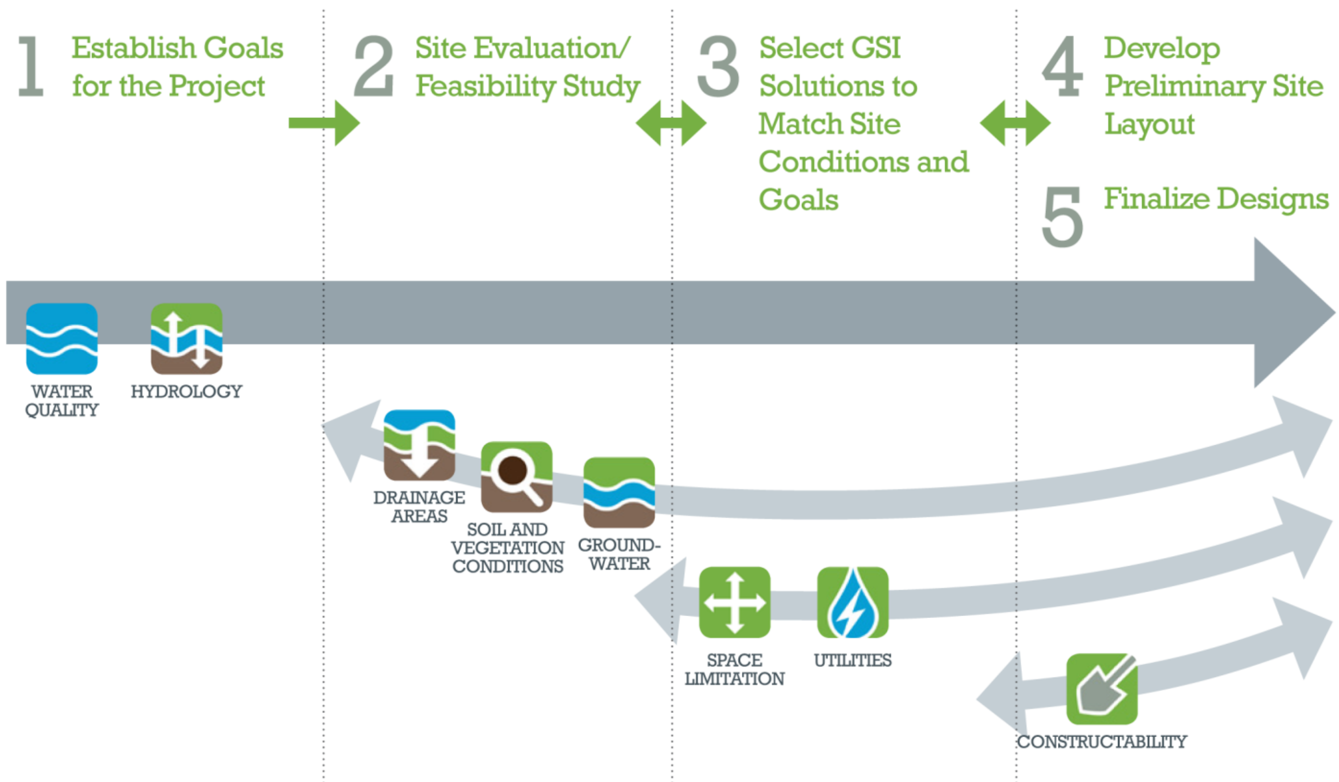
Chapter 2

GSI Process and Criteria

This chapter introduces each step in the GSI evaluation process and describes the design criteria to be considered at each of the steps.

The ACHD Policy Manual (Section 8000) defines the requirements of stormwater systems within ACHD, and the Design Manual (Section 8200) contains the standards and guidance for selecting and designing permanent stormwater BMPs. The process presented in this chapter has been developed based on the existing ACHD Policy Manual. This process is intended to supplement the above-mentioned sections of the ACHD Policy Manual.

As shown below, some steps are linear and some are iterative (indicated by one-way and two-way arrows). In the right column are the design criteria that may need to be considered more than once and in more than one step depending on the number of iterations of the steps. Please note that this guidance manual does not cover steps 4 and 5; these are included only to demonstrate the complete process.



Step 1: Establish Goals for the Project

Clearly establish the project goals at the outset of the design process. These goals may include treatment requirements, runoff volume reduction, aesthetics, community benefits, and other Permit requirements. The project goals will influence site layout, selection, sizing, and design of the GSI practices. All projects must meet ACHD Performance Standards (Section 8007).

WATER QUALITY

Per the ACHD Policy Manual, stormwater runoff from roadway projects must be retained within the project limits rather than being released to downstream receiving water bodies. Receiving water bodies can be both surface and subsurface water and must be identified and limitations must be understood and accounted for in stormwater facilities design.

The overall relationship between the proposed project site and the proximity of receiving water bodies (upstream, downstream, and groundwater) must be considered. The site stormwater management approach must consider impacts to receiving water bodies throughout the project life cycle, including construction, operation, and maintenance.

UNIQUE ADA COUNTY CONSIDERATIONS

- There are two total maximum daily loads (TMDLs) or water quality improvement plans that include load allocations for sediment, phosphorus, and bacteria discharges to the Boise and Snake Rivers. These allocations will require load reductions from the stormwater system.
- Determine if any of the receiving water bodies are impaired (303(d) listed) or have other water quality consideration requirements (refer to Table 2-1 below). Prior to discharging to an impaired water body, stormwater should be treated on site for the pollutants of concern.
- Obtain permission from the canal company, irrigation district, or drainage district prior to discharging to canals.

HYDROLOGY

Impervious surfaces dictate the amount of runoff that the site will generate during a storm event and, therefore, should be minimized.

The existing hydrologic characteristics of a project site should be studied early and existing flow paths should be accommodated as feasible. In retrofit situations, consider existing road grades. The site must be evaluated for downstream erosion potential due to increased flows from the developed site including cumulative impacts on canals and leakage and breakage issues.

UNIQUE ADA COUNTY CONSIDERATIONS

- Average annual precipitation is 11.5 inches and approximately 75 percent of precipitation occurs between November and May.
- Natural surface hydrology has been significantly altered by the canal irrigation system in Ada County, particularly with respect to stormwater drainage and groundwater recharge, and should be accounted for in design.

Surface Water Beneficial Uses

TABLE 2-1: Ada County Surface Water Uses and Concerns

	Beneficial Uses	Conditions/Pollutants of Concern
Lower Boise River	Cold water aquatic life	Flow alteration
	Salmonid spawning	Substrate habitat alterations
	Domestic water supply	Sediment
	Primary contact recreation	Dissolved oxygen
	Secondary contact recreation	Oil and grease
	Wildlife habitat	Nutrients
		Bacteria
		Temperature
Blacks Creek	Cold water aquatic life	Dissolved oxygen
	Wildlife habitat	Sediment
	Secondary contact recreation	Nutrients
Fivemile Creek	Cold water aquatic life	Dissolved oxygen
	Modified cold or warm water biota	Sediment
	Secondary contact recreation	Nutrients
		Bacteria
Tenmile Creek	Cold water aquatic life	Dissolved oxygen
	Modified cold or warm water aquatic life	Sediment
	Secondary contact recreation	Nutrients
		Bacteria
Mason Creek	Modified cold or warm water aquatic life	Dissolved oxygen
	Secondary contact recreation	Sediment
		Nutrients
		Bacteria
Indian Creek	Cold water aquatic life	Dissolved oxygen
	Seasonal cold water biota	Sediment
	Salmonid spawning	Nutrients
	Primary contact recreation	Temperature
	Secondary contact recreation	Oil and grease
	Wildlife habitat	Bacteria

Stream uses and conditions/pollutants of concern from Idaho Department of Environmental Quality (IDEQ) subbasin assessments for the Lower Boise River and major tributaries (IDEQ, 2001a and 2001b) and Idaho's 2012 Integrated Report (IDEQ, 2013).

Ada County Vicinity Map and Surface Waters

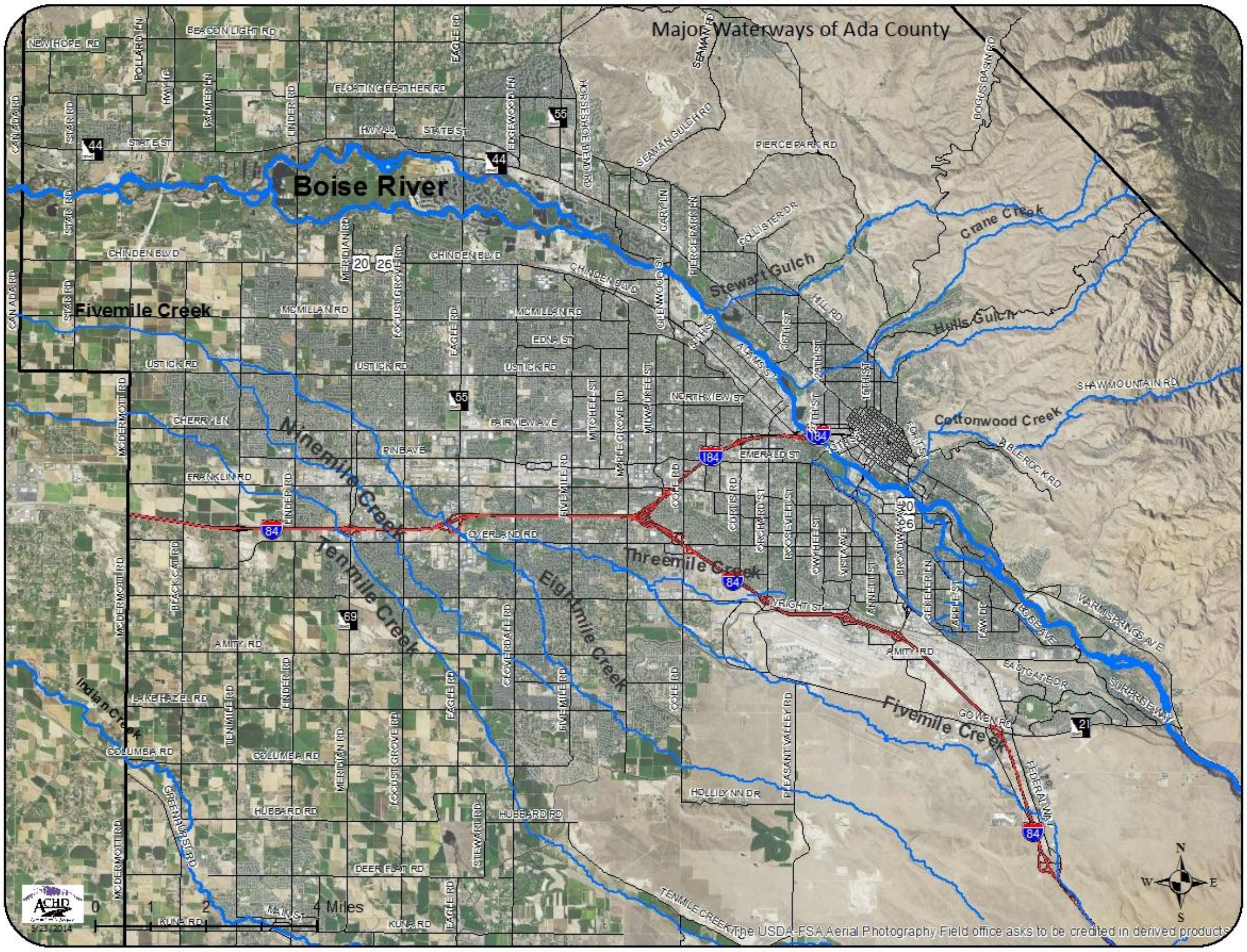


FIGURE 2-1
Site map of Ada County with waterways in the Phase I Permit area

Step 2: Site Evaluation/Feasibility Study

It is important to understand the project site, including limiting conditions and stormwater runoff volumes that require management.

General siting considerations for infiltration facilities include infiltration rates of at least 0.5 inch per hour (in./hr), minimum groundwater separation of 3 feet from the proposed facility bottom to seasonal high groundwater elevation, mild slopes, and available space within the right-of-way. If right-of-way space is limited, adjacent areas may be acquired or areas owned by local jurisdictions may be used by agreement.

DRAINAGE AREA

When evaluating the drainage areas use the following GSI concepts: divide the site into sub-basins, treat runoff at the source, and limit runoff travel distance for receiving treatment. Drainage patterns, road grades, contributing areas, and land uses can be determined from preliminary surveys of the area.

UNIQUE ADA COUNTY CONSIDERATIONS

- All sites should retain and treat the first 0.6 inch of water quality capture volume (V_{WQ}) from the 24-hour event. The V_{WQ} must be 100 percent managed on site with no discharge to surface waters. See the Policy Manual for more details.

SOIL AND VEGETATION CONDITIONS

The soils underlying proposed practices should be defined prior to design. This will also help identify whether soil modification is required. Soils that have adequate drainage and permeability (Soil Types A, B) are typically appropriate for GSI techniques, while soils with poor drainage and permeability (Soil Types C, D) are either not appropriate for infiltration, or will require additional design modifications.

UNIQUE ADA COUNTY CONSIDERATIONS

- Identify whether the site contains a hardpan layer that can restrict water infiltration and reduce downward movement of water.
- Potential areas of soil erosion can be preliminarily identified using resources such as the Natural Resources Conservation Service (NRCS).
- Assess the proposed vegetation for warm/cool season, maintenance requirements, salinity tolerance, etc. See Table 2-2 for references.

Step 2: Site Evaluation/Feasibility Study

GROUNDWATER

Infiltration GSI techniques, such as bioretention, may be constrained by factors such as high groundwater elevation. Feasibility of an infiltration facility depends on both the permeability of soil and the depth to groundwater. The site must be assessed for depth to groundwater, existing groundwater flow direction and gradient, and any potential risk to groundwater contamination.

UNIQUE ADA COUNTY CONSIDERATIONS

- The depth to groundwater table can vary based on seasonal and irrigation influences.
- Underdrains in ACHD are discouraged due to maintenance issues. If an underdrain is required, the designer should coordinate with ACHD to ensure that the proposed system is maintainable.

Step 3: Select GSI Solutions to Match Site Conditions and Goals

Using the findings of the site evaluation and the project goals, select the appropriate solution(s) for the site. Choose GSI practices that can treat and retain stormwater runoff on site and also satisfy ACHD requirements.

SPACE LIMITATION

Many GSI features require land area to accommodate the required stormwater treatment volume. Design components such as area and depth of a facility are based upon engineering calculations and right-of-way constraints.

Retrofit projects require that existing soil conditions be evaluated for infiltration capacity along the right-of-way. There are multiple demands for space in the right-of-way, including stormwater treatment, bicycle lanes, sidewalks, utilities, parking, and traffic lanes. Space limitations can present a challenge when installing green infrastructure in the right-of-way along public streets. Current use of the developed right-of-way should be fully understood before it is proposed for conversion into a treatment area to minimize negative impacts to the public.

ADDITIONAL CONSIDERATIONS

- Determine the width and type of the existing right-of-way. If the available right-of-way is not adequate, consider acquiring additional land to accommodate the facility or make deeper facilities.
- Coordinate with other jurisdictions and local agencies where geographical overlap occurs with ACHD facilities.

UTILITIES

The location of underground utilities, such as water, sewer, stormwater, and gas, and aboveground utilities, such as power and phone utilities, must be identified.

Utility vaults can be a difficult constraint to maneuver around when placing stormwater facilities within streets and parking lots. At a minimum, utility vaults should be located outside of the stormwater facility footprint.

Plant size and structural stability should be considered within the context of the surrounding aboveground and underground infrastructure. Species with aggressive rooting tendencies should not be selected if underground utilities are present.

ADDITIONAL CONSIDERATIONS

- Call Idaho Digline to locate the underground utilities in and around the project site.
- Map existing utilities and utility easements on the site plan.

Steps 4 and 5

Develop Preliminary Site Layout

Lay out the site using GSI elements: divide the site into subwatersheds, treat runoff at the source, limit runoff travel distances to receive treatment, increase tree canopy, and minimize impervious surfaces.

Lay out the required site features in a way that will accommodate GSI practices. Explore the feasibility of replacing pavement and traditional stormwater BMPs with GSI practices (e.g., pave with permeable pavers, retrofits with bioretention curb extensions and bulb-outs, allow impervious areas to drain onto or across pervious areas to promote infiltration).

Lay out stormwater treatment facilities (GSI practices and/or ACHD-approved BMPs) to accommodate site limitations including avoiding placement in areas with infiltration rates of native soils less than 0.5 in./hr and avoiding placement in areas with less than 3 feet of groundwater separation from the bottom of the facility. The designer should coordinate stormwater management needs with other disciplines and resolve any issues such as utility conflicts and space limitations. If soil cover will be reduced over existing underground utilities, close coordination with the utility providers is needed to verify that utility relocation is not necessary to accommodate the GSI facilities.

Consider constructability and operation and maintenance of the proposed treatment facilities. Coordinate early with Operation and Maintenance staff for review and input on the feasibility of the proposed facilities. Maintenance agreements with other parties may be necessary.

Additional GSI site layout considerations include functional impacts based on variations in site layout, traffic patterns, safety concerns, parking volume and locations, and potential encroachment issues.

Finalize Designs

Once the required engineering reports and tests are complete (survey, geotechnical, etc.), use findings to update sizing assumptions and incorporate into final design.

CONSTRUCTABILITY

Constructability of any potential stormwater treatment facility must be considered early in design. An assessment of facility constructability should be completed once the entire site layout, including all improvements, is complete.

Information Needed for Site Evaluation

TABLE 2-2: Information Needed for Site Evaluation

Suitability Criteria	Information Source	Effect on Design and Use of GSI Practices
1. Establish Goals for the Project		
Water Quality	Aerial photographs TMDLs/303(d) listings http://www.deq.state.id.us/water-quality/surface-water/tmdls/table-of-sbas-tmdls.aspx NPDES Permit requirements http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/Current+ID1319#permits Lower Boise River Basin Plan http://www.deq.state.id.us/regional-offices-issues/boise/basin-watershed-advisory-groups/lower-boise-river-wag.aspx	Used to identify any impaired water bodies impacted by the project site. If impaired receiving waters exist, ensure that the treatment BMPs are capable of treating the pollutant(s) of concern.
2. Site Evaluation/Feasibility Study		
Hydrology and drainage area	Topographic maps Aerial photographs Survey data Existing storm drain system details	Used for placing and sizing the BMPs and to determine the volume of flow that can be expected at the project site.
Soil and vegetation conditions	**Soil**: Aerial photographs Vicinity map Field reconnaissance Geotechnical design report Natural Resources Conservation Service (NRCS) http://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/ U.S. Geological Survey (USGS) http://www.usgs.gov **Vegetation**: *Landscaping with Native Plants of Intermountain Range (Native Plant Society, INPS)* Idaho Roadside Revegetation Handbook (Kingery et al.) http://itd.idaho.gov/highways/ops/maintenance/Roadside/Roadside_Management.htm Native Plants for Idaho Roadside Restoration and Revegetation Programs (Robson and Kingery, 2006) http://itd.idaho.gov/highways/ops/maintenance/Roadside/Roadside_Management.htm	Used to determine existing soil type, depth to bedrock or poorly drained soils, and site permeability to determine the feasibility of GSI implementation. Used to identify slopes that may require a minimum setback for infiltration facilities. Used to determine appropriate vegetation for the site conditions and BMP treatment requirements.

Information Needed for Site Evaluation

TABLE 2-2: Information Needed for Site Evaluation (Continued)

Suitability Criteria	Information Source	Effect on Design and Use of GSI Practices
2. Site Evaluation/Feasibility Study		
	Stormwater Plant Materials: A Resource Guide for Boise Public Works (Boise Public Works Department, 2000) http://publicworks.cityofboise.org/services/water-management/drainage-control/	
Groundwater	Well records Geotechnical design report U.S. Geological Survey (USGS)	Used to determine limitations of infiltration at sites with shallow groundwater tables.
3. Select GSI Solutions to Match Site Conditions and Goals		
Utilities	Site inspection Call Idaho Digline	Used to determine the design requirements for horizontal and vertical utility separations. Use of design components such as underdrains might also be affected by the proximity of existing utilities.
Space limitation (right-of-way)	Field reconnaissance Consultation with local jurisdictions and adjacent property owners	Used to evaluate the amount of space available and the need for property acquisition.
Infiltration testing requirements	Policy Manual 8010 http://www.achdidaho.org/AboutACHD/PolicyManual.aspx	Used to determine the site-specific infiltration rate; critical to design effective infiltrative GSI practices.
4. Develop Preliminary Site Layout		
Constructability	All of the sources listed above	Constructability encompasses all the above suitability criteria and any additional factors: vehicular access and use, volume of traffic, ease of maintenance, seasonal consideration, public acceptance, and life cycle cost analysis.
5. Finalize Designs		

Chapter 3

ACHD Streets and GSI Practices

This chapter includes a brief introduction to four GSI practices—tree systems, bioretention, permeable pavers, and bio-swales—that ACHD believes to be the most applicable to future projects under its jurisdiction.

GSI practices presented in this guidance manual have been selected based on the specific jurisdictional responsibilities associated with ACHD. The application of GSI practices is specifically limited to right-of-way opportunities. The facilities presented in this manual can be applicable in many ACHD right-of-way situations. ACHD has selected these GSI practices with the understanding that maintenance and aesthetics are also important components of implementation.

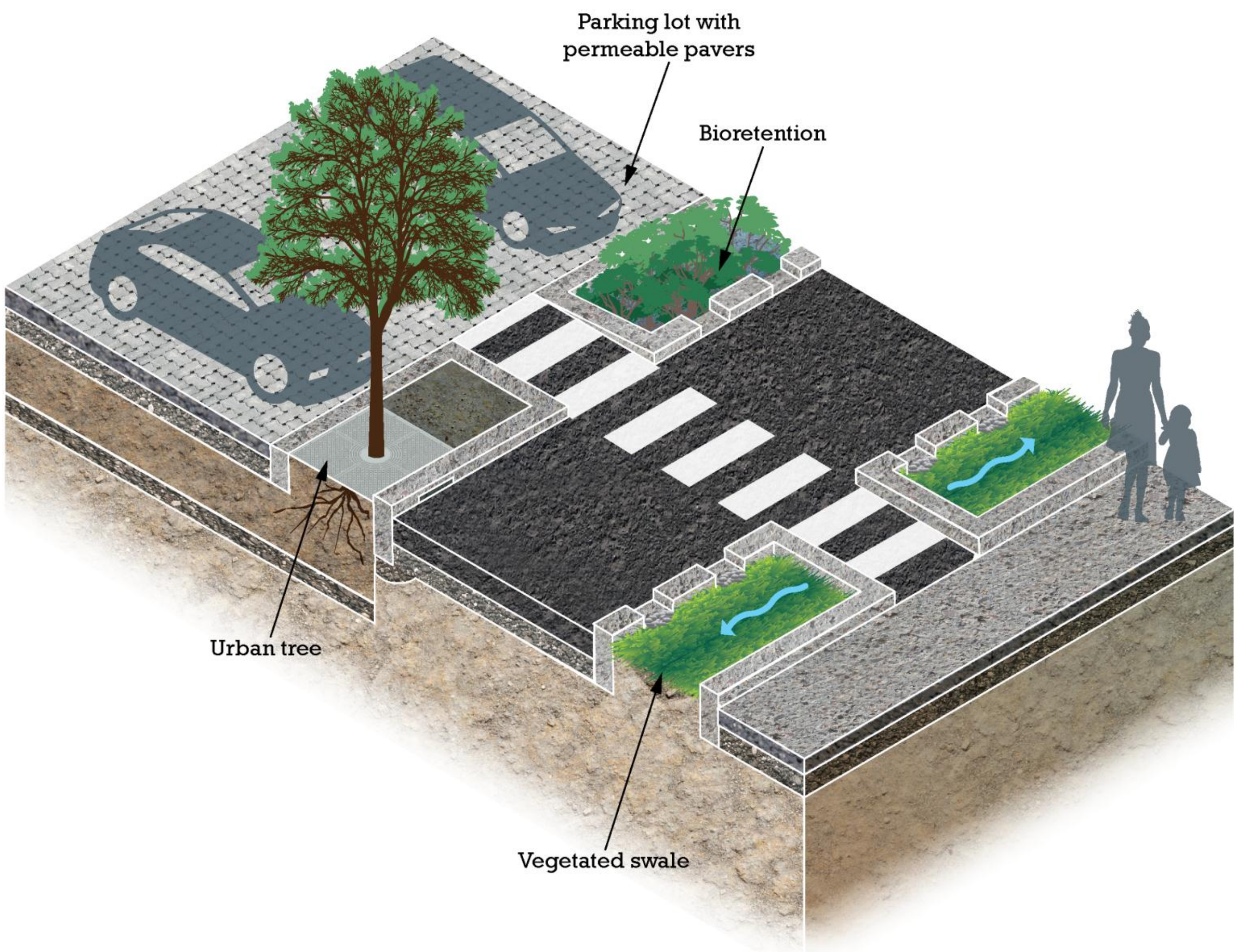


FIGURE 3-1
Various types of GSI practices can be implemented to address both the quantity and quality of stormwater runoff to achieve water quality improvement.

ACHD Street Types

This chapter describes the various profiles and street types used by ACHD and provides a brief introduction to four GSI practices: tree systems, bioretention, permeable pavers, and bio-swales. ACHD believes these practices to be the most applicable to future projects under its jurisdiction.

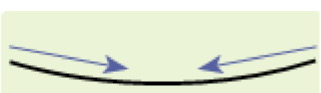
Profile and street distinctions are important to consider as it is the impervious street surfaces that generate stormwater runoff. Successful GSI implementation is dependent on having a thorough understanding of street uses, opportunities, and constraints associated with different street types.

The four street types described in this chapter are residential, commercial, arterials, and alleys. This chapter also includes street profiles that illustrate how stormwater runoff flows off of the street. Street profiles can be crowned, inverse-crowned, or super-elevated, as shown below.

GSI practices presented in this guidance manual have been selected based on the specific jurisdictional responsibilities associated with ACHD. The application of GSI practices is specifically limited to right-of-way opportunities. The facilities presented in this manual can be applicable in many ACHD right-of-way situations. ACHD has selected these GSI practices with the understanding that maintenance and aesthetics are also important components of implementation.

CROWN

The most common street profile is a crowned street with stormwater draining to the sides of the street. There is often a curb-and-gutter system directing flow into a stormwater drain inlet. These drain inlets are located at the middle or end of each block depending on the block length.



INVERSE CROWN

An inverse-crowned street is the opposite of a crowned street and directs runoff to the center line of the street. This type of street is common with alleys.

SUPER-ELEVATED

Streets can also be designed to shed all the water to just one side of the street.

ACHD Street Types

RESIDENTIAL STREETS

Residential streets are access-oriented street networks with lower travel speeds. Residential streets may have onsite parking. These types of streets have the fewest conflicts with utilities and the greatest ability to easily create landscape space or modify existing landscape space for stormwater management.

GSI retrofit opportunities include curb extension bioretention, permeable pavers, and planting strip bioretention for treatment. These practices have an added benefit of calming traffic and can be installed in underutilized parking spaces. For newly developing areas, tree systems could also be used.

Institutional uses offer opportunities for innovative solutions. Runoff can be treated within adjacent park space or on school properties where agreements are possible.

FIGURE 3-2
A residential street in Ada County with potential opportunities for GSI retrofits.

COMMERCIAL STREETS

Commercial streets in downtown areas and along arterials offer some great opportunities for GSI applications. However, they also present some of the most difficult constraints to overcome. These constraints include fierce competition for space among on-street parking, pedestrians, street trees, and utilities.

Bioretention planters and tree systems can serve as both the landscape amenity and stormwater treatment. Permeable pavers serve as both the hardscape for parking and pedestrians and stormwater treatment.

FIGURE 3-3
Right-of-way availability can be limited in commercial areas where parking is frequently used.

ACHD Street Types

ARTERIAL STREETS

Arterials are high-volume streets that generate significant amounts of stormwater runoff and primarily service vehicle traffic with little emphasis on walkability or bike transit. Some arterials have landscaped medians where GSI practices could potentially be implemented.

Areas that do not require paving, such as medians and traffic islands, may be able to be replaced with pervious areas, if grades allow. Tree systems and bioretention planters may be appropriate if properly designed to handle flows from larger impervious areas and if they have pretreatment that is maintainable. On smaller arterials, dedicated parking lanes may be able to be converted to permeable pavers to treat up to two additional lanes.

Tree systems, bioretention practices, and permeable paver sidewalks are appropriate for high density areas where business districts expect an enhanced streetscape.

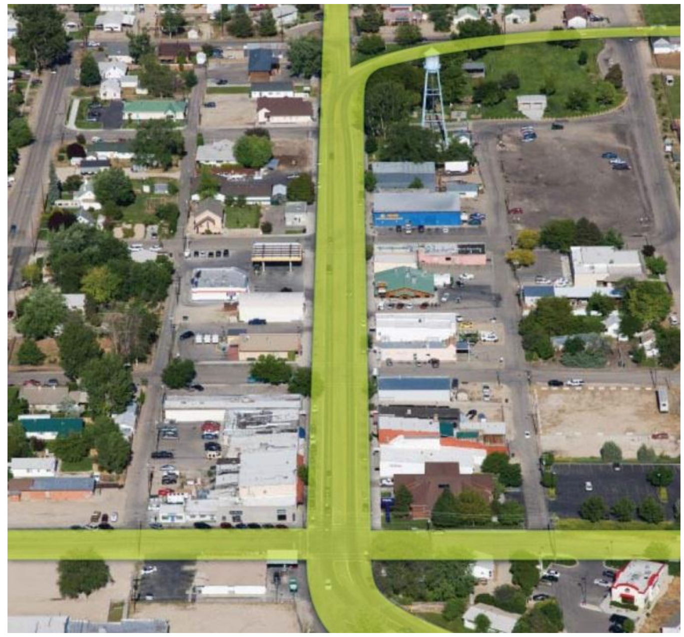


FIGURE 3-4
Because of higher speeds on arterial streets, some GSI practices may not be appropriate.

ALLEY

Alleys are narrow passageways between or behind buildings. Alleys are usually designed for vehicular or pedestrian access. The GSI application that is typically feasible in alleys is permeable pavers. Design constraints in alleys include limited amount of space and utilities.

FIGURE 3-5
Alleys can be placed throughout a city. Evaluation of location in the drainage basin and expected traffic volumes should inform project siting.

Tree Systems

Tree systems encompass several practices including tree trenches, tree cells, and the use of structural soils. Tree practices that receive stormwater mimic certain physical, chemical, and biological processes that occur naturally and help to manage stormwater in the subsurface environment. Tree systems provide a broad range of environmental, aesthetic, and community benefits.

COMMUNITY

Enhances neighborhood aesthetics

Reduces noise and glare

Increases pedestrian safety

Improves air quality

Increases canopy cover

Requires minimal surface footprint

CLEAN WATER

Improves water quality

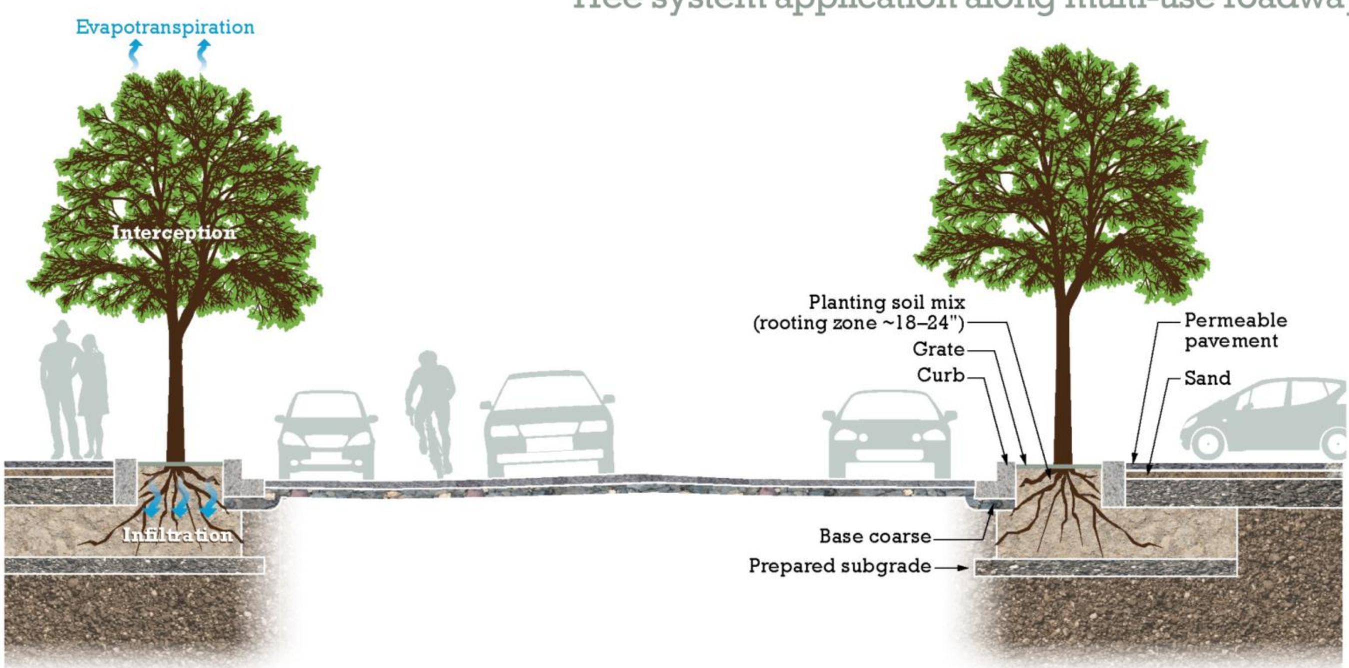
Reduces stormwater runoff

Manages stormwater in the subsurface environment

Promotes stormwater evapotranspiration

Uptakes nutrients

Tree system application along multi-use roadway



Tree Systems

Potential Applications

- Residential/suburban and ultra-urban areas
- Method to manage runoff volume
- Complement to other GSI techniques such as permeable pavers
- Tree practices are an ideal and potentially important BMP in urban retrofit situations where existing stormwater treatment is absent or limited

Residential	Limited
Commercial	Yes
Arterial	Yes
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Medium
Maintenance	Medium
Summer/Winter Performance	High
Community Benefit	High

Limitations

- Requires adequate underground rooting space
- Underground and above-ground utility conflicts must be evaluated
- Requires careful selection of tree species

Tree systems create attractive thoroughfares for pedestrians and a more walkable city.

The structural component of the tree system profile allows installation of this compact GSI facility under structural roadway sections.

Bioretention

Bioretention areas are shallow vegetated depressions that provide storage and encourage infiltration through retention. Bioretention areas remove pollutants by filtering stormwater through plants adapted to the local climate and soil conditions. Further, the infiltration process promotes the adsorption of pollutants into the underlying soils. Bioretention can be included in many right-of-way features including planting strips, stormwater planters, bulb-outs, medians, and chicanes.

COMMUNITY

Enhances roadway aesthetics

Improves road safety

Requires minimal space

CLEAN WATER

Removes pollutants

Reduces runoff volume

Alleviates flooding

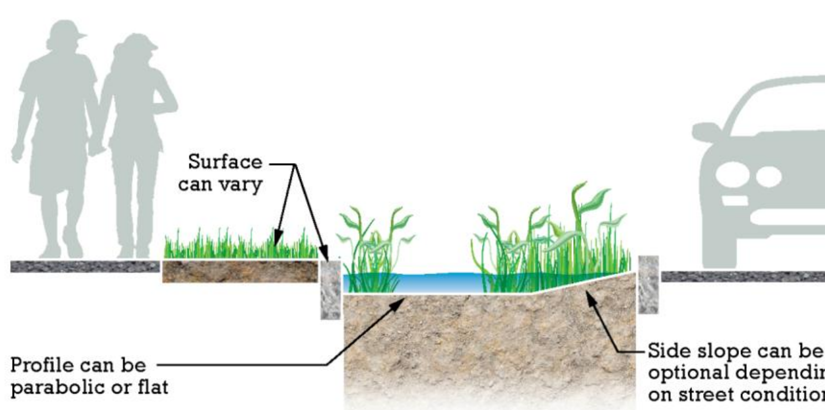
Decreases runoff temperature

Uptakes nutrients

Existing curb retained while installing a bioretention along a neighborhood collector street. *Source: Kevin Robert Perry/City of Portland*

Accessible pedestrian ramps can also be integrated into the design.
Source: Dave Elkin/City of Portland

Typical Bioretention Profile



Bioretention

Potential Applications/Retrofits

- Method to manage runoff volume and mitigate peak discharge rates
- Provides medium to biodegrade petroleum-based solvents and hydrocarbons
- Traffic-calming device in commercial and residential settings

Residential	Yes
Commercial	Yes
Arterials	Limited
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Medium
Maintenance	Medium
Summer/Winter Performance	Medium
Community Benefit	High

Bioretention areas can be designed as any size or shape needed to meet space limitations while providing stormwater treatment.

Limitations

- Designed to capture small storm events
- Not suitable for locations where the seasonally high groundwater table is near the surface
- Must consider existing on-street parking conditions, street width, and vehicle turning radii when using the bulb-outs
- Additional maintenance required to establish vegetation
- Requires careful selection of plants and soil mix for optimum performance (tolerate summer drought/low rainfall, ponding fluctuations and saturated soil conditions for lengths of time)
- May require third party agreement for maintenance

Permeable Pavers

Permeable interlocking concrete pavement (permeable pavers) is comprised of concrete pavers separated by joints filled with small stones. Permeable pavers prevent the generation of runoff by allowing precipitation falling on the surface to infiltrate through the pavers into the underlying soil. They are attractive, easy to repair, and can withstand light traffic vehicle loads.

Gaps in the pavers allow water to soak into the ground.
Source: Mutual Materials

Residential streets can be retrofitted with permeable paving in the parking zone of the street. *Source: Nevue Ngan Associates*

COMMUNITY

Eliminates standing water on pavement

Reduces pollutants splashed from vehicles

Provides dual purpose for right of way areas

CLEAN WATER

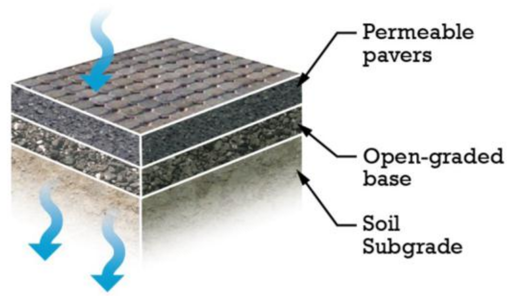
Improves water quality

Reduces pollutant loading

Reduces runoff rate and volume

Retrofits developed areas for additional stormwater management

Typical permeable pavers profile



Permeable Pavers

Potential Applications

- Commercial streets, alleys, and residential access roads
- Road retrofit projects
- Ultra-urban conditions with interior drainage
- Reduces size of traditional stormwater infrastructure such as detention ponds
- Most appropriately applied in low to medium traffic areas (e.g., residential roads, alleys, etc.)

Residential	Yes
Commercial	Yes
Arterials	Limited
Alleys	Yes

ADDITIONAL CONSIDERATIONS

Capital Cost	High
Maintenance	Medium
Summer/Winter Performance	Medium/High
Community Benefit	Medium/ High

Limitations

- Requires placement on well-drained native soil
- Limited to low traffic speed roadways
- Not applicable in areas down slope of steep, erosion-prone areas
- Requires careful construction and installation for optimal performance
- Requires higher maintenance than conventional pavements
- Not applicable where concentrated pollutant spills occur or where sand/ deicer is used in winter

Permeable pavers are attractive and easy to repair, and they can withstand vehicle loads.

Permeable pavers implemented in an alley retrofit project.

Bio-swale

Bio-swales are long, fairly shallow depressions that often use a curved or sinuous form to convey and slow water. They have a porous filter medium (usually soil-based) and are planted with native or non-native grasses and other vegetation. They work to treat stormwater by slowing and infiltrating flow and create an environment for plant uptake of pollutants. They enhance landscape aesthetics.

COMMUNITY

Enhances roadway aesthetics

Uses minimal space

Requires low maintenance costs

CLEAN WATER

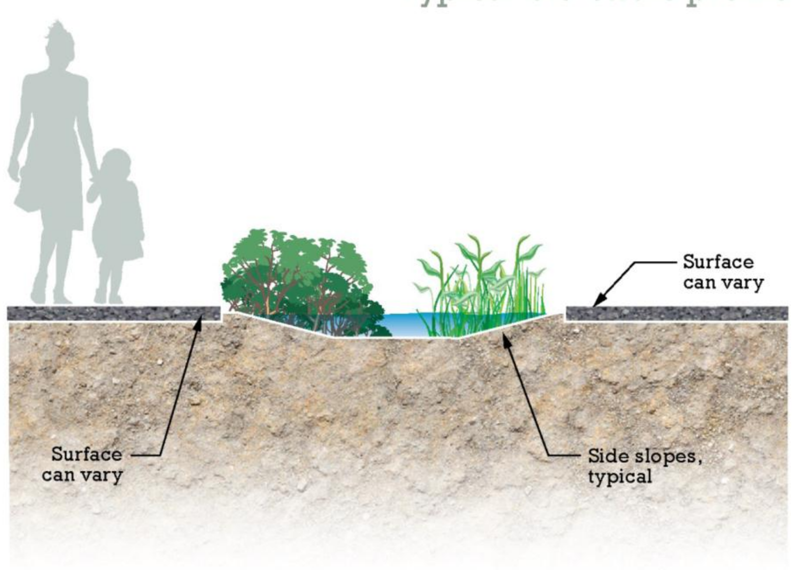
Improves water quality

Manages runoff volume

Mitigates peak discharge rates

Uptakes nutrients

Typical bio-swale profile



Bio-swale that conveys flows along an arterial street. *Source: Nevue Ngan Associates*

Bio-swale

Potential Applications

- Method to manage runoff volume and mitigate peak discharge rates
- Provides medium to biodegrade petroleum-based solvents and hydrocarbons
- Alternative to conventional curb-and-gutter conveyance systems
- Pretreatment and/or primary treatment

Residential	Yes
Commercial	Yes
Arterial	Yes
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Low/Medium
Maintenance	Medium
Summer/Winter Performance	Medium
Community Benefits	Medium

Limitations

- Long, continuous space may not be available in retrofit conditions
- Additional maintenance required to establish vegetation
- Option to incorporate other streetscape elements within swales (lighting, signage, etc.) may be limited
- Effectiveness decreased by compacted soils, frozen ground conditions, short grass heights, steep slopes, large storm events, high discharge rates, high velocities and short runoff contact time

Bio-swales are designed to convey stormwater runoff while also providing water quality treatment benefits.

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Chapter 4

GSI Practice Applications

The GSI applications presented in this chapter illustrate the ways in which GSI practices —tree systems, bioretention areas, permeable pavers, and bio-swales—can be incorporated into ACHD projects. The applications illustrated in this chapter can be incorporated in both new development and redevelopment projects.

This chapter focuses on the application of GSI practices to the typical street types that can be expected on ACHD projects, as introduced in Chapter 3.

The applications illustrated in this chapter can be incorporated into both new development and redevelopment projects. Retrofits for stormwater quality improvements must be considered on any project including repair work involving land disturbance of 5,000 ft^2 or more in areas with an existing, conventional storm drain system. GSI practices are to be incorporated as retrofits when feasible.

The GSI practices presented in this chapter are believed by ACHD to be most applicable to their projects based on the limited right-of-way opportunities within the jurisdiction. This is not a comprehensive list of all GSI practices and/or applications. ACHD will consider other GSI practices for incorporation into new development and redevelopment projects on a case-by-case basis in accordance with Section 8202.7 of the ACHD Design Manual.

TABLE 4-1: ACHD Street Types and GSI Applications

	Tree Systems	Bioretention Areas	Permeable Pavers	Bio-swales
Residential	No	Yes	Yes	Yes
Commercial	Yes	Yes	Yes	Yes
Arterials	Yes	Limited	Limited	Yes
Alleys	No	No	Yes	No

Tree Systems: Commercial, Arterial, and Residential

Use of trees to manage stormwater runoff encompasses several practices including tree trenches, tree cells, and the use of structural soils.

A stormwater tree trench is a subsurface trench installed in the sidewalk area that includes a series of street trees along either a section or the total length of the subsurface trench. It is designed to manage stormwater runoff by connecting the subsurface trench to one or more inlets (types vary), which allows runoff from the street and sidewalk to flow into the subsurface trench. A tree cell or pit can accommodate a single tree.

A primary strategy used to improve the subsurface environment for trees and to provide stormwater infiltration is the incorporation of rigid, load-bearing cells that are filled with uncompacted soil or structural soils (e.g., Silva cells).

Structural soils are highly porous, manufactured aggregate mixes, designed to be used under asphalt and concrete pavements as the load-bearing and leveling layer. Structural soil provides a soil component to the aggregate mix that facilitates root growth—common road bases do not have this tree-friendly component.

FIGURE 4-1
Before: This right-of-way system collects runoff in low spots along a flat alignment.

This GSI practice is considered most appropriate for use in commercial areas and along arterial streets.

The steps on the following pages demonstrate the GSI design process and the design criteria that must be evaluated while considering tree systems as the stormwater management option for a given site.

FIGURE 4-2
This rendering shows added hydraulic connections to new urban tree GSI practices to eliminate standing water and to provide treatment.

Tree Systems: Step 1

Establish Goals for the Project

Goals should be developed to ensure that additional environmental, economic, and aesthetic functions are considered throughout the design process. The following design criteria must be considered when designing tree systems.

WATER QUALITY

Receiving water bodies (surface and subsurface) must be identified and limitations must be understood and accounted for in the design process. The overall relationship between the proposed project site and proximity of receiving water bodies must be evaluated.

UNIQUE ADA COUNTY CONSIDERATIONS

- The pollutants of concern identified in Ada County include phosphorus, sediments, and bacteria.
- Determine if any of the receiving water bodies are impaired (303(d) listed) or have other water quality consideration requirements.

URBAN TREE DESIGN CONSIDERATIONS

- Verify that the urban tree facility will be effective in treating the pollutants of concern for the project site receiving water bodies.

HYDROLOGY

The existing hydrologic characteristics of a project site should be studied carefully to ensure that the trees in the facility receive the optimum amount of moisture to sustain the vegetation.

UNIQUE ADA COUNTY CONSIDERATIONS

- Average annual precipitation is 11.5 inches and approximately 75 percent of precipitation occurs between November and May.
- If the project site is near an irrigation canal, consider the potential for stormwater runoff to discharge directly to the canal.

URBAN TREE DESIGN CONSIDERATIONS

- Maintain an unsaturated area in the tree rooting zone and a wetter area below for improved retention and available soil moisture in drier periods.
- Ensure a design drawdown time of 48 hours to encourage aerobic conditions and good root distribution.
- Supplemental irrigation may be necessary.

Tree Systems: Step 2

Site Evaluation/Feasibility Study

It is important to understand your project site including any limiting conditions as well as stormwater runoff volumes that require management. The following design criteria must be considered when designing tree systems within the ACHD jurisdiction.

DRAINAGE AREA

Existing drainage patterns must be maintained by placing stormwater facilities in strategic locations. The primary goal is to minimize the impervious surfaces and mimic the natural hydrologic drainage pattern so that the amount of runoff generated from the site is minimized.

UNIQUE ADA COUNTY CONSIDERATIONS

- All sites should retain and treat the required V_{WQ}.
- The V_{WQ} must be 100 percent managed on site with no discharge to surface waters.
- There may be exceptions to these considerations in retrofit projects.

URBAN TREE DESIGN CONSIDERATIONS

- Drainage areas must be appropriately delineated to provide optimal moisture to the trees; saturated conditions are more problematic than dry conditions.
- If there is potential for extended ponding, explore options for appropriate drainage strategies (e.g., underdrains).
- In areas with an existing storm drain system, the facility can be designed with an overflow into the existing storm drain system during large storm events.

SOIL AND VEGETATION CONDITIONS

Determining the feasibility of tree systems must include an aboveground and underground site evaluation for both soil analysis and tree selection. When tree systems are used as infiltration facilities, an infiltration rate of at least 0.5 in./hr is needed in the native soil at the invert of the facility.

UNIQUE ADA COUNTY CONSIDERATIONS

- Identify whether the site contains a hardpan layer that can restrict water infiltration and reduce downward movement of water.
- Assess the tree species for size, maintenance requirements, and salinity tolerance.

URBAN TREE DESIGN CONSIDERATIONS

- Manufactured soil analysis for trees should include soil texture, compaction requirements, permeability, and chemical constituents.
- Prevent compaction of manufactured soils in the tree planting areas in order to increase the volume for stormwater storage and stormwater treatment.
- If the soils evaluation determines that there is a potential for dense, compacted soil under the facility and the tree root system is expected to grow outside of the tree box, consult an arborist for appropriate tree species selection.
- Use permeable pavers for sidewalks surrounding the trees to allow gas exchange and increase soil moisture.

Tree Systems: Step 2

GROUNDWATER

The feasibility of urban tree facilities is dependent on the groundwater elevation. For all projects, depth of groundwater and seasonal variation of the groundwater table must be assessed. The required minimum groundwater separation from the bottom of the infiltration facility is 3 feet.

UNIQUE ADA COUNTY CONSIDERATIONS

- The depth to groundwater table can vary based on seasonal and irrigation influences.

URBAN TREE DESIGN CONSIDERATIONS

- If groundwater protection areas are nearby, consider installing an impermeable liner.

Tree Systems: Step 3

Select GSI Solutions to Match Site Conditions and Goals

Using the findings of the site evaluation and the project goals, verify whether tree systems are the best GSI solution for the site. The following design criteria must be considered when designing tree systems within the ACHD jurisdiction.

SPACE LIMITATION

Determine the width of right-of-way available for installing the tree systems. Also coordinate with other jurisdictions and local agencies where geographical overlap occurs with ACHD facilities. Consider the growth of the tree above and below ground and the ultimate space required for a mature tree.

TREE SYSTEMS DESIGN CONSIDERATIONS

- Assess the soil condition within the available right-of-way. Assess below-ground root space relative to pavement, building, and utility setback requirements.

UTILITIES

Consult with Idaho Digline and service providers to locate the underground and aboveground utilities in and around the project site. Utility vaults can be a difficult constraint to maneuver around when placing stormwater facilities. Map existing utilities and utility easements on the site plan.

TREE SYSTEMS DESIGN CONSIDERATIONS

- Design appropriate measures to protect existing utilities, as needed—particularly underground and overhead utilities as the trees mature.
- Determine requirements for horizontal and vertical separations required for publicly owned utilities.

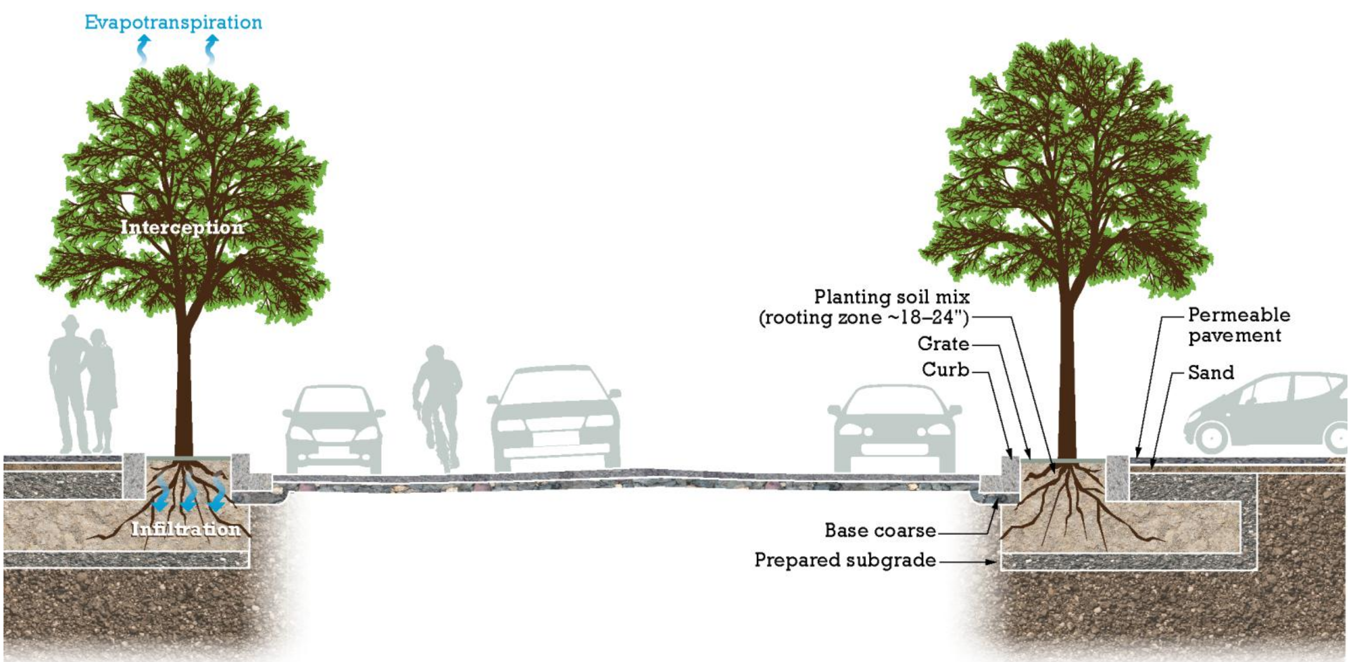

FIGURE 4-3
Urban trees provide a broad range of environmental, aesthetic, and community benefits.

Tree Systems: Additional Considerations

GENERAL CONSIDERATIONS

- Tree systems must be designed with emergency overflows to convey runoff in excess of the facility capacity. The overflow system must be designed in accordance with the ACHD Design Manual.
- If flow control is a project goal, consider incorporating additional structural framework sections and manufactured soils to increase storage capacity.
- Because of this flexibility with the structural framework, tree systems can be used for both small and large catchment areas.
- As with any filtration and infiltration BMPs, pretreatment is recommended to prevent clogging of the media, particularly when permeable pavement is used in conjunction with the tree practice.
- Vehicle and pedestrian sight lines should be considered.
- Consider conflicts with signage.

LIMITATIONS

- Trees need adequate horizontal surface width and below-grade soil depth.
- Trees might conflict with other structures such as basements and foundations.
- Careful selection of tree species is essential to achieve maximum benefits. Consult with the City forester.

MAINTENANCE

- Trees should be typically “limbed up,” ensuring that branches grow above and away from the sidewalk. Trees with drooping or low growing branches can create hazards for nearby pedestrians or vehicles.
- Supplemental irrigation will be necessary as trees must be watered once every 2 to 3 days for the first few months, then as needed.
- Spot weeding, pruning, erosion repair, trash removal, and mulch raking might be necessary twice during the growing season.
- At least once every 3 years, sediments in pretreatment cells/inflow points must be removed and the mulch layer (if any) must be replaced.
- Maintenance agreements with other parties may be necessary.

Bioretention Areas: Residential and Commercial

Bioretention planters have vertical sidewalls and are often narrow and rectangular in shape. The walls allow bioretention planters to maximize the amount of stormwater retained within a small footprint. These facilities promote infiltration, storage, filtration, and attenuation of peak flows and volumes generated by specified storm events. The soil mix and plant species can be designed to remove targeted pollutants from stormwater.

Bioretention practices can be of any size or shape and can be used for both new development and redevelopment projects. The self-contained structure of bioretention planters permits them to be installed in close proximity to utilities, driveways, trees, light standards, and other landscape features. Bioretention planters can be constructed immediately adjacent to the roadway, in the boulevard, or as a green feature within the pedestrian area (i.e., sidewalks and pathways).

FIGURE 4-4
This low spot collects runoff in the unpaved area adjacent to the traveled way, which can mobilize sediment into runoff.

The steps on the following pages demonstrate the GSI process and the design criteria that must be evaluated while considering bioretention as the stormwater management option for a given site.

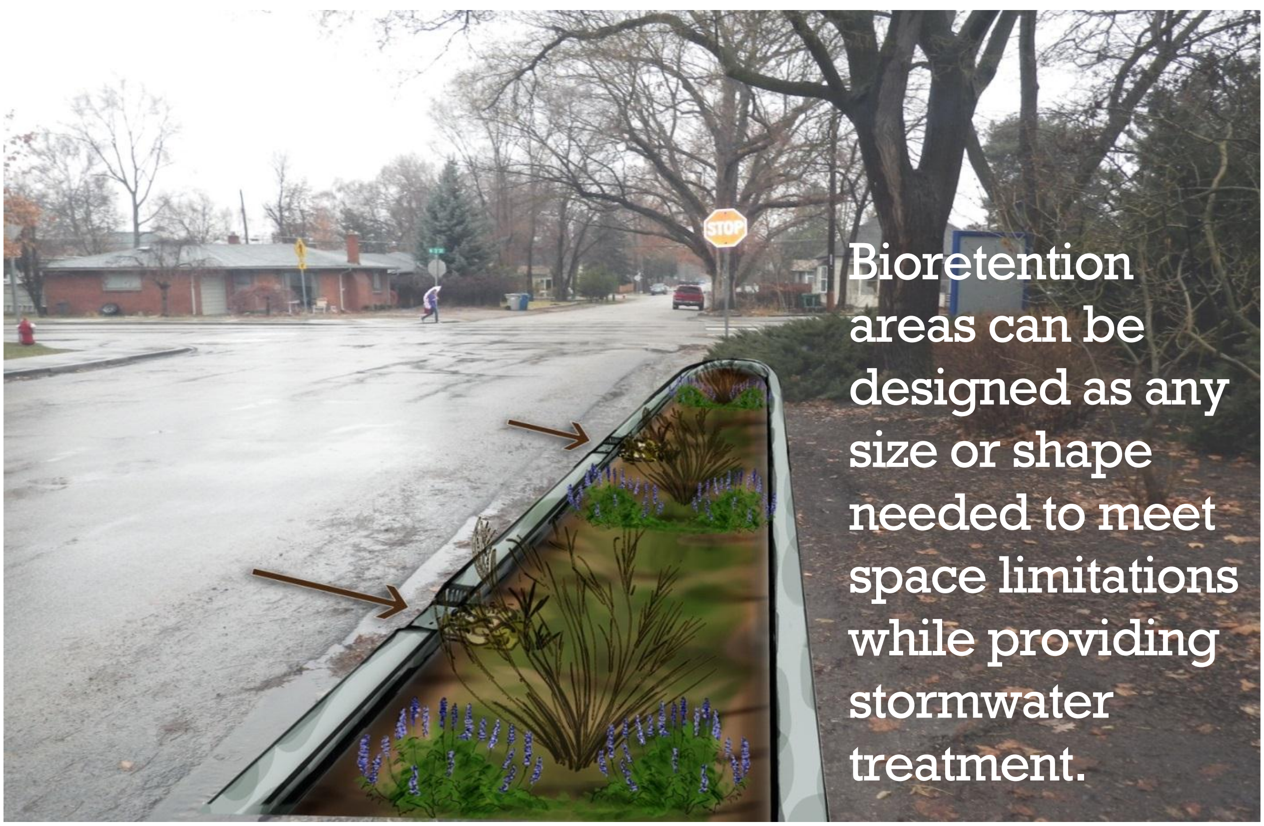

FIGURE 4-5
This rendering shows incorporation of a bioretention area that utilizes the existing topography to intercept runoff. The bioretention area will also filter out sediment.

Bioretention Areas: Step 1

Establish Goals for the Project

It is important to clearly establish the project goals at the outset of the design process. Goals should be developed to ensure that additional environmental, economic, and aesthetic functions are considered throughout design. The following design criteria must be considered when designing bioretention facilities.

WATER QUALITY

Receiving water bodies (surface and subsurface) must be identified and limitations must be understood and accounted for in the design process. The overall relationship between the proposed project site and proximity of receiving water bodies must be evaluated.

UNIQUE ADA COUNTY CONSIDERATIONS

- The pollutants of concern identified in Ada County include phosphorus, sediments, and bacteria.
- Determine if any of the receiving water bodies are impaired (303(d) listed) or have other water quality consideration requirements.

BIORETENTION DESIGN CONSIDERATIONS

- Verify if the bioretention facility will be effective in treating the pollutants of concern for the project site receiving water bodies.

HYDROLOGY

The existing hydrologic characteristics of a project site should be studied carefully to ensure that the plants in the facility receive the optimum amount of moisture to sustain the vegetation.

UNIQUE ADA COUNTY CONSIDERATIONS

- Average annual precipitation is 11.5 inches and approximately 75 percent of precipitation occurs between November and May.
- If the project site is near an irrigation canal, consider the potential for stormwater runoff to discharge directly to the canal. Direct discharges to the canal system are prohibited.

BIORETENTION DESIGN CONSIDERATIONS

- Cold climate adaptation for bioretention designs includes extending the filter bed below the frost line and selecting salt-tolerant vegetation.
- In cold climates, bioretention areas can be used as snow storage areas with salt-tolerant and non-woody plant species.
- Supplemental irrigation will be necessary for plant establishment.

Bioretention Areas: Step 2

Site Evaluation/Feasibility Study

It is important to understand your project site including limiting conditions such as stormwater runoff volumes that require management. The following design criteria must be considered when designing bioretention facilities

DRAINAGE AREA

Existing drainage patterns must be maintained by placing stormwater facilities in strategic locations. The primary goal is to minimize the impervious surfaces and mimic the natural hydrologic drainage pattern so that the amount of runoff generated from the site is minimized.

UNIQUE ADA COUNTY CONSIDERATIONS

- All sites should retain and treat the required water quality capture volume (V_{WQ}).
- The V_{WQ} must be 100 percent managed on site with no discharge to surface waters.
- There may be exceptions to these considerations in retrofit projects.

BIORETENTION DESIGN CONSIDERATIONS

- Individual bioretention cells should not be used to treat large drainage areas.
- According to the Eastern Washington Low Impact Development Guidance Manual, the maximum ponding depth recommended for a bioretention facility is 12 inches with maximum surface pool drawdown time of 24–48 hours.
- Steeper side slopes may be necessary and require additional attention for erosion control, plant selection, vehicle and pedestrian safety, etc.
- An elevated drain can be used and will provide benefits including improved stormwater retention, plant survival in drier months, and possible nitrogen removal.
- Curb cuts used for bioretention areas in high-use roadways may require a higher level of maintenance due to increased accumulation of coarse pollutants and trash in the flow entrance.
- Consider road grades in retrofit situations.

SOIL AND VEGETATION CONDITIONS

Manufactured soil media and soils underlying and surrounding the facility are the principal design elements for determining infiltration capacity, sizing, and associated conveyance structures. Although the bioretention soil mix usually has a higher infiltration rate than the surrounding subgrade, it must be ensured that the infiltration rate of native soil at the facility invert is at least 0.5 in./hr.

UNIQUE ADA COUNTY CONSIDERATIONS

- Identify whether the site contains a hardpan layer that can restrict water infiltration and reduce downward movement of water.
- Plant selection should consider tolerance for drought conditions, periods of infrequent inundation, extreme heat, and winter conditions including snow cover and freezing. The varied nature of these factors make plant selection and availability important design considerations.

BIORETENTION DESIGN CONSIDERATIONS

- Manufactured soil analysis for bioretention should include soil texture, compaction requirements, permeability, and chemical constituents.
- Where the surrounding native soils have adequate infiltration rates, bioretention can be used as a primary or supplemental retention system.
- Select appropriate plants that can tolerate contaminants present at the site. Other factors for plant selection include sun exposure, soil moisture, and adjacent plant communities.
- In some cases, adapted, drought-tolerant species may be better suited to bioretention facilities than native species.
- Plantings may also need to withstand added stresses associated with snow plowing and snow storage.

Bioretention Areas: Step 2

SOIL AND VEGETATION CONDITIONS

(Continued)

- Pesticides or herbicides should not be applied in bioretention areas if possible; therefore, manual invasive species control may be necessary.
- Prevent compaction of soils in the facility in order to increase the volume for stormwater storage and stormwater treatment.
- Protect the bioretention area from surrounding uses (e.g., pedestrians, vehicles, ongoing maintenance activities).
- Allow soils to dry out periodically in order to restore hydraulic capacity to receive flows from subsequent storms, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.
- Bioretention areas can be designed with or without a mulch layer; however, there are advantages to providing a mulch application. This includes reduction in weed establishment, regulation of soil temperatures, and addition of organic matter to soil.
- When siting facilities, avoid locations where existing tree roots will be impacted by construction activities.

GROUNDWATER

For all projects, depth of groundwater, seasonal variation of the groundwater table, and existing groundwater flow direction and gradient must be assessed. The required minimum groundwater separation from the bottom of the infiltration facility is 3 feet.

UNIQUE ADA COUNTY CONSIDERATIONS

- The depth to groundwater table can vary based on seasonal and irrigation influences.

BIORETENTION DESIGN CONSIDERATIONS

- Separation from a hydraulic restriction layer (hardpan layer or water table) is an important design consideration for infiltration and flow control performance.
- Protecting groundwater quality is a critical factor when infiltrating stormwater.
- If groundwater protection areas are nearby, consider installing an impermeable liner.
- Bioretention facilities should not be installed within an area where groundwater drains into an erosion hazard or landslide hazard area.

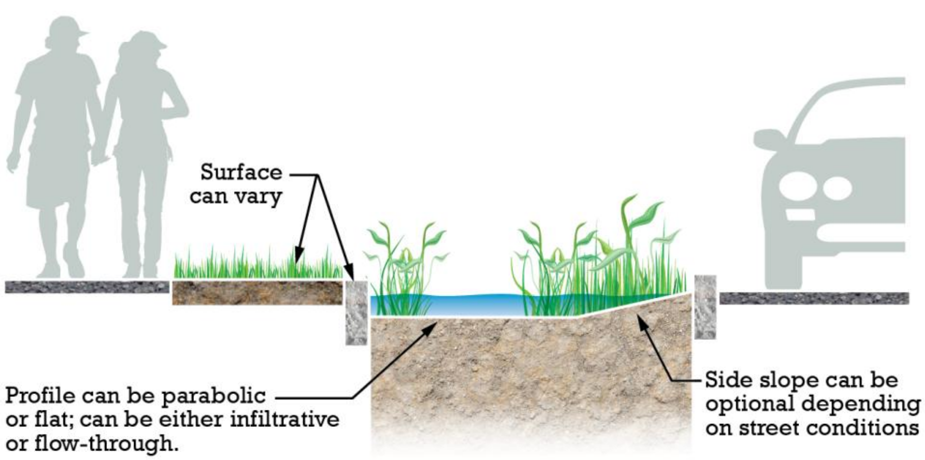

FIGURE 4-6
Typical profile of a bioretention area.

Bioretention Areas: Step 3

Select GSI Solutions to Match Site Conditions and Goals

Using the findings of the site evaluation and the project goals, verify that bioretention facilities are the best GSI solution for the site. The following design criteria must be considered when designing bioretention facilities.

SPACE LIMITATION

Determine the width of right-of-way available for installing the bioretention facilities. Assess the soil condition and density of existing vegetation within the available right-of-way.

BIORETENTION DESIGN CONSIDERATIONS

- Bioretention areas are ideal for integrating within highly urbanized streetscapes or within other road right-of-ways with tight space constraints.
- Bioretention facilities can be included in many right-of-way features including planting strips, stormwater planters, bulb-outs, medians, and chicanes.
- Bioretention areas (bulb-outs) can be used for traffic calming.
- Determine whether setbacks from the easements are required for tree installation.
- Incorporating bioretention (bulb-outs) in urban settings could impact other site uses, such as sidewalks, bicyclists, and parking spaces.
- The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with ACHD requirements.
- Bioretention curb extensions can create a safer pedestrian zone by increasing the buffer width between the sidewalk and roadway.
- Bioretention areas can be incorporated into redevelopment projects as the location, size, and facility spacing can be adjusted to accommodate existing roadway and storm drain conditions.

UTILITIES

Consult with Idaho Digline and service providers to locate the underground and aboveground utilities in and around the project site. Utility vaults can be a difficult constraint to maneuver around when placing stormwater facilities. Map existing utilities and utility easements on the site plan.

BIORETENTION DESIGN CONSIDERATIONS

- Determine whether utilities need to be moved or if new utilities need to be extended to the site.
- Consult local jurisdiction requirements for horizontal and vertical separations required for publicly owned utilities, such as water, sewer, and stormwater pipes.
- Consult the appropriate franchise utility owners for utility separation requirements, which may include communication and/or gas.
- Extensive potholing may be needed during project planning and design to develop a complete understanding of the type, location, and construction of all utilities that may be impacted by the project.
- Consult local jurisdiction guidelines for appropriate bioretention area setbacks from wellheads, fire hydrants, onsite sewerage systems, basements, foundations, utilities, slopes, contaminated areas, and property lines.

Bioretention Areas: Additional Considerations

GENERAL CONSIDERATIONS

- Pretreatment, such as a settling forebay, vegetated filter strip, or stone diaphragm, often precedes the bioretention to remove particles that would otherwise clog the filter bed.
- Bioretention areas must be designed with emergency overflows to convey runoff volumes in excess of the facility capacity. The overflow system must be designed in accordance with the ACHD Design Manual.
- Generally, bioretention areas are applicable to small catchment areas and provide limited opportunity for water quality flow control.

LIMITATIONS

- Bioretention facilities should not be installed within areas where groundwater drains into an erosion hazard or landslide hazard areas.
- Curb cuts used for bioretention areas in high-use roadways may require a higher level of maintenance due to increased accumulation of coarse pollutants and trash in the flow entrance.
- Curb extensions can reduce the amount of on-street parking and can impact the traffic capacity of a road. In some cases, municipalities may require traffic and parking studies to evaluate the potential impacts.

MAINTENANCE

- Bioretention areas require periodic plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities.
- Providing more frequent and well-timed maintenance (e.g., weeding prior to seed dispersal) during the first 3 years will ensure greater success and reduce future maintenance of bioretention areas.
- Supplemental irrigation will be needed as watering will likely be required during prolonged dry periods after plants are established.
- Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred.
- Prepare and follow the maintenance plan schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Occasional pruning and removal of dead plant material may be necessary.
- Invasive or nuisance plants should be removed regularly and not allowed to accumulate and exclude planted species.
- Nutrient and pesticide inputs should not be required and may degrade the pollutant processing capability of bioretention area.
- Maintenance agreements with other parties may be necessary.

Permeable Pavers: Residential and Commercial

Permeable pavers prevent the generation of runoff by allowing precipitation falling on the surface to infiltrate into the stone reservoir and, where suitable conditions exist, into the underlying soil. They are attractive and easy to repair, and they can withstand vehicle loads.

Permeable pavers can be used for both new development and redevelopment projects. They are most appropriately applied in low to medium traffic areas (e.g., residential roads, alleys, etc.) that typically receive low levels of contaminants. Permeable pavement is typically designed to manage rainfall landing directly on the permeable pavement surface. Permeable pavement surfaces may accept run-on from adjacent impervious areas such as driving lanes or rooftops. Adjacent areas that have the potential to run onto the pavers must be stabilized to prevent sediment transport as it accelerates surface clogging. To prevent clogging, ensure that adjacent pervious areas are stabilized and the winter maintenance plan does not include sanding.

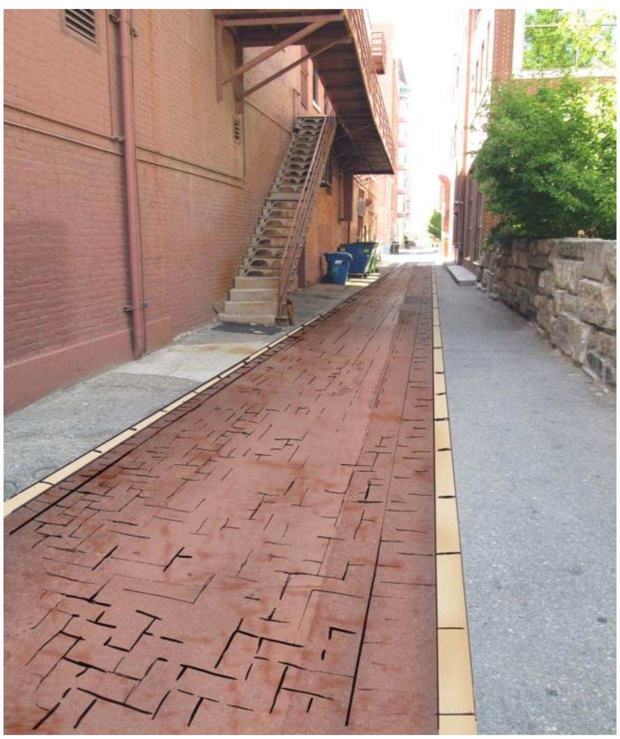

FIGURE 4-8
This rendering shows the incorporation of permeable pavers, which are an aesthetically pleasing addition to this space.

FIGURE 4-7
Stormwater collects and the profile conveys runoff along the centerline of this alley.

The steps on the following pages demonstrate the GSI design process and the design criteria that must be evaluated while considering permeable pavers as the stormwater management option for a given site.

Permeable pavers are attractive and easy to repair, and they can withstand vehicle loads.

Permeable Pavers: Step 1

Establish Goals for the Project

It is important to clearly establish the project goals at the outset of the design process. Goals should be developed to ensure that additional environmental, economic, and aesthetic functions are considered throughout the design process. The following design criteria must be considered when designing permeable pavers.

WATER QUALITY

Receiving water bodies (both surface and subsurface) must be identified and limitations must be understood and accounted for in the design process. The overall relationship between the proposed project site and proximity of receiving water bodies must be evaluated.

UNIQUE ADA COUNTY CONSIDERATIONS

- The pollutants of concern identified in Ada County include nutrients (nitrogen and phosphorus), sediments, and bacteria.
- Determine if any of the receiving water bodies are impaired (303(d) listed) or have other water quality consideration requirements.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- Water quality treatment can be attained by infiltrating runoff through soils or a treatment layer that meets specific criteria.

HYDROLOGY

The existing hydrologic characteristics of a project site should be studied carefully to ensure that the expected flows and the existing flow paths are understood. The existing conditions should be incorporated into the design if possible.

UNIQUE ADA COUNTY CONSIDERATIONS

- Average annual precipitation is 11.5 inches and approximately 75 percent of precipitation occurs between November and May.
- If the project site is near an irrigation canal, consider the potential for stormwater runoff to discharge directly to the canal.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- When designed to take run-on from other catchment areas, permeable pavement areas must be protected from sedimentation, which can cause clogging and degraded facility performance.
- Acceptable pretreatment for sediment removal should be included for any stormwater flows that run-on to permeable pavers.

Permeable Pavers: Step 2

Site Evaluation/Feasibility Study

It is important to understand your project site including limiting conditions such as stormwater runoff volumes that require management. Permeable pavers are appropriate for small catchment areas like alleys. The following design criteria must be considered when designing permeable pavers.

DRAINAGE AREA

Existing drainage patterns must be maintained by placing stormwater facilities in strategic locations. The primary goal is to minimize the impervious surfaces and mimic the natural hydrologic drainage pattern so that the amount of runoff generated from the site is minimized.

UNIQUE ADA COUNTY CONSIDERATIONS

- All sites should retain and treat the required V_{WQ}.
- The V_{WQ} must be 100 percent managed on site with no discharge to surface waters.
- There may be exceptions to these considerations in retrofit projects.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- The capacity of the underlying gravel reservoir limits the contributing area to permeable pavers.
- Detention structures can be installed on the subgrade and below the pavement to detain subsurface flow, increase infiltration, and increase maximum slope recommendation.
- Minimum amount of run-on from adjacent surfaces is preferred so that clogging can be prevented, and the long-term performance of the pavement system can be maximized.

SOIL AND VEGETATION CONDITIONS

Determining the feasibility of permeable pavers must include an aboveground and underground site evaluation for soil analysis.

UNIQUE ADA COUNTY CONSIDERATIONS

- Identify whether the site contains a hardpan layer that can restrict water infiltration and reduce downward movement of water.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- Determining the infiltration rate of the underlying soil profile is necessary to design the aggregate base depth for stormwater storage and drain system (optional).
- To properly prepare and maintain infiltration capacity and structural support of permeable paver subgrades, a professional engineer should analyze soil conditions for infiltration capability at anticipated compaction and load-bearing capacity given the anticipated soil moisture conditions.
- Pervious liners between the subgrade and aggregate base are not required or necessary for many soil types; however, they are recommended to prevent the migration of fine sediments into the aggregate base when the pavers are susceptible to intercepting runoff with fines.
- An overflow or elevated drain may be installed in the aggregate base of a permeable pavement system if the infiltration capacity of the subgrade soil is not adequate to protect the pavement from wearing.
- Careful attention to subgrade preparation during installation is required to balance the needs for structural support while maintaining infiltration capacity.

Permeable Pavers: Step 2

GROUNDWATER

The feasibility of permeable pavers is dependent on the groundwater elevation. For all projects, depth of groundwater, seasonal variation of the groundwater table, and existing groundwater flow direction and gradient must be assessed. The required minimum groundwater separation from the bottom of the infiltration facility is 3 feet.

UNIQUE ADA COUNTY CONSIDERATIONS

- The depth to groundwater table can vary based on seasonal and irrigation influences.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- If groundwater protection areas are nearby, consider installing an impermeable liner.
- Separation to a hydraulic restriction layer (hardpan layer, or water table) is an important design consideration for infiltration and flow control performance.
- Permeable pavers should not be installed within an area where groundwater drains into an erosion hazard or landslide hazard area.
- Permeable pavers should not be installed where seasonal high groundwater is within 3 foot of the bottom of the aggregate base.

Permeable Pavers: Step 3

Select GSI Solutions to Match Site Conditions and Goals

Using the findings of the site evaluation and the project goals, verify whether permeable pavers are the best GSI solution for the site. The following design criteria must be considered when designing permeable pavers within ACHD jurisdiction.

SPACE LIMITATION

Determine the width of right-of-way available for installing permeable pavers. Coordinate with other jurisdictions and local agencies where geographical overlap occurs with ACHD facilities.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- Permeable pavers reduce the need for traditional stormwater infrastructure such as detention ponds.
- Permeable pavers might be the only viable option for stormwater management in ultra-urban conditions with limited space.

UTILITIES

Consult with Idaho Digline and service providers to locate the underground and aboveground utilities in and around the project site. Utility vaults can be a difficult constraint to maneuver around when placing stormwater facilities. Map existing utilities and utility easements on the site plan.

PERMEABLE PAVERS DESIGN CONSIDERATIONS

- Consult local jurisdiction requirements for horizontal and vertical separations required for publicly owned utilities, such as water, sewer, and stormwater pipes.
- Consult the appropriate franchise utility owners for utility separation requirements, which may include communication and/or gas.
- Permeable pavers should not be installed where installation of the pavers would threaten the safety or reliability of existing underground utilities, underground storage tanks, or road subgrades.

Permeable Pavers: Additional Considerations

GENERAL CONSIDERATIONS

- Generally, permeable pavers are applicable to small catchment areas like alleys.

  The Interlocking Concrete Pavement Institute (ICPI) provides technical information on best practices for permeable interlocking concrete pavement (PICP) design, specification, construction, and maintenance. Manufacturers or suppliers of particular pavers should be consulted for materials and guidelines specific to that product. Experienced contractors with a certificate in the ICPI PICP Installer Program should perform installations.

LIMITATIONS

- Permeable pavers should not be used in areas where excessive sediment is deposited on the surface. When sediments clog the pavement on a regular basis, maintenance requirements will also be high.
- Permeable pavers should not be installed where concentrated pollutant spills are likely or where infiltration will result in the transport of pollutants to deeper soil or groundwater.
- Permeable pavers should not be installed where sites receive regular, heavy applications of sand for maintaining traction during winter.

Permeable pavers should not be installed where installation of the pavers would threaten the safety or reliability of existing underground utilities, underground storage tanks, or road subgrades.

MAINTENANCE

- Surrounding landscaped areas should be inspected regularly and possible sediment sources should be controlled immediately.
- Clean permeable pavers to maintain infiltration capacity at least once or twice annually.
- Utility cuts should be backfilled with the same aggregate base used under the paving to allow continued conveyance of stormwater through the base and to prevent migration of fines.
- Deicing and sand application is not recommended.
- Vacuum and sweeping frequency will likely be required more often if sand is applied.
- Pavers can be removed individually and replaced when utility work is complete.
- Replace broken pavers as necessary to prevent structural instability in the surface.
- Permeable pavement can be plowed, although raising the blade height 25 mm may be helpful to avoid catching pavers or scraping the surface of the permeable pavers.

Bio-swale: Residential and Commercial

Bio-swales are long, shallow conveyance channels that are densely planted with a variety of native grasses and shrubs. Vegetation in the swale slows the water to allow sedimentation, filtration through the soil matrix and root zone, and infiltration into the underlying native soil, where suitable conditions exist.

Bio-swales allow infiltration to occur over an extended duration of time. Small check dams can be added perpendicular to the flow to add infiltration or step pools. Bio-swales are an excellent alternative to conventional curb-and-gutter conveyance systems because they provide pretreatment.

Research from Portland, Oregon, indicates that swales planted with native species filter more pollutants than swales planted with turf. Bio-swales may not be well-suited to high-density urban areas because they require a relatively large area of pervious surfaces.

FIGURE 4-9
An existing, under-utilized area adjacent to parking provides an opportunity to incorporate a bio-swale.

The steps on the following pages demonstrate the GSI design process and the design criteria that must be evaluated while considering bio-swales as the stormwater management option for a given site.

FIGURE 4-10
This rendering shows a bio-swale that provides both water quality benefits and community benefits.

Bio-swale: Step 1

Establish Goals for the Project

It is important to clearly establish the project goals at the outset of the design process. Goals should be developed to ensure that additional environmental, economic, and aesthetic functions are considered throughout design. The following design criteria must be considered when designing bio-swales.

WATER QUALITY

Receiving water bodies (both surface and subsurface) must be identified and limitations must be understood and accounted for in the design process. The overall relationship between the proposed project site and proximity of receiving water bodies must be evaluated.

UNIQUE ADA COUNTY CONSIDERATIONS

- The pollutants of concern identified in Ada County include phosphorus, sediments, and bacteria.
- Determine if any of the receiving water bodies are impaired (303(d) listed) or have other water quality consideration requirements.

BIO-SWALE DESIGN CONSIDERATIONS

- Verify if the bio-swale will be effective in treating the pollutants of concern for the project site receiving water bodies.
- If the project site requires downstream discharges, ensure that the swale will provide required treatment.

HYDROLOGY

The existing hydrologic characteristics of a project site should be studied carefully to ensure that the plants in the facility receive sufficient moisture to sustain the vegetation.

UNIQUE ADA COUNTY CONSIDERATIONS

- Average annual precipitation is 11.5 inches and approximately 75 percent of precipitation occurs between November and May.
- If the project site is near an irrigation canal, consider the potential for stormwater runoff to discharge directly to the canal.

BIO-SWALE DESIGN CONSIDERATIONS

- Some minor design changes may be needed for cold and arid climates.
- In cold climates, bio-swales can be used as snow storage areas with salt-tolerant and non-woody plant species.
- Supplemental irrigation will likely be necessary to establish vegetation.

Bio-swale: Step 2

Site Evaluation/Feasibility Study

It is important to understand your project site including limiting conditions such as stormwater runoff volumes that require management. The following design criteria must be considered when designing bio-swales.

DRAINAGE AREA

Existing drainage patterns must be maintained by placing stormwater facilities in strategic locations. The primary goal is to minimize the impervious surfaces and mimic the natural hydrologic drainage pattern so that the amount of runoff generated from the site is minimized.

UNIQUE ADA COUNTY CONSIDERATIONS

- All sites should retain and treat the required V_{WQ}.
- The VWQ must be 100 percent managed on site with no discharge to surface waters.
- There may be exceptions to these considerations in retrofit projects.

BIO-SWALE DESIGN CONSIDERATIONS

- Steeper side slopes may be necessary and require additional attention for erosion control, plant selection, vehicle and pedestrian safety, etc.
- The Eastern Washington Low Impact Development Guidance Manual recommends that the maximum ponding depth be limited to 12 inches with maximum surface pool drawdown time of 24–48 hours.

SOIL AND VEGETATION CONDITIONS

Manufactured soil media and soils underlying and surrounding the facility are the principal design elements for determining infiltration capacity, sizing, and associated conveyance structures. Although the soil mix, typically composed of a highly permeable sandy mineral aggregate and compost, usually has a higher infiltration rate than the surrounding subgrade, it must be ensured that the infiltration rate of native soil at the facility invert is at least 0.5 in./hr.

UNIQUE ADA COUNTY CONSIDERATIONS

- Identify whether the site contains a hardpan layer that can restrict water infiltration and reduce downward movement of water.

BIO-SWALE DESIGN CONSIDERATIONS

- Manufactured soil analysis for bio-swale should include soil texture, compaction requirements, permeability, and chemical constituents.
- Where the surrounding native soils have adequate infiltration rates, swale can be used as a primary or supplemental retention system.
- Plant selection should consider tolerance for drought conditions, periods of infrequent inundation, extreme heat, and winter conditions including snow cover and freezing. The varied nature of these factors make plant selection and availability important design considerations.
- In some cases, adapted, drought-tolerant species may be better suited to bio-swales than native species.
- Plantings may also need to withstand added stresses associated with snow plowing and snow storage.
- Pesticides or herbicides should not be applied in bio-swales, if possible.
- In areas with low-infiltration soils, consider installing underdrains with a flow control structure.

Bio-swale: Step 2

SOIL AND VEGETATION CONDITIONS

(Continued)

- Prevent compaction of soils in the facility in order to increase the volume for stormwater storage and stormwater treatment.
- Protect the swale area from surrounding uses (e.g., pedestrians, vehicles, ongoing maintenance activities).
- Allow soils to dry out periodically in order to restore hydraulic capacity to receive flows from subsequent storms, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.
- Manual invasive species control may be necessary.

GROUNDWATER

For all projects, depth of groundwater, seasonal variation of the groundwater table, and existing groundwater flow direction and gradient must be assessed. The required minimum groundwater separation from the bottom of the infiltration facility is 3 feet.

UNIQUE ADA COUNTY CONSIDERATIONS

- The depth to groundwater table can vary based on seasonal and irrigation influences.

BIO-SWALE DESIGN CONSIDERATIONS

- Separation from a hydraulic restriction layer (hardpan layer or water table) is an important design consideration for infiltration and flow control performance.
- If groundwater protection areas are nearby, consider installing an impermeable liner.

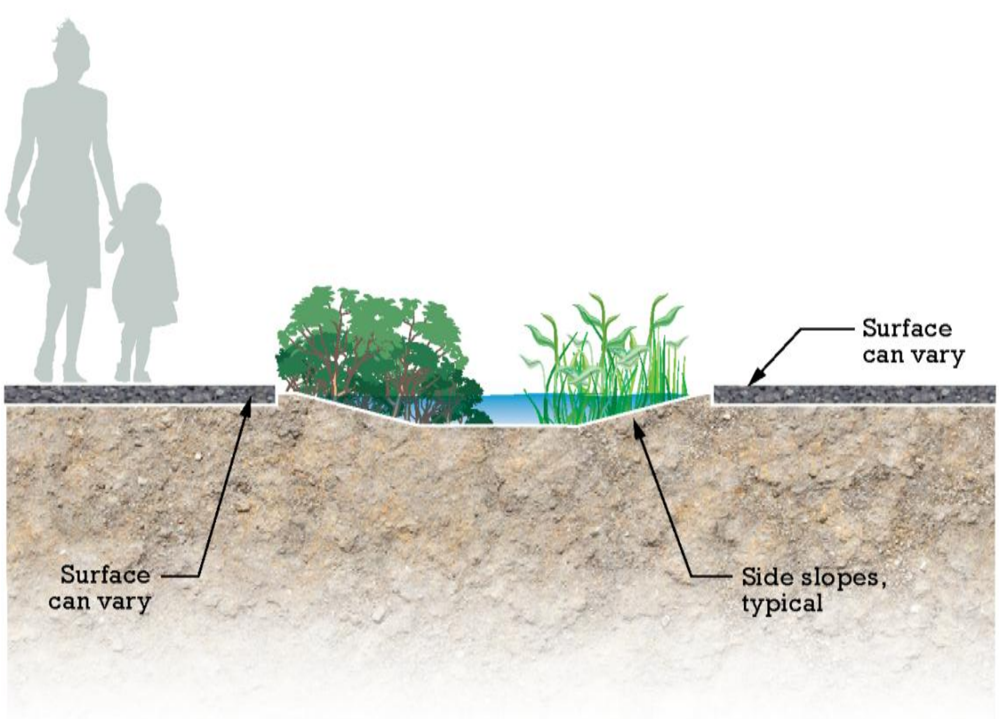

FIGURE 4-11
Typical profile of a bio-swale

Bio-swale: Step 3

Select GSI Solutions to Match Site Conditions and Goals

Using the findings of the site evaluation and the project goals, verify that bio-swales are the best GSI solution for the site. Existing site drainage conveyance features that can be protected and credited as a GSI practice must be identified. The following design criteria must be considered when designing bio-swales.

SPACE LIMITATION

Determine the width of right-of-way available for installing the bio-swales. Assess the soil condition and density of existing vegetation within the available right-of-way. Protect existing vegetated areas that can be credited as GSI practices.

BIO-SWALE DESIGN CONSIDERATIONS

- Bio-swales can be installed in rights-of-way along roads.
- The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with ACHD requirements.

UTILITIES

Consult with Idaho Digline and service providers to locate the underground and aboveground utilities in and around the project site. Utility vaults can be a difficult constraint to maneuver around when placing stormwater facilities. Map existing utilities and utility easements on the site plan.

BIO-SWALE DESIGN CONSIDERATIONS

- Determine requirements for horizontal and vertical separations required for publicly owned utilities.
- Determine whether utilities need to be moved or if new utilities need to be extended to the site.
- Consult local jurisdiction requirements for horizontal and vertical separations required for publicly owned utilities, such as water, sewer, and stormwater pipes.
- Consult the appropriate franchise utility owners for utility separation requirements, which may include communication and/or gas.
- Extensive potholing may be needed during project planning and design to develop a complete understanding of the type, location, and construction of all utilities that may be impacted by the project.
- Consult local jurisdiction guidelines for appropriate bio-swale setbacks from wellheads, onsite sewerage systems, basements, foundations, utilities, slopes, contaminated areas, and property lines.

Bio-swale: Additional Considerations

GENERAL CONSIDERATIONS

- Swales are typically designed as on-line conveyance treatment systems. Outlets, outfalls, and all other stormwater conveyance components must be designed in accordance with the ACHD Design Manual.
- If water quality flow control is a project goal, consider designing the swale flatter and deeper to increase time of concentration and flow depth.
- Because swales are a conveyance practice they can be sized to convey flows from both small and large catchment areas.
- The design configuration of bioswales is flexible; therefore, it is unlikely that any two bioswales will be exactly the same. Variations in site conditions provide the opportunity for creative design.

LIMITATIONS

- Swale effectiveness can be decreased by compacted soils, frozen ground conditions, short grass heights, and steep slopes as well as by large storm events, high discharge rates, high velocities, and short runoff contact time.
- Individual bio-swales should not be used to treat large drainage areas.
- Curb cuts used for swales in high-use roadways may require a higher level of maintenance due to increased accumulation of coarse pollutants and trash in the flow entrance.
- Bio-swales should not be installed within an area where groundwater drains into an erosion hazard or landslide hazard area.

MAINTENANCE

- Erosion and introduction of sediment from surrounding land uses should be strictly controlled after construction by amending exposed soil with compost and mulch, planting exposed areas as soon as possible, and armoring outfall areas.
- Bio-swales require periodic plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities.
- Providing more frequent and well-timed maintenance (e.g., weeding prior to seed dispersal) during the first 3 years will ensure greater success and reduce future maintenance of bio-swales.
- In more arid environments, watering may be required during prolonged dry periods after plants are established.
- Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred.
- Prepare and follow the maintenance plan schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Occasional pruning and removing dead plant material may be necessary.
- Invasive or nuisance plants should be removed regularly and not allowed to accumulate and exclude planted species.
- Fertilizer and pesticide application should not be required and may degrade the pollutant processing capability of the bio-swale.
- Bio-swales provide an area for snow storage where snowmelt can be infiltrated. Impacts to vegetation and water quality should be evaluated in design.

Chapter 5

Next Steps

Green stormwater infrastructure can offer a promising strategy for ACHD in reducing the impact of stormwater to the surrounding environment and it can significantly improve stormwater quality management.

Pilot studies are required by the Permit to validate the efficiency and local limitations associated with GSI in the Treasure Valley. Some specific limitations that may be identified in these pilot studies include absorption rates for pollutants of concern, influence of magnesium chloride on plants and soils, vegetative establishment limitations, groundwater impacts, and overall effectiveness in retrofit situations. All of these limitations will be specific to the conditions found in both Ada County and the greater Treasure Valley area.

The following implementation strategies and barriers may influence the program outcome.

CONDUCT OUTREACH AND EDUCATION

Reaching out to the community may be one of the single most effective tools to successful GSI implementation. Creating awareness of what GSI practices are and how they are being used can increase the success rate of the program. Focus should be placed on common GSI techniques, benefits of GSI practices, and the ecological/ environmental importance of effective stormwater management. Informational and technical workshops can be used to communicate to design and technical groups and site tours can be used to show community members how GSI practices function to help preserve the health of our regional water.

Informational resources can be delivered in a variety of ways that include online resources, e-mailed pamphlets or booklets to educate the community, media advertisements, and informational flyers.

INTEGRATE GSI INTO PUBLIC CODE/POLICIES

While the GSI design process is being developed and evaluated with pilot studies, GSI practice codes and standards should be developed simultaneously. Building institutional relationships can help strengthen partnerships to leverage opportunities with local jurisdictions. Expectations can vary greatly between different cities, counties, and ACHD.

Interdisciplinary partnerships may help bridge limitations of statute and ACHD capabilities to better integrate each partner's interests, areas of expertise, and local values.

CREATE GSI INCENTIVES

To implement a GSI program successfully throughout ACHD, legislative, institutional, economic, and social goals need to be consistent. Many programs can be adopted to help promote the use of GSI such as waiving plan review fees if GSI is included in the design and offering a stormwater fee reduction or credit. While long lag times may be present in reforming policy and people's willingness to accept new GSI techniques, flexibility and visually demonstrating the effectiveness of GSI can aid in the process of GSI integration to standard stormwater management practices.

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Attachments

Attachment A: Fact Sheets

Green Stormwater Infrastructure Facility

Tree Systems

Tree systems encompass several practices including tree trenches, tree cells, and the use of structural soils. Tree practices that receive stormwater mimic certain physical, chemical, and biological processes that occur naturally and help to manage stormwater in the subsurface environment. Tree systems provide a broad range of environmental, aesthetic, and community benefits.

COMMUNITY

Enhances neighborhood aesthetics

Reduces noise and glare

Increases pedestrian safety

Improves air quality

Increases canopy cover

Requires minimal surface footprint

CLEAN WATER

Improves water quality

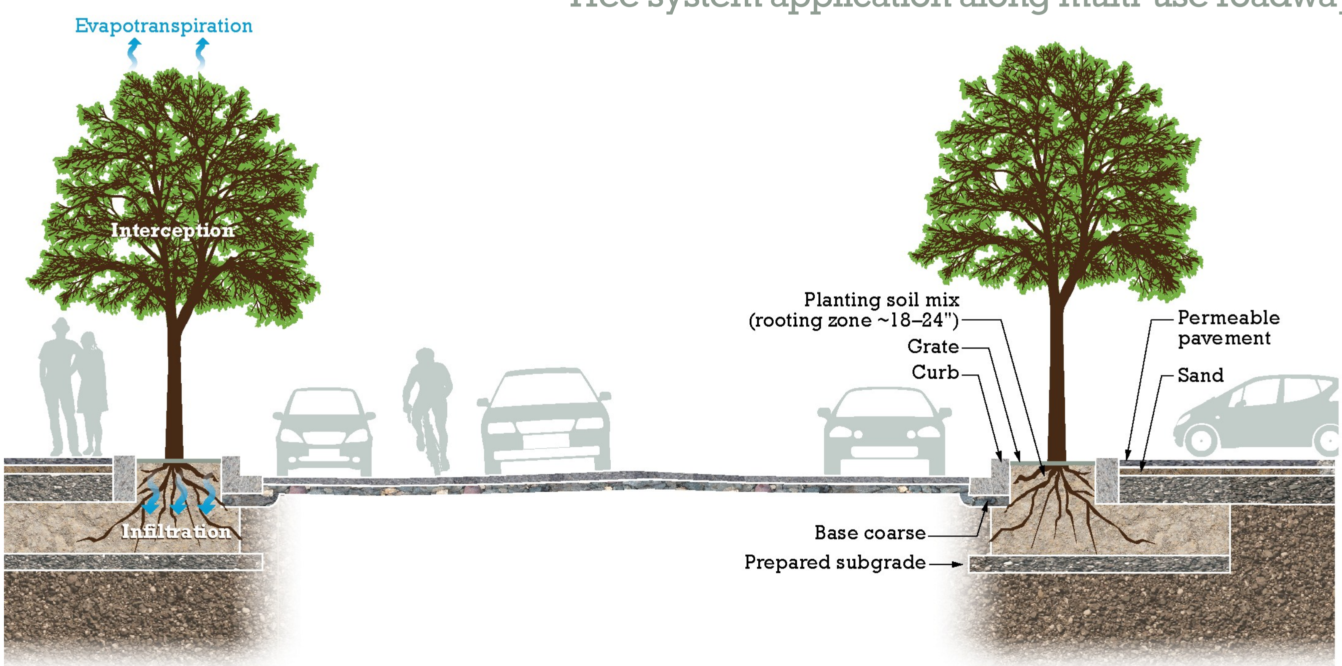
Reduces stormwater runoff

Manages stormwater in the subsurface environment

Promotes stormwater evapotranspiration

Uptakes nutrients

Tree system application along multi-use roadway



Potential Applications

- Residential/suburban and ultra-urban areas
- Method to manage runoff volume
- Complement to other GSI techniques such as permeable pavers
- Tree practices are an ideal and potentially important BMP in urban retrofit situations where existing stormwater treatment is absent or limited

Residential	Limited
Commercial	Yes
Arterial	Yes
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Medium
Maintenance	Medium
Summer/Winter Performance	High
Community Benefit	High

Limitations

- Requires adequate underground rooting space
- Underground and above-ground utility conflicts must be evaluated
- Requires careful selection of tree species

Tree systems create attractive thoroughfares for pedestrians and a more walkable city.

The structural component of the tree system profile allows installation of this compact GSI facility under structural roadway sections.

ACHD Committed to Service

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Visit our web site at www.achdidaho.org

See Ada County Highway District Green Stormwater Infrastructure Guidance Manual for additional information.

Green Stormwater Infrastructure Facility

Bioretention Areas

Bioretention areas are shallow vegetated depressions that provide storage and encourage infiltration through retention. Bioretention areas remove pollutants by filtering stormwater through plants adapted to the local climate and soil conditions. Further, the infiltration process promotes the adsorption of pollutants into the underlying soils. Bioretention can be included in many right-of-way features including planting strips, stormwater planters, bulb-outs, medians, and chicanes.

COMMUNITY

Enhances roadway aesthetics

Improves road safety

Requires minimal space

CLEAN WATER

Removes pollutants

Reduces runoff volume

Alleviates flooding

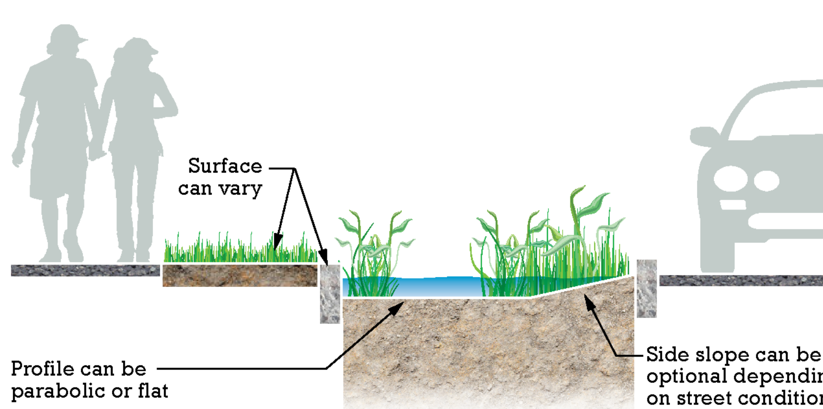
Decreases runoff temperature

Uptakes nutrients

Existing curb retained while installing a bioretention along a neighborhood collector street. *Source: Kevin Robert Perry/City of Portland*

Accessible pedestrian ramps can also be integrated into the design. *Source: Dave Elkin/City of Portland*

Typical Bioretention Profile



Potential Applications/Retrofits

- Method to manage runoff volume and mitigate peak discharge rates
- Provides medium to biodegrade petroleum-based solvents and hydrocarbons
- Traffic-calming device in commercial and residential settings

Residential	Yes
Commercial	Yes
Arterials	Limited
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Medium
Maintenance	Medium
Summer/Winter Performance	Medium
Community Benefit	High

Limitations

- Designed to capture small storm events
- Not suitable for locations where the seasonally high groundwater table is near the surface
- Must consider existing on-street parking conditions, street width, and vehicle turning radii when using the bulb-outs
- Additional maintenance required to establish vegetation
- Requires careful selection of plants and soil mix for optimum performance (tolerate summer drought/low rainfall, ponding fluctuations and saturated soil conditions for lengths of time)
- May require third party agreement for maintenance

Bioretention areas can be designed as any size or shape needed to meet space limitations while providing stormwater treatment.

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Green Stormwater Infrastructure Facility

Permeable Pavers

Permeable interlocking concrete pavement (permeable pavers) is comprised of concrete pavers separated by joints filled with small stones. Permeable pavers prevent the generation of runoff by allowing precipitation falling on the surface to infiltrate through the pavers into the underlying soil. They are attractive, easy to repair, and can withstand light traffic vehicle loads.

Gaps in the pavers allow water to soak into the ground. ***Source: Mutual Materials***

Residential streets can be retrofitted with permeable paving in the parking zone of the street. *Source: Nevue Ngan Associates*

COMMUNITY

Eliminates standing water on pavement

Reduces pollutants splashed from vehicles

Provides dual purpose for right of way areas

CLEAN WATER

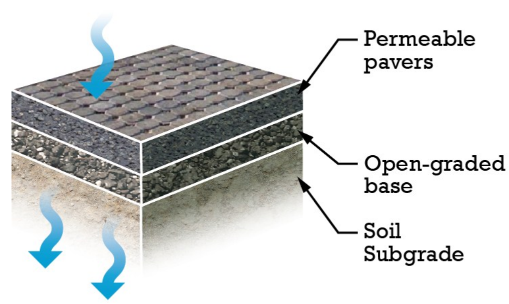
Improves water quality

Reduces pollutant loading

Reduces runoff rate and volume

Retrofits developed areas for additional stormwater management

Typical permeable pavers profile



Potential Applications

- Commercial streets, alleys, and residential access roads
- Road retrofit projects
- Ultra-urban conditions with interior drainage
- Reduces size of traditional stormwater infrastructure such as detention ponds
- Most appropriately applied in low to medium traffic areas (e.g., residential roads, alleys, etc.)

Residential	Yes
Commercial	Yes
Arterials	Limited
Alleys	Yes

ADDITIONAL CONSIDERATIONS

Capital Cost	High
Maintenance	Medium
Summer/Winter Performance	Medium/High
Community Benefit	Medium/ High

Limitations

- Requires placement on well-drained native soil
- Limited to low traffic speed roadways
- Not applicable in areas down slope of steep, erosion-prone areas
- Requires careful construction and installation for optimal performance
- Requires higher maintenance than conventional pavements
- Not applicable where concentrated pollutant spills occur or where sand/ deicer is used in winter

Permeable pavers are attractive and easy to repair, and they can withstand vehicle loads.

Permeable pavers implemented in an alley retrofit project.

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Green Stormwater Infrastructure Facility

Bio-swale

Bio-swales are long, fairly shallow depressions that often use a curved or sinuous form to convey and slow water. They have a porous filter medium (usually soil-based) and are planted with native or non-native grasses and other vegetation. They work to treat stormwater by slowing and infiltrating flow and create an environment for plant uptake of pollutants. They enhance landscape aesthetics.

COMMUNITY

Enhances roadway aesthetics

Uses minimal space

Requires low maintenance costs

CLEAN WATER

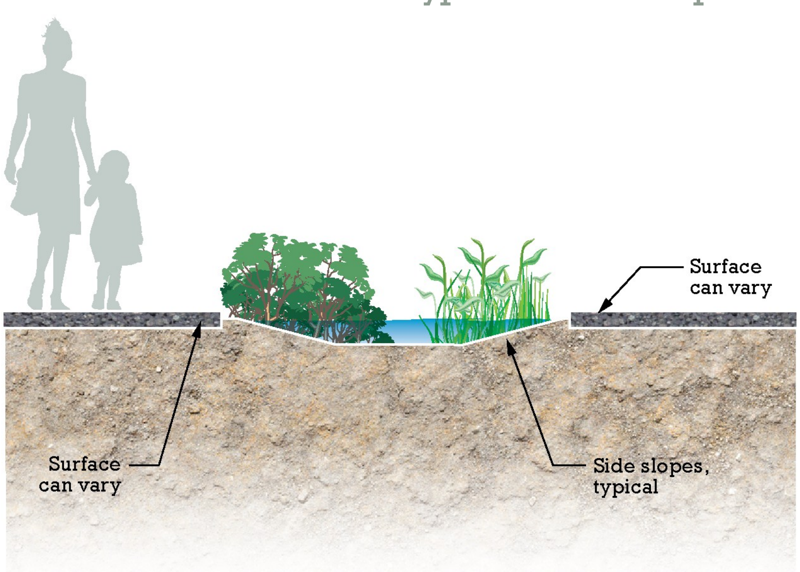
Improves water quality

Manages runoff volume

Mitigates peak discharge rates

Uptakes nutrients

Typical bio-swale profile



Bio-swale that conveys flows along an arterial street. *Source: Nevue Ngan Associates*

Potential Applications

- Method to manage runoff volume and mitigate peak discharge rates
- Provides medium to biodegrade petroleum-based solvents and hydrocarbons
- Alternative to conventional curb-and-gutter conveyance systems
- Pretreatment and/or primary treatment

Residential	Yes
Commercial	Yes
Arterial	Yes
Alleys	No

ADDITIONAL CONSIDERATIONS

Capital Cost	Low/Medium
Maintenance	Medium
Summer/Winter Performance	Medium
Community Benefits	Medium

Bio-swales are designed to convey stormwater runoff while also providing water quality treatment benefits.

Limitations

- Long, continuous space may not be available in retrofit conditions
- Additional maintenance required to establish vegetation
- Option to incorporate other streetscape elements within swales (lighting, signage, etc.) may be limited
- Effectiveness decreased by compacted soils, frozen ground conditions, short grass heights, steep slopes, large storm events, high discharge rates, high velocities and short runoff contact time

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Attachment B: Context TM

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Technical Memorandum

Prepared for: Ada County Highway District

Project Title: Green Stormwater Infrastructure Design Manual

Project No.: 145441

Technical Memorandum

Subject: Green Stormwater Infrastructure Background, Context, and Site Analysis Technical Memorandum

Date: February 20, 2014

To: Joan Meitl

Tom Ferch

From: Ted A. Douglass

Copy to: Amy Neal, P.E.

Erica Anderson Maguire

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Introduction

In response to the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit requirement to implement green stormwater infrastructure (GSI) as a method of stormwater management, Ada County Highway District (ACHD) is preparing a GSI Design Guide. GSI is a stormwater runoff best management practice (BMP) comprised of a variety of processes and techniques designed to simulate pre-disturbance hydrologic processes including temporary storage, infiltration, and evapotranspiration. GSI approaches may help generate a valuable range of benefits to the Ada County community and environment including reduction of flooding events, enhanced neighborhood and business landscapes, improved groundwater recharge, improved water quality, and restoration of aquatic habitat.

This technical memorandum is written to assist the design manual user in understanding the complex hydrological relationships that may influence the success of GSI development and the critical components that will need to be considered in order for the GSI solutions to be implemented effectively. It presents the current hydrological conditions associated with ACHD's jurisdiction including climate, hydrology, hydrogeology, soils, and vegetation. Site-specific soil descriptions, depth to groundwater, and infiltration rate assessments are not detailed in this document. The limitations and concerns that may be encountered in the implementation of GSI solutions are also identified.

Section 1 of the document provides a brief history of stormwater management, driving water quality issues that impact ACHD, objectives of GSI, and a brief history of GSI at ACHD.

Section 2 provides a regional context of the Ada County climate, surface hydrology, groundwater characterization, soil characterization, and vegetation characterization.

Section 3 provides general guidance of what GSI is and includes some cursory design considerations when looking to implement GSI.

Section 1: ACHD Stormwater Background

Section 1 includes a brief description of stormwater management in Ada County, including the impacts of urbanization and permit requirements.

1.1 Impacts of Urbanization

Urbanization of the landscape within Ada County has affected the quantity and quality of stormwater runoff from rainfall and snowmelt. Land development has altered the natural hydrologic processes and reduced the landscape's ability to temporarily store and infiltrate runoff. Impervious surfaces such as parking lots and streets prohibit infiltration and convey runoff, and the associated pollutant load, offsite and into surrounding water bodies. Changes in the landscape have led to increased streamflow during storm events, lower groundwater recharge in impervious areas, lower baseflow during dry weather, and higher watershed and in-stream erosion.

Stormwater runoff is a significant source of pollutants of concern to the Lower Boise River in part due to land development. The characteristics of stormwater runoff vary from site to site and are dependent on the physical characteristics of the development and land use activities. Stormwater pollution from urban areas typically contain nutrients (phosphorus and nitrogen from soil erosion and landscape fertilization), oil and grease (from automobiles), and litter. Pollutants such as bacteria (from animal waste); sediment (from new construction areas); and pesticides, herbicides, and fertilizers (from application) are also common in urban areas. While individual pollutant sources may not contribute a substantial load, cumulative runoff discharges can have a significant impact on surface water quality.

Historically, stormwater management involved controlling only the peak discharge of stormwater runoff and conveying runoff to the nearest receiving water to minimize flooding. Traditional stormwater management systems are typically engineered using physical structures, such as pipes and catch basins, that collect and convey stormwater away from developed sites. Stormwater has traditionally been viewed as a waste product and has typically been controlled by structural devices including curbs, gutters, culverts, ditches, and canals.

There is now a desire to address both the quantity and quality of stormwater runoff to achieve surface water and aquatic ecosystem improvements. This has created a need to evolve from the use of traditional stormwater conveyance practices to GSI applications. GSI design targets minimal land disturbance, increasing infiltration, and reducing stormwater runoff volume at the source to more closely mimic natural hydrology. GSI is designed to replicate pre-development environmental conditions and reduce the impact on the local environment. GSI approaches may help generate a valuable range of benefits to the Ada County community and environment including reduction of flooding events, enhanced neighborhood and business landscapes, improved groundwater recharge, improved water quality, and restoration of aquatic habitat.

1.2 Permit Requirements

Many factors including regulatory requirements, design requirements, and internal policies have historically driven stormwater management in Ada County. Current ACHD stormwater guidance is outlined in the ACHD Stormwater Policy and Design Manual. The ACHD Stormwater Policy defines the management of stormwater in Ada County and outlines the standards and procedures to mitigate the impacts of urban stormwater runoff. The Design Manual provides tools and guidance for stormwater systems within Ada County and is supplemental to the Stormwater Policy. The Stormwater Policy and Design Manual largely focus on a requirement for ponds, catch basins, and flood-routing to accommodate the runoff from a design storm with a 100-year return frequency.

The stormwater discharges have been regulated by NPDES stormwater permits issued by United States Environmental Protection Agency (USEPA) since 1997. ACHD is responsible for building, operating, maintaining, and improving urban streets, rural roads, alleys, and public rights-of-way (ROW) in the cities of Boise, Eagle, Garden City, Kuna, Meridian, and Star, and in unincorporated areas of Ada County. Stormwater conveyances and BMPs associated with the ROW are operated by ACHD with the exception of routes and stormwater facilities operated by the Idaho Transportation Department (ITD). It is estimated that ACHD is solely responsible for approximately 1,044 outfalls that discharge to the Boise River and its associated tributaries within the permitted area.

The Boise River is the largest water body that flows through Ada County. The Boise River receives stormwater runoff discharges from a large watershed with many outfalls and numerous tributaries; the Boise River and its tributaries are water quality limited for some beneficial uses. Idaho's 2012 Integrated Report, published by the Idaho Department of Environmental Quality (IDEQ), identifies specific pollutants of concern associated with each listed water body per Sections 303(d) of the Clean Water Act. The Integrated Report identifies specific pollutants of concern associated with each listed water body. The pollutants of concern for the water bodies identified in Ada County are included in Section 2.3 Table 2-1.

In addition, the NPDES MS4 permit includes a requirement to evaluate existing pollutant loads of pollutants of concern and requires a demonstration of load reductions associated with the MS4. In those areas of the community with a storm drain system, a GSI retrofit may be a good solution for achieving the required pollutant load reductions given the space limitations within the older developed areas.

1.3 Green Stormwater Infrastructure

GSI employs several stormwater BMPs designed to simulate pre-disturbance hydrologic processes including temporary storage, infiltration, and evapotranspiration. GSI practices emphasize conservation, minimal disturbance, the use of onsite natural features, site planning, and distributed stormwater management practices that are integrated into new developments, urban retrofits, and infrastructure improvements.

The primary objective of GSI is to reduce the quantity of stormwater runoff and the associated pollutant load leaving a site and entering the surface water system. The goal of GSI implementation is to prevent measurable physical, chemical, and biological degradation of streams, lakes, wetlands, and other natural aquatic systems from the impacts of urbanization. Typical development practices reduce, disrupt, or entirely eliminate native vegetation, upper soil layers, and native drainage patterns. The stormwater runoff volume and pollutant load reduction objectives of GSI are achieved through the following general site design objectives, adapted from the *Low Impact Development Technical Guidance Manual for Puget Sound*:

- conservation measures
  - maximize retention of native forest cover and restore disturbed vegetation to intercept, evaporate, and transpire precipitation
  - preserve permeable, native soil and enhance disturbed soils to store and infiltrate storm flows
  - retain and incorporate topographic site features that slow, store, and infiltrate stormwater
  - retain and incorporate natural drainage features and patterns
- site planning and minimizing site disturbance techniques
  - utilize a multidisciplinary approach that includes planners, engineers, landscape architects, and architects at the initial phases of the project
  - locate roads away from critical areas and soils that provide effective infiltration
  - minimize road networks (density) and reduce or eliminate road stream crossings
  - minimize total impervious surface area and minimize or eliminate effective (directly connected) impervious surfaces
- distributed and integrated management practices
  - manage stormwater as close to its origin as possible by utilizing small-scale, distributed hydrologic controls
  - create a hydrologically rough landscape that slows storm flows and increases time of concentration
  - increase reliability of the stormwater management system by providing multiple or redundant GSI flow control practices
  - integrate stormwater controls into development design and utilize the controls as amenities — create a multifunctional landscape
  - reduce reliance on traditional conveyance and pond technologies
- maintenance and education
  - develop reliable and long-term maintenance programs with clear and enforceable guidelines
  - educate GSI project homeowners and landscape management personnel (depending on jurisdictional responsibility) on the operation and maintenance of GSI systems and promote community participation in the protection of those systems and receiving waters
  - GSI and ACHD

- – Permeable pavers, bioretention swales, green roofs, and temporary stormwater storage are some of the GSI practices that have been implemented in Ada County. Permeable pavers are by far the most common GSI practice. ACHD has constructed a bioretention area adjacent to its administrative offices in Garden City. In 2014, ACHD plans to retrofit two alleys in downtown Boise with permeable pavers and has approved the use of permeable pavers for the roads in the most recent phase of development in the Bridge Tower subdivision in the City of Meridian. ACHD is currently identifying opportunities for integrating additional GSI practices into drainage projects including street repairs, design retrofits, and other neighborhood projects as appropriate. This effort includes incorporating GSI into streetscape standards for newly developed areas where use of traditional stormwater controls is limited by site conditions such as high groundwater levels.
- – The City of Boise has installed permeable pavers in parking lots and alleys in downtown Boise. Bioretention facilities have also been installed within Boise city limits by private entities such as Metro Car Wash in downtown Boise. ACHD has implemented permeable pavers on a street (36th Street Project) as opposed to just parking lots. Green roofs have been installed at the following five locations:
- – Micron Business and Economics Building at Boise State University

- Barber Park Green Building in Boise
- Mulvaney Medical Office Building in Boise
- Idaho Botanical Garden at the Lewis and Clark Garden Gazebo

Per NPDES MS4 permit IDS-027561, within Ada County, different jurisdictions such as ACHD, Boise State University, City of Boise, City of Garden City, Drainage District 3, and Idaho Transportation District 3 are required to develop GSI initiatives for their jurisdictions. The permittees are required to develop a strategy to provide incentives for the increased use of GSI techniques in private and public sector development projects. Permittees are also required to complete an effectiveness evaluation of at least three GSI pilot study projects.

Attachment D includes a list of locations where GSI practices have been implemented by different jurisdictions. In addition, permeable pavers have been installed at a number of locations in the City of Meridian but are not included in the list.

Section 2: Site Conditions: Ada County

Ada County is located in southwestern Idaho and encompasses the cities of Boise, Meridian, Eagle, Kuna, Star, and Garden City, as shown on Figure 2-1. It is currently the state's most populous county. The Treasure Valley is the broader region in which Ada County is located. The geologic setting of the Treasure Valley encompasses the Western Snake River Plain, which was formed by continental extension that now separates the Boise Mountains from the Owyhee Mountains.

This section includes a description of the regional climate; surface hydrology; and groundwater, soil, and vegetation characteristics in Ada County. It is important to consider these Ada County characteristics when designing GSI techniques.

Because of the substantial variations in local geology, irrigation, topography, and native vegetative cover, assessments of GSI practice suitability should be conducted on a site-by-site basis according to the site evaluation procedures identified in ACHD Policy Manual Section 8000 (ACHD, 1996). Site-specific investigations should be performed to determine the depth to groundwater, soil conditions, long-term infiltration rates, groundwater mounding potential, and potential interactions with land and water use in the immediate and adjoining areas. The IDEQ acknowledges the potential of stormwater runoff to impact groundwater quality in IDEQ Policy Memorandum PM98-3 (IDEQ, 1998). The GSI practices sanctioned by ACHD align with the goals and objectives of this policy.

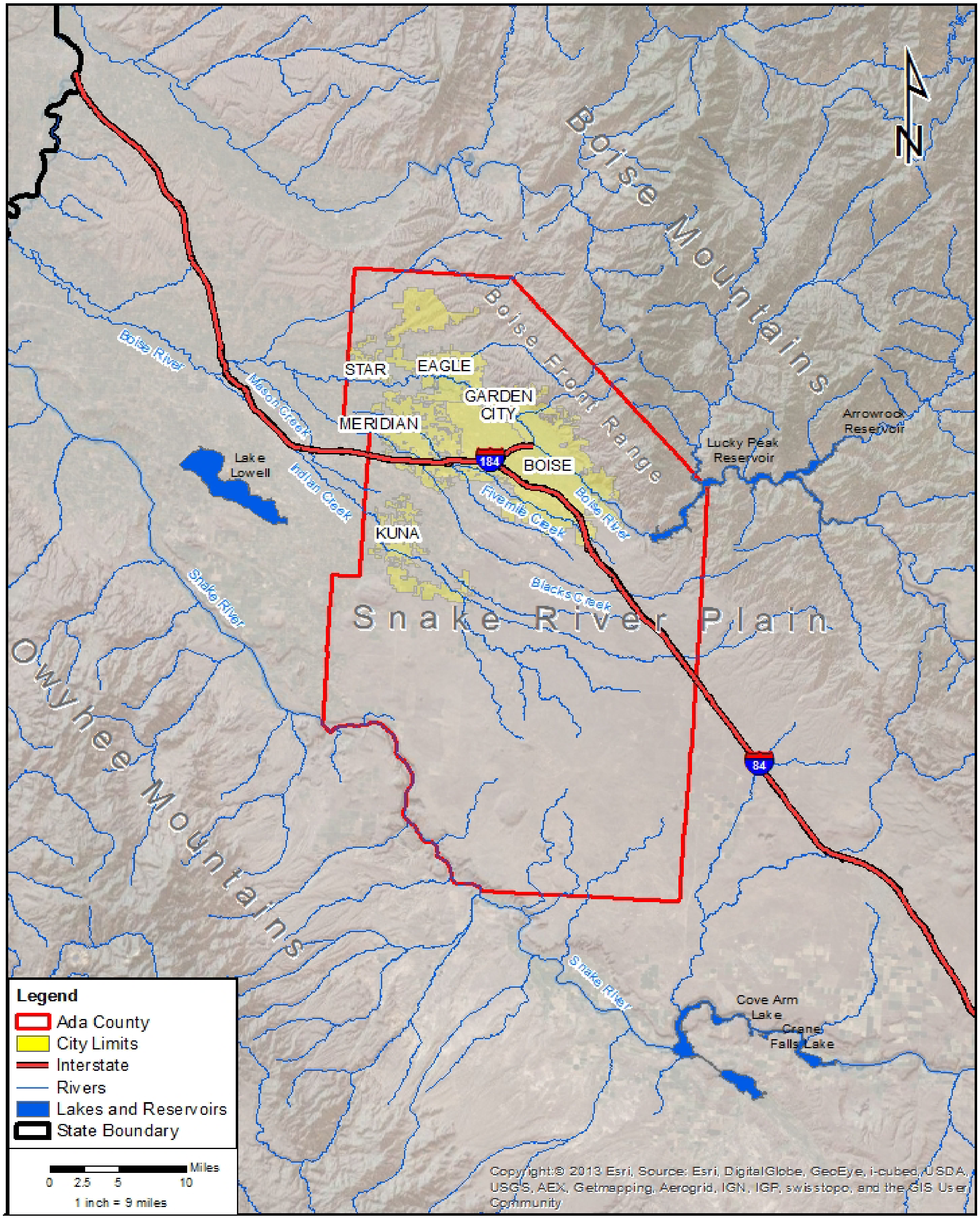

Figure 2-1. Site map of Ada County

2.1 Regional Climate

The climate of Ada County is classified as semi-arid, with an average annual precipitation of 11.5 inches (1939–2013) (National Weather Service [NWS], 2014a). Regional geography of the Northwest and Rocky Mountain states has a strong effect on the arid climate of Ada County. Air masses headed inland from the Pacific Ocean often lose a substantial amount of moisture as they rise over mountain ranges such as the Cascades and the Blues in Oregon and the Owyhee Mountains of southwest Idaho. The Rocky Mountains, to the northeast of the valley, often block cold air masses originating in the Arctic from moving into the area, which results in milder winters than other regions east of the Rocky Mountains at the same latitude (NWS, 2009).

The area typically experiences four distinct seasons with substantial variations in temperature and precipitation. NWS historical data shows that diurnal temperature fluctuations of 40 degrees or more are fairly common in any season. Winter low temperatures often reach 0ºF and lower for short periods of time, but typical average temperatures for the winter months range between 30ºF and 37ºF. Summer extremes often exceed 100ºF. Summer monthly averages range between 67ºF and 75ºF (NWS, 2014b).

On average, approximately 75 percent of area precipitation occurs between November and May and can take the form of rain or snow. Average snowfall accumulation is around 20 inches but varies greatly from year to year. Storms during this colder weather period are often widespread, producing steady precipitation. Precipitation during the warmer months is more likely to take the form of frequent, isolated, and intense showers and thunderstorms (NWS, 2009).

2.2 Surface Hydrology

Snowmelt is the single greatest source of surface water in the Treasure Valley. Snowpack in the Boise Basin (the mountain ranges adjacent to the north and to the east of the Treasure Valley) contributes approximately 90 percent of the surface water flowing through the Treasure Valley area (Idaho Water Resource Board [IWRB], 2012). The majority of snowmelt runoff occurs between March and July. The three reservoirs in the Boise Basin — Lucky Peak, Arrowrock, and Anderson Ranch — act as flood control and storage facilities. The farthest reservoir from Ada County is Anderson Ranch (not shown in Figure 2-1), which is located 25 miles southeast of Arrowrock reservoir. All of the reservoirs are located east of Ada County in the Boise Mountains. The Boise River originates at Lucky Peak and flows across the northern part of Ada County and then through Canyon County to the west. The segment of the Boise River flowing through Ada County is classified as the Lower Boise River. The Lower Boise River watershed encompasses approximately 1,290 square miles (IDEQ, 2013), including the majority of Ada and Canyon counties. Major tributaries of the Lower Boise River include Blacks, Fivemile, Tenmile, Indian, and Mason Creeks.

Natural surface hydrology has been significantly altered by the canal irrigation system in Ada County, particularly with respect to stormwater drainage and groundwater recharge. Canals run throughout the rural and urbanized areas of Ada County. Just below Lucky Peak, a portion of the discharge from the reservoir is diverted for irrigation use. Irrigation flows are typically used from April through October, though the irrigation season may be truncated in low-water years. From the diversion dam an annual average of 1.6 million acre-feet of irrigation water is disbursed throughout approximately 1,170 miles of canals to serve 350,000 acres of land (IWRB, 2012).

Irrigation is a major source of aquifer recharge as it percolates through the soil on fields and lawns where it is applied in addition to seepage through the bottoms of canals and storage ponds (IWRB, 2012). In low-lying areas farther downstream, a series of drains have been constructed to drain shallow groundwater and either return it to the Boise River or retain it for irrigation use in the area.

2.3 Surface Water Quality

The surface water bodies, or receiving waters, in Ada County have been designated for a variety of beneficial uses including domestic and agricultural water supply, recreation, and habitat for cold and warm water biota. Urban stormwater runoff impacts to receiving waters can include, but are not limited to, flow alteration, temperature, sediment, nutrients, bacteria, and chemical pollutants such as pesticides and oil and grease. Agricultural runoff and return flows often carry many of these same concerns but in different concentrations and levels of influence.

IDEQ has recently published its 2012 Integrated Report on the quality of Idaho's waters. Table 2-1, below, provides a summary of the designated beneficial uses of the Lower Boise River and its major tributaries as well as the listed impairments. The listed impairments can be translated to pollutants or conditions of concern. The table was populated using subbasin assessments published by IDEQ in 2001 and the most recent version of IDEQ's interactive mapping interface which has been updated to include data from the Draft 2012 Integrated Report. As reports are completed, the mapping interface is updated, and the most recent information is made available through the IDEQ website. Additional information on the smaller tributaries and some canals can also be accessed through the IDEQ website.

Many of the pollutants of concern listed for receiving waters are present in stormwater runoff. Pollutant sources in urban development will vary site by site. The choice of GSI practice and the design should be informed in part by the potential pollutants in the drainage area to be treated by GSI.

The pollutants of concern identified in Ada County include nutrients (nitrogen and phosphorus), sediment, and bacteria. Nitrogen concentration reduction requires the biological processes of nitrification and denitrification. Phosphorus concentration can be reduced both chemically and biologically. Sediment and bacteria concentrations are typically reduced through the infiltration process.

Table 2-1. Ada County Surface Water Uses and Concerns

Surface Water Body	Beneficial Uses	Conditions/Pollutants of Concern
Lower Boise River	• Cold water aquatic life • Salmonid spawning • Domestic water supply • Primary contact recreation • Secondary contact recreation • Wildlife habitat	• Flow alteration • Substrate habitat alterations • Sediment • Dissolved oxygen • Oil and grease • Nutrients • Bacteria • Temperature
Blacks Creek	• Cold water aquatic life • Wildlife habitat • Secondary contact recreation	• Dissolved oxygen • Sediment • Nutrients
Fivemile Creek	• Cold water aquatic life • Modified cold or warm water biota • Secondary contact recreation	• Dissolved oxygen • Sediment • Nutrients • Bacteria
Tenmile Creek	• Cold water aquatic life • Modified cold or warm water aquatic life • Secondary contact recreation	• Dissolved oxygen • Sediment • Nutrients • Bacteria
Mason Creek	• Modified cold or warm water aquatic life • Secondary contact recreation	• Dissolved oxygen • Sediment • Nutrients • Bacteria
Indian Creek	• Cold water aquatic life • Seasonal cold water biota • Salmonid spawning • Primary contact recreation • Secondary contact recreation • Wildlife Habitat	• Dissolved oxygen • Sediment • Nutrients • Temperature • Oil and grease • Bacteria

Stream uses and conditions/pollutants of concern from IDEQ subbasin assessments for the Lower Boise River and major tributaries (IDEQ, 2001a and 2001b) and Idaho's 2012 Integrated Report (IDEQ, 2013).

2.4 Groundwater Characterization

This section includes a characterization of groundwater in Ada County, including geology and hydrogeology, the groundwater table, and stormwater-groundwater interaction.

2.4.1 Geology and Hydrogeology

The Snake River Plain in Ada County is a sedimentary basin that has been filled in by a series of volcanic deposits overlain by sediments from lakes and streams (Wood and Clemens in Petrich and Urban, 2004). The sedimentary strata that form the deep aquifer contain interbedded mudstones, sands, and gravels, which have been tilted and offset by faulting (Squires and Wood, 2001). The mudstones block the groundwater flow while the sands and gravels transmit flow. This results in a deep, complex regional aquifer and hydraulic connectivity between zones that is not well understood.

General flow direction of the deep aquifer in northern Ada County trends to the northwest; whereas, in southern Ada County, flow trends south toward the Snake River (Petrich and Urban, 2004). Regional groundwater flow paths are dependent on topography, groundwater recharge, and stratigraphic sequences.

Northern Ada County has a shallow groundwater aquifer that includes the floodplain of the Boise River and a series of river terraces, or benches (Figure 2-2). The sediments that form the floodplain and the terraces consist of lenses of clays, sands, and gravels in varying thicknesses. These lenses are laterally discontinuous throughout the floodplain and the terraces. Basalt flows are also interbedded in the older terrace sediments (U.S. Geological Survey [USGS], 1998).

In many places of the valley, thick clay layers in the stratigraphic sequence separate the shallow aquifer from the deep regional aquifer. However, the clay layers are laterally discontinuous, and while multiple clay layers in aggregate can form a more expansive barrier to flow, the discontinuity allows for hydraulic connections between the aquifers (Petrich and Urban, 2004).

2.4.2 Groundwater Table

The groundwater table refers to the surface of the shallow unconfined aquifer. The depth to the groundwater table and direction of flow of groundwater in the shallow unconfined aquifer are more variable than in the deep regional aquifer. In the shallow unconfined aquifer these parameters are modified on a localized scale by influences from topography, infiltration, and preferential flow paths in the near-surface geology (Petrich and Urban, 2004)

The generalized groundwater elevation contours included on Figure 2-2 illustrate an overall groundwater flow direction in the shallow aquifer that trends to the west and northwest, similar to that of the deep aquifer. However, in the areas along the Boise River corridor groundwater typically flows toward the river and in closer proximity may flow parallel to the river. Area creeks and agricultural drains also affect the local movement of the aquifer. The depth to water in the shallow aquifer along the Boise River floodplain can range from less than 5 feet to more than 15 feet. Depth to water increases on the terraces and with distance from the Boise River. Generally, depth to water on the terraces close to the river (Whitney Terrace and Boise Terrace) ranges from 25 to 50 feet or more below ground surface, and depth to water measurements exceeding 100 feet below ground surface are common farther from the river on the higher terraces (Petrich and Urban, 2004).

The elevation of the groundwater table can increase or decrease by several feet in response to percolation of irrigation water through the soil, seepage from surface water bodies, and stormwater infiltration features. Fluctuations in water table levels can occur on both a seasonal and event basis. These fluctuations in depth to water can alter flow direction on a local scale throughout the year (USGS, 1998). Seasonal fluctuations in depth to water and flow direction generally become less pronounced as depth to water increases.

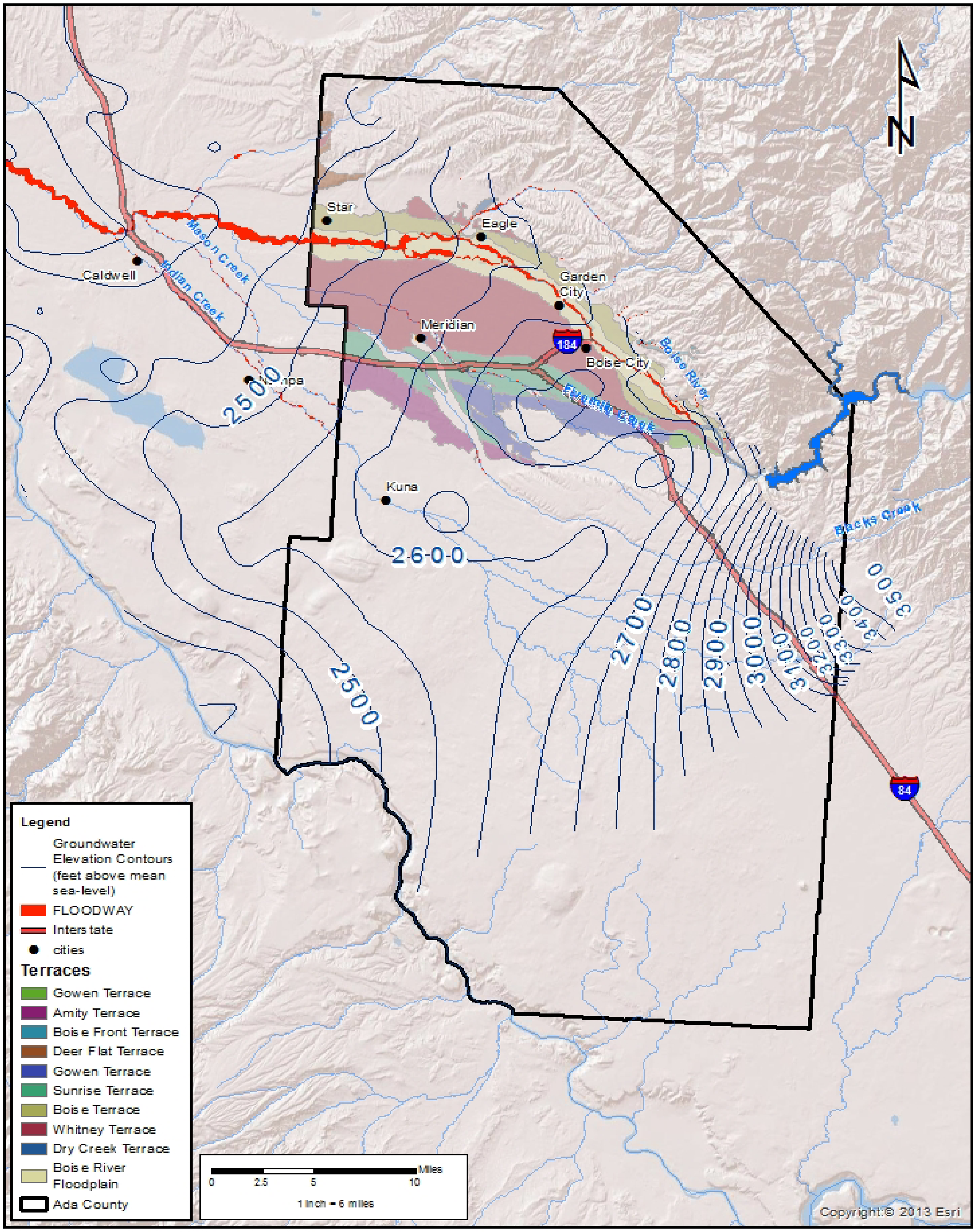

Figure 2-2. Shallow groundwater contours of Ada County

2.4.3 Stormwater-Groundwater Interaction

According to a study by the Idaho Water Resource Board (IWRB, 2012), approximately 94 percent of water for domestic, construction, municipal, and industrial use in the Treasure Valley comes from groundwater sources. The effect of stormwater infiltration on groundwater quality can vary greatly on a localized scale. There are many factors that influence the effect of stormwater runoff on groundwater quality including stormwater runoff quantity and quality, depth to shallow groundwater, groundwater quality, physical and chemical soil characteristics, and biological activity in the soil and groundwater. Most of the wells that supply water for the uses mentioned above draw from the deeper regional aquifer and may not be directly impacted by stormwater infiltration. More information on groundwater usage and groundwater quality specific to Ada County is provided in Attachment A.

Soil and vegetation can reduce contaminant concentrations in stormwater (nutrients, sediment, metals, bacteria) through filtration of particulate pollutants by soil, vegetation, and organic matter; adsorption of dissolved contaminants into soil complexes; and uptake by organisms and vegetation. However, varying concentrations of contaminants can remain in the stormwater as it percolates down into the shallow groundwater system. Though concentrations are often low, contaminants in groundwater resulting from urban stormwater infiltration may include petroleum compounds; pesticides and insecticides; nutrients, phosphorus, and nitrogen; and heavy metals. When these contaminants are dissolved in the stormwater or groundwater some become more mobile (nitrate, chloride, other salts) while others tend to become less mobile (phosphate, most metals). Physical, chemical, and biological processes in the soil and groundwater system attenuate some of these constituents. Remaining contaminants may migrate to shallow groundwater wells or seep into nearby surface waters such as streams, canals, and drains.

2.5 Soil Characterization

This section includes a characterization of soils in Ada County, including soil types, subdivisions, and limitations. The variability in depth and soil drainage of all soil types limits GSI planning without site specific soil investigations. Soils are a critical component of GSI solutions. Defining and amending soils provides improved effectiveness. This section describes the local soils in Ada County and how they can influence the effectiveness of GSI solutions.

2.5.1 Soil Types

Soil types are categorized into four hydrologic soil groups (HSGs): HSG A, B, C, and D, based primarily on infiltration rates. The HSGs are also differentiated by physical properties (percent sand, silt, and clay) (U.S. Department of Agriculture [USDA], 1980). The four hydrologic soil groups are as follows:

- Group A: Primarily coarse to medium sand soils having a high infiltration rate (low runoff potential) and a high rate of water transmission. These consist of deep, well-drained to excessively drained sands and gravels. Group A soils typically provide the ability to receive stormwater runoff at a high rate, but following each rain event, Group A soils retain little soil moisture for plant growth unless rain events occur with some regularity. These soils move a greater rate of water and have an important application in GSI design. Sandy and gravely soils have high water transmission rates but may affect the suitability of soil material for some plant species. These soils may have to be amended with organic matter to improve water holding capacity to support some desired native or regionally adapted species in GSI.
- Group B: Fine sands, silts, and loamy soils have a moderate infiltration rate and a moderate rate of water transmission. These consist of moderately deep or deep, moderately well-drained or well-drained soils that have a moderately fine texture to moderately coarse texture. Group B soils have a higher plant available moisture holding capacity than Group A soils, and Group B soils will support a greater variety of native plant species compared to Group A soils. For design of GSI landscaping, Group B soils are not

ideal for roadside infiltration of high intensity stormwater runoff but support a greater diversity of plant species in other applications.

- Group C: Fine texture silty and clayey soils having a slow infiltration rate and a slow rate of water transmission. These consist of soils that have a layer that impedes the downward movement of water or soils that have a moderately fine texture or fine texture. These soils may restrict the amount of water that can be received in GSI applications. Group C soils may require physical alteration of restrictive layers to reach water infiltration requirements depending on depth of those layers, depth of groundwater, and desired goals of the application. If managed correctly to improve infiltration, Group C soils typically have very high plant available moisture holding capacity and can also support a wide diversity of native plant species.
- Group D: Soils having a very slow infiltration rate (high runoff potential) and very slow rate of water transmission. These consist of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material (USDA, 1980). Group D soils could affect water processing capacity in GSI application and could require physical alterations, soil amendments, and have smaller water holding capacities than other soil groups. Restrictive layers may require removal or breakage. Group D soils are ideal for wetlands applications if left unaltered.

Ada County hydrologic soil classifications and draining characteristics are shown on Figure 2-3. The majority of the soils in the Boise River floodplain are Groups A and B due to the alluvial nature of the floodplain. The largest group of soils in Ada County is Group C, followed by Groups B, D, and A, respectively, and a small range of soils are a mixture of different hydrologic groups. Many C and D soils have restrictive clay layers or duripans that act as impervious barriers, especially in northwestern Ada County. Duripans are subsurface cemented layers, usually found in arid or semi-arid regions, which restrict soil management and vertical movement of water through the layer. They occur at varying depths and widths in Ada County (Figure 2-3). GSI treatments should consider the depth of any duripan or restrictive layers. Physical alteration or breakage of the duripan may be required depending on the depth of the layer and engineering of the GSI application.

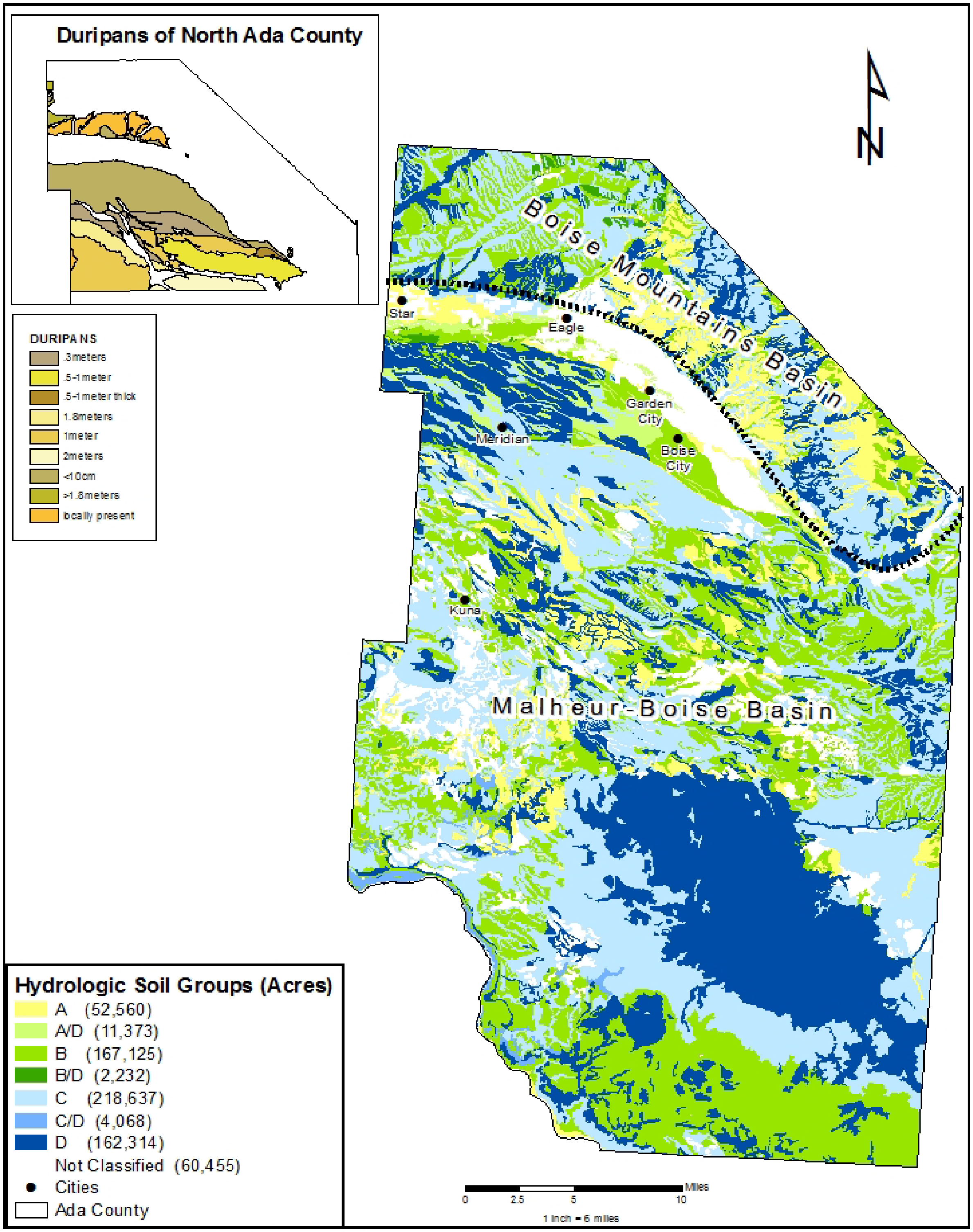

Figure 2-3. Hydrologic soil groups of Ada County

2.5.2 Soil Subdivisions

The soils of Ada County can be generally grouped into two separate divisions, those derived from the Idaho Batholith subdivision of the Northern Rocky Mountain province (the Boise Mountains) and those in the Malheur-Boise Basin section of the High Lava Plains sub-province of the Columbia intermountain province (USDA, 1980). All soil descriptions were obtained from the 1980 Soil Survey of Ada County Area, Idaho, produced by the USDA Soil Conservation Service (USDA, 1980). Further information on the types of soil and descriptions of hydrologic soil groups are provided in Attachment B. The two primary Ada County soil subdivisions are summarized below:

- **Soils from Boise Mountains.** The soils found in the Boise Mountains are further categorized into two soil types. The first soil type is described as moderately deep and very deep and well-drained and is found at an elevation range of 3,000 to 5,750 feet above mean sea level (amsl). These soils occur from nearly level topography to moderate to steep slopes in the foothills in northeastern Ada County (USDA, 1980).

  The second soil type in the Boise Mountains is described as very deep and well-drained to excessively drained and is found at an elevation range of 2,800 feet to 3,400 feet amsl. These soils occur on lacustrine foothills in northern Ada County.

- **Soils from Malheur-Boise Basin.** The soils found in the Malheur-Boise Basin section are also further categorized into two soil types. The first soil type is described as very deep, it has poor drainage, and it is found at an elevation range of 2,500 feet to 2,700 feet amsl. These soils occur along the Boise River floodplain and in low terraces of Ada County and make up about 13 percent of Ada County soils. GSI applications on or near the Boise River floodplain and low terraces should consider the poor drainage and restrictions of these soils during planning stages.

  The second soil type in the Malheur-Boise Basin is described as shallow to very deep, somewhat poorly drained to somewhat excessively drained, and is found in drainage ways and soils on alluvial terraces, basalt plains, dissected alluvial plains, alluvial fans in canyons, and in rubble land on canyon walls. These soils make up approximately 63 percent of Ada County soils. Depth and drainage of soils will vary from site to site.

The two primary soil subdivisions define general characteristics of soils found in Ada County. All four hydrological soil groups occur in each general subdivision. GSI planning should consider more specific soil characteristics, and each site should define soil type and characteristics prior to design.

2.5.3 Soil Limitations

Soil limitations are a function of the physical and chemical properties of the soil and can impact the potential use of GSI practices. Site-specific identification of soil types and limitations is essential during project planning to ensure the success of GSI projects. Limitations of Ada County soils include the following:

- **Restrictive layers.** Soils described in hydrologic soil groups C and D in Ada County typically consist of a high clay component that acts as a restrictive layer and reduces the infiltration capabilities of the soil. If the designer does not account for this, the GSI facility could fail or require increased maintenance. Many areas, especially in western Ada County, have a hardpan layer that can restrict water infiltration and reduce downward movement of water. Restrictive layers can artificially raise groundwater levels during irrigation, which could further reduce water infiltration rates. Mitigation measures, such as soil amendments and mechanical alteration of restrictive soils, underdrains, can be applied to promote successful infiltration in restrictive soils.
- **Compacted soil layers in developed areas.** Similar to naturally occurring restrictive soils, many soils in developed areas have been compacted for development. Compaction of soils with finer elements, such as clays, can create more restrictive properties than the naturally occurring soil. Similar measures to

physically alter compacted soils described above for restrictive soils could be used to mitigate compaction.

- **Sandy soils.** Sandy soils can limit species selection for GSI applications. Although sandy soils provide high infiltration rates and low runoff, they often contain fewer plant nutrients and restrict the growth of plant species not adapted to sandy soils. These soils could be mixed with soils with finer components or organic additives with water-retaining properties to promote plant growth.
- **Chemical composition of soil.** Chemical composition of soils may restrict successful plant establishment and growth of certain species. Site-specific soil identification can be used to identify the plant species that are not adapted to chemical properties of the soil. The best approach is to properly identify site soils and choose species that are native or adaptive to those soil characteristics.

2.6 Vegetation Characterization

This section includes a characterization of vegetation in Ada County, including historical vegetation, current vegetation, vegetation considerations, and vegetation limitations.

2.6.1 Historical Vegetation

Ada County falls within the Columbia Plateau Ecoregion, which is characterized by an expanse of volcanic plains and valleys covered by sagebrush intermixed with perennial grasslands (Idaho Fish and Game, 2005). Generally, elevation and moisture increases from south to north toward the base of the Boise Mountains and north of the city of Boise. Elevation and average annual precipitation increase from the Boise Valley into the Boise Mountains, changing the vegetation types from xeric communities to more mesic communities.

Much of the native vegetation has been converted into urban, residential, and agricultural development, as shown on Figure 2-4. Southern Ada County borders the Snake River and contains semi-desert dry grasslands and salt shrub vegetation. Northern Ada County borders the Boise Mountains and rises in elevation, transitioning from sagebrush steppe vegetation cover to mountain big sagebrush, warm mesic shrub, and Douglas fir and Ponderosa pine forested communities.

Another natural plant community that exists in Ada County is the riparian and wetland ecosystem along the corridor of the Boise River. Although the cover area composes only a small part of the overland cover of the county, it is an important ecosystem and a focal point of urban development of cities such as Boise, Garden City, and Eagle. The corridor is a mixture of mature cottonwood forest, scrub shrub, and emergent wetlands that buffer the Boise River from development. The proximity to the river supplies high groundwater levels and supports hydric soils adjacent to the river, its tributaries, and portions of its floodplain. Native vegetation includes black cottonwood (*Populus trichocarpa*), willow species (*Salix sp.*), alders, and herbaceous wetland species including rushes (*Juncus sp.*), sedges (*Carex sp.*), and common cattail (*Typha latifolia*).

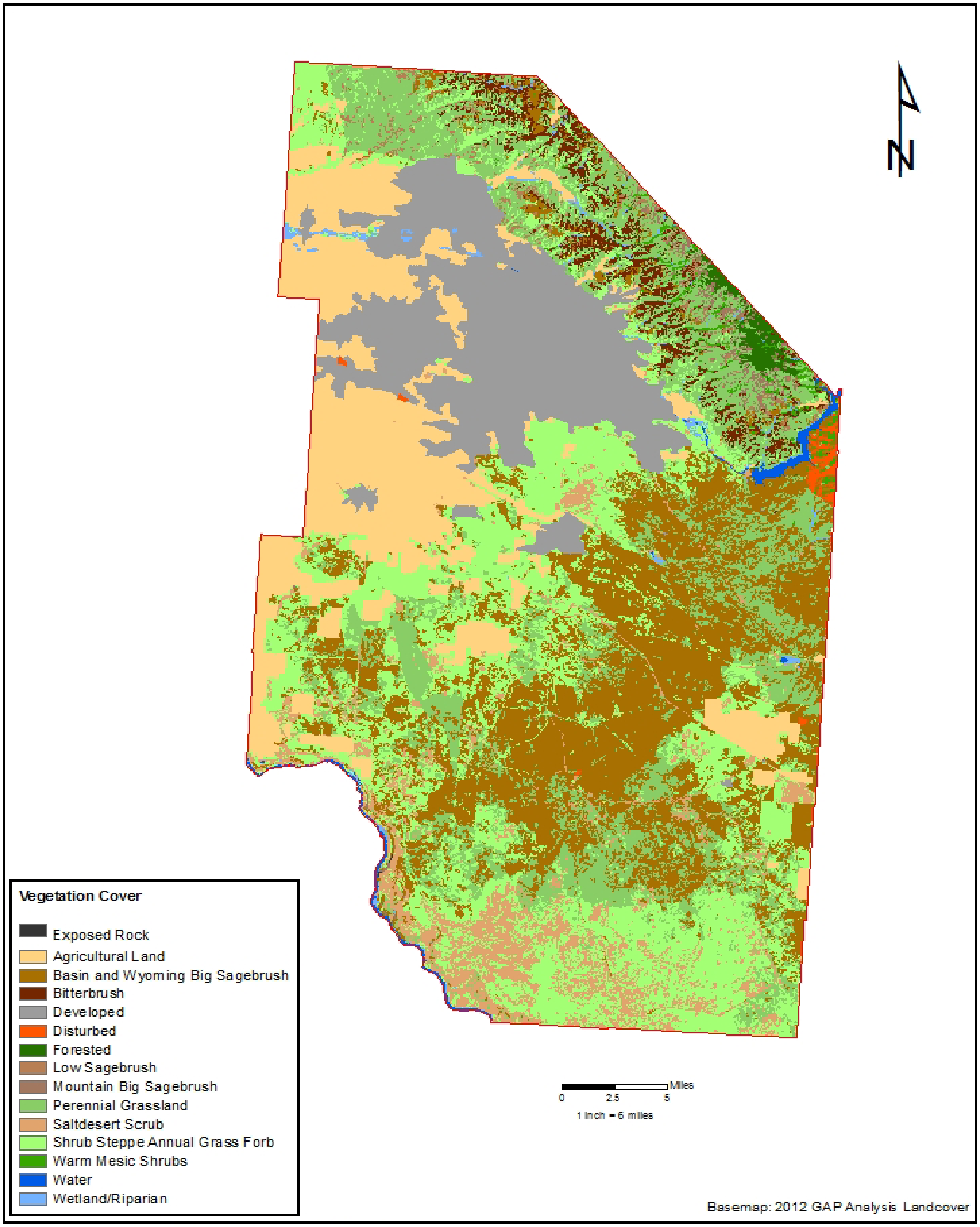

Figure 2-4. Vegetation cover in Ada County

2.6.2 Current Vegetation

As a result of population growth in Ada County, much of the native vegetation communities have been transformed into agricultural or urban landscapes. The urban areas have been developed around the city of Boise mainly along the west corridor of the Boise River. Vegetation communities have transitioned from riparian cottonwood forest and sagebrush steppe communities to urban landscapes. However, a variety of decorative native and non-native species are dominant in the developed areas of the county. Urban trees serve as an important part of the urban vegetation. A 2013 study of the Treasure Valley urban tree canopy reported that 10 percent of the Treasure Valley and 20 percent of the city of Boise was under tree canopy cover (Plan-it Geo, 2013). The City of Boise Community Forestry Department has published a guide to planting trees in urban areas of the city. The guide provides a list of native or regionally adapted trees to use in landscaped areas. It also provides a list of species that are not allowed to be planted in public rights-of-way because they are weak, quick-decaying, or invasive species.

Many native species or regionally adapted species can be used in place of exotic species in landscape practices. Most of the species described in the native communities in Attachment C do well in an urban setting because they are adapted to the native soils and climate of the area. GSI applications may also desire more aesthetic landscaping than native plants can provide. Regionally adapted species can provide more desirable aesthetics and similar characteristics for stormwater management.

Several resources are available for choosing plant species for GSI. A list of resources for choosing native and regionally adapted plants for Ada County include the following:

- The Idaho Native Plant Society (INPS) published a planting guide in cooperation with Boise State University and the U.S. Bureau of Land Management, titled *Landscaping with Native Plants of the Intermountain Region* (BLM, 2003).
- The INPS also provides a detailed list of species that are natively found in the Boise area.
- Idaho Roadside Revegetation Handbook prepared for the ITD by the University of Idaho (Kingery et al., 2003).
- Native Plants for Idaho Roadside Restoration and Revegetation Programs, prepared by ITD, The National Institute for Advanced Transportation Technology, and the University of Idaho (Robson and Kingery, 2006).
- Stormwater Plant Materials: A Resource Guide for Boise Public Works (Boise Public Works Department, 2000).

Information on plant communities of the Columbia Basin is available in Attachment C of this document.

2.6.3 Vegetation Considerations

Plant species with low maintenance can reduce the long-term cost of GSI applications. Characteristics such as growth rate, size at maturity, and seasonal needs of plants should be considered when selecting plant species for each application. Another consideration is the reproductive systems and dormant state of plants. Some plants produce large or abundant seeds/seed pods that are released every season. Many trees and shrubs also lose their leaves during fall and winter months. This may produce large amounts of litter that require cleaning maintenance or could reduce the functionality of the treatment application by blocking soil exposure or clogging flow areas or filters.

2.6.4 Vegetation Limitations

All GSI designs should use native or regionally adapted species, as applicable, to ensure that the project is sustainable and requires less management and maintenance. However, there are certain limitations when using native vegetation for GSI applications in Ada County, which include the following:

- **Short growing season.** Much of the native vegetation is adapted to arid conditions and has a short growing season. The physiology of many of the native species is adapted to low water conditions and dry seasons in southwestern Idaho. Therefore, application where water supply is artificially high may alter the growth of some species, reducing the effectiveness of the application and increasing maintenance requirements.
- **Long establishment period.** Due to the natural community conditions, native plants have adapted to the short growing season and often have a long establishment period. Initial efforts to establish mature plants in a GSI facility may increase if species are selected that require long establishment periods (e.g., Idaho fescue is slow to establish but has abundant growth and a deep root system once established).
- **Challenge of finding soil-specific plants.** Selection of species according to site-specific soil conditions is important to the viability of the species in the application. For example, if a grass species such as Indian rice grass is selected in high clay content soils, the viability of the plant may be reduced, which would increase maintenance efforts. Since most soils used for bioretention areas would likely be manufactured soils (mixed to reach retention goals), soil limitations on plant selection would be minimal. Soil and vegetation relations by soil type and characteristic vegetation can be found in the USDA Soil Survey of Ada County, Table 6 (USDA, 1980).
- **Presence of invasive species.** Ada County has invasive plant species that specialize in establishing in exposed or disturbed soils. Much of the rangelands and open spaces are dominated with invasive species and require treatment prescriptions to reduce or eliminate them to allow the establishment of native or regionally adaptive plants. They can increase the potential for constant maintenance of vegetative applications.
- **Commercial availability and cost.** Availability and cost should be considered during planning and identification of plant species that meet the functional and aesthetic goals. Many native and regionally adaptive plants are available at local and regional nurseries. Local suppliers more likely stock plants or seeds adapted or native to the climate of Ada County. Availability and cost may restrict what plants are available both locally and regionally. Some suppliers can obtain or grow specific orders if given enough notice and growing time to meet the desired number of plants for GSI applications.

Section 3: GSI Design Process

For a given GSI project, design principles should be considered to address the regulatory requirements, site characteristics, construction method, and long-term maintenance. When applying design principles it is important to identify both the opportunities and the limitations of a given site. The following describes the general design process/principles for ACHD adapted from the *Eastern Washington Low Impact Development Guidance Manual* (Carlson et al., 2013).

Establish Goals for the Project

The design process begins by clearly establishing the goals for the project, as these will ultimately drive the site layout, selection, sizing, and design of the GSI facility. A GSI project can have one or more of the following goals:

- meet core element requirement for runoff treatment and/or flow volume control
- retrofit existing developments for water quality improvement
- improve neighborhood aesthetics and mobility

Identify Applicable Design Standards and Requirements

The standards and requirements that may influence GSI facility site design include the following:

- stormwater regulations and design standards
- setback requirements for infiltration facilities
- setback requirements for structures (e.g., cisterns may require setbacks from property lines)
- soil and subsurface hydrology evaluation and reporting requirements
- sizing methodologies
- street network design standards

Selecting GSI Solutions to Match Site Conditions and Goals

Once the goals for the project are established and the design standards are identified, GSI solutions are then chosen on the basis of the following factors:

- ability to meet site goals
- soils and subsurface hydrology
- available space for siting facilities
- constructability
- ease of maintenance
- public acceptance
- life cycle cost analysis

Develop Preliminary Site Layout

The preliminary site layout is an iterative process intended to balance and optimize the proposed project, avoid site constraints, conserve vegetation, and exploit storage and infiltration opportunities. During the preliminary site layout development, the following strategies to minimize impervious cover, and especially directly connected impervious cover, should be explored:

- paving with permeable paving to accommodate infiltration
- installing stormwater curb extensions and bulb outs in low density along the streets where on-street parking is under used
- allowing impervious surfaces to drain into or across pervious areas prior to entering the drainage network

It is important to note that site-specific subsurface soils and groundwater testing should be completed prior to developing the site layout to determine the capability of the site to support different types of GSI practices. The infiltration capacity of the native soils is an extremely important consideration in determining the applicability and effectiveness of different types of GSI practices. Testing is required at the location of each GSI practice.

Finalize Designs

Once the GSI facility has been properly sized, the design team can prepare the final site design documents. This step entails updating and refining the preliminary site plan to develop final sizing and facility layout and confirming that the site goals are met. Depending on the extent of subsurface testing completed during the preliminary site layout, additional testing may be needed. This is especially true if GSI practices have been located in previously unused areas. If the goals established for the project are not met, some iteration may be needed to reach the final design. The final design documents will also include construction details. To ensure GSI practices are designed and constructed throughout the ACHD area in a consistent manner, standard construction details should be provided to local engineers and developers along with design methodology and standards.

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Attachment A: Groundwater Usage

Groundwater Usage

According to the Idaho Water Resource Board, in 2012 approximately 94 percent of water for domestic, construction, municipal, and industrial use in the Treasure Valley came from groundwater sources. This equates to approximately 150,000 acre-feet per year. Conversely, approximately three irrigation water sources (approximately 50,000 acre-feet) came from groundwater sources. Domestic wells typically draw from shallow aquifers, while municipal production wells, and many wells used for irrigation, draw from the deeper regional aquifer system.

In 1998 the U.S. Geological Survey (USGS) and Idaho Department of Environmental Quality (IDEQ) published a groundwater report analyzing groundwater quality data collected from 884 wells in northern Ada County over 11 years. Conclusions from the study indicate that the majority of groundwater sources were suitable for beneficial uses including drinking water supplies. Groundwater quality results from a limited number of water-bearing zones were found to have more limited use based on contaminant levels exceeding water quality standards.

Naturally occurring contaminants found to exceed standards include total dissolved solids (TDS) and radon. Ten of the wells sampled contained elevated levels of TDS (exceeding the secondary drinking water standard of 500 milligrams per liter). These wells were generally less than 400 feet deep and were dispersed geographically across the study area.

Radon, a naturally occurring gas present in varying concentrations in rocks and soils, can often be present as a dissolved gas in groundwater. There is currently no established maximum concentration limit established for radon in drinking water. The U.S. Environmental Protection Agency (EPA) has proposed regulations that would require that public drinking water supplies contain no more than 4,000 picocuries per liter (pCi/L) if the state or area has an indoor air monitoring program for radon established. In the absence of an indoor air monitoring program, the drinking water supplies would be required to contain no more than 300 pCi/L (EPA, 1999). Radon levels exceeding 300 pCi/L were reported in over 90 percent of the wells sampled. Approximately 25 percent of levels reported exceeded 1,000 pCi/L.

Various contaminants resulting from spills, leaks, and other land use activities are present in varying and localized areas throughout Ada County. Chemicals and wastes that have been spilled, leaked, or dumped can sometimes infiltrate into the groundwater. Instances of contamination in this case are a localized issue with a specific source. Regulatory agencies investigate these issues on a case-by-case basis, working toward cleanup efforts as necessary. These types of problems are more common in industrialized and urban areas.

Nitrate has been identified as a contaminant contributing to groundwater degradation on a broader scale. Nitrate contamination of groundwater most typically results from leaching of nitrate from the surface through soils to the groundwater. Potential sources of nitrate contamination include animal wastes, septic sewer systems, and nitrogen-based fertilizers. Elevated nitrate concentrations are more typical outside of urban areas (USGS and IDEQ, 1998).

Attachment B: Ada County Soil Subdivisions

Ada County Soil Subdivisions

The soils of Ada County can be generally grouped into two separate divisions, those derived from the Idaho Batholith subdivision of the Northern Rocky Mountain province (the Boise Mountains) and those in the Malheur-Boise Basin section of the High Lava Plains sub-province of the Columbia intermountain province (U.S. Department of Agriculture [USDA], 1980). All soil descriptions were obtained from the 1980 Soil Survey of Ada County Area, Idaho, produced by the USDA Soil Conservation Service (USDA, 1980).

The soils found in the Boise Mountains are described as moderately deep and very deep, and are well-drained. They are found at an elevation range of about 3,000 to 5,750 feet above mean sea level (amsl). They occur from nearly level topography to moderate to steep slopes in the foothills, receive on average 16 inches of annual precipitation, and have on average 120 frost-free days. These soils occur in northeastern Ada County and account for approximately 9 percent of the county soils (USDA, 1980). The soil map unit for these soils is:

1. **Searles-Ladd-Ola:** sloping to very steep, well-drained, moderately deep, and very deep soils; on granitic mountains.

The second soil type in the Boise Mountains occurs on lacustrine foothills. These soils occur at elevations from 2,800 feet to 3,400 feet amsl. They are described as very deep and well-drained to excessively drained. They receive 12 inches of annual precipitation and about 120 frost-free days on average. They make up about 15 percent of Ada County soils. This soil type is broken up into the following two soil map units:

1. **Quincy-Lankbush-Brent:** low rainfall; nearly level to very steep, excessively drained and well-drained, very deep soils; on alluvial fans and terraces in the Boise Foothills.
2. **Cashmere-Tindahay:** nearly level to steep, well-drained and somewhat excessively drained, very deep soils; in drainageways and on alluvial fans and low alluvial terraces in the Boise Foothills.

The soils found in the Malheur-Boise Basin section are divided into two groups. The two soil groups are found in the floodplains and low terraces and in drainageways and soils on alluvial terraces, basalt plains, dissected alluvial plains, and alluvial fans in canyons and rubble land on canyon walls.

The soils found in the floodplains and low terraces of Ada County are described as very deep and are poorly drained and somewhat poorly drained or well-drained. These soils occur along the Boise River in Ada County. Elevation ranges from 2,500 to 2,700 feet amsl. These soils make up about 13 percent of Ada County soils and are a good source of sand and gravel. Most of the soils are used for urban development and agricultural purposes. These soils are described as the following two soil map units:

1. **Notus-Moulton-Falk:** nearly level, poorly drained and somewhat poorly drained, very deep soils; on flood plains and the adjacent low alluvial terraces.
2. **Power-Aeric Haplaquepts-Jenness:** nearly level to sloping, poorly drained and well-drained, very deep soils; in drainageways and on low alluvial terraces.

The soils on alluvial terraces, basalt plains, dissected alluvial plains, and alluvial fans in canyons and rubble land on canyon walls are described as shallow to very deep and are somewhat poorly drained, well-drained, and somewhat excessively drained. These soils make up approximately 63 percent of Ada County; they receive 10 inches of annual precipitation and have 150 frost-free days on average. Vegetation on these soils is dominated by sagebrush and bunchgrasses. This soil group contains the following eight soil map units:

1. **Purdam-Abo-Power:** nearly level to sloping, somewhat poorly drained and well-drained, moderately deep and very deep soils; on low alluvial terraces.
2. **Colthorp-Elijah-Purdam:** nearly level to sloping, well-drained, moderately deep and shallow soils; on intermediate alluvial terraces and basalt plains.

3. **Tenmile-Chilcott-Kunaton:** nearly level to very steep, well-drained, shallow to very deep soils; on high alluvial terraces, basalt plains, and dissected alluvial plains.
4. **Power-McCain-Purdam:** nearly level to sloping, well-drained, moderately deep and very deep soils; on basalt plains and low alluvial terraces.
5. **Chilcott-Kunaton-Sebree:** nearly level to sloping, well-drained, shallow and moderately deep soils; on basalt plains and high alluvial terraces.
6. **Scism-Truesdale-Turbyfill:** nearly level to steep, well-drained, moderately deep and very deep soils; on basalt plains.
7. **Scism-Feltham-Garbutt:** nearly level to sloping, well-drained and somewhat excessively drained, moderately deep and very deep soils; on alluvial terraces, alluvial fans, and basalt plains.
8. **Rubble land-Trevino Feltham:** steep and very steep Rubble land on canyon walls; and nearly level to moderately steep, well-drained and somewhat excessively drained, shallow and very deep soils on alluvial fans and basalt plains and in canyons.

Attachment C: Ada County Vegetation

Plant Communities of Columbia Basin

Plant communities of the Columbia Plateau Ecoregion are typically named according to the dominant shrub and grass species found in the community. The following seven general native vegetation types are found in Ada County:

1. **Sagebrush steppe communities (basin and Wyoming big sagebrush):** This is the most common plant community associated with the Snake River Plain. The dominant cover species is Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*) with an understory of bunchgrasses, primarily bluebunch wheatgrass (*Pseudoroegneria spicata ssp. spicata*) and Thurber's needlegrass (*Achnatherum thurberianum*). A mature community is composed of approximately 45 to 55 grasses, 25 to 35 shrubs, and 10 to 20 forbs. Basin big sagebrush (*Artemisia tridentata ssp. Tridentata*) also occurs in pockets of deeper soils often associated with higher moisture content, such as locations adjacent to seasonal washes and north-facing slopes. Associated soils have medium textured surfaces that may be gravelly, well-drained with moderately slow to rapid permeability, and generally moderately deep but can be shallow over fractured basalt or fractured duripan (USDA, 2009).
2. **Perennial grasslands:** This community is rare in Ada County. Many areas may appear at a glance to be grasslands but are usually pockets in sagebrush communities void of shrubs due to disturbance factors or land use practices. However, native grasslands do exist. They are typically dominated by Idaho fescue (*Festuca idahoensis*), bluebunch wheat grass, and Sanberg bluegrass (*Poa secunda*). Perennial grasslands have a large variety of forb species and can be as much as 25 forbs. Associated soils vary but typically are loam, silt loam, or clay loam with clay or silty clay subsoils. Soils are 20 to 40 inches deep over bedrock or a duripan. The clayey subsoil prevents root penetration and water below 18 inches (NRCS, 2009).
3. **Shrub steppe annual grass and forb communities (including invasive annual grasses):** This community is considered a slightly disturbed or transition community in Ada County. Historically the areas of this community were sagebrush steppe communities that have been affected by natural or human-caused disturbances. The community still has a shrub component, typically big sagebrush species but may also be dominated by green rabbitbrush (*Chrysothamnus viscidiflorus*) or rubber rabbitbrush (*Ericameria nauseosa*). The bunch grass understory of sagebrush steppe has been reduced or replaced by annual, typically invasive species, such as cheatgrass (*Bromus tectorum*). Associated soils are the same, although soil structure may vary due to the loss of root mass of dominant shrubs and bunchgrasses.
4. **Salt desert scrub communities:** These communities occur in the most arid region in Ada County along the northern rim of the Snake River Canyon. The dominant shrub component varies from fourwing saltbush (*Atriplex canescens*), shadscale saltbrush (*Atriplex confertifolia*), winterfat (*Drascheninnikovia lanata*), and bud sagebrush (*Picrothamnus desertorum*), typically occurring in vegetation mosaics. Understory species include Sandburg bluegrass, sixweeks fescue (*Vulpia octoflora*), and Indian ricegrass (*Achnatherum hymenoides*) in sandier soils. Much of this community in Ada County has been invaded with cheatgrass due to land use practices and range fires. Shrub cover is less than sagebrush steppe communities and understories contain less biomass than other communities in the county. Salt shrub communities occur due to low precipitation and high summer temperatures. Soils are often saline and calcareous, medium to fine-textured, alkaline soils and include some coarser textured soils. Much of the soils contain extensive biological soil crust.
5. **Mountain big sagebrush and bitterbrush communities:** These communities occur in the Boise Foothills and have a dominant canopy cover of mountain big sagebrush and bitterbrush. Understory components are similar to sagebrush steppe communities and include bunchgrasses including bluebunch wheatgrass, basin wildrye (*Leymus cinereus*), bottlebrush squirreltail (*Elymus elymoides*), and Sandberg blue-

grass. Common forb species include balsamroot, lupine, buckwheat, and phlox species. Associated soils include gravelly, very gravelly or cobbly loams, and gravelly coarse sandy loams (USDA, 2009).

6. **Warm mesic shrubs:** This community occurs in the upper elevation of the Boise Mountains. It is the transition community between mountain big sagebrush and bitterbrush communities and the dry forest communities in the Boise Mountains. This community is a mixture of alder (*Alnus sp.*), serviceberry (*Amerlanchier alnifolia*), snowberry (*Symphoricarpos albus*), snowbrush ceanothus (*Ceanothus velutinus*), and chokecherry (*Prunus virginiana*). This community composes a very small component of the vegetation landscape in Ada County.
7. **Dry forest:** These communities occur in the upper elevations of the Boise Mountains. Dominant tree species natural to the forest are dominated by Douglas fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*). The understory contains large deciduous and evergreen shrubs and large bunchgrasses such as bluebunch wheatgrass. This community composes a very small component of the vegetation landscape in Ada County.

Attachment D: GSI Applications in Ada County

Use of Permeable Pavers

- Whole Foods Parking Lot, Front and Broadway, Boise
- Watershed Center, Linder Road Wastewater Treatment Plant Parking Lot, Boise http://bee.cityofboise.org/watershed/visit/about/
- Hyatt Wetlands Parking Lot, Maple Grove and MacMillan, Boise http://www.cityofboise.org/projects/hyatt-wetland/
- Harrison Ranch Fire Station, Warm Springs Avenue, Boise http://fire.cityofboise.org/media-releases/2012/07/grand-opening-boise-fire-station-15/
- Retrofit of two alleys in downtown Boise: design (2013); construction (2014)
- 36th Street Project, Garden City
- Parking lot adjacent to Whitewater Boulevard, Boise
- Bridgetower Subdivision (Ten Mile and MacMillan) side streets

Use of Bioretention

- Municipal Park Parking Lot, Walnut Street, Boise
- Boise Public Library Ustick Branch Parking Lot http://www.boisepubliclibrary.org/locations/library!-at-cole-ustick/ (click on Going Green brochure)
- Ada County Highway District Offices, 37th and Adams, Garden City
- Linen District parking lot (adjacent to Linen Building)
- Metro Car Wash, Downtown Boise

Use of Green Roofs

- Micron Business and Economics Building, Boise State University http://go.boisestate.edu/micron-business-and-economics-building/
- Barber Park Green Building, Eckart Road, Boise http://www.greenroofs.com/projects/pview.php?id=317
- Mulvaney Medical Office Building, St. Als Campus, Boise http://www.greenroofs.com/projects/pview.php?id=1372
- Student Union Building, University of Idaho, Moscow http://www.uidaho.edu/studentaffairs/idaho-commons-and-student-union/student-union/about-the-sub/green-roof-project
- Idaho Botanical Garden: Lewis and Clark Garden Gazebo