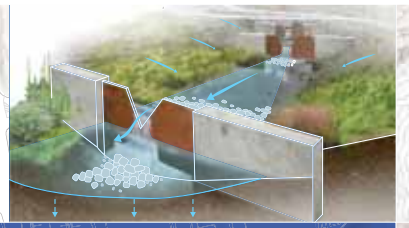
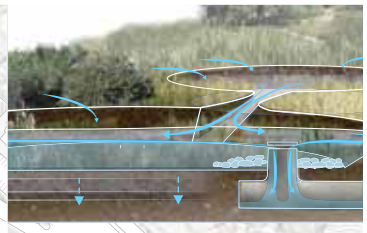
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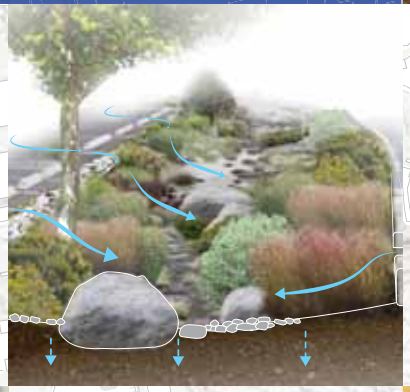


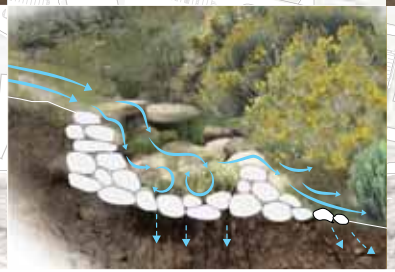
LOW IMPACT DEVELOPMENT STANDARDS

SEPTEMBER 18, 2017
LA-UR-17-27537









Los Alamos
NATIONAL LABORATORY

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ACKNOWLEDGMENTS

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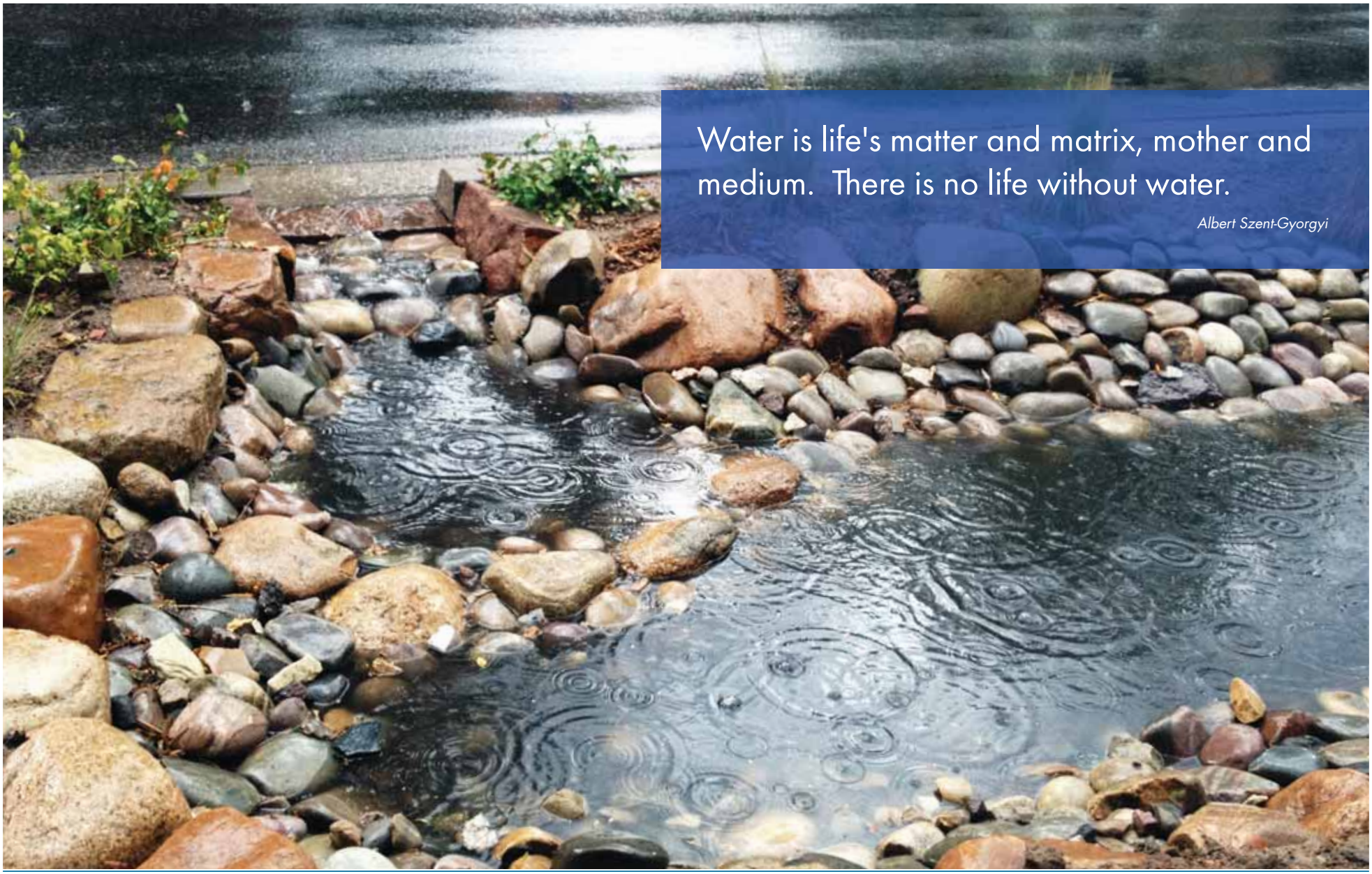
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- Organization of LID Standards

LID CONCEPT + APPLICATIONS 3

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- Permeable Paving
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- Control Basin
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Water is life's matter and matrix, mother and medium. There is no life without water.
Albert Szent-Gyorgyi

INTRODUCTION

PURPOSE OF THE LOW IMPACT DEVELOPMENT (LID) STANDARDS

The goal of the LID Standards is to provide guidance on the planning, design, construction and maintenance of green infrastructure (GI) features at Los Alamos National Laboratory. The success of LID at LANL is dependent on maintaining a consistent approach to achieve effective application, operation, and maintenance of these storm water control features.

RELATIONSHIP TO LID MASTER PLAN

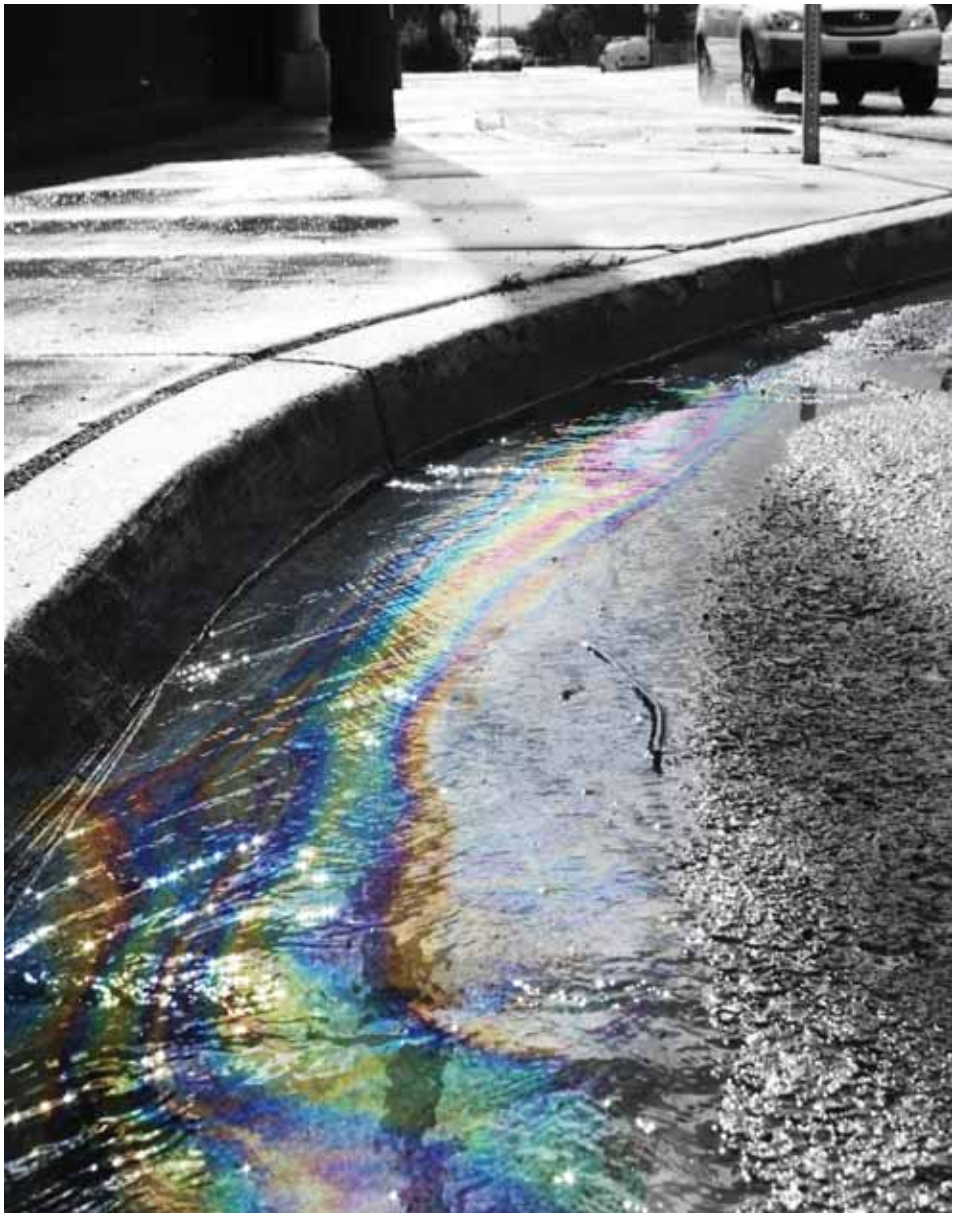
The LANL LID Master Plan describes the vision, goals, and overarching approach to implementing LID strategies on Los Alamos National Laboratory. In addition, the plan describes potential LID projects located in Technical Areas (TAs) 03, 35, and 53.

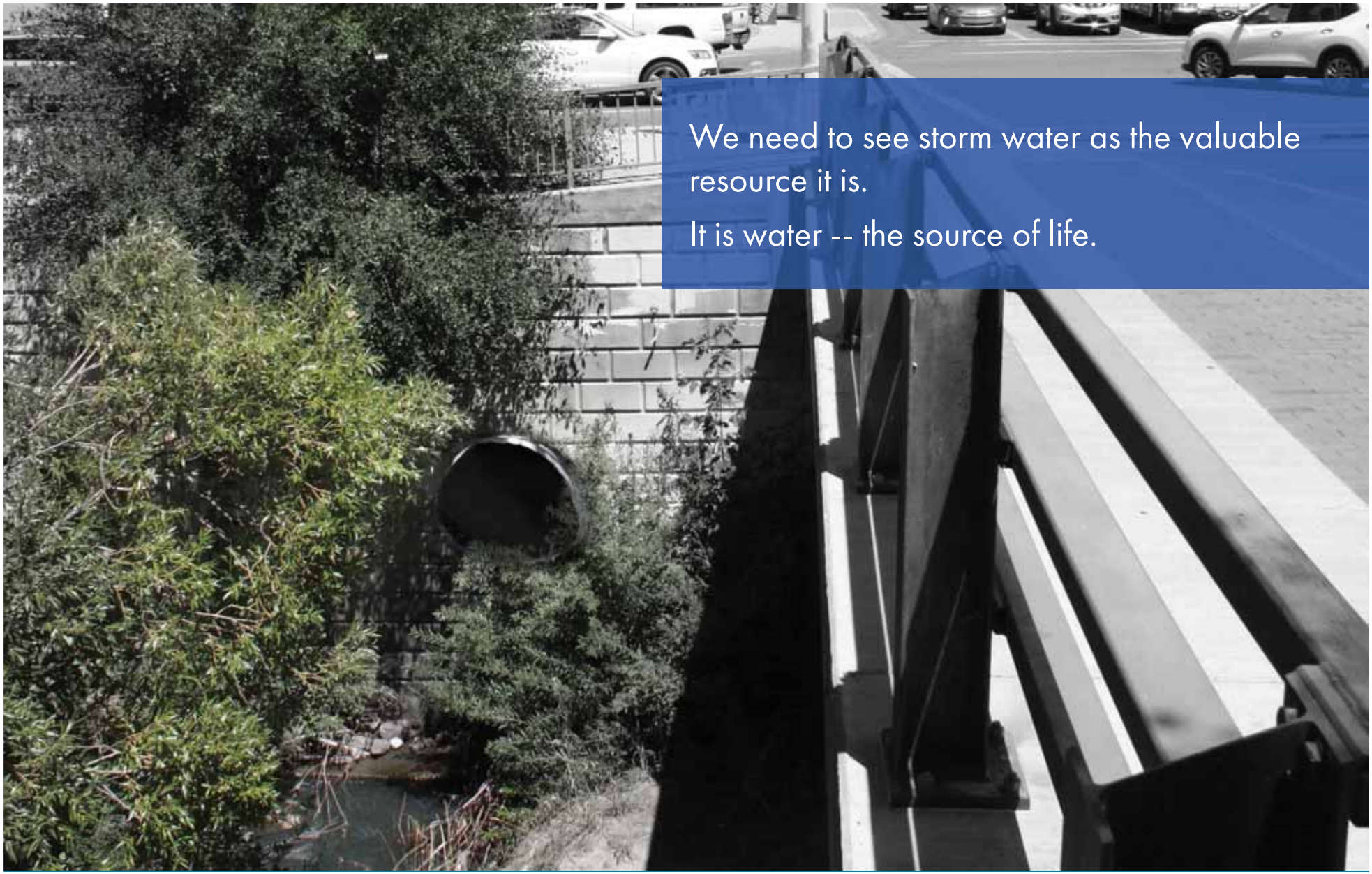
The LID Standards are intended to provide guidance on planning, design, construction, and maintenance of LID described in the Master Plan or implemented at other LANL locations. That includes projects as small as repair of minor storm water erosion controls, retrofitting LID in developed areas, and storm water management associated with new development.

ORGANIZATION OF LID STANDARDS

The LID Standards is organized to:

- provide an overview of LANL LID concepts and approaches,
- describe a variety of GI methodologies,
- provide specific LANL GI design standards.




We need to see storm water as the valuable resource it is.
It is water -- the source of life.

LID CONCEPT + APPLICATIONS

LID CONCEPTS

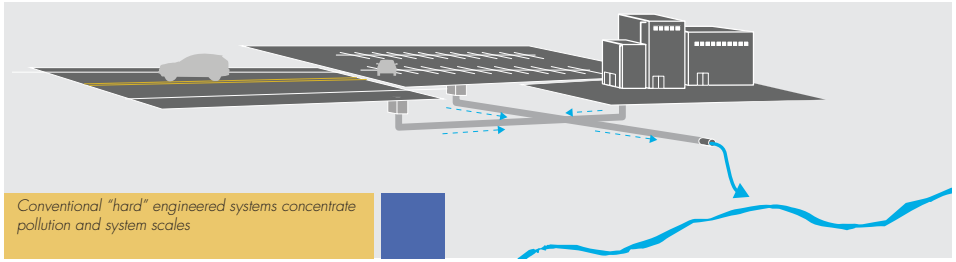
LID uses landscapes, soils and plants to address surface water pollution treatment and management.

Current conventional "hard" engineered systems that pipe and concentrate surface runoff increase non-point source pollution effects from hydrocarbons, chemicals, heavy metals and soil erosion produced by every day modern activities such as driving, agriculture and development. Low-Impact Development *(LID)* advances a concept of "soft" landscape engineered systems that compliment and mitigate affects of hard engineered systems.

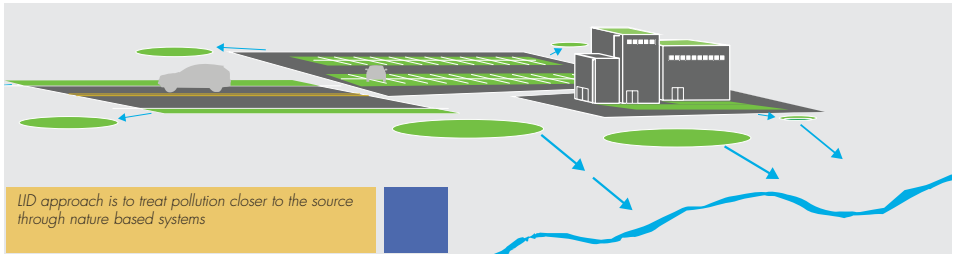
The LID strategy is to apply a holistic watershed management approach–which requires planning as well as design and engineering. A comprehensive LID approach looks at all components within the watershed for opportunities to treat surface water runoff flows and quality. LID supports and enhances the natural hydrological functions of every site to improve surface water quality and enhance the overall biologic and environmental health of the site.

There are Five Core Concepts associated with designing for LID.

1. Conserve or restore natural areas wherever possible (refrain from paving over the whole site if it is not necessary).
2. Minimize the development impact on hydrology.
3. Manage runoff rate and duration from the site (maintain or restore pre-development hydrology).
4. Minimize scale of treatment (integrate LID/GI throughout developed areas to manage storm water close to the source).
5. Implement pollution prevention, proper maintenance and public education programs.

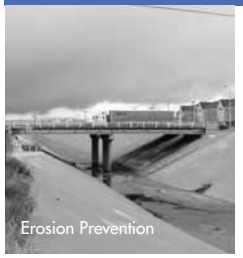


Conventional "hard" engineered systems concentrate pollution and system scales



LID approach is to treat pollution closer to the source through nature based systems

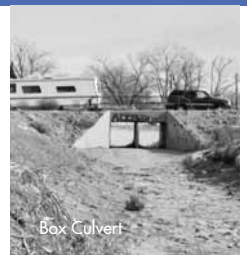
CONVENTIONAL ENGINEERING APPROACHES



Erosion Prevention



Dissipater



Box Culvert



Storm Drain

GREEN INFRASTRUCTURE SOLUTIONS



Storm water Channels



Vegetated Swale



Dissipater



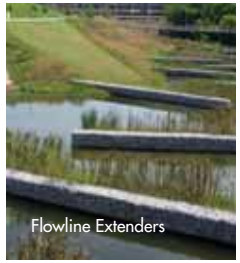
Terraces / Level Spreaders



Oxbow



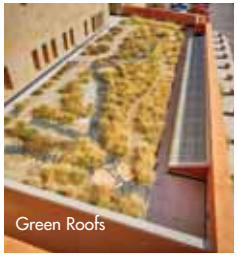
Check Dams



Flowline Extenders



Control Basin



Green Roofs



Permeable Paving

CONVENTIONAL ENGINEERING

Conventional "hard" engineering primarily pipes and conveys storm water to large detention ponds with no treatment. They simply transfer pollution from one site to another.

SOFT ENGINEERING

Soft engineering mimics natural ecological systems by integrating plants and soils to mitigate discharge and treat and contain waterborne pollutants and sediment.

BMP AND LID

LANL has a Storm water Best Management (BMP) Practices Manual that describes construction related Storm Water BMP's. The LID Standards fully complements this LID Master Plan.

LID GENERAL METHODOLOGIES

LID emphasizes conservation and use of on-site natural features to protect water quality.

This approach implements engineered, small-scale hydrological controls to replicate the pre-development hydrological regime of watersheds through:

- infiltration
- filtration
- detention
- evapotranspiration
- reuse

LID OPPORTUNITIES AT LANL

This LANL LID Master Plan identifies a broad range of opportunities for the application of LID and GI. The opportunities range from simple preservation of LID buffer spaces, to integration into planning and architecture, to constructed improvements.

The diagram on the next page illustrates conceptually where LID and GI methods can be incorporated and integrated. The methods noted below each development area type are indications of where they are most often applied. All methods can be used in all zones as appropriate to site conditions.

The intent is to lead the Laboratory to approach this issue from a wider framework rather than just as a storm water issue to be addressed after construction. It is to consider how LID and GI can be integrated in all Laboratory processes from site-wide master plan, through project definition, budgeting, design, construction, and maintenance.

Some LID opportunities can be completed relatively easily and quickly. Others will require considerable time and effort to implement. Both types of opportunities are important to a comprehensive LID approach.

EXAMPLE LID METHODOLOGIES

LID GI methods or techniques are illustrated in the following section.

The actual design and style of each method can vary widely. In urban settings, the method may be part of a very detailed landscape design. In rural settings, the same method might be very pastoral and natural in look and feel. Although aesthetics are important, LID is concentrated more on how the element functions within the hydrological needs of the project.

CONVENTIONAL ENGINEERING

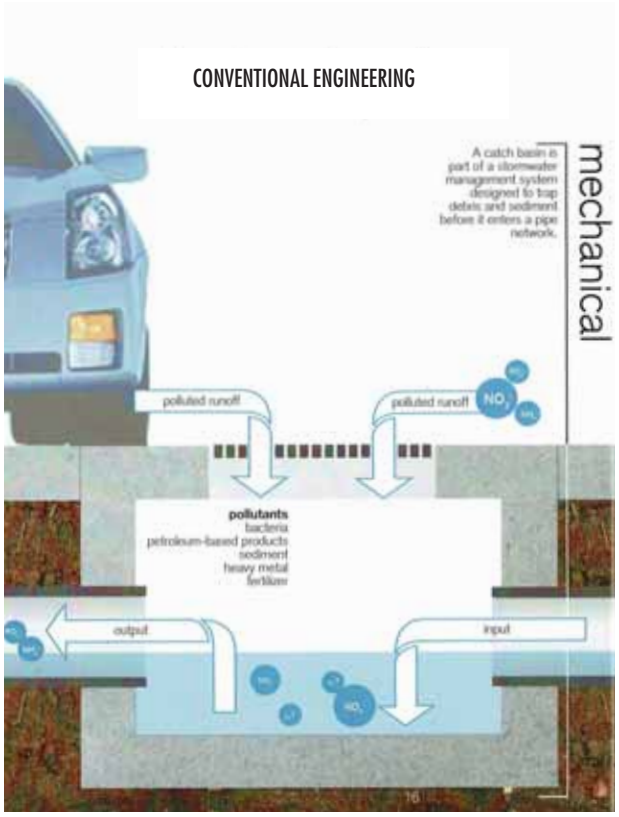


IMAGE SOURCE: LID: LOW IMPACT DEVELOPMENT a design manual for urban areas. Fay Jones School Of Architecture, University Of Arkansas.

SOFT ENGINEERING

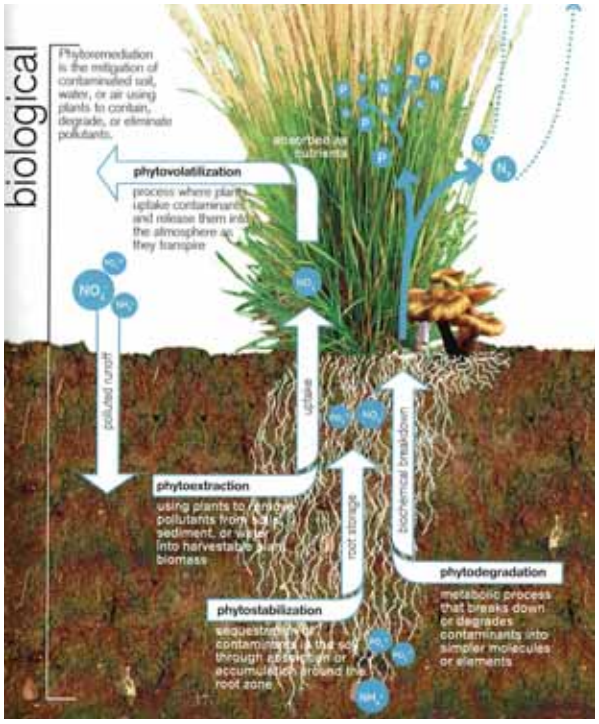


IMAGE SOURCE: LID: LOW IMPACT DEVELOPMENT a design manual for urban areas. Fay Jones School Of Architecture, University Of Arkansas.

LID + ENVIRONMENTAL WELL BEING

A specific goal for LID is to integrate natural processes and beautiful landscapes back into our built environments.

Although a seemingly ephemeral and low priority in today's hyper-digital designed world, research is finding that humans have an innate need for natural environments at perhaps a basic, evolutionary level. Humans evolved within nature and there may be essential needs we have as a species to retain that connection on a daily basis.

LID is centered on integrating nature, vegetation, and natural materials into the design of storm water management features. This emphasis on including vegetation is paramount. Plants are extremely effective in removing and storing air and waterborne pollutants, while reducing the migration of sediments. Plants provide the most accessible way for humans to re-engage with nature over a wide variety of settings.

For LANL, the importance of the natural beauty of the land is part of its scientific history. During the high-pressure, critical years that the Laboratory led the development of our nation's atomic capabilities in WWII, a consistent sentiment in the diaries and memories of the scientists and staff was of the enormous importance of being surrounded by the natural environment. The outstanding beauty of this landscape provided a place for solitude and respite for workers to re-energize and expand their thinking.

The LID Master Plan imagines that the modern day Laboratory needs those same resources to continue to conduct exceptional scientific practices and to continue to attract the best minds. An effective and efficient way to achieve that is to implement LID in LANL development efforts. It supports the required storm water management needs and reconnects us with our greater natural world.


Entry Pond Perspective - Existing


Entry Pond Perspective - Re-envisioned


Wellness Center Perspective - Existing


Wellness Center Perspective - Re-envisioned


Physics South Parking Perspective - Existing


Physics South Parking Perspective - Re-envisioned

STORM WATER REUSE STRATEGY

Harvesting rainfall runoff for reuse is a storm water reduction strategy that should be systemically considered and evaluated for existing and future buildings at LANL. The need to preserve potable water for drinking and food production is likely to increase as regional water supplies are affected by climatic change and increasing human demand. One of the most readily available opportunities for LANL to capture rainfall for reuse is from rooftops. With the almost 2000 structures at LANL, the storm water reuse opportunity is substantial.
Benefits to water harvesting roof runoff are:

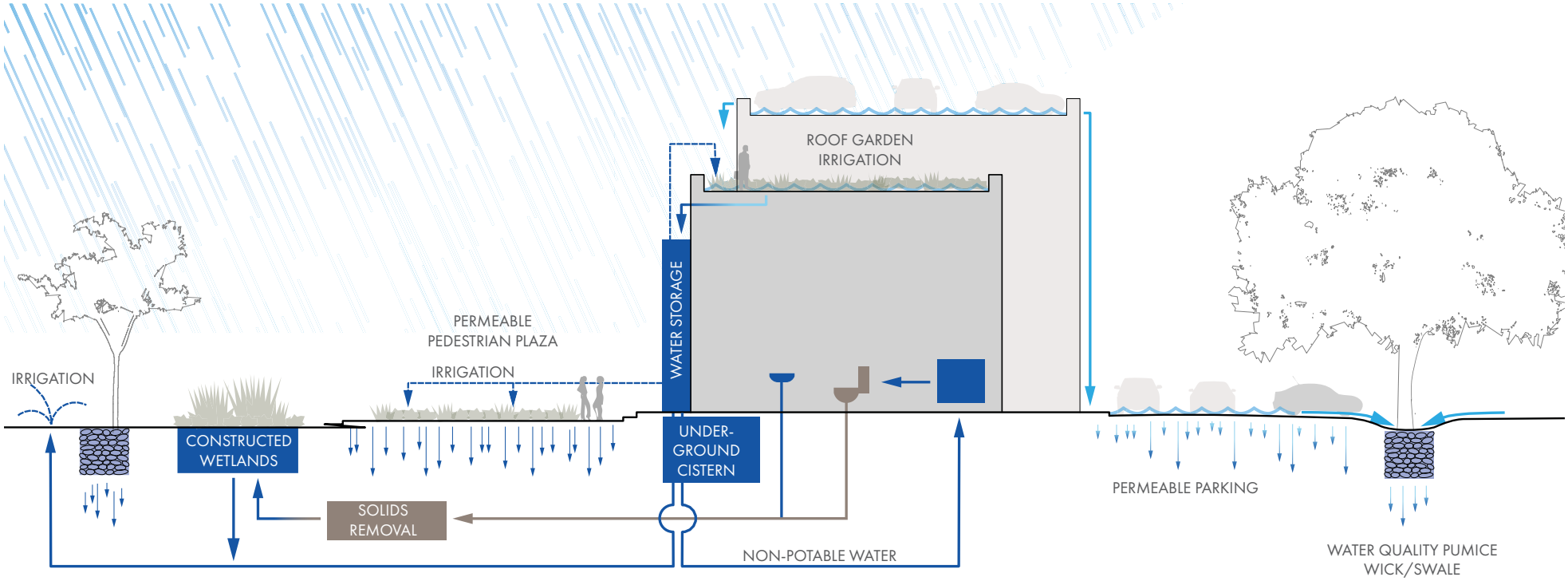
- reduction to the need for LANL storm water detention and management systems, due to the removal of roof areas from contributing runoff flows
- reduction of off-site storm water flow impacts as overall runoff quantities are decreased, due to the removal of roof areas from contributing to the overall LANL storm volume,
- reduction of potable water use by using harvested roof water for irrigation, toilet flushing, cooling towers, wash down, and other water uses that do not require potable water quality,
- enhanced use of sustainable design throughout LANL, and,
- integrating green roofs can reduce heat island effects and treat runoff to improve water quality.

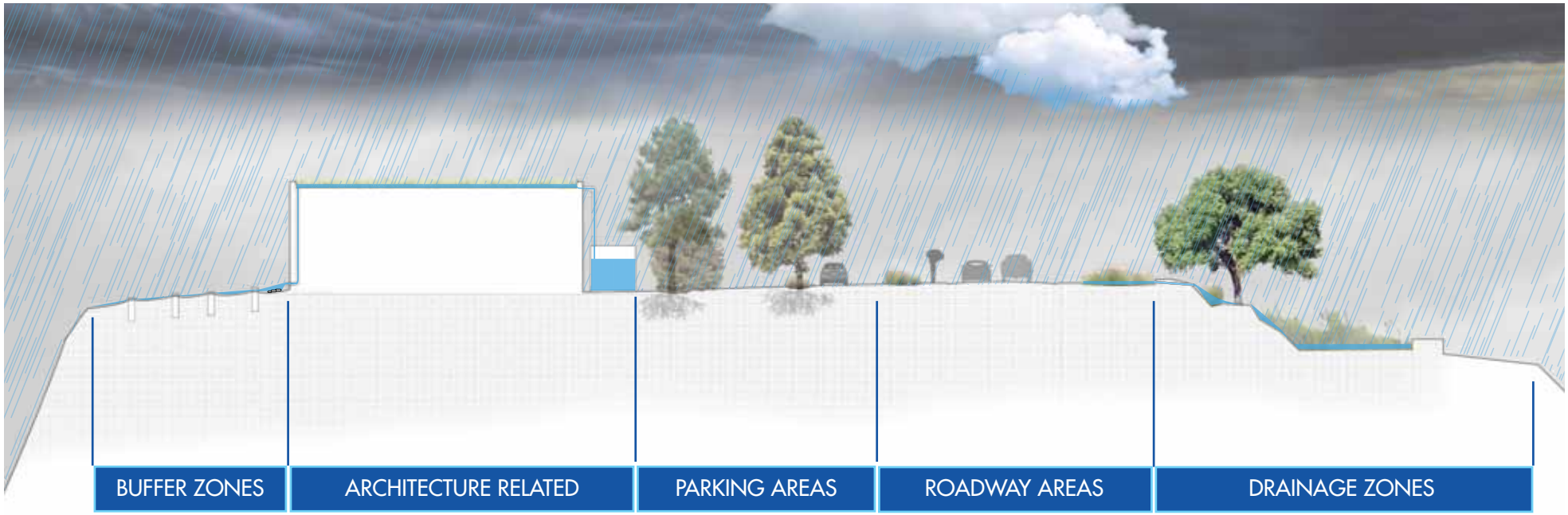
EXISTING BUILDING ROOFS

Many of the large existing structures and buildings at LANL pipe roof runoff directly to canyon edges. Often these pipes are deeply buried. Thus, the best opportunity for recapturing roof runoff for reuse is at a time when the building is undergoing re-roofing or building renovation. Opportunities may include redirecting runoff to ground level infiltration and GI improvements, or to cisterns or storage tanks for irrigation or other non-potable uses.

FUTURE BUILDINGS

Future buildings plans should include strategies for reusing harvested roof runoff. Integrative design that incorporates opportunities such as reuse lines to toilets, cisterns for storage, green roofs for storm water quality treatment, and irrigation systems designed for recycled water use, creates more sustainable and resilient building for a changing future. Storm water reuse improvements are least expensive and most effective when incorporated during the initial planning and design of a building or structure.





BUFFER ZONES

- LID natural buffers
- Terraces/level spreaders
- Flowline extenders

ARCHITECTURE RELATED

- Green roofs
- Cisterns

PARKING AREAS

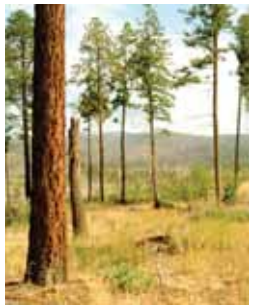
- Vegetated swales/bio-swales
- Permeable paving
- Subsurface chambers

ROADWAY AREAS

- Vegetated swales/check dams
- Bio-Retention cells/oxbows
- Storm water channels
- Permeable paving

DRAINAGE ZONES

- LID natural buffers
- Vegetated swales/check dams/'V'weirs
- Disspaters/zuni bowls
- Control basins
- Flowline extenders













LID NATURAL BUFFER

Description:

Preserve undeveloped natural landscaped areas for LID uses.

Benefits:

Natural buffers retain the environmental functions of the native landscape. This is one of the lowest cost LID methods that is available at the Laboratory.

Constraints:

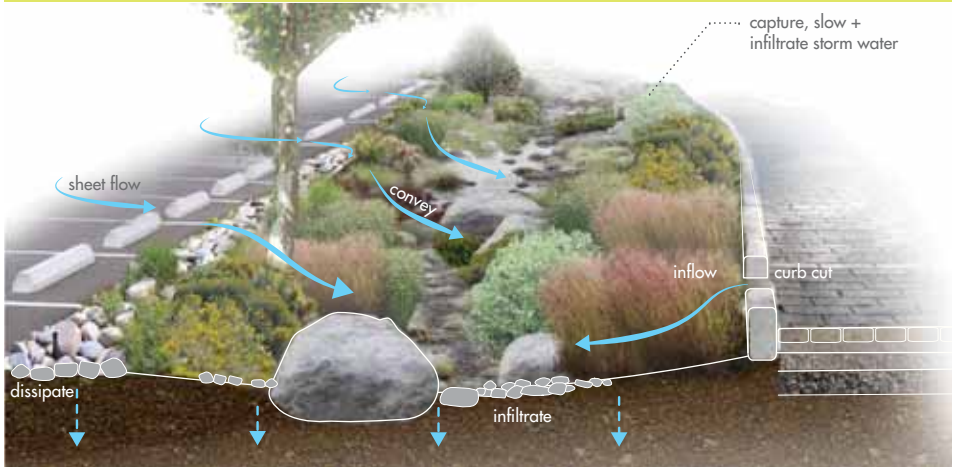
- can impact size of developable area on a site

Budget Range:

- no cost or low

Applicability and Considerations:

- LID natural buffers should match fire buffer requirements along canyon edges
- LID should be considered for incorporation within security buffers



VEGETATED SWALE / BIO-SWALE

Description:

Vegetated swales are broad, shallow depressions designed to convey and infiltrate storm water runoff.

Benefits:

Swales allow storm water infiltration, water treatment and sediment filtration. Swales are useful in areas with slight to moderate slopes. Vegetated swales are one of the most implemented GI methods in both urban and rural areas.

Constraints:

- shallow soils
- sub-surface utilities

Budget Range:

- low

Applicability and Considerations:

- vegetated swales generally require minimal space
- swales can be incorporated within open space at the edges of buildings and parking areas and bottoms of shallow slopes, with varying scales of vegetation improvements

URBAN EXAMPLE





RURAL EXAMPLE







STORM WATER CHANNEL

Description:

Storm water channels are structured conveyances designed to infiltrate storm water into subsoils and carry runoff at higher volume flows.

Benefits:

Storm water channels provide infiltration, storm flow attenuation and pollutant filtration. These channels are useful along roads and other linear features that generate high runoff volumes and velocity.

Constraints:

- slow soil percolation rate
- sub-surface utilities

Budget Range:

- low to moderate

Applicability and Considerations:

- storm water channels require minimal area, and are typically located along roads or paved areas
- effective in areas with high flow volumes

URBAN EXAMPLE

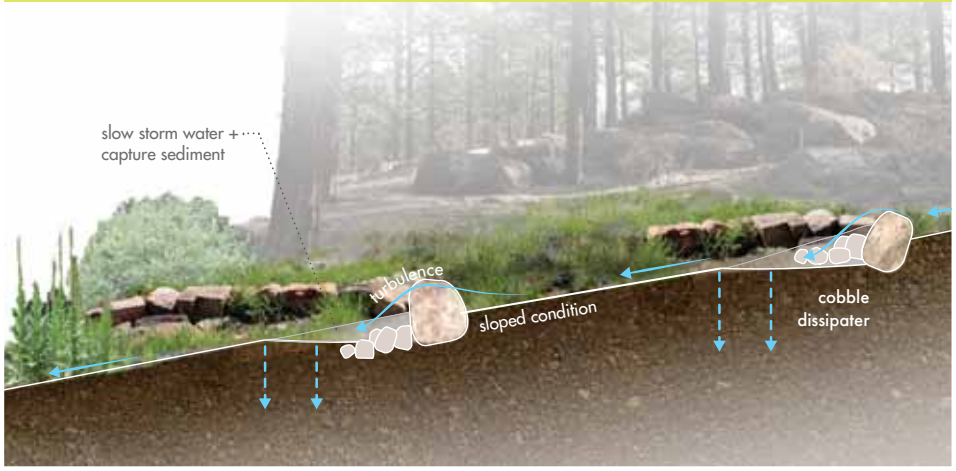




RURAL EXAMPLE







CHECK DAM / SWALE

Description:

Check dams are small, shallow controls constructed across a swale, drainage ditch, or waterway.

Benefits:

These are used to counteract erosion by reducing water flow velocity.

Constraints:

- highly erodible soils

Budget Range:

- low

Applicability and Considerations:

- use on small volume flow channels
- use for small scale erosion control
- use when natural aesthetics are important

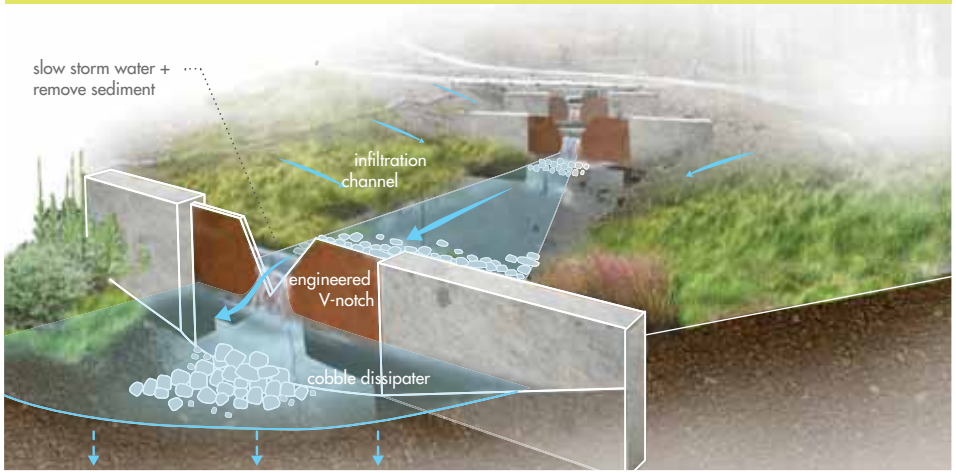
URBAN EXAMPLE



RURAL EXAMPLE







'V' WEIR / SWALE

Description:

A 'V' weir is simply a 'v' notch in a plate or structure that is placed to obstruct open channel flow.

Benefits:

The weir allows a measured volume of water to flow through the notch while helping to attenuate storm flows and rates.

Constraints:

- highly erodible soils
- excessive debris in contributing area

Budget Range:

- low to moderate

Applicability and Considerations:

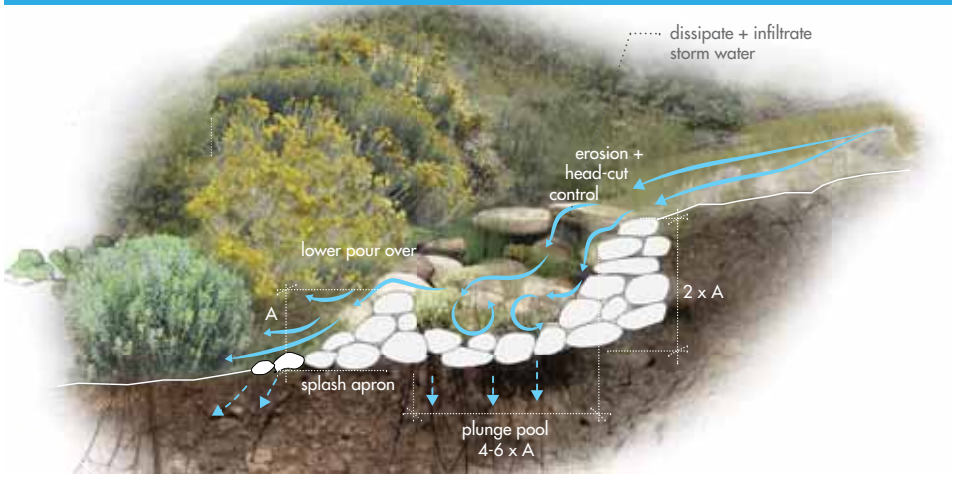
- similar applicability as for rock check dams
- use when durability, longevity, aesthetics and reduction of maintenance are important

URBAN RURAL EXAMPLE



RURAL EXAMPLE





DISSIPATER / ZUNI BOWL

Description:

Dissipaters and zuni bowls use roughened surfaces and deep basins along the flowline to break up water flows and remove energy.

Benefits:

Dissipaters and zuni bowls are most effective in managing headcuts and channel erosion.

Constraints:

- highly collapsible soils when wet
- excessive debris in contributing area

Budget Range:

- low to moderate

Applicability and Considerations:

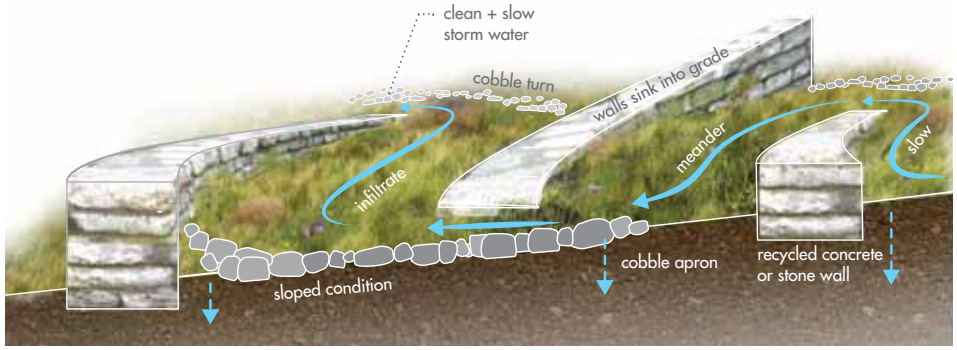
- designed to treat small drainage areas, and located where the potential for erosion is high
- can be used as a pretreatment device in conjunction with other storm water treatment methods

URBAN EXAMPLE



RURAL EXAMPLE





FLOW LINE EXTENDER

Description:

Flowline extenders are a series of linear structures placed across a storm water flowline, causing the flowline to meander, thereby extending the length of its route.

Benefits:

By making the length of the flow line longer, storm water has more time to infiltrate, filter pollutants, and remove sediments. They are most effective in relatively wide, shallow sloped areas.

Constraints:

- highly erodible or collapsible soils

Budget Range:

- low to moderate

Applicability and Considerations:

- use when reduction of flow speed and increased infiltration is desired and where flow detention is not desired
- best on relatively flat slopes on wide channel

URBAN EXAMPLE

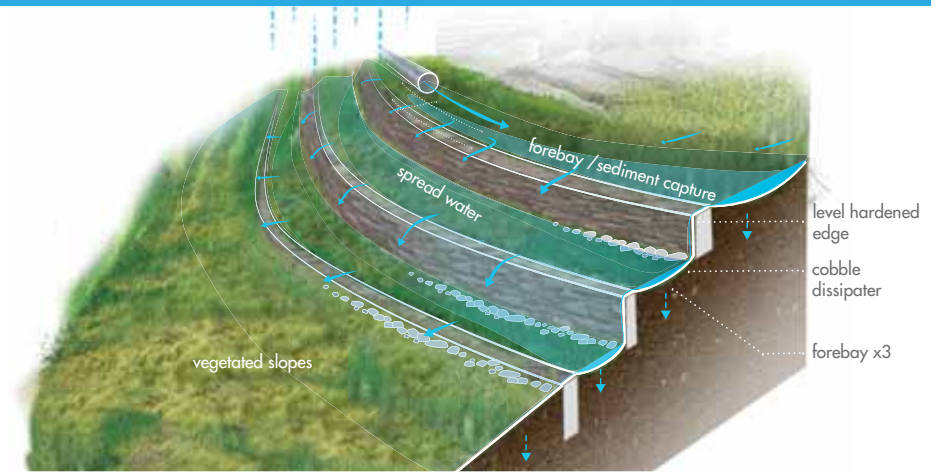




RURAL EXAMPLE







TERRACE / LEVEL SPREADER

Description:

Terraces and level spreaders disperses storm water across a level, hardened edge.

Benefits:

Terraces and level spreaders help prevent concentrated erosion in sheet flow areas. By spreading runoff, the terraces allow for infiltration across a wide zone and support vegetation.

Constraints:

- highly erodible or collapsible soils

Budget Range:

- low to high

Applicability and Considerations:

- useful in drainage zones with substantive slopes across the area
- landscape irrigation system for the establishment of plantings may be necessary

URBAN EXAMPLE

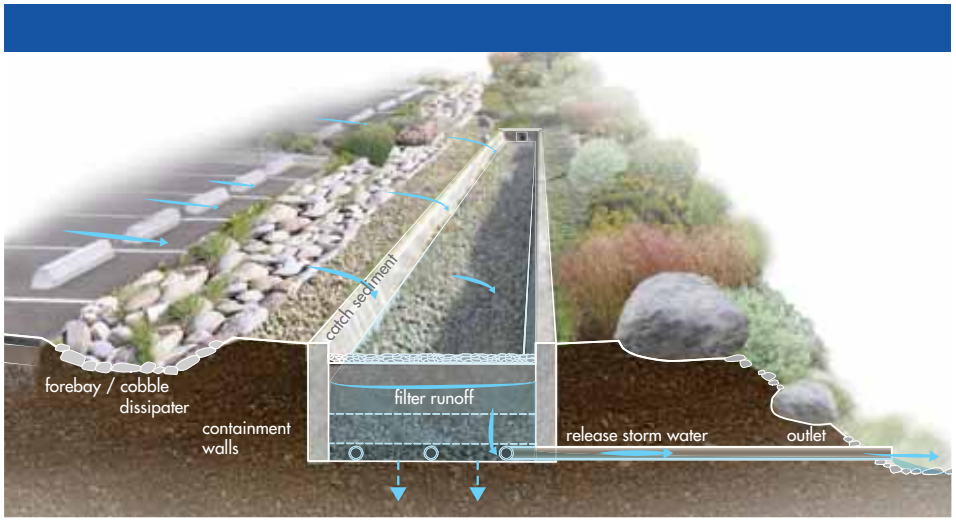




RURAL EXAMPLE







FILTER MEDIA

Description:

A feature with granular or aggregate materials such as gravels, mulches and manufactured media selected and layered to filter pollutants from storm water.

Benefits:

Filter medias are important to use in areas where heavy metals and other pollutants can be effectively mitigated or removed from storm water.

Constraints:

- should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter
- head requirement to approximately 3 feet

Budget Range:

- moderately expensive to construct and maintain

Applicability and Considerations:

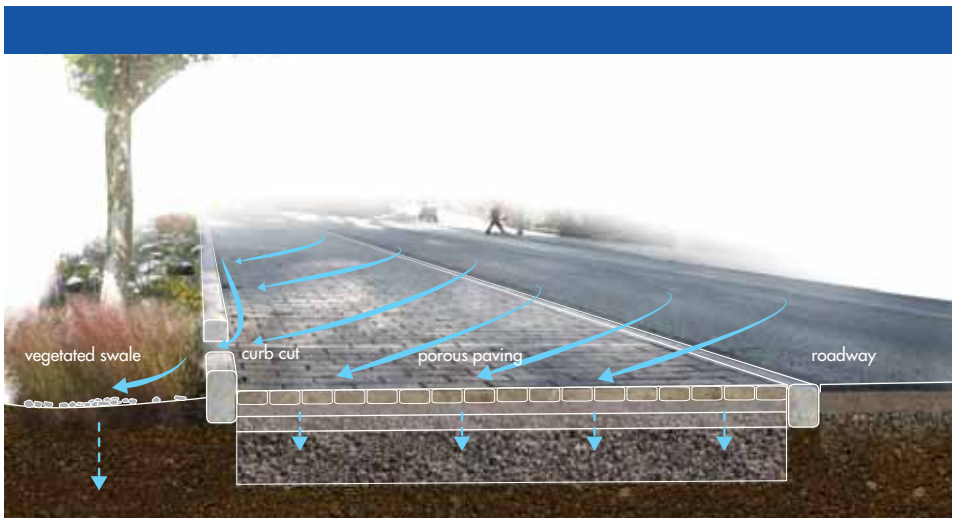
- utilized for treating runoff from drainage areas that have large amounts of impervious surfaces. sand filters can be modified to fit in locations with limited space

URBAN EXAMPLE



RURAL EXAMPLE





PERMEABLE PAVING

Description:

Permeable paving uses porous paving materials on a designed sub-base that allow the percolation of storm water through the sub-strata.

Benefits:

This paving system reduces runoff, traps suspended solids and filters pollutants from surface runoff. Permeable pavement is especially effective in treating runoff from parking areas and roadways. Permeable paving materials that can be used include: supported gravel, porous asphalt, porous concrete, slubbed bricks, and slubbed concrete pavers.

Constraints:

- low soil percolation rate or high expansion or collapsibility potential
- not feasible where traction sand is applied
- more costly than traditional pavement types

Budget Range:

- moderate to high

Applicability and Considerations:

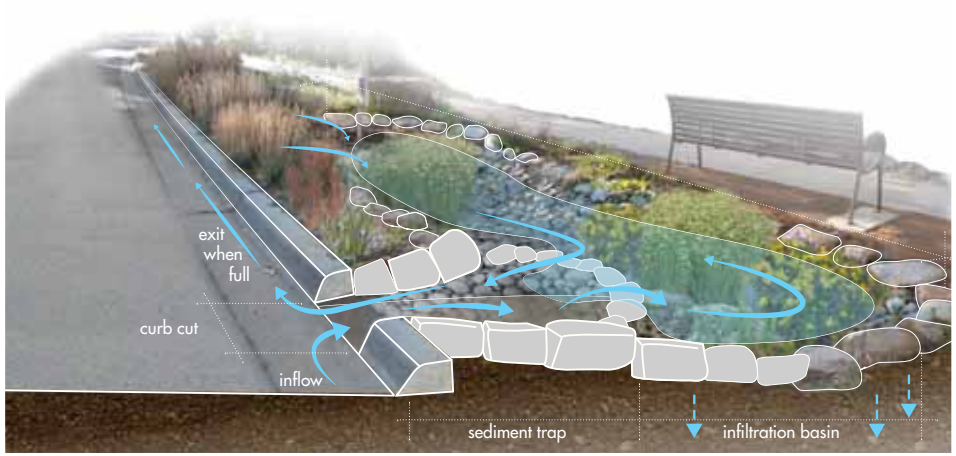
- best utilized in low traffic parking areas, where car speeds do not exceed 30 mph
- used in roadways, parking lanes, pedestrian walkways, fire access lanes, and emergency access lanes

URBAN EXAMPLE



RURAL EXAMPLE





BIO-RETENTION CELL / OXBOW

Description:

A landscaped depression or shallow basin that temporarily captures storm water from roadways. When the capacity of the cell is reached water bypasses the inlet point.

Benefits:

Bio-retention cells or oxbows retain, infiltrate, treat and reduce runoff volumes. Plants and soil in the bio-retention cell provide physical, chemical and biological treatment of pollutants. Bio-retention cells and oxbows are particularly effective along road sections with flat gradients. They are very effective in capturing low volume storm events.

Constraints:

- steep grades

Budget Range:

- low for rural applications
- may be moderate to high for urban locations

Applicability and Considerations:

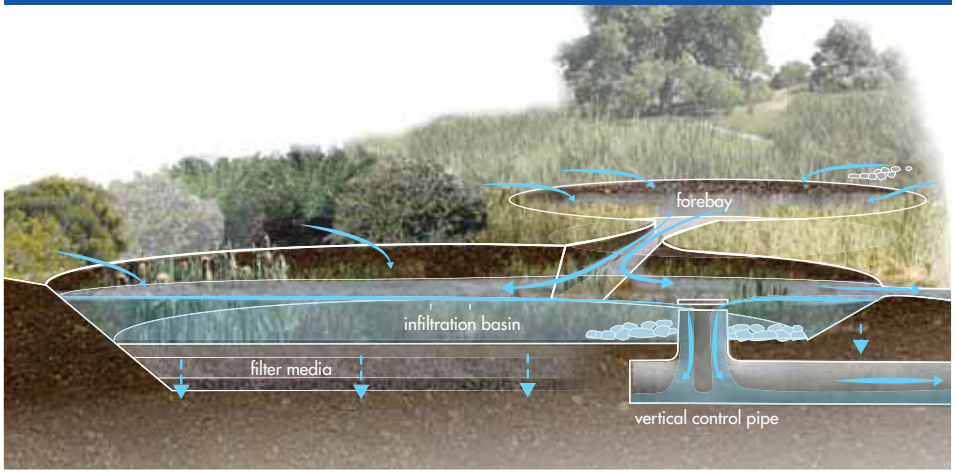
- highly effective along flat sections of roadways or parking areas to slow, infiltrate and treat storm water

URBAN EXAMPLE



RURAL EXAMPLE





CONTROL BASIN / FILTER MEDIA VERTICAL CONTROL PIPE

Description:

Control basins collect storm water and release it at a controlled rate through a designed outlet system or a subsurface underdrain and often with an accompanying filter media.

Benefits:

Control basins help reduce risks to downstream areas from flooding and erosion by temporarily detaining flows. They infiltrate storm water and, if constructed with plant islands and/or a media filter, can treat storm water pollution and sediment migration.

Constraints:

- excessive debris or sediment potential from contributing area

Budget Range:

- low for rural applications
- may be moderate to high for urban locations

Applicability and Considerations:

- designed to treat large and small drainage areas
- utilize in both urban and rural settings
- design to treat runoff from roadways, parking lots, buildings, and other impervious surfaces

URBAN EXAMPLE

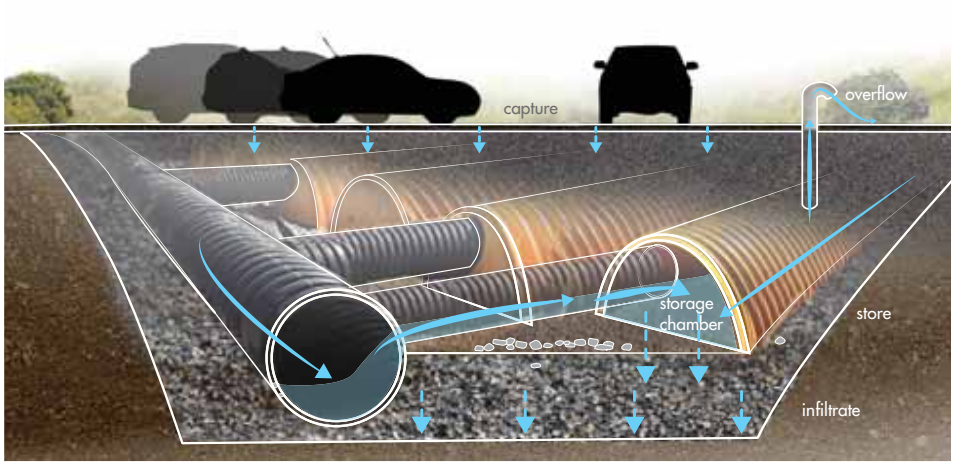




RURAL EXAMPLE







SUB-SURFACE CHAMBER

Description:

Sub-surface chambers collect storm water, infiltrate and release flows while preserving surface areas for other uses such as parking.

Benefits:

Sub-surface chambers help reduce risks to downstream areas from flooding or erosion by detaining and infiltrating storm water. They are most applicable in heavily developed areas that need to preserve surface uses such as parking and substantially improve storm water flow management. When designed with root barriers, they are valuable in supporting adjacent vegetated areas.

Constraints:

- low soil percolation rate or high expansion or collapsibility potential

Budget Range:

- moderate to high

Applicability and Considerations:

- useful where surface uses such as parking need to be retained, and storm water detention is needed
- can be an effective supplemental water source for adjacent vegetated areas
- Use root barriers at perimeters to reduce root invasions into chambers

URBAN / RURAL EXAMPLE







CISTERN

Description:

Roof-catchment cisterns are systems used to collect and store rainwater from buildings.

Benefits:

Cisterns are effective in developed areas that have managed landscapes. When the harvested storm water is use for landscape irrigation, cisterns help to reduce potable water consumption, support landscape health, and increase soil moisture and infiltration capability. Coordinating the design of the roof catchment area with the cistern capacity is an important component of cistern design.

Constraints:

- area available for cisterns
- access for maintenance
- material selection for long-term durability

Budget Range:

- moderate to high

Applicability and Considerations:

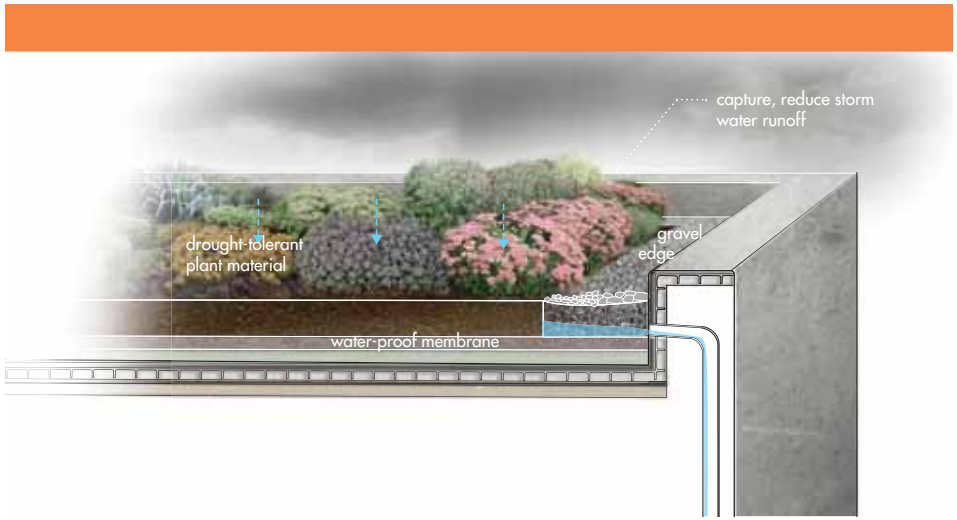
- above ground cisterns are generally used for small to medium volumes, while belowground cisterns can be sized for large volumes
- consider utilizing a manufacturer who provides design services, support, and extended warranty

URBAN EXAMPLE




RURAL EXAMPLE



GREEN ROOF

Description:

A green roof is system that partially or completely covers building's roof with vegetation and a growing medium over a waterproofing membrane.

Benefits:

Green roofs provide immediate treatment, control and reuse of rain water. Modern green roof systems are available as complete design and installation packages that come with long-term warranties and maintenance options. Green roofs provide other important environmental benefits, including reduction of heat-island effect, and a reduction in building energy consumption for heating and cooling.

Constraints:

- building roof structure
- sun exposure/ wind exposure
- water proofing capability
- irrigation + maintnenace access

Budget Range:

- moderate to high

Applicability and Considerations:

- can be applied on new or retrofitted to existing buildings to attenuate storm water flows
- look for manufacturers and suppliers who provide design service support, as well as a product warranty after installation

URBAN EXAMPLE



Green Infrastructure Method	Infiltration	Filtration	Storage/Detention	Evaporation/Transpiration
LID NATURAL BUFFER	●	●		●
VEGETATED SWALE / BIO-SWALE	●	●		●
STORM WATER CHANNEL	●	●		●
CHECK DAM + 'V' WEIR / SWALE	●		●	
DISSIPATER / ZUNI BOWL	●		●	
FLOWLINE EXTENDER	●	●		●
TERRACE / LEVEL SPREADER	●	●		●
FILTER MEDIA		●		
PERMEABLE PAVING	●		●	
BIO-RETENTION CELL / OXBOW	●		●	
CONTROL BASIN	●	●	●	●
SUB-SURFACE CHAMBER	●		●	
CISTERN		●	●	
GREEN ROOF	●	●		●



PROCESS SEQUENCE

LID PROJECT PROCESS

Project Definition Phase

- Incorporate LID and GI into project scopes and budgets.
- Identify who will manage and monitor LID and GI after project completion.

Project Proposal Phase

- Provide base information available during proposal phase.
- Obtain site information showing boundary and existing improvements within project area.
- Identify general topography and drainage pattern.
- Identify existing utilities alignments.
- Identify access and environmental needs.
- Identify the urban-rural design quality for LID and GI improvements to be used in the project design.
- Add LID Standards into design guidance in proposal request.
- Confirm that costs for LID and GI improvements are reflected in the bids and final contract.

Project Design Phase

- During plan concept development, conduct site analysis for potential LID and GI improvements.
- Ensure an SME who is familiar with LID is involved in reviews and approvals, and participates in project development.
- Identify hold points for inspection and approvals during construction.
- Obtain topographical survey of site at minimum 1’ contours.
- Confirm existing conditions.
- Conduct soils analysis and percolation rate tests as required for proposed design.
- Analyze contributing surface runoff and potential storm water capture area.
- Confirm how existing storm water structures or improvements will affect or be affected by the proposed project.
- Confirm during 30/60/90/100% project reviews that LID and GI are incorporated in the design and cost estimates.

CONSTRUCTION

- Ensure construction personnel have the proper experience and qualifications to install LID projects.
- Project must include a submittal process directed to SME's who have the authority to approve actual materials used.

INSPECTION

- Identify appropriate materials and enforce 'hold points' for field inspections to occur at predetermined stages during construction.
- Use qualified inspectors who are familiar with LID Standards and methodologies.

MAINTENANCE + MONITORING

Regular maintenance and monitoring is required to keep LID components functioning as designed, and helps to avoid expensive repairs. The following are general maintenance guidelines that are to be addressed for each LID construction project.

- Provide a LID Maintenance + Monitoring Plan, outlining the basic following items:
  a. Who is responsible for maintenance and monitoring?
  b. List the types of maintenance and monitoring activities necessary, when maintenance and monitoring should occur, and establish a checklist outlining what aspects need to be evaluated.
  c. Identify performance criteria for each maintenance activity listed within the LID Maintenance Plan.
  d. What is the estimated cost for each activity identified in the Plan, including monitoring?
- Ensure on-going maintenance and monitoring activities by qualified staff.
- Include maintenance and monitoring activities within the annual budget by developing estimates based upon the defined LID Maintenance Plan.
- Distribute and communicate the schedules for maintenance and monitoring activities at determined locations, outlining the scope of work to be performed.
- Employees performing maintenance and monitoring are to provide feedback to the Maintenance point of contact for unusual conditions, areas needing repairs or special maintenance.
- Integrate changes to the LID Maintenance + Monitoring Plan based upon feedback from the field.

LID GENERAL DESIGN REQUIREMENTS

There are general design considerations for all storm water improvements implemented at LANL. The following are mandated by either LANL policies and procedures, or by other agencies with regulatory roles in LANL storm water management.

SWMUs and AOCs

Solid Waste Management Units (SWMU), or Area of Concern (AOC) are areas with special considerations for environmental or hazards management. These are general considerations for those areas.

- Do not direct storm water to a SWMU, or AOC.
- Water should not be encouraged to pond on a SWMU or AOC.
- Based on the site constituents, environmental media (e.g. soil, sediment, surface and ground water) may constitute solid waste and/or hazardous waste. If there is any potential for accumulated sediment or other media to be considered waste, a waste determination must be made and documented. For guidance, see the Laboratory's procedures on Waste Management.
- BMPs/GI used on SWMUs or AOCs may be considered waste based on site constituents and BMP use. Consider the use of biodegradable or permanent BMPs that can be left on site.

LID SPECIFIC DESIGN REQUIREMENTS

Once a LID project has been identified, there are general site specific considerations that need to be investigated. All LANL projects are required to use the Permits Requirements-Identification (PR-ID) and the Excavation/Fill/Soil Disturbance Permit Request (EX-ID) processes to identify project issues and requirements.

FUNCTION IN LANL STORM WATER SYSTEM

Understanding the function of the GI feature is basic to GI design. The GI potential role and function relative to the overall storm water system/LID helps clarify the critical considerations that need to be addressed in the specific design.

- How large is the capture area that contributes storm water to this GI location?
- Are surface slope and gradient controls needed?
- Is it possible to spread and reduce the pollutant concentration of storm water?
- Is it possible to infiltrate the storm water within the GI feature?
- How will the vegetative component of GI work in this project?

GENERAL DESIGN REQUIREMENTS:

LANL projects should incorporate these general design requirements for LID and GI components.

RUNOFF

- Identify drainage areas for each control measure to be designed.
- Calculate flow-rates, volumes, and velocities to support sizing of LID features.
    - Comply with the requirements identified in LANL Engineering Standards Manual (ESM), Chapter 3 (Civil)
    - Identify the appropriate storm event (i.e., pre-development hydrology, water quality storm, etc.) for design use
- Calculate channel flow velocity and shear stress for LID control design and material selection (i.e., rock sizing, turf reinforcement mat, etc.).
- LID features shall be designed to infiltrate/discharge ponded storm water within 96 hours.

SLOPES

Understanding the slopes and gradients surrounding and within the project area affects the selection of strategies that are best suited to the specific situation.

- Flatter slopes are better locations for strategies that store or infiltrate storm water.
- Steeper slopes most often require flow and energy dissipation as major components of the design to help prevent soil migration and erosion.
- Slopes should be stabilized with appropriate erosion control measures (i.e., hydro-mulch, turf reinforcement mat, rock, etc.) based on slope steepness and site conditions.

SOILS

Soils information is important in determining infiltration and structural design options for LID/GI.

- Perform soils percolation tests using a industry standard field or laboratory standard tests.
    - Optimal infiltration rate is >0.5 inches/hour
- Check for erodibility to evaluate needs for flow energy dissipation and sedimentation potential and/or erosion.
- Evaluate the need for soil amendments to support vegetation growth.
- Soil Compaction:
    - To prevent over compaction, minimize use of heavy equipment on soils to be used for infiltration.
    - For areas intended to infiltrate storm water flows, native soils shall not be compacted any greater than 85% maximum dry density.
    - Soils beneath structural components (i.e., footings, concrete walls, etc.) shall be compacted to 90% or greater dry density.

VEGETATION

Including and establishing vegetation is an important functional component of LID/GI.

- Disturbed areas shall be stabilized with perennial vegetation.
- Vegetation should be drought tolerant and able to withstand periodic inundation.

UTILITIES

In more developed areas of LANL, locations for GI are often utility corridors. Investigating utilities for alignment and bury depth is an important part of basic site analysis.

- Obtain mapping of existing and abandoned utilities within the project area as early as possible during the project planning and design phase.
- Obtain information from LANL infrastructure and utilities groups regarding alignments, bury depths and limitations for activities such as grade modifications and runoff infiltration considerations.
- Potholing will be necessary to confirm location and depth of buried utilities.

ACCESS

LID and GI improvements need to include security and access requirements.

- Identify security and safety access requirements at the earliest stages of project planning.
- Provide access for maintenance.

LID SPECIFICATIONS STANDARDS

The following amendments are recommended for project specifications that include LID and GI components. They will need to be integrated into the overall format and content of the project specifications.

PART 1 / GENERAL

A. Definitions

1. Berm Fill: On site materials which are primarily used to construct storm water berms where relatively low to moderate hydraulic conductivity material properties are desirable.
2. Engineered Fill: Imported materials primarily used to construct storm water berms where relatively low to moderate hydraulic conductivity material properties are desirable.
3. Excavation Slope: An inclined surface formed by removing material from below existing grade.
4. Embankment Slope: An inclined surface formed by placement of material above surrounding grade.

B. Site Conditions

1. Areas to be backfilled are free of debris, snow, ice, and water, and surfaces are not frozen. Backfill material shall be in a thawed state before being placed, mixed, or compacted. Compensatory measures can be used and should be described in a cold weather protection plan and approved by LANL.

PART 2 / MATERIALS

A. Embankment Fill

1. Excavated on-site or imported material from other LANL properties usually consisting of, but not limited to, crushed tuff. Blending to meet material requirements is acceptable. Material shall have a PI greater than 7 and shall contain less than 2 percent organic matter, rocks or other deleterious matter which might impede compaction or cause zones of high permeability.

B. Berm Fill

1. Excavated material obtained from on site may be used for berm fill. If sufficient materials are not available on site or if on-site materials do not have the specified properties, materials from an off-site borrow area may be used. Off-site materials may be mixed with on-site materials in the proportions necessary to meet the requirements of this section.
2. Berm fill shall consist of any on-site or imported clean material, containing less than 2 percent organic material, debris and other deleterious materials and shall meet the following gradation requirements as determined by ASTM D422 except as otherwise approved by the LANL STR or LANL PE.

   Sieve Size Percent Passing
   2.0 inch 100
   ¼ inch 75 – 100
   No. 10 60 – 85
   No. 200 30 – 45

   The fraction passing the No. 200 sieve shall not be greater than 0.667 of the fraction passing the No. 40 sieve. Berm fill shall have a PI between 10 and 20. Testing shall be in conformance with ASTM D4318.
3. For material manufactured through mixing or blending, perform conformance testing on a minimum of every 200 tons, or when the parent material has changed, whichever occurs first.

C. Engineered Fill

1. Engineered fill shall be produced from mixing base course aggregate with clay, containing less than 2 percent organic material, debris and other deleterious materials.
2. Granular berm fill shall meet the following gradation requirements as determined by ASTM D422 except as otherwise approved by the LANL STR or PE to obtain the required gradation. Material may be mixed on or off-site:

   Sieve Size Percent Passing
   2.0 inch 100
   1.0 inch 98 – 100
   ¼ inch 65 – 80
   No. 10 45 – 70
   No. 200 21 – 35

   The fraction passing the No. 200 sieve shall not be greater than 0.667 of the fraction passing the No. 40 sieve.

PART 3 / EXECUTION

A. Inspections

At project start, inspection points for storm water improvements shall be established and integrated with general project inspections. Include within those inspection points the following:

1. Initial layout of storm water improvements for field adjustments as needed.
2. Verification that over-compaction of soils where infiltration is required has not occurred.
3. Proper seeding methods and materials (i.e., seed tags, mulch types, application rates).
4. Installation of erosion control materials per manufacturer recommendations (i.e., turf reinforcement mat anchor trenches and staple patterns).
5. Use of appropriate LID construction and site stabilization materials.
6. Compliance with predefined hold points.

B. Sub-grade preparation

1. Under storm water structures existing sub-grade should be compacted to ninety (90) percent maximum dry density to a minimum 8" depth below the bottom of structure or as noted on the plans.
2. Where infiltration is required, soils shall not be compacted greater than eighty-five (85%) maximum dry density.
3. Unless specifically noted on plans, storm water features shall not have geotextiles, or plastic sheeting, or other similar materials laid under rip-rap, gravels, mulches or other similar porous layers.


Great things are done by a series of small things brought together.
Vincent Van Gogh

LID STANDARDS

The following LID Standard Details are standards for GI improvements on LANL projects. For each detail, discussions and recommendations pertaining to the following categories are included to inform the application, construction and maintenance:

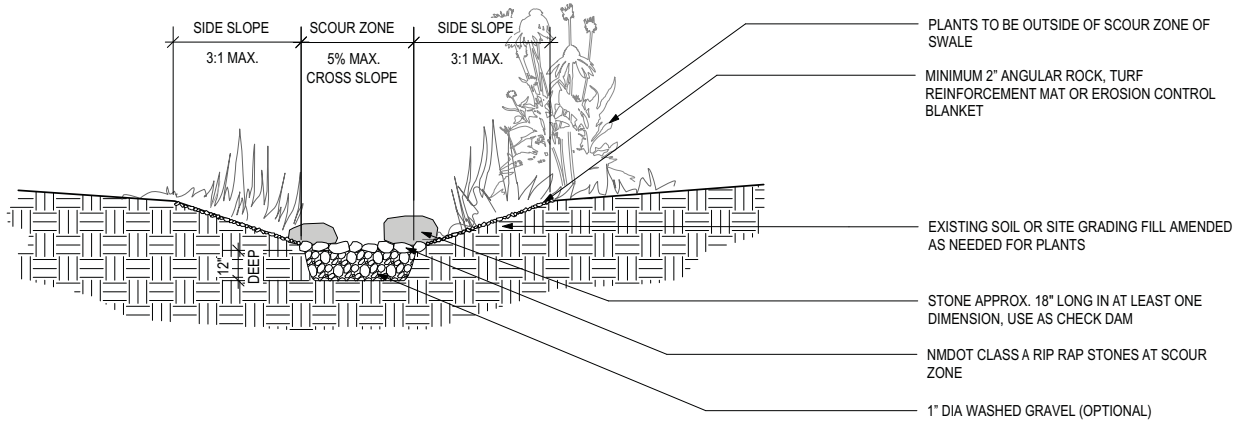
- Applicability
- Limitations
- Siting criteria
- Design + Construction Criteria
- Inspection and maintenance

STANDARDS LIST (SEPT. 2017)

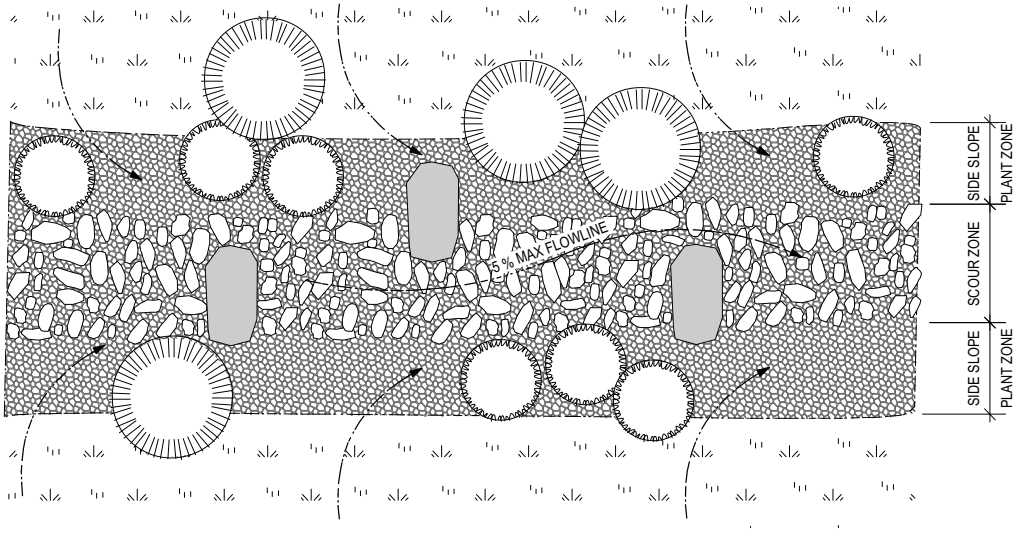
- Vegetated Swale
- Storm Water Channel
- One-Rock Check Dam
- Check Dam + V-weir
- Zuni Bowl
- Sloped Dissipater
- Flowline Extender
- Level Spreader
- Filter Media
- Permeable Paving
- Bio-Retention Cell / Oxbow
- Control Basin
- Cistern

VEGETATED SWALE

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:
- SOILS IN BANK AND BOTTOM OF SWALE SHOULD NOT BE OVERCOMPACTED TO PROMOTE INFILTRATION.

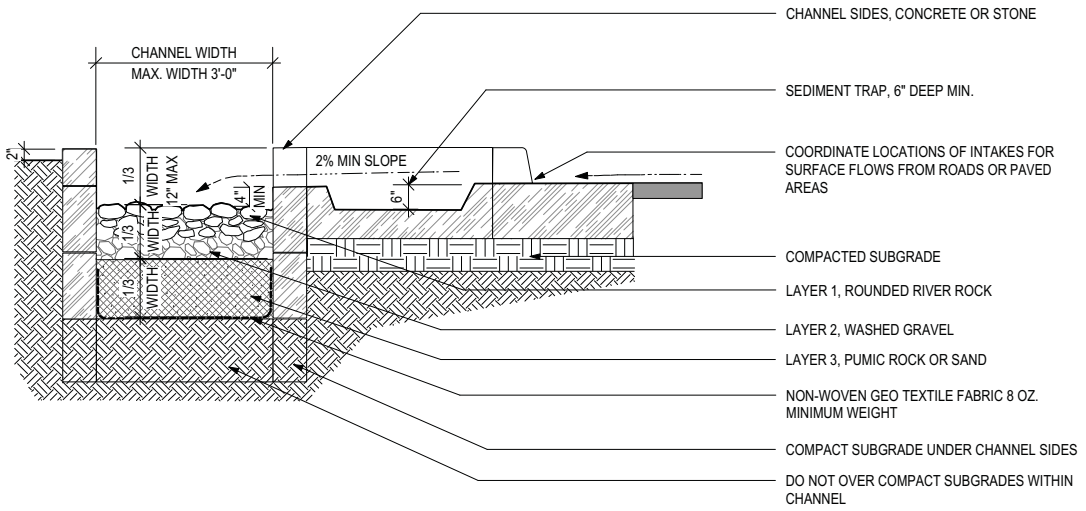
SITING CRITERIA:
- SWALES WORK BEST ON THE LOW SIDE OF A TOPOGRAPHIC FEATURE.

DESIGN CRITERIA:
- CHANNEL VELOCITY SHALL AVOID RATES THAT WOULD ERODE VEGETATED BANKS AND/OR EXCEED MANUFACTURER RECOMMENDATIONS FOR SOIL EROSION CONTROL MATERIAL.
- RECOMMENDED MAXIMUM LONGITUDINAL SLOPE 5%.
- INCORPORATE CHECK DAMS AT REGULAR INTERVALS.
- ENSURE CENTER OF SWALE IS LOWER THAN OUTSIDE EDGES.
- CHECK SOIL INFILTRATION. OPTIMUM RANGE IS >0.5" OF INFILTRATION PER HOUR.
- PROVIDE APPROPRIATE EROSION AND FLOW DISSPATERS AT THE ENTRY AND EXIT POINTS OF SWALE.
- NATIVE SOILS OR AMENDED SOILS SHALL BE SUITABLE FOR SUPPORTING VEGETATIVE COVER.
- VEGETATION SHOULD BE DROUGHT TOLERANT, AND ABLE TO WITHSTAND PERIODIC INUNDATION.
- IN AREAS WHERE APPROPRIATE, GRASS SWALES MAY BE USED. PROVIDE SUPPLEMENTAL IRRIGATION TO AREA.
- SWALES SHOULD BE DESIGNED TO BLEND WITH THE CONTEXT OF THE SURROUNDING LANDSCAPE.

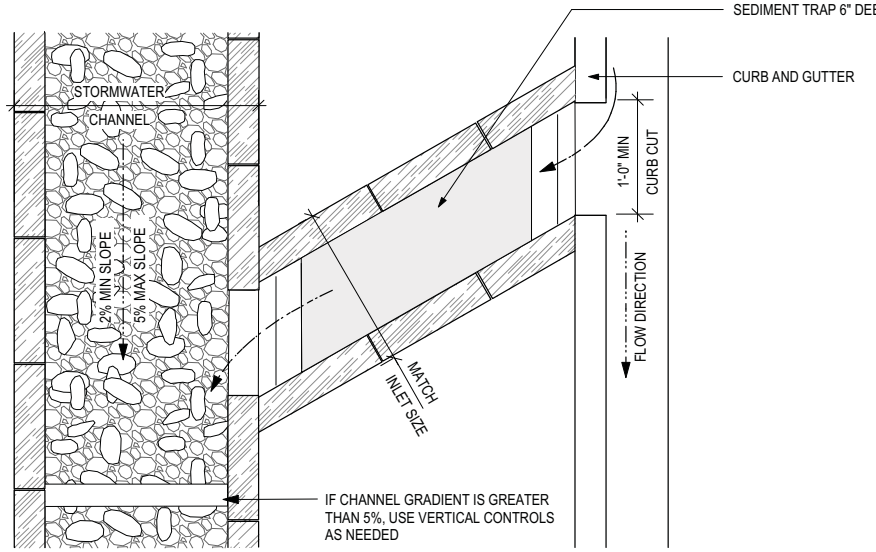
CONSTRUCTION CRITERIA:
- SEED SWALE BOTTOM AND SIDE SLOPES PRIOR TO STABLIZATION IN ACCORDANCE WITH LANL REQUIREMENTS.
- DO NOT MOW WITH HEAVY EQUIPMENT OR IN AREAS OF LESS THAN 4" TO 6" INCHES OF SOIL DEPTH.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:
- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF SIDE SLOPES, AND DEBRIS, TRASH AND SEDIMENT ACCUMULATIONS AT INLETS AND OUTLETS.

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:
- STORM WATER CHANNELS SHOULD AVOID AREAS WITH HIGHLY ERODIBLE SOILS AND SLOPES GREATER THAN 8%.
- EXISTING SUBSURFACE UTILITES MAY LIMIT USE OF THIS METHOD.

SITING CRITERIA:
- STORM WATER CHANNELS ARE ABLE TO EFFECTIVELY HANDLE DRAINAGE AREAS LESS THAN 5 ACRES.
- SAFETY MEASURES FOR VEHICLES AND PEDESTRIANS MAY BE REQUIRED, I.E. RAILINGS, POSTS, ETC.

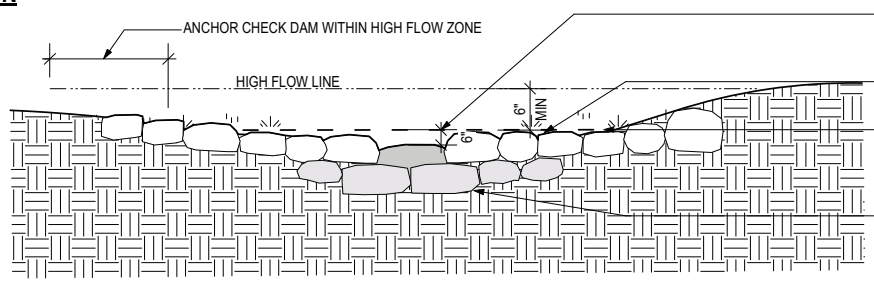
DESIGN CRITERIA:.
- CHANNEL BOTTOM GRADIENT SHOULD BE 5% OR LESS. VERTICAL CONTROLS SHOULD BE PLACED IN CHANNEL IF GRADIENT IS STEEPER. TOP OF VERTICAL CONTROLS SHOULD BE 1" LOWER THAN TOP OF LAYER 1.
- MULTIPLE CHANNEL INLETS CAN BE INCORPORATED ALONG THE LENGTH OF THE STORM WATER CHANNEL.
- A SEDIMENT TRAP (6" DEEP) SHALL BE INCLUDED AT EACH STORM WATER CHANNEL INLET. THE OUTLET OF SEDIMENT TRAP SHALL BE LOWER IN ELEVATION THAN THE INLET.
- PROVIDE VELOCITY AND EROSION CONTROL AT CHANNEL OUTFALL.
- CHANNEL SIDE MATERIAL OPTIONS:
  - STONE
  - CONCRETE
- IF CONCRETE IS UTILIZED IT SHALL CONFORM WITH LANL REQUIREMENTS. IF STONE IS UTILIZED IT SHALL BE SIZED BASED ON CHANNEL VEOCITIES AND VERTICAL/HORIZONTAL SHEER CONSIDERATIONS.

CONSTRUCTION CRITERIA:
- SOILS UNDER CHANNEL BOTTOM SHOULD NOT BE OVERCOMPACTED TO PROMOTE INFILTRATION.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:
- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF SIDE SLOPES, AND DEBRIS, TRASH AND SEDIMENT ACCUMULATIONS AT INLETS AND OUTLETS.
- STORM WATER CHANNELS HAVE A LIFE SPAN OF 10-15 YEARS IF REGULARLY MAINTAINED.

ONE-ROCK CHECK DAM

ELEVATION



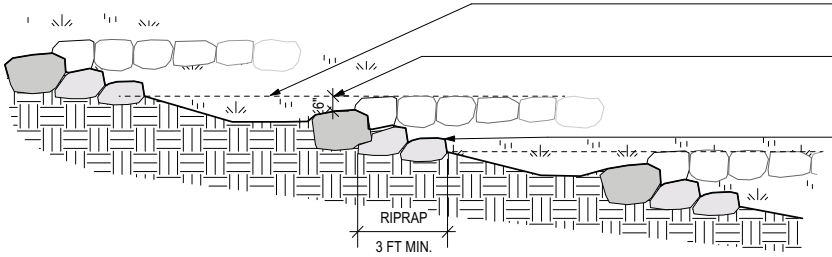
PLACE KEYSTONE AT APEX OF CHECK DAM, KEYSTONE SHOULD BE MINIMUM 18" DIAMETER, AND SET 6" BELOW TOP OF REST OF CHECK DAM.

TOP OF CHECK DAM TO BE MINIMUM 6" BELOW HIGH FLOW LINE

TOP OF CHECK DAM TO BE LEVEL

EXTEND RIP RAP DOWN CHANNEL A MINIMUM 3 FEET

SECTION

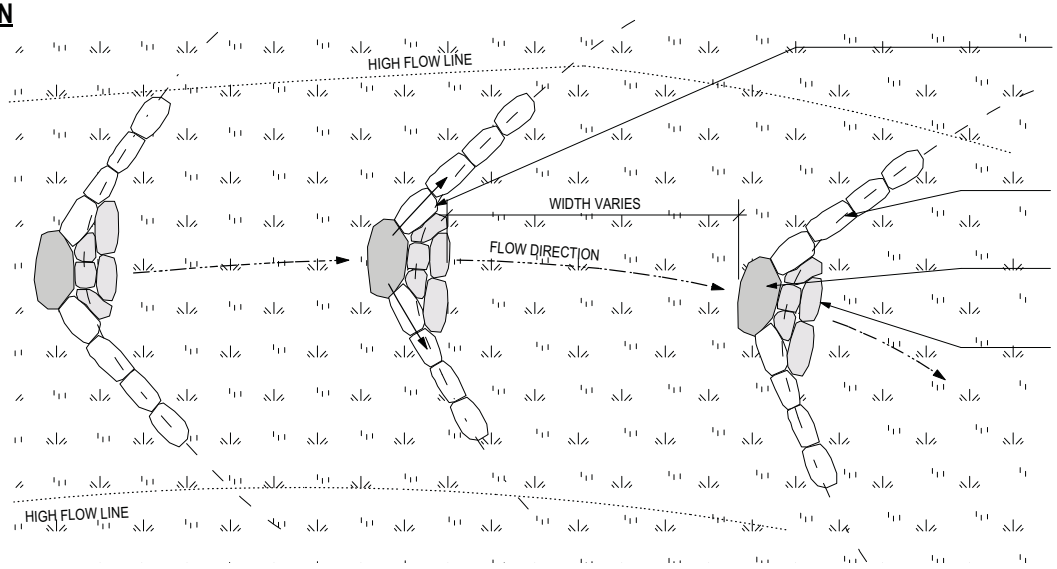


TOP OF CHECK DAM TO BE LEVEL WITH TOE OF UPSTREAM DAM

KEYSTONE, SET 6" BELOW REST OF CHECK DAM; ANGLE KEYSTONE BACK UPSTREAM SLIGHTLY; BURY KEYSTONE A MINIMUM 1/2 OF ITS DEPTH

RIP RAP

PLAN



POSITION STONES ON BOTH SIDES OF KEYSTONE AND LAY DIRECTIONALLY TO FLANK AND HOLD KEYSTONE IN PLACE

BUILD CHECK DAM AT CENTER OF FLOW LINE

KEYSTONE; MIN 18" DIA; PLACE AT APEX OF CHECK DAM

RIP RAP

NOTES:

DESIGN LIMITATIONS:

- TO BE USED WHEN DETAINED WATER HEIGHT IS 18 INCHES OR LESS.
- LONGITUDINAL SLOPE OF CHANNEL SHOULD BE LESS THAN 8%.

SITING CRITERIA:

- SHOULD BE INSTALLED AS A SERIES OF CHECK DAMS.
- EFFECTIVE IN SHALLOW, LOW FLOW CONVEYANCES.

DESIGN CRITERIA:

- CHECK DAM HEIGHT AND WIDTH TO BE DESIGNED FOR SPECIFIC LOCATION.
- MOST EFFECTIVE WHEN REGULARY SPACED.
- INTEGRATE WITH VEGETATED SWALES IF POSSIBLE.
- VEGETATION SHOULD BE PLACED AWAY FROM CHECK DAM STRUCTURE AND BE ABLE TO WITHSTAND PERIODIC INUNDATION.

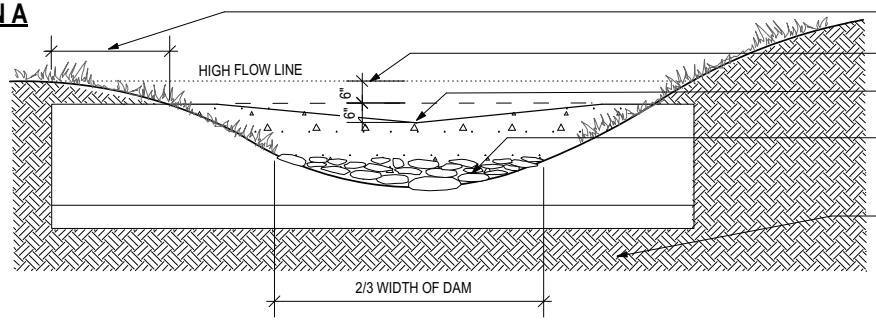
CONSTRUCTION CRITERIA:

- SOILS IN BOTTOM OF SWALE SHOULD NOT BE OVERCOMPACTED TO PROMOTE INFILTRATION.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:

- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF SIDE SLOPES, AND DEBRIS, TRASH AND SEDIMENT ACCUMULATION.
- IF EROSION OF THE CHANNEL IS EVIDENT AND/OR THE CHECK DAM STRUCTURE IS DEGRADED MAINTENANCE/REPLACEMENT IS REQUIRED.

SECTION A



ANCHOR CHECK DAM INTO SIDE SLOPES TO HIGH FLOW LINE

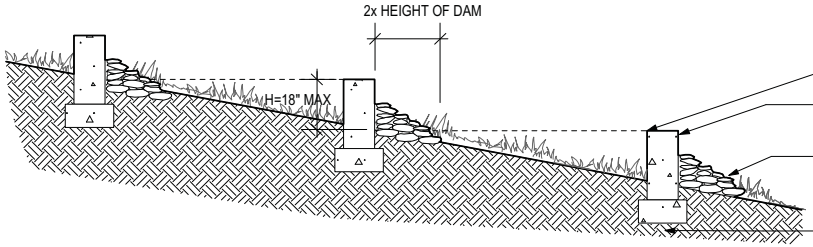
TOP OF CHECK DAM TO BE MINIMUM 6" BELOW HIGH FLOW LINE

FORM SPILL WAY 6" BELOW TOP OF DAM

RIP RAP SPLASH APRON

COMPACT SUBGRADE

SECTION B



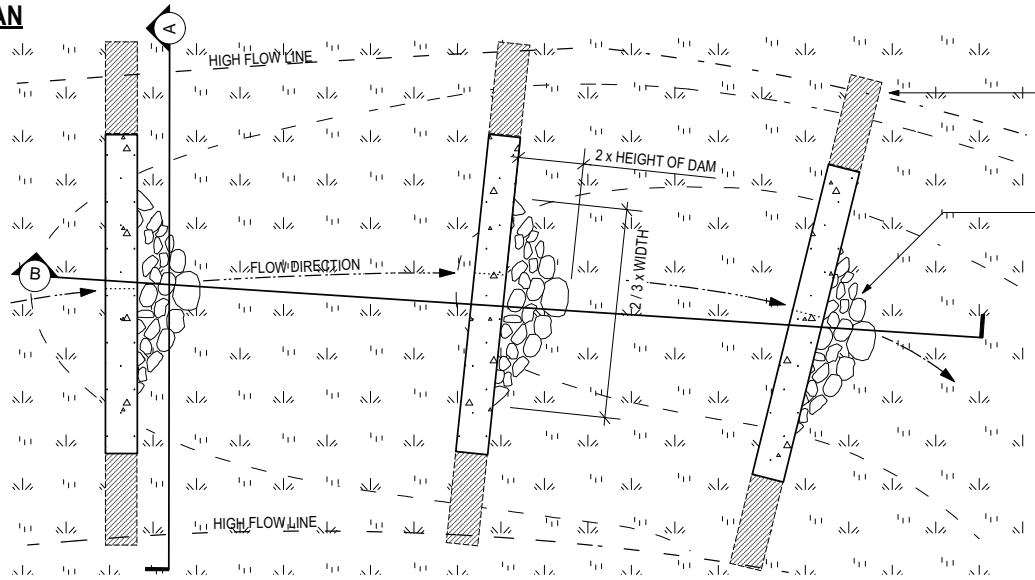
EXAMPLE SHOWN AS CONCRETE, SEE NOTATIONS FOR ALTERNATE MATERIALS

TOP OF CHECK DAM TO BE LEVEL WITH TOE OF UPSTREAM DAM

RIP RAP SPLASH APRON DOWN STREAM LENGTH TO BE MINIMUM TWICE HEIGHT OF CHECK DAM ABOVE GROUND AND 2/3 WIDTH OF DAM

COMPACT SUBGRADE

PLAN



PLACE CHECK DAM PERPENDICULAR TO FLOW DIRECTION WITH ENDS ANCHORED INTO SIDE SLOPES

RIP RAP SPLASH APRON

NOTES:

DESIGN LIMITATIONS:
- TO BE USED WHEN DETAINED WATER HEIGHT IS 18 INCHES OR LESS.
- LONGITUDINAL CHANNEL SLOPE SHOULD BE LESS THAN 8%.

SITING CRITERIA:
- BEST WHEN PART OF A SERIES OF CHECK DAMS.

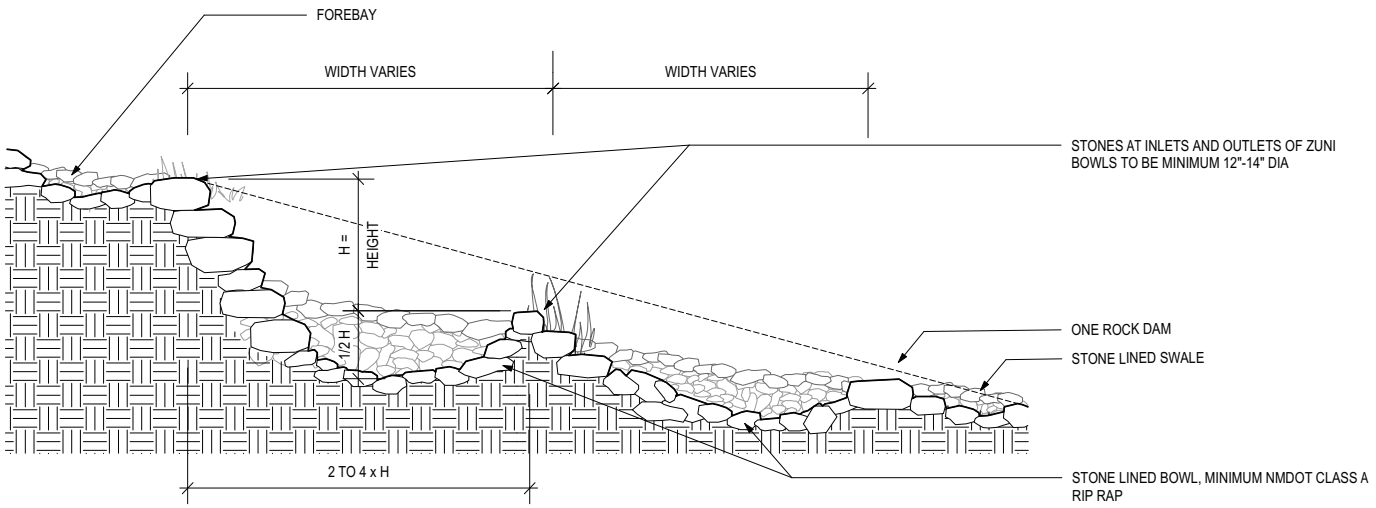
DESIGN CRITERIA:
- CHECK DAM HEIGHT AND SPILLWAY DIMENSIONS TO BE SIZED BASED ON THE VELOCITIES IN THE CHANNEL.
- CHANNEL VELOCITY SHALL NOT EXCEED MANUFACTURER SPECIFICATIONS FOR ANY MATERIAL USED IN THE CHANNEL.
- RIP RAP CLASS SIZE SHALL BE MINIMUM NM DOT CLASS A OR DETERMINED BASED ON CHANNEL VELOCITIES.
- MOST EFFECTIVE WHEN REGULARY SPACED.
- IF CONCRETE IS UTILIZED IT SHALL CONFORM WITH LANL ENGINEERING REQUIREMENTS.
- NON-WOVEN 8 OZ. MINIMUM WEIGHT GEOTEXTILE UNDER RIP RAP APRON.
- MATERIALS OPTIONS FOR CHECK DAM MATERIALS:
  - ROCK
  - CONCRETE
  - METAL PLATE

CONSTRUCTION CRITERIA:
- SOILS IN BOTTOM OF SWALE SHOULD NOT BE OVERCOMPACTED TO PROMOTE INFILTRATION.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

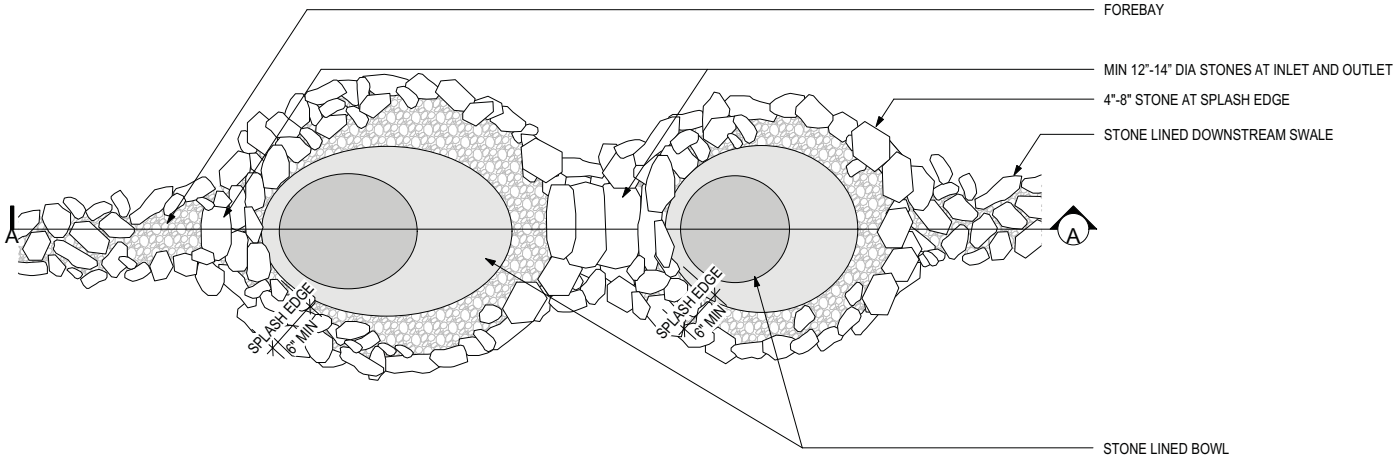
INSPECTION + MAINTENANCE:
- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF SIDE SLOPES, AND DEBRIS, TRASH AND SEDIMENT ACCUMULATION.
- REMOVE SEDIMENT IF OVER ½ THE ORIGINAL HEIGHT OF THE CHECK DAM.
- IF EROSION OF THE CHANNEL IS EVIDENT AND/OR THE CHECK DAM STRUCTURE IS DEGRADED, MAINTENANCE OR REPLACEMENT IS REQUIRED.

ZUNI BOWL

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:
- ZUNI BOWLS WORK BEST ON UNCOMPACTED SOILS.
- ZUNI BOWLS SHALL NOT BE INSTALLED ON SLOPES GREATER THAN 30%.
- ZUNI BOWLS SHALL NOT BE INSTALLED ON SITES WITH UNSTABLE SOILS.

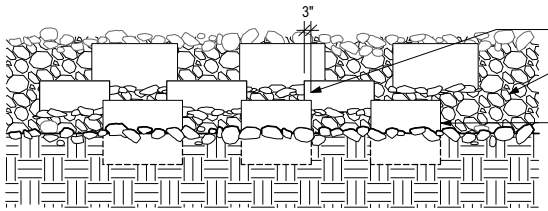
SITING CRITERIA:
- ZUNI BOWLS WORK BEST WITH CONTRIBUTING DRAINAGE AREAS OF LESS THAN 5 ACRES.
- ZUNI BOWLS SHOULD BE SITED WHERE FLOWS ARE CONCENTRATED FROM A SINGLE OUTFALL OR POINT.

DESIGN CRITERIA:
- MINIMUM 12"-14" DIA STONE SHALL BE USED TO BUILD INLET AND OUTLET STRUCTURES.
- ENSURE THE CHANNEL BETWEEN BOWLS IS SIZED TO MANAGE THE FLOW PASSING BETWEEN THE BOWLS.
- PROVIDE A COBBLE SPLASH EDGE AROUND THE PERIMETER OF THE ZUNI BOWLS THAT IS A MINIMUM 6" WIDE.
- ZUNI BOWLS SHALL NOT INCLUDE UNDERLAYMENT IN ORDER TO PROMOTE INFILTRATION.
- AN OPTIONAL FOREBAY CAN BE CONSTRUCTED TO REMOVE DEBRIS.
- ZUNI BOWLS SHOULD VISUALLY BLEND WITH THE SURROUNDING LANDSCAPE.

CONSTRUCTION CRITERIA:
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS AREA FOR MAINTENANCE.

INSPECTION + MAINTENANCE:
- INSPECT AT LEAST ANNUALLY FOR EROSION AND DEGRADATION, DEBRIS, TRASH AND SEDIMENT ACCUMULATION.
- REMOVE SEDIMENT IF OVER 3" IN DEPTH.

SECTION A

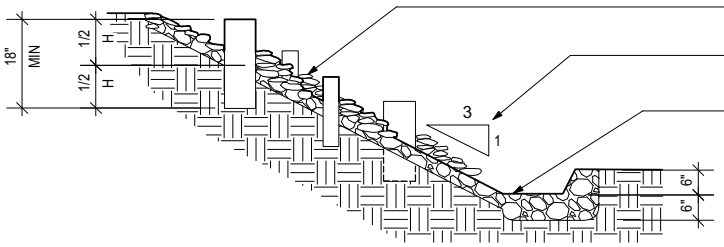


OVERLAP BY 3" MIN TO AVOID SCOURING BETWEEN DISSIPATERS

RIP RAP

DISSIPATER BURIED 1/2 HEIGHT (H) OF MATERIAL; MINMUMI HEIGHT OF DISSIPATER 18"

SECTION B

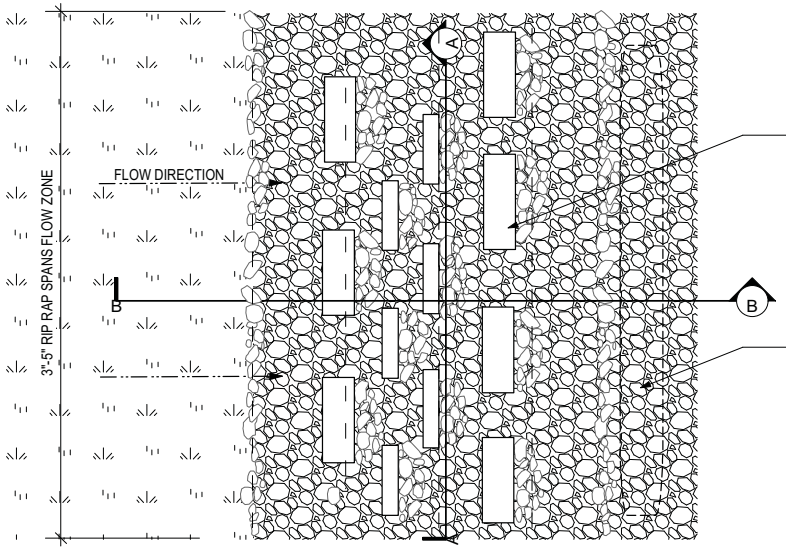


RIP RAP THROUGHOUT SPILLWAY FLOW ZONE

3:1 OR STEEPER SLOPE RECOMMENDED

SCOUR ZONE, MINIMUM 6" DEEP

PLAN



DISSIPATER BLOCKS, BURIED MIN 1/2 OF HEIGHT OF BLOCK OR STONE AND PERPENDICULAR TO FLOW DIRECTION

COBBLE SCOUR ZONE, 6" DEPTH

NOTES:

DESIGN LIMITATIONS:

- STRUCTURAL CAPACITY OF SOILS ARE REQUIRED TO SUPPORT DISSIPATERS.
- INTENDED FOR SHARP GRADE BREAKS ON MODERATELY CONCENTRATED SHEET FLOW AREAS WITH HIGH POTENTIAL FOR MULTIPLE EROSION POINTS.

SITING CRITERIA:

- CONFIRM STRUCTURAL CAPACITY OF EXISTING SOIL TO SUPPORT DISSIPATERS.
- ABILITY TO SPREAD INCOMING FLOW TO BE LESS THAT 2" FLOW DEPTH ACROSS SPILLWAY.
- UTILIZE ON 3:1 SLOPES OR STEEPER.

DESIGN CRITERIA:

- RECOMMENDED SLOPE OF SPILLWAY IS 3:1 OR STEEPER.
- ARMOR SPILLWAY SURFACE AREA WITH MINIMUM NMDOT CLASS A RIP RAP.
- OVERLAP EDGES OF DISSIPATERS TO AVOID SCOURING BETWEEN.
- MINIMUM HEIGHT OF DISSIPATERS IS 18".
- DISSIPATER MATERIAL OPTIONS:
  - STONE
  - CONCRETE
  - METAL

CONSTRUCTION CRITERIA:

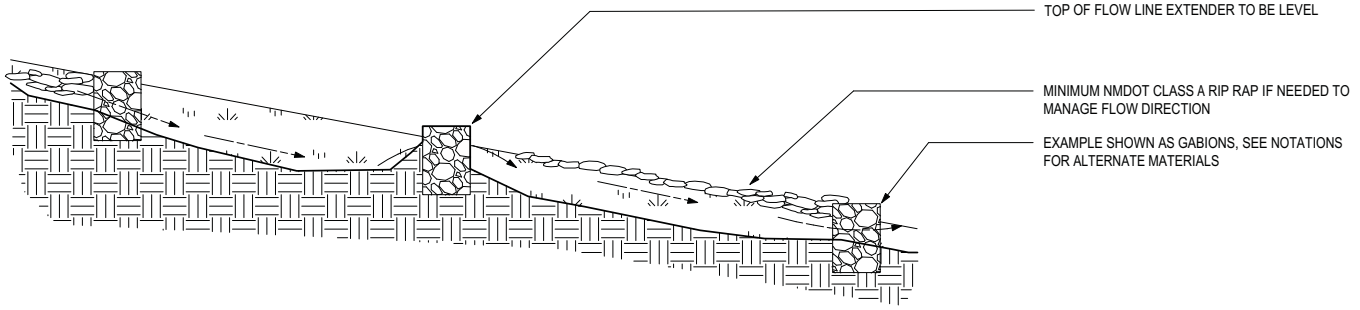
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:

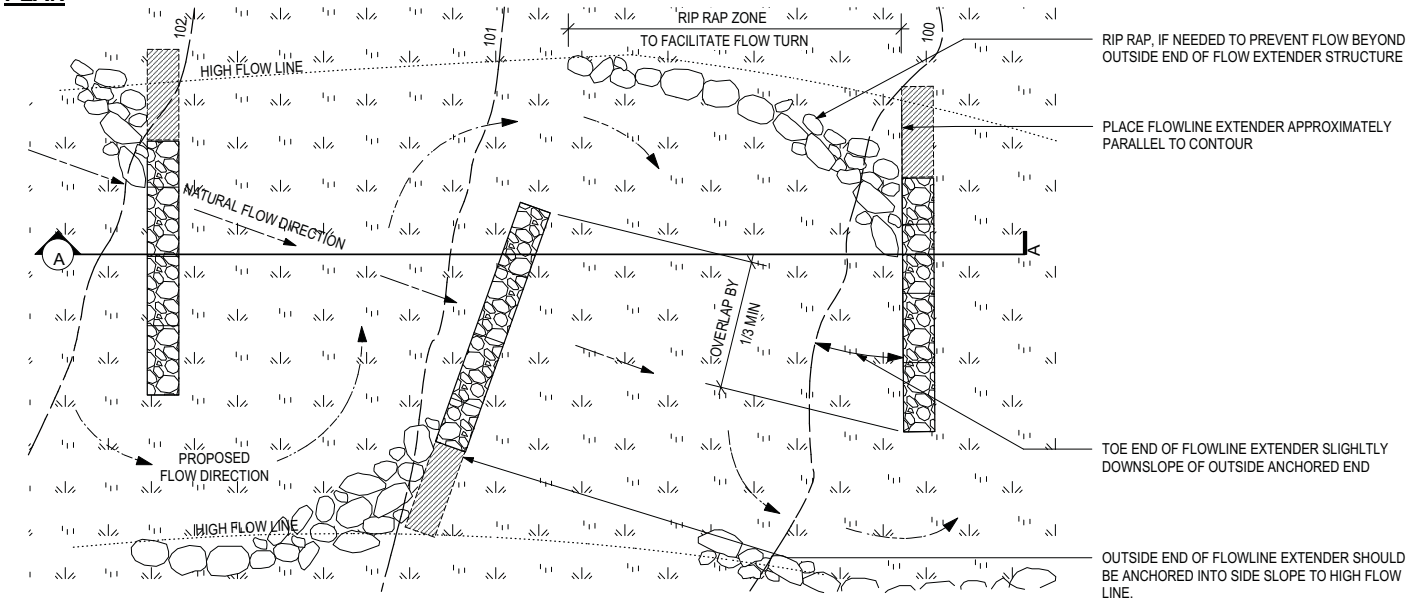
- INSPECT AT LEAST ANNUALLY FOR EROSION AND DEGRADATION OF SLOPES, DEBRIS, TRASH, SEDIMENT ACCUMULATION, AND WEED CONTROL .
- INSPECT FOR DISPLACED RIP RAP AND SCOURING AFTER HIGH FLOW EVENTS.

FLOWLINE EXTENDER

SECTION A



PLAN



NOTES:

DESIGN LIMITATIONS:
- NOT INTENDED FOR USE WITHIN A CONCENTRATED FLOW PATH (CHANNEL).
- LONGITUDINAL SLOPE OF FLOW AREA SHOULD BE LESS THAN 8%.

SITING CRITERIA:
- CONFIRM STRUCTURAL CAPACITY OF EXISTING SOIL TO SUPPORT FLOWLINE EXTENDER.
- SHALL BE USED IN A SERIES OF FLOWLINE EXTENDERS.

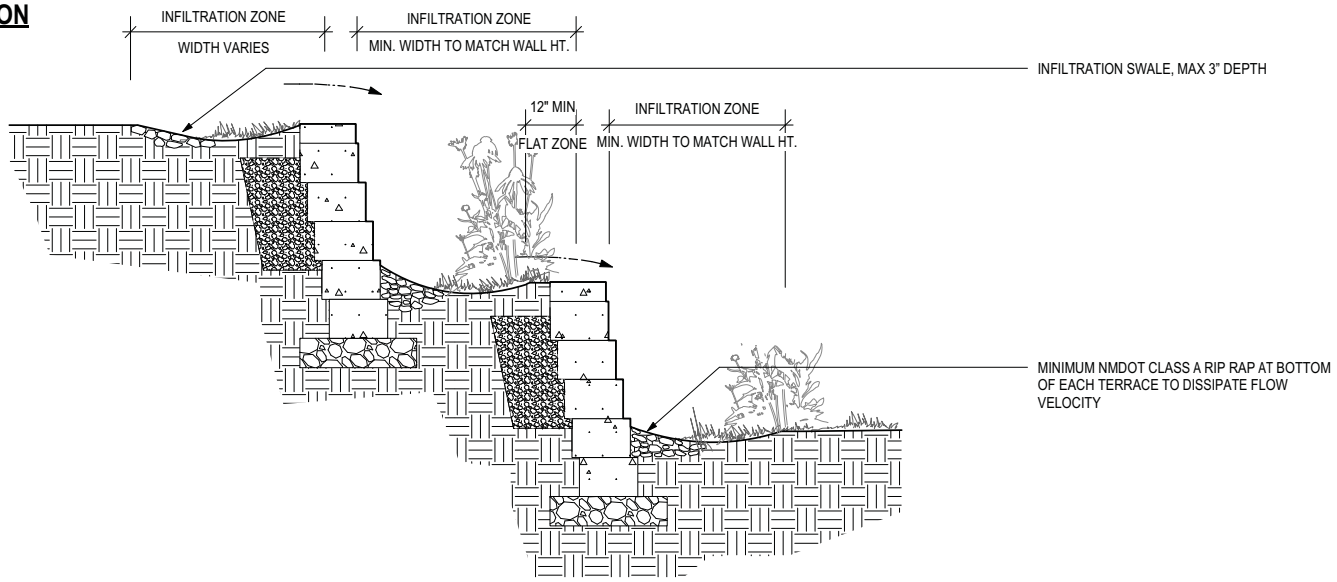
DESIGN CRITERIA:
- CROSS SWALE SLOPE SHOULD BE LESS THAN 4%.
- UTILIZE RIP RAP AT ENDS OF FLOW LINE EXTENDERS IF NEEDED TO TURN FLOWS.
- FLOW EXTENDER MATERIAL OPTIONS:
  - INTERLOCKING BLOCK WALL SYSTEM
  - STONE
  - GABIONS
  - EARTHEN BERM
- IF USING EARTHEN BERM, STABLIZE BERMS WITH PERENNIAL VEGETATION AND TURF REINFORCEMENT MAT.
- VEGETATE AREAS BETWEEN THE FLOW EXTENDERS UTILIZING SEEDING METHODS THAT WILL WITHSTAND MINOR CONCENTRATED FLOW.
- REQUIRES SOILS SUITABLE FOR VEGETATION GROWTH.

CONSTRUCTION CRITERIA:
- SOILS IN AREA SHALL BE SUITABLE FOR VEGETATIVE COVER.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

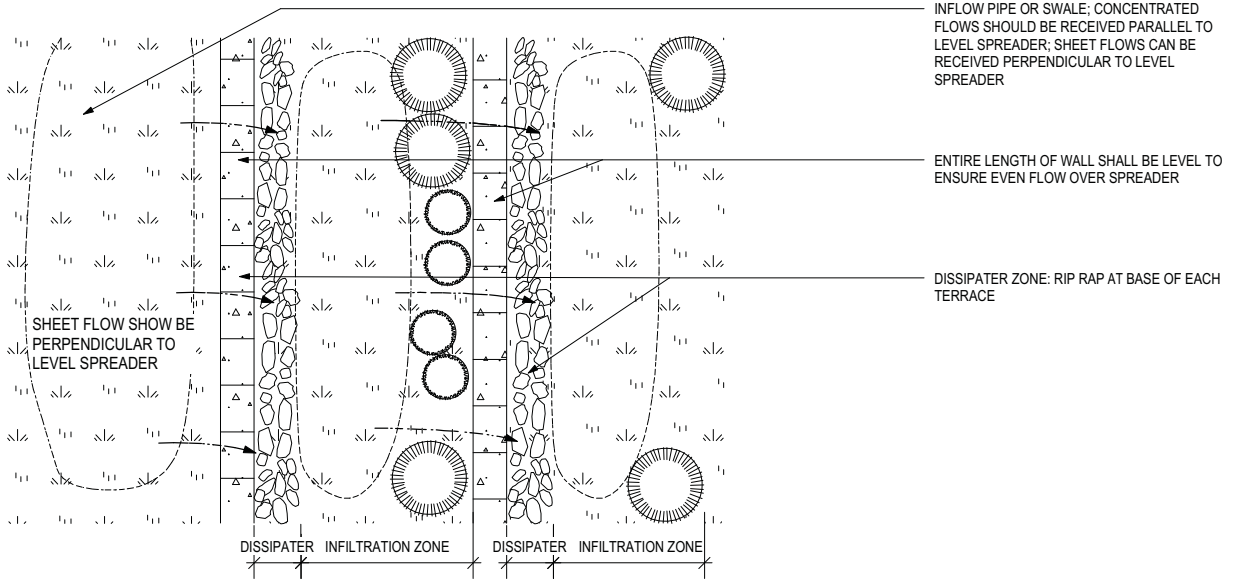
INSPECTION + MAINTENANCE:
- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF STRUCTURES, DEBRIS, AND TRASH.

LEVEL SPREADER

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:

- LEVEL SPREADERS ARE ONLY SUITED FOR SHEET FLOW AREAS WITH MINIMALLY CONCENTRATED FLOWS.
- LEVEL SPREADERS SHALL NOT BE SITUATED IN AREAS WITH HIGHLY ERODIBLE SOILS.

SITING CRITERIA:

- LEVEL SPREADERS SHOULD NOT BE PLACED IN AREAS THAT COULD BE TRAFFICKED BY CARS OR PEOPLE.
- LEVEL SPREADERS SHOULD BE PLACED A MINIMUM OF 15' FROM THE EDGE OF FOUNDATIONS OR BUILDINGS.
- REQUIRES SOILS SUITABLE VEGETATION GROWTH.

DESIGN CRITERIA:

- AVOID CREATING TERRACES GREATER THAN 30" TALL.
- TERRACES SHOULD BE SPACED.
- IF CONCRETE IS UTILIZED IT SHALL CONFORM WITH LANL REQUIREMENTS.
- TERRACE MATERIAL OPTIONS:
  - INTERLOCKING BLOCK WALL SYSTEM
  - STONE
  - GABIONS
  - CONCRETE
- VEGETATION FOR LEVEL SPREADERS SHOULD BE DROUGHT TOLERANT.

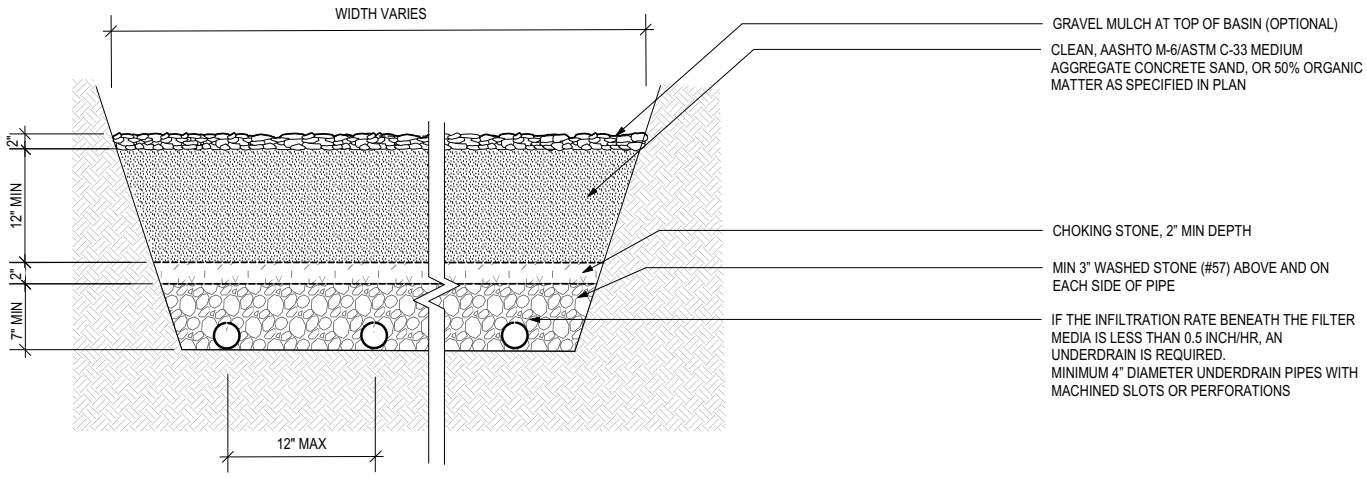
CONSTRUCTION CRITERIA:

- TOP ELEVATION OF EACH TERRACE WALL SHALL BE LEVEL ACROSS THE LENGTH OF EACH WALL.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:

- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION, DEBRIS, AND TRASH.

SECTION



NOTES:

DESIGN LIMITATIONS:.

- DESIGNED TO TREAT CONTRIBUTING DRAINAGE AREAS THAT ARE LESS THAN 5 ACRES.

SITING CRITERIA:

-TYPICALLY PLACED ALONG THE PERIMETER OF DRAINAGE AREAS.
- DO NOT INSTALL WHERE EROSIVE VELOCITIES AND HIGH SEDIMENT LOADS ARE A CONCERN.
- DO NOT INSTALL WHERE CONSTRAINTS WILL NOT ALLOW FOR REQUIRED MEDIA THICKNESS OR PONDING DEPTH.
- FILTER MEDIA FUNCTIONALITY IS PROPORTIONAL TO DEPTH OF TUFF (ROCK). FOUR FEET MINIMUM DEPTH REQUIRED.

DESIGN CRITERIA:

- MEDIA SHALL BE SPECIFIED IN PLANS.
- THE TOP OF THE SAND FILTER SHOULD BE LEVEL.
- INSTALL IN LINEAR TRENCH, CHANNELS, OR IN OPEN BASINS OR PONDS.
- DESIGN SHALL INCLUDE AN EMERGENCY OUTLET CONSISTING OF A RISER PIPE OR STABILIZED SPILLWAY.
- FOREBAY OR SEDIMENT CATCHMENT FEATURE REQUIRED FOR USE WITH ALL MEDIA FILTERS TO PREVENT CLOGGING AND TO DISSIPATE FLOWS.
- AT MINIMUM PROVIDE ONE (1) UNDERDRAIN PER 1000 SF. OF SURFACE AREA.
- SPACING OF UNDERDRAIN PIPES SHALL BE NO GREATER THAN 1' ON CENTER.
- INSTALL UNDERDRAINS WITH MINIMUM SLOPE OF 1% TO OUTLET END.
- AT A MINIMUM INCLUDE CLEANOUT PIPES AT EACH END OF THE UNDERDRAIN.
- MEDIA DEPTH SHALL BE MINIMUM OF 12" OVER UNDERDRAIN PIPES.
- AVOID FILTER FABRIC BETWEEN MEDIA LAYERS AND AROUND UNDERDRAIN PIPES.

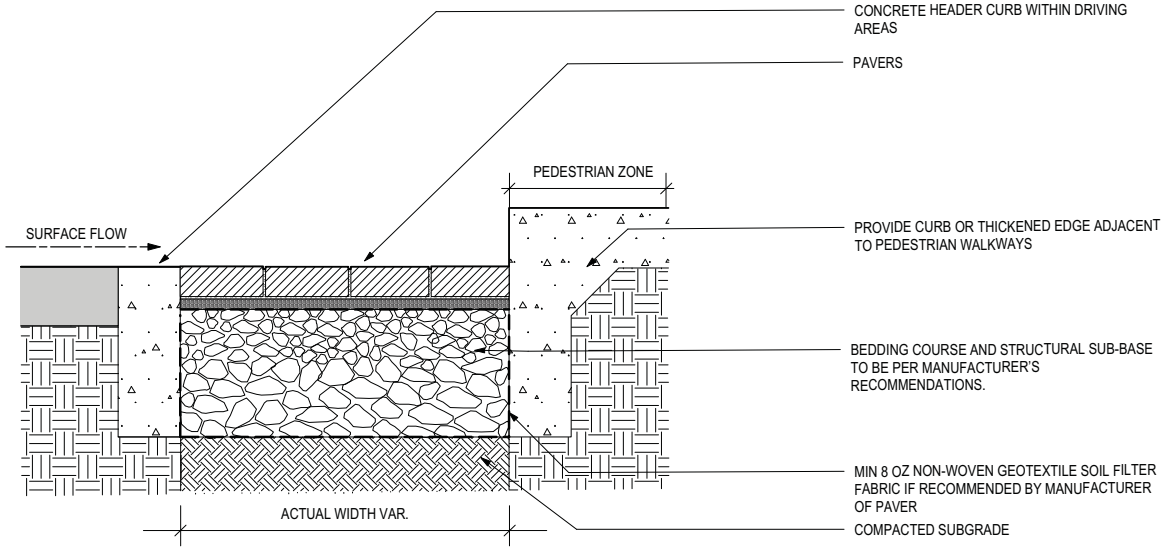
CONSTRUCTION CRITERIA:

- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

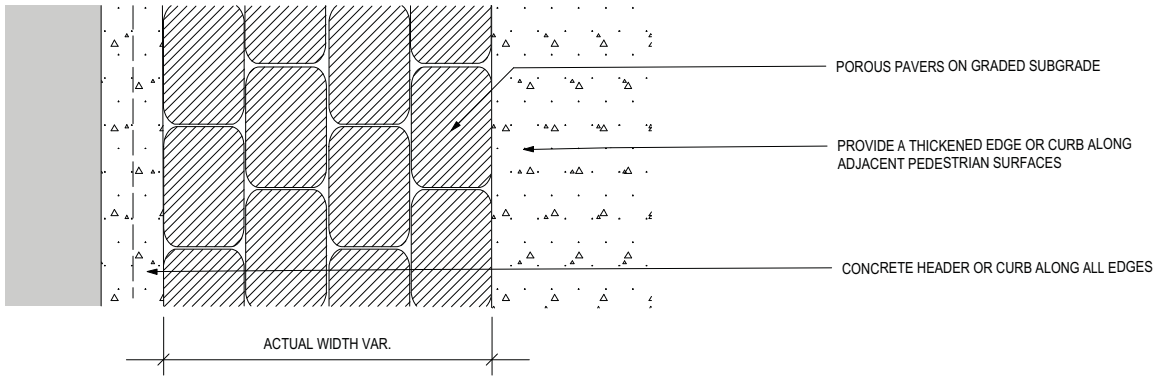
INSPECTION + MAINTENANCE:

- INSPECT FILTER MEDIA FOR PONDING IF THE MEDIA DOES NOT FULLY DRAIN AFTER 96 HOURS. INSPECT UNDERDRAIN PIPES FOR CLOGGING. IF PIPES ARE NOT CLOGGED, REPLACE THE TOP 2" OF MEDIA.
- PIPE CLEANOUTS REQUIRE ANNUAL INSPECTION FOR CLOGGING. FLUSHING MAY BE NEEDED.
- REMOVE VISIBLE SURFACE SEDIMENT, TRASH, DEBRIS AND LEAF LITTER ACCUMULATION TO PREVENT FILTER CLOGGING.
- REMOVE SEDIMENT FROM FOREBAY WHEN IT REACHES 6" DEPTH.
- INSPECT OUTLETS AND EMBANKMENTS FOR DAMAGE OR DEGRADATION.
- MEDIA FILTERS, IF ROUTINELY MAINTAINED, HAVE A SYSTEM EXPECTANCY OF 5-20 YEARS.

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:

- POROUS PAVERS ARE BEST UTILIZED IN LIGHT TRAFFIC AREAS WHERE HEAVY LOADS (TRACTOR TRAILERS/HEAVY EQUIPMENT STORAGE) ARE LIMITED.

SITING CRITERIA:

- PAVERS SHOULD NOT BE INSTALLED ON SLOPES EXCEEDING 5%.
- PAVERS SHOULD NOT BE INSTALLED IN AREAS WHERE TUFT IS LESS THAN 12" BELOW THE BOTTOM OF THE RECOMMENDED SUBBASE.
- APPROPRIATE WITHIN SNOW MELT STORAGE AREAS.

DESIGN CRITERIA:

- DESIGN PER MANUFACTURER RECOMMENDATIONS.
- A CONCRETE RESTRAINING EDGE SHOULD BE INSTALLED AROUND EDGES OF PERMEABLE PAVEMENT SYSTEMS.
- IF PERMEABLE CONCRETE PAVERS ARE USED, SELECTION CRITERIA SHOULD INCLUDE:
  - PAVERS RATED FOR TRAFFIC/WEIGHT USING THE AREA
  - MINIMUM AVERAGE COMPRESSIVE STRENGTH 0F 8000 PSI
  - SLUBBED SIDE FACES
  - CHAMFERED TOP EDGES
- OTHER PERMEABLE PAVEMENT OPTIONS INCLUDE:
  - GRAVEL SUPPORT SYSTEMS
  - PERMEABLE CONCRETE
  - PERMEABLE ASPHATIC CONCRETE

CONSTRUCTION CRITERIA:

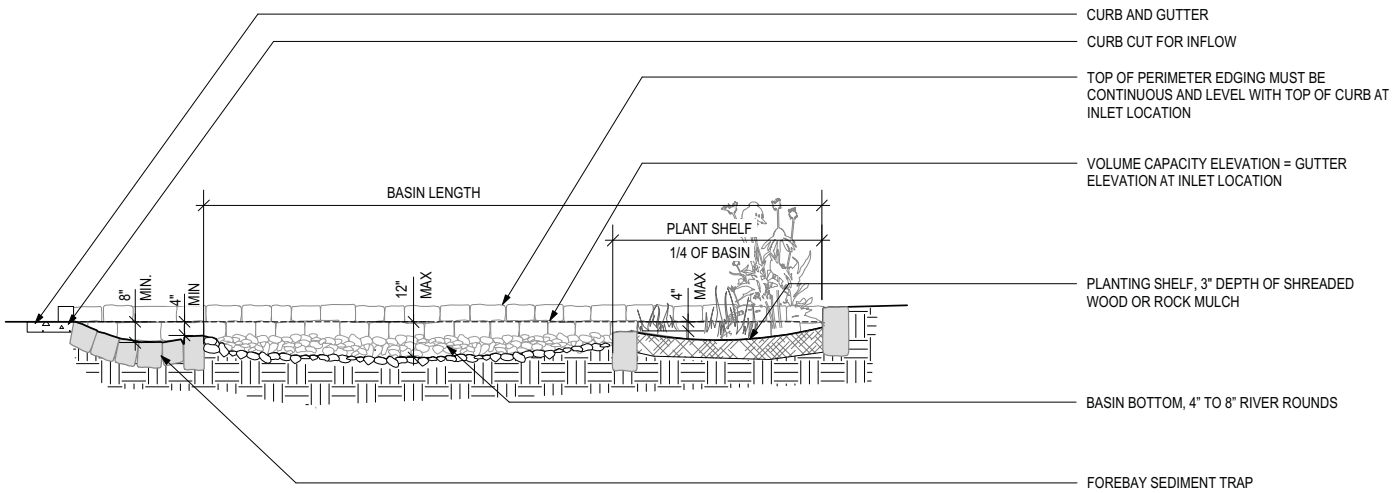
- INSTALL PER MANUFACTURER'S RECOMMENDATIONS.
- OVERCOMPACTION OF SUBSTRATES WILL ADVERSELY AFFECT PERFORMANCE.
- ENSURE SUBGRADES ARE PROPERLY INSTALLED TO PREVENT THE FINISH SURFACE FROM BECOMING UNEVEN OVER TIME.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:

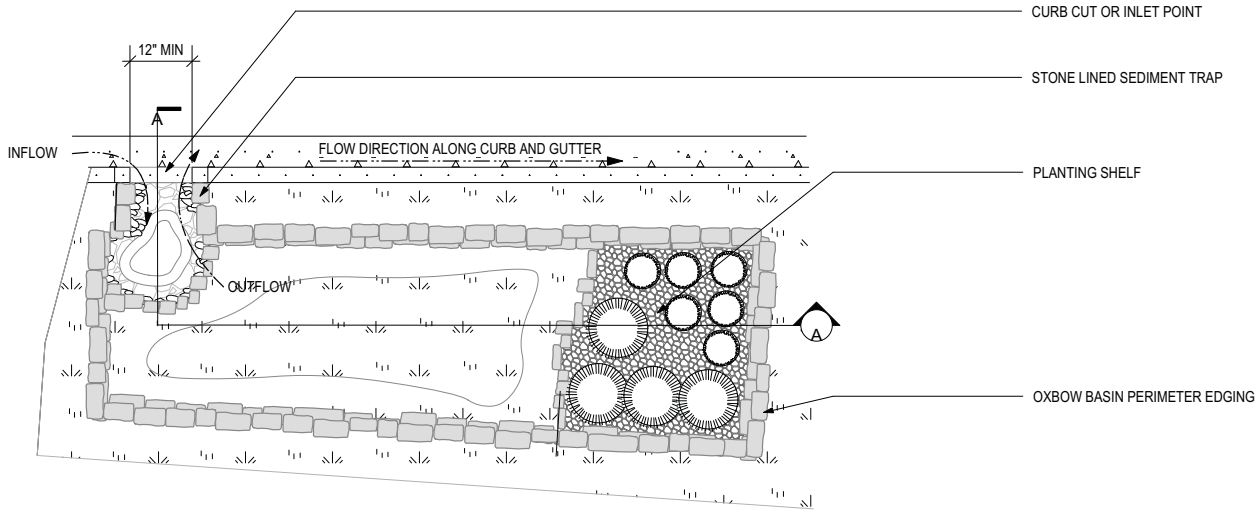
- REGULAR AND POSSIBLY SPECIALIZED MAINTENANCE MAY BE NEEDED TO ENSURE PERMEABLITY.
- PAVER SYSTEM SHOULD BE INSPECTED FREQUENTLY THE FIRST YEAR AND ANNUALLY THEREAFTER.
- REGULARLY REMOVE DEBRIS AND LITTER FROM PAVER AREA.
- DAMAGED PAVERS SHOULD BE REPLACED ANNUALLY.
- IF RUNOFF IS NOT INFILTRATING INTO THE SUBBASE, DETERMINE IF PAVERS NEED CLEANING OR SUBBASE NEEDS REPLACEMENT.

BIO-RETENTION CELL / OXBOW

SECTION



PLAN



NOTES:

DESIGN LIMITATIONS:
- EFFECTIVE IMPLEMENTATION REQUIRES RELATIVELY FLAT AREA.
- SOILS MUST SUSTAIN VEGETATION GROWTH.

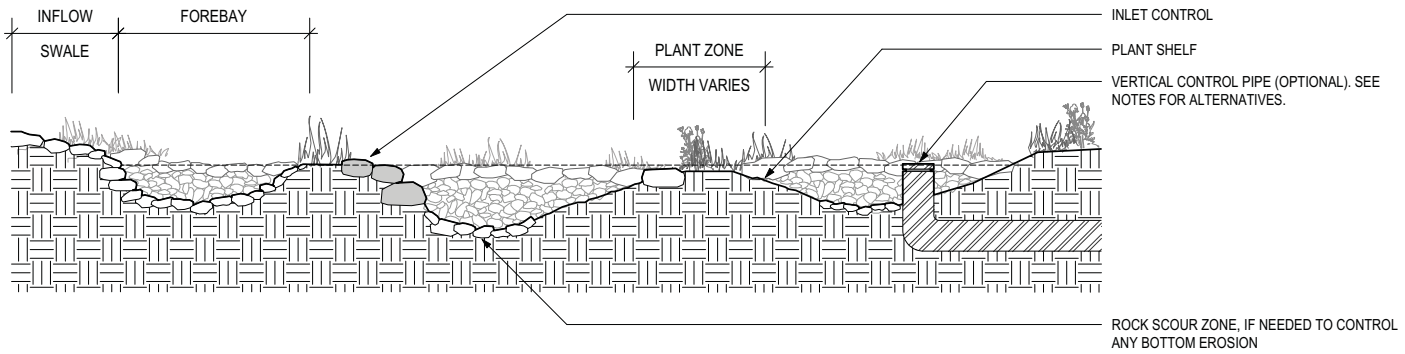
SITING CRITERIA:
- LOCATE IN AREAS TO CAPTURE RUNOFF FROM ROADWAYS AND PARKING LOTS.
- SITE IN AREAS WHERE TUFF IS AT LEAST 18" BELOW THE BOTTOM OF THE FEATURE.

DESIGN CRITERIA:
- IF INFILTRATION IS LOW (<0.5"/HR) CONSIDER PLACEMENT OF A MIN. 12" SAND LAYER UNDER BASIN.
- SEDIMENT TRAP SHALL BE SIZED TO CONTAIN 5% OF THE TOTAL OXBOW DETENTION VOLUME.
- TOP ELEVATION OF SEDIMENT TRAP INTERIOR WALL SHALL BE MINIMUM 4" BELOW GUTTER INLET ELEVATION.
- INTERIOR WALL AT PLANTING AREA SHALL BE A MAXIMUM OF 4" BELOW GUTTER INLET ELEVATION.
- PLANTING ZONE SHALL BE STABLIZED WITH 3" DEPTH OF SHREDDED WOOD OR ROCK MULCH.
- VEGETATION SHOULD BE DROUGHT TOLERANT, AND ABLE TO WITHSTAND PERIODIC INUNDATION.
- OXBOWS SHOULD BE DESIGNED TO BLEND WITH THE CONTEXT OF THE SURROUNDING LANDSCAPE.
- OXBOW EDGING MATERIALS OPTIONS IN URBAN CONDITIONS:
  - CONCRETE
  - STONE
- OXBOW EDGING MATERIALS OPTIONS IN RURAL CONDITIONS:
  - CONCRETE
  - STONE
  - BERMS

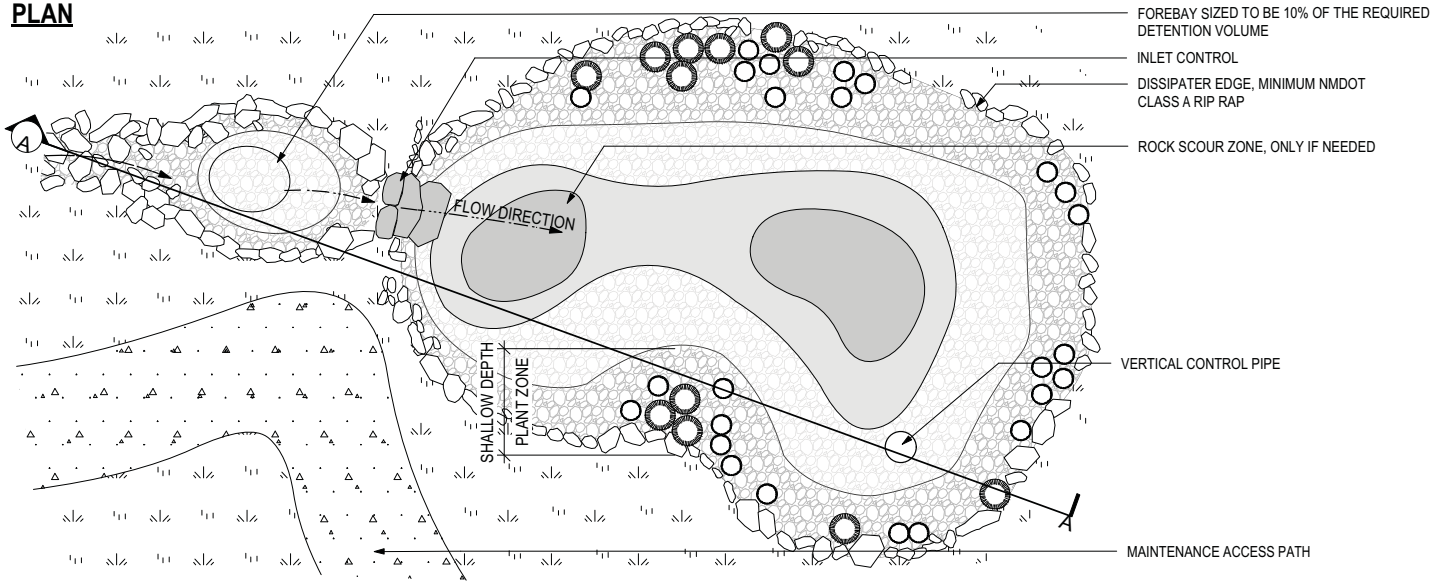
CONSTRUCTION CRITERIA:
- DO NOT OVERCOMPACT BASIN SOILS.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:
- DO NOT MOW VEGETATION WITHIN OXBOWS.
- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF STRUCTURES, DEBRIS, TRASH AND SEDIMENT ACCUMULATIONS.
- INSPECT AND REPAIR AS NEEDED TO ENSURE RUNOFF FLOWS THROUGH FULL LENGHT OF THE OXBOW.

SECTION A



PLAN



NOTES:

DESIGN LIMITATIONS:

- CONTROL BASINS CAN CREATE ZONES OF PONDING, AND MAY REQUIRE ADDITIONAL SAFTEY MEASURES.

SITING CRITERIA:

- CONTROL BASINS SHOULD BE SITED IN AREAS WITH ADEQUATE OPEN SPACE.
- CONTROL BASINS SHOULD NOT BE LOCATED ON STEEP SLOPES OR ON HIGHLY ERODIBLE SOILS.
- CONTROL BASINS CAN BE SITED TO HANDLE LARGE DRAINAGE AREAS.
- IF FILTER MEDIA IS INCORPORATED, CONTROL BASINS MAY BE SITED IN LOCATIONS WHERE WATER QUALITY IS A CONCERN.

DESIGN CRITERIA:

- BASIN GRADING SHALL BE DESIGNED TO SPREAD FLOW EVENLY ACROSS THE BASIN SURFACE.
- MAXIMUM SIDE SLOPES 3:1.
- WATER DEPTH SHOULD BE BETWEEN 18"-48".
- INCLUDE ADDITIONAL FREEBOARD IN BASIN CAPACITY DESIGN TO ACCOMMODATE SEDIMENT ACCUMULATION.
- IF INFILTRATION RATE IS LOW (<0.5"/HR) CONSIDER PLACEMENT OF A MIN. 12" SAND LAYER UNDER BASIN
- OUTLET STRUCTURE SHOULD BE DESIGNED TO PROMOTE INFILTRATION AND REDUCE OUTLET VELOCITIES TO PREDEVELOPMENT VALUES.
- OUTLET STRUCTURES ARE NOT LIMITED TO VERTICAL CONTROL PIPES AS SHOWN AND MAY INCLUDE OTHER OPTIONS (I.E. OVERFLOW WEIRS, UNDERDRAINS, ETC.).
- VERTICAL CONTROL PIPES SHALL INCLUDE TRASH RACKS.
- CONSIDER INSTALLATION OF FEATURES (I.E., STAFF GAGES) TO MEASURE AND TRACK SEDIMENT ACCUMULATION.
- VEGETATION SHOULD BE DROUGHT TOLERANT SPECIES ABLE TO WITHSTAND PERIODIC INUNDATION.

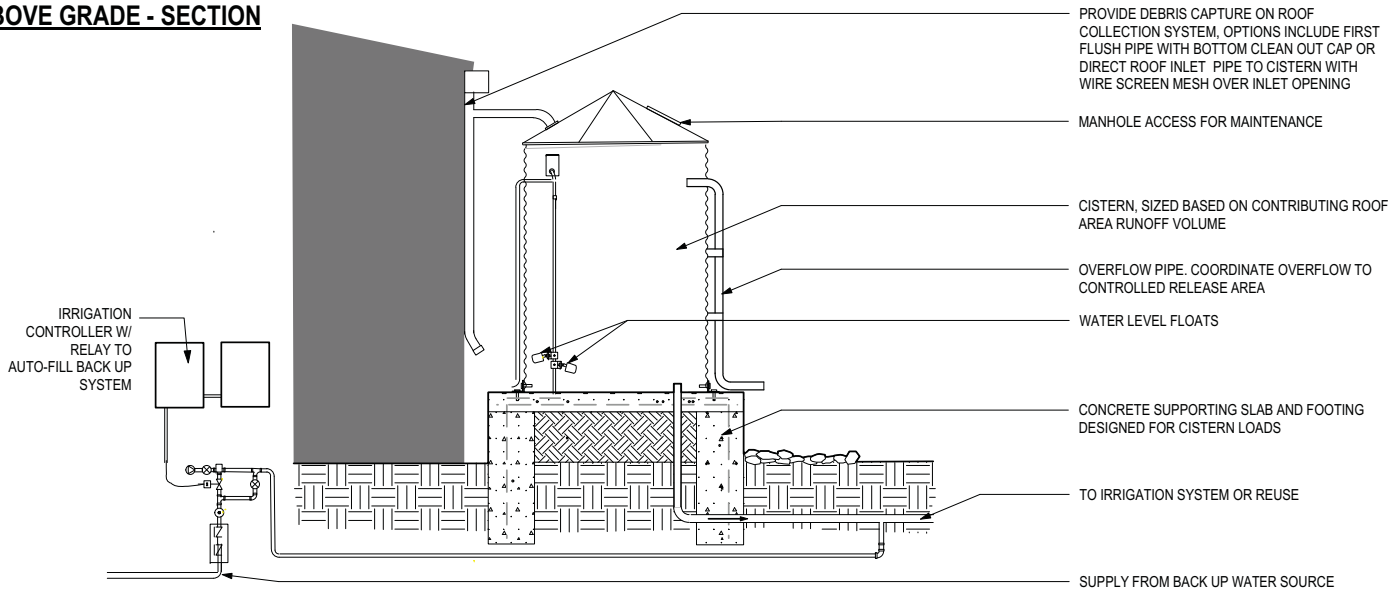
CONSTRUCTION CRITERIA:

- SOILS SHALL BE SUITABLE FOR VEGETATION GROWTH.
- ENSURE INLET AND OUTLET ELEVATIONS MATCH DESIGN SPECIFICATIONS.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

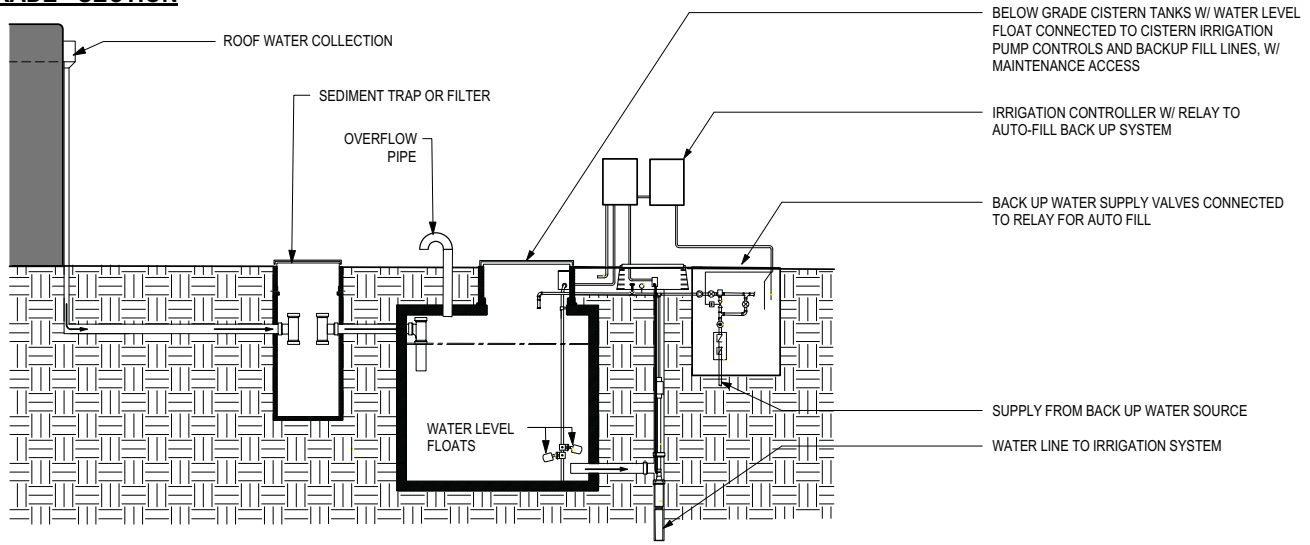
INSPECTION + MAINTENANCE:

- INSPECT AT LEAST ANNUALLY FOR ADEQUATE PERENNIAL VEGETATION COVERAGE, EROSION AND DEGRADATION OF STRUCTURES, DEBRIS, AND TRASH.
- SEDIMENTS IN BASIN SHOULD BE REMOVED WHEN MINIMUM REQUIRED DETENTION VOLUME IS COMPROMISED.
- VEGETATION ACCUMULATION SHOULD BE REMOVED EVERY 10 YEARS AT MIMIMUM.

ABOVE GRADE - SECTION



BELOW GRADE - SECTION



NOTES:

DESIGN LIMITATIONS:
- ABOVE GROUND STORAGE SYSTEMS MAY BE SUSCEPTIBLE TO FREEZING AND CRACKING DURING WINTER MONTHS.

SITING CRITERIA:
- SITE CISTERNS TO UTILIZE GRAVITY-FED PRESSURE TO OPERATE.
- AVOID PLACING VEGETATION WITH INTRUSIVE ROOTS NEAR OR ON TOP OF BELOW GRADE TANKS.
- AVOID PLACING CISTERNS ON THE NORTH SIDE OF BUILDINGS.

DESIGN CRITERIA:
- PREFABRICATED TANKS OF PLASTIC, METAL, OR CONCRETE SHOULD USED.
- THE INTERIOR OF THE STORAGE TANK SHOULD BE ACCESSIBLE FOR PERIODIC INSPECTION AND MAINTENANCE.

CONSTRUCTION CRITERIA:
- INSTALL PER MANUFACTURER SPECIFICATIONS.
- DISCHARGE OVERFLOW TO CONTROLLED RELEASE AREA.
- IDENTIFY APPROPRIATE MATERIALS AND HOLD POINTS FOR INSPECTION AND APPROVAL DURING CONSTRUCTION.
- PROVIDE ACCESS FOR MAINTENANCE.

INSPECTION + MAINTENANCE:
- REMOVE LEAVES AND OTHER DEBRIS FROM GUTTERS, INFLOW AND OUTFLOW PIPES, AND "FIRST FLUSH PIPES" OR FILTERS PRIOR TO BOTH WINTER AND SUMMER.
- CLEAN AND TEST SYSTEM AT THE BEGINING OF SPRING TO ENSURE THAT THE SYSTEM IS WORKING PROPERLY.
- INSPECT WATER TANKS AT LEAST ANNUALLY FOR FUNCTIONALLITY, DEGRADATION, AND REQUIRED MAINTENANCE. CAP AND LOCK TANKS FOR SAFETY.

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