• 2012: Public and private partners engage state legislature to fund program

• June 2012: LID Training Steering Committee

• 2012-2013: Washington State LID Training Plan developed: [www.wastormwatercenter.org/statewide-lid-training-program-plan](http://www.wastormwatercenter.org/statewide-lid-training-program-plan)

• Training program built from state LID Training Plan.
Statewide LID Training Program

OVERVIEW OF PROGRAM

PROJECT LEAD

HERRERA

CORE TEAM

CASCADIA

Veda Environmental

ADDITIONAL TRAINING SUPPORT

CH2M HILL

Kindred Hydro

Leaping Frog Films

SvR Design Company

StormwaterONE
Statewide LID Training Program

OVERVIEW OF PROGRAM

- Implementation of first round of trainings (September 2014 through May 2015)
- 64 trainings offered in current phase (through June 2015)
- Three levels: Introductory, Intermediate, and Advanced
- Train the Trainer program for service providers and LID topic experts
# Statewide LID Training Program

## Overview of Program

### Introductory

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction to LID for Eastern Washington</td>
</tr>
<tr>
<td>2.1</td>
<td>Introduction to LID for Inspection &amp; Maintenance Staff</td>
</tr>
<tr>
<td>2.2</td>
<td>Introduction to LID for Developers &amp; Contractors: Make Money be Green</td>
</tr>
</tbody>
</table>

### Intermediate

<table>
<thead>
<tr>
<th>Module</th>
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<tbody>
<tr>
<td>3.1</td>
<td>Intermediate LID Topics: NPDES Phase I &amp; II Requirements</td>
</tr>
<tr>
<td>3.2</td>
<td>Intermediate LID Design: Bioretention</td>
</tr>
<tr>
<td>3.3</td>
<td>Intermediate LID Design: Permeable Pavement</td>
</tr>
<tr>
<td>3.4</td>
<td>Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
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<td>Intermediate LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
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<td>Intermediate LID Design: Hydrologic Modelling</td>
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### Advanced

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<tr>
<td>5.1</td>
<td>Advanced Topics in LID Design: Bioretention</td>
</tr>
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<td>Advanced Topics in LID Design: Permeable Pavement</td>
</tr>
<tr>
<td>5.3</td>
<td>Advanced Topics for Long-term LID Operations: Bioretention</td>
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<td>Advanced Topics in LID Design: Hydrologic Modeling</td>
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<td>Advanced Topics in LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
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### Train the Trainers

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<tr>
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<td>Service Providers</td>
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<tr>
<td>9.2</td>
<td>LID Topic Experts</td>
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# Statewide LID Training Program

## TODAY’S TRAINING

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<th><strong>ADVANCED</strong></th>
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<td>2.2</td>
<td>3.3</td>
<td>5.3</td>
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<td></td>
<td>Advanced Topics in LID Design: Site Assessment, Planning &amp; Layout</td>
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## TRAIN THE TRAINERS

| 9.1              | 9.2              |
| Service Providers | LID Topic Experts |
Intermediate Site Assessment, Planning and Layout

WESTERN WASHINGTON
INSTRUCTORS

JASON KING, RLA
ASLA LEED AP
Senior Landscape Architect
Key project experience: Stormwater design for development, site design, green roofs, stormwater art, ecological planning

CHRIS WEBB, PE
LEED FELLOW
Associate Engineer
Key project experience: permeable pavement, bioretention, rainwater harvesting
AGENDA

1. introduction and regulations
2. principles of LID site design
3. LID site design process
4. site assessment and layout
5. site planning and infrastructure
6. trees
7. exercises
8. wrap up
AGENDA

1. introduction and regulations
2. principles of LID site design
3. LID site design process
4. site assessment and layout
5. site planning and infrastructure
6. trees
7. exercises
8. wrap up
LEARNING OBJECTIVES

1. Participants gain an intermediate level understanding of overall site assessment with particular attention to infiltration capability of soils for roadway, lot and open space layout within the LID context.

2. Participants gain an intermediate level understanding of appropriate layout for roadway, lot and open space to protect site hydrology and create livable and attractive developments.

3. Participants will gain an intermediate level understanding of techniques to protect native soil and vegetation during site development.
LOGISTICS

SCHEDULE

• 8-hour training with two breaks
• Lunch on your own
• Sign in and sign out

OTHER LOGISTICS

• Restroom location
• Food
• Turn off cell phones
• Q&A at end of each section
LID Principles: Pre-developed forest
LID Principles: Developed condition

2012 LID Technical Guidance Manual for Puget Sound
LOW IMPACT DEVELOPMENT (LID): Stormwater Management Strategy

- **Site design & planning techniques** emphasizing conservation

- **Use of small-scale & distributed** engineered controls to closely mimic pre-development hydrologic processes

- Minimizing the concentration of stormwater

- Careful assessment of site soils and strategic site planning to best use those soils for stormwater management
LID Principles: Site Design And Planning

- Minimize disturbance
- Reduce impervious surface
- Protect and restore native soils and vegetation
- Manage stormwater close to the source in a system of distributed practices
- Disconnect impervious surfaces

**Traditional**

**LID**
LID BMPs: Small-Scale Engineering Controls

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Synonyms for LID BMPs:

Green Stormwater Infrastructure (GSI), Integrated Management Practices (IMPs), and On-Site Stormwater Management BMPs
INTRODUCTION & REGULATIONS

Western WA NPDES Permit

National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits (2013-2018 permit cycle)

<table>
<thead>
<tr>
<th>Municipal Stormwater Permittees in Washington State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1 Permittees</strong></td>
</tr>
<tr>
<td>Seattle</td>
</tr>
<tr>
<td>Tacoma</td>
</tr>
<tr>
<td>Clark County</td>
</tr>
<tr>
<td>King County</td>
</tr>
<tr>
<td>Pierce County</td>
</tr>
<tr>
<td>Snohomish County</td>
</tr>
<tr>
<td>82 Cities</td>
</tr>
<tr>
<td>5 Counties</td>
</tr>
<tr>
<td>18 Cities</td>
</tr>
<tr>
<td>5 Counties</td>
</tr>
</tbody>
</table>

**Secondary Permittees:** Approximately 45; such as ports and universities

To see a listing of permittees visit [http://www.ecy.wa.gov/programs/wq/stormwater/municipal/MuniStrmWtrPermList.html](http://www.ecy.wa.gov/programs/wq/stormwater/municipal/MuniStrmWtrPermList.html)
Review and revise development related codes, rules & standards (i.e. adopt the 2012 Stormwater Manual)

Timeline for updating local codes

**Phase I**
- Per Section S5.C.5.b of the Phase I Permit
- June 30, 2014
- June 30, 2015

**Phase II**
- Per Section S5.C.4 of the Phase II Permit
- Dec. 31, 2016*
- June 30, 2017
- June 30, 2018

Most Permitees, Lewis Co. and Cowlitz Co., City of Aberdeen

* = Or GMA update deadline
### Subset of On-site Stormwater Management BMPs used to meet MR #6 or MR #7 (may also be used to meet MR #5)

<table>
<thead>
<tr>
<th>Onsite SW Management BMP</th>
<th>Flow Control Credit</th>
<th>Treatment Credit¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Amendment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dispersion</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Retaining &amp; Planting Trees</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rainwater Harvesting</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bioretention²</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Permeable Pavement³</td>
<td>X</td>
<td>X²</td>
</tr>
<tr>
<td>Vegetated Roofs ³</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

¹ Meets basic, enhanced and phosphorus treatment when infiltrating through soil per Ecology treatment requirements

² Where permeable pavement is over soils meeting the suitability criteria or a treatment layer is included

³ Also considered SW Treatment & Flow Control BMPs/Facilities (additional requirements in regard to long term inspection, operations, and maintenance apply)
AGENDA

1. Introduction and regulations
2. Principles of LID site design
3. LID site design process
4. Site assessment and layout
5. Site planning and infrastructure
6. Trees
7. Exercises
8. Wrap up
The typical construction approach is to strip, cut, fill and pound.

PRINCIPLES OF LID SITE DESIGN: Conventional Site Development Practices and Impacts
PRINCIPLES OF LID SITE DESIGN: Conventional Site Development Practices and Impacts

- Compaction can extend 24”+ with heavy loads on wet soils.
- Compaction usually in top 6-8 inches of soil for tractors weighing less than 10 tons/axle.
- Track vs tires inflated to higher pressures...compaction appears to increase with increased tire pressure.

U of Missouri and Minnesota Extension
Management of large clearing and grading operations is expensive and time consuming.
PRINCIPLES OF LID SITE DESIGN: Conventional Site Development Practices and Impacts

• Stream biota significantly reduced at SS levels of 50-80 mg/L (Corish 1995).

• Schueler reported median TSS concentrations of 4,145 mg/L leaving construction sites with no TESC and 283 mg/L with TESC.
PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation
PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

- 23.92 acres
- 103 Lots (4,143 sq ft ave.)
- 15 acres (63%) Open space
- Effective impervious area approaching 0%

Statewide LID Training Program

INTERMEDIATE SITE ASSESSMENT, PLANNING AND LAYOUT
Hydrologic modeling comparing a conventional development and the flow reduction benefits from individual practices for a low impact development design.

### PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

<table>
<thead>
<tr>
<th></th>
<th>Detention storage reduced (ft$^3$)</th>
<th>Detention storage required (ft$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional development</td>
<td></td>
<td>270,000</td>
</tr>
<tr>
<td>Low impact development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- reduce development envelope</td>
<td></td>
<td>-149,019</td>
</tr>
<tr>
<td>- and use bioretention</td>
<td></td>
<td>-40,061</td>
</tr>
<tr>
<td>- and use minimal excavation foundation</td>
<td></td>
<td>-7,432</td>
</tr>
<tr>
<td>- and use 20’ wide permeable road</td>
<td></td>
<td>-29,988</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>-226,500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43,500</td>
</tr>
</tbody>
</table>
PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

BMP T5.30 Full Dispersion
• 65/10/0.
• Sliding dispersion scale.
PRINCIPLES OF LID SITE DESIGN: Urban Development and Small Lots

Possible but challenging to conserve and protect native soils and vegetation in dense development settings

Danielson Grove/Triad and Associates
It takes a village...and fines to protect trees and soil.

- Contractor training
- Bonding/fines
- Signage
• Conventional street design increases drainage network and efficiency.
• Local street right of ways can constitute over 25 percent of the typical urban watershed.
• Streams with buffers constitute about 10 percent of this sample watershed.
PRINCIPLES OF LID SITE DESIGN: Road Networks

Street layout with 23 stream crossings
No local street crossings of stream corridors

Street layout with 63 stream crossings
Extend Metro street spacing standard
across stream corridors (maximum of 520 ft.)
PRINCIPLES OF LID SITE DESIGN: Scale of Analysis

- Home
- Planned Development
- Community
- Watershed
- County/City
- Region
PRINCIPLES OF LID SITE DESIGN: Regional Planning

Avoid open-space fragmentation

15,000 sq. ft. lots

5,000 sq. ft. lots
PRINCIPLES OF LID SITE DESIGN: Regional Planning

Project vs. regional clustering

Project by project cluster development

Regional cluster development
PRINCIPLES OF LID SITE DESIGN: Regional Planning

Project vs. regional clustering

Arterials
PRINCIPLES OF LID SITE DESIGN: Small Contributing Areas
AGENDA

- Introduction and regulations
- Principles of LID site design
- LID site design process
- Site assessment and layout
- Site planning and infrastructure
- Trees
- Exercises
- Wrap up
LID SITE DESIGN PROCESS: Overview

1. Project baseline/charter
2. Develop basis of design
3. Develop team and engage stakeholders
4. Site inventory and analysis
5. Site assessment and develop Site Plan
LID SITE DESIGN PROCESS: Project Baseline/Charter

- Project Scope
- Project Schedule
  - Construction
  - Plant Establishment
- Construction Budget
- Jurisdiction and Code Requirements
- Sustainability Goals defined
- Maintenance Capabilities
LID SITE DESIGN PROCESS: Develop Basis of Design

• Project Background
  • Specification and drawing format
  • Sustainability requirements
  • Property restrictions and easements
  • Permitting and point of compliance

• Site Civil
  • Frontage and Right-of-Way requirements
  • Civil grading criteria
  • Utility criteria

• Landscape Design Criteria
  • Existing tree preservation
  • Buffers
LID SITE DESIGN PROCESS: Develop Team and Engage Stakeholders

- Owner/Developer
- Public agency reviewers
  - Land use Planners/Zoning
  - Transportation
  - Utility department
  - Stormwater Management
  - Other
- Architect
- Civil Engineer
- Surveyor
- Landscape Architect
- Geotechnical Engineer
- Wetland/Biologist
- Arborist
- Outreach
- Community stakeholders
- Fire & Police Department
- Owner’s contractor
- Funding partners
- Maintenance staff
- Other?
Gather existing analysis, inventories, and historic information:
  • Soil surveys and analyses
  • Historic records of altering wetlands/stream channels
  • Aerial photos
  • Maps and site reconnaissance to verify topography
  • Location of groundwater protection areas and/or well head protection zones
  • Descriptions of local site geology

Site reconnaissance and characterization
  • Characterize hydrologic, geologic and biologic conditions
  • Used to inform overall design and location of infrastructure
  • Investigate steep slopes and landslide hazards near project site
LID SITE DESIGN PROCESS: Stormwater Site Plan

NPDES Permit Minimum Requirement #1 Preparation of Stormwater Site Plans:

- Use site-appropriate development principles to retain native vegetation and minimize impervious surfaces to the extent feasible.
- Local codes will change to incorporate certain LID principles.
- Prepare a Stormwater Site Plan for local government review
LID SITE DESIGN PROCESS: Stormwater Site Plan

Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance
LID SITE DESIGN PROCESS: Stormwater Site Plan

1. Site Analysis: Collect and Analyze Information on Existing Conditions (Volume 1, Section 3.3.1)

- Survey
- Soils Report
  - Professional (on-site sewage designer OK if only MR #1 - #5)
  - Surveys, test pits, borings
  - Ksat field tests or grain size analysis
  - Depth to restrictive layer – need winter data
  - Lateral flow assessment (MR #1 - #9)
  - Vegetation survey of any protected areas
LID SITE DESIGN PROCESS: Stormwater Site Plan

Site Procedures and Design Guidance for Bioretention/Rain Garden (Volume 3, Section 3.4)

- Small Commercial: one small-scale PIT
- Large Commercial: small-scale PIT every 5,000 sq. ft.
- Residential: small-scale PIT at each potential site
  - Per 200 feet for long, narrow layout; e.g. road ROW
  - Groundwater thru wet season – adequate clearance?
- Correction factor for native soils: $CF_v = 0.33$ to 1
- WWHM guidance
- Legal Documentation
LID SITE DESIGN PROCESS: Stormwater Site Plan

Stormwater – related Site Procedures and Design Guidance for Permeable Pavement (Volume 3, Section 3.4)

• Sites where only MR 1 – 5 apply:
  • Infiltration test per 5,000 sq. ft./wet season ground water

• Commercial sites where MR 1 – 9 apply:
  • Small-scale PIT per 5000 sq. ft.; at least 1 per site

• Residential sites where MR 1 – 9 apply
  • Small-scale PIT per 200 ft of road & every lot
  • Criteria for reduction of test frequency
  • Groundwater thru wet season
LID SITE DESIGN PROCESS: Stormwater Site Plan

Stormwater – related Site Procedures and Design Guidance for Permeable Pavement (Volume 3, Section 3.4)

- Assignment of Infiltration Correction Factors
- Soil Suitability Confirmation
- Project Submission Requirements
- WWHM Modeling
- Legal Documentation
Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance
LID SITE DESIGN PROCESS: Stormwater Site Plan

5. Permanent Stormwater Control Plan (Volume 1, Section 3.1.5)

- Site Hydrology for Projects under MR #1 – #5:
  - Drawings for location of all On-site SW BMPs & drainage areas
  - Design details, figures, maintenance instructions (recordable documents)
  - Justification for infeasibility decisions, OR
  - Demo compliance with LID Performance Standard if applicable
LID SITE DESIGN PROCESS: Stormwater Site Plan

5. Permanent Stormwater Control Plan (Volume 1, Section 3.1.5)

- Site Hydrology for Projects under MR #1-#9:
  - Summary
  - Performance Standards, Treatment, Lists
  - LID Features
  - Flow Control System (MR #7)
  - Water Quality System (MR #6)
  - Conveyance System
LID SITE DESIGN PROCESS: Stormwater Site Plan

Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance
LID SITE DESIGN PROCESS: Stormwater Site Plan

7. Complete Stormwater Site Plan (Volume 1, Section 3.1.7)

- O&M manuals for all “stormwater treatment and flow control facilities”
  - Includes bioretention, permeable pavement, & vegetated roofs that help meet MR #6 or #7.
- Declaration of Covenant & Grant of Easement
  - For all stormwater treatment & flow control facilities
  - For all other on-site stormwater management BMPs
  - Signed & recorded for each lot
LID SITE DESIGN PROCESS: Stormwater Site Plan

7. Complete Stormwater Site Plan (Volume 1, Section 3.1.7)

- Track lot obligations
- Plat/short plat approvals
- Deed info & restrictions
  - Covenant & Easement
  - Drawings, design details, maintenance instructions
  - Impervious/pervious requirements
AGENDA

1. Introduction and regulations
2. Principles of LID site design
3. LID site design process
4. Site assessment and layout
5. Site planning and infrastructure
6. Trees
7. Exercises
8. Wrap up
SITE ASSESSMENT AND LAYOUT

Use site analysis to guide site planning, reducing environmental impacts and achieve LID design objectives.
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Four general objectives:

- Minimize disturbance
- Locate lots for dispersing stormwater to open space areas
- Orient lots to maximize on-lot infiltration or open conveyance
- Locate lots adjacent to, or with views or, open space
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Prevalent Strategies:

• Cluster homes
• Narrow lot frontages to reduce road length per home
• Reduce front yard setbacks to reduce driveway length
• For grid or modified grid layouts, lengthen street blocks to reduce the number of cross streets and overall road network per home
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Large lot yield plan

2012 LID Technical Guidance Manual for Puget Sound
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Rural cluster

• 30% reduction in impervious surface when lot size reduced from 1.4 to 0.25 acres (MD Office of Planning).

• Increase in road network and driveways primary driver for impervious increase.
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Increase density, create appropriate building heights and scale, and conserve open space with strategic design.
SITE ASSESSMENT AND LAYOUT: Road Layout

Typical grid road layout

- Impervious coverage: 27-36%
- Less adaptive to site features.
- Promotes transit and connectivity with more direct access to services.
SITE ASSESSMENT AND LAYOUT: Road Layout

Typical curvilinear road layout

• Impervious coverage: 15-29%
• More adaptive to site features.
• Generally discourages transit with longer, less connected system.
SITE ASSESSMENT AND LAYOUT: Road Layout

Hybrid or LID road layout

- Impervious coverage: similar percentage to other layouts.
- Adaptive to site features and uses site features (particularly water as an organizing theme).
- Can provide good connectivity and fire and safety access.
SITE ASSESSMENT AND LAYOUT: Road Layout

Road width and turnarounds
SITE ASSESSMENT AND LAYOUT: Road Layout

• Design to enhance street landscape and buffer pedestrians and homes from roadway
SITE ASSESSMENT AND LAYOUT: Buildings

- Reduce building footprint (build up)
- Orient the long axis of the building along topographic contours to reduce cutting and filling
- Control roof runoff onsite
- Use low impact foundations
- Limit clearing and grading to road, utility, building pad, landscape areas
SITE ASSESSMENT AND LAYOUT: Open Space

- Preserve open space through clustering, building design, site planning
SITE ASSESSMENT AND LAYOUT: Costs and Benefits

- Reduce O&M costs
- Reduce in storm drainage infrastructure
- Reduce paving

Triple Bottom Line Benefits:
- Jobs and economic benefits
- Community livability and neighborhood vitality
- Sustainable product life cycle
- Energy impact and production
- Eco-system benefits
- Agriculture and food production
- Innovations and new market development
Q&A
introduction and regulations

principles of LID site design

LID site design process

site assessment and layout

site planning and infrastructure

trees

exercises

wrap up
SITE PLANNING AND INFRASTRUCTURE:

Zoning

• Comprehensive Plan goals and policies

• Zoning code
  • Landscaping, Native Vegetation, Tree Protection, and Open Space
  • Impervious Surface Standards
  • Bulk and Dimensional Standards
  • Site Plan Review
  • Parking

• Development Code and Standards
  • Clearing and Grading Standards
  • Engineering and Street Standards
SITE PLANNING AND INFRASTRUCTURE: Small Lots

- Small lots often require:
  - Flexible code
  - Narrow side and front yard setbacks...consider fire and safety (sprinklers, fireproof siding)
  - Effective use of open space and lot layout
SITE PLANNING AND INFRASTRUCTURE:
Small Lots
SITE PLANNING AND INFRASTRUCTURE:
Small Lots

Statewide LID Training Program

INTERMEDIATE SITE ASSESSMENT, PLANNING AND LAYOUT
SITE PLANNING AND INFRASTRUCTURE: Stormwater

- **Strategic Stormwater Management**
  - Reduce TIA and eliminate EIA where possible
  - Increase infiltration
  - Combined stormwater treatment and open space/landscaping
SITE PLANNING AND INFRASTRUCTURE: Utilities

- Place water and sewer lines in disturbed areas
- Cluster water meters to minimize construction disturbance
- Cluster dry utilities under proposed sidewalks in joint trenches
SITE PLANNING AND INFRASTRUCTURE:
Utilities
SITE PLANNING AND INFRASTRUCTURE: Circulation Layout

- Integrate pedestrian with storm where possible
- Layout pedestrian to access open space
- Fire and safety!
SITE PLANNING AND INFRASTRUCTURE: Integrating Open Space

• Create open space areas as community amenity and to store and slow stormwater flows during winter when the areas are less active recreationally

• Integrate open space into traffic calming designs

• Use open space to break up visual landscape for homes facing the road/each other

• Create open space pathways between homes (green streets)

Danielson Grove
SITE PLANNING AND INFRASTRUCTURE: Case Study

St. Thomas School, Media, WA

Site Planning: limit impermeable surface, open space, retained existing trees and soils, reduction in infiltration

- Stormwater management: reduction of impervious surfaces, amended top soil, bioretention, permeable pavement
- Construction: shared infrastructure facilities, adjustments to permeable pavement spec
SITE PLANNING AND INFRASTRUCTURE: Case Study

St. Thomas School, Media, WA

- Stormwater management: reduction of impervious surfaces, amended top soil, bioretention, permeable pavement
SITE PLANNING AND INFRASTRUCTURE:
Case Study

St. Thomas School, Media, WA

- Construction: shared TESC and WQ Treatment facilities, testing permeable pavement, reduce impacts on existing trees
introduction and regulations

principles of LID site design

LID site design process

site assessment and layout

site planning and infrastructure

trees

exercises

wrap up
TREES: Integrating Stormwater Management

Multiple benefits

- Energy conservation
- Air quality
- Carbon sequestration
- Aesthetics and increased property value
- Stormwater flow reduction
TREES: Integrating Stormwater Management

- Trees may be used for stormwater management through careful assessment of subgrade soils, groundwater levels, and site drainage patterns
- Volume of storage for stormwater dependent on volume and type of soil
- Preventing compaction and increasing volume of soil increases volume for stormwater storage

LID retrofit in New Jersey Streetscape includes street trees
TREES: Integrating Stormwater Management

Stormwater concepts:

1. Larger mature trees provide more stormwater benefits than small trees
2. Evergreen trees provide more stormwater benefits than deciduous trees
3. Adequate soil volume and quality are critical for healthy long-lived trees
4. Proper drainage design is critical...too much water can kill a tree faster than too little
TREES: Integrating Stormwater Management

Site Assessment:

- Available above ground growing space
- Overhead wires and other utilities
- Vehicle and pedestrian sight lines
TREES: Integrating Stormwater Management

Considerations for location and type of tree (cont’d):

- Below ground root space and ground level planting
  - Proximity to paved areas, utilities, and underground structures

- General:
  - Availability of soil and water
  - Prevailing wind direction and sun exposure
  - Maintenance
  - Shade, windbreak, privacy screening, air quality….

Sunset Maple uprooting sidewalk along 34th Ave (Madrona) Seattle, WA

Increased tree pit size
TREES: Integrating Stormwater Management

Guidelines for tree placement and Protection

• Plant in the best/appropriate places with highest quality soils and adequate soil volume
• Design for larger growing spaces
• Do not restrict trunk flare of mature tree
• Use pervious pavement for hard surfaces around trees
• Protect the tree from surrounding activities
• Drainage
TREES: Integrating Stormwater Management

Drainage

• If not directing flow to tree area and seasonally high GW below tree pit subgrade then likely no under-drain needed.

• If directing flow to tree area careful consideration of soils, tree species and under-drain.

• Generally planting pit above rooting zone (18-24 in.) should drain down within 48hrs.

• If under-drains used, incorporate an accessible control structure if possible.

• SilvaCell has GULD for WA.

SilvaCell installation, Edmonds, WA
TREES: Integrating Stormwater Management

Reducing soil compaction

• Clearly mark protection areas, soil storage/staging areas, existing tree protection areas on plans and site

• Review plans and coordinate throughout construction with construction foreman and crew

• Robust fencing and signage declaring protection objectives and penalties to violating protection areas

• If access unavoidable:
  • Foot access: 6 inch layer of arborist wood chip mulch (AWC) and water
  • Vehicle access: 1 inch steel plate or 4 inch thick timber plank over 2-3 inches of AWC (min of ¾ inch plywood over 6-8 inches of mulch)
TREES: Construction Impacts

Reducing compaction (long-term)

1. New Trees
   • Mulch tree planting bed with 2-4” of AWC. Keep chips 1’ back from trunk. Replenish 1-3 years
   • Barriers
     • Wheel stops.
     • Low fences.
     • Curbs.

2. Existing trees
   • Mechanical
   • Soil amendments (compost and other biological products)
TREES: Tree Protection Zone

Tree Protection Zone (TPZ)
- Area (radial distance) based on the radial distance m/ft
- Identified by a certified arborist
- Protect during development

Determining the Tree Protection Zone

To calculate the optimum tree protection zone (see Table 11-1):
1. Evaluate the species tolerance of the tree: good, moderate, or poor.
2. Identify tree age: young, mature, overmature.
3. In Table 11-1, find the distance from the trunk that should be protected per unit of trunk diameter.
4. Multiply the distance by the trunk diameter to calculate the optimum radius for the tree protection zone.

Examples:

(Left) A 15-year-old, healthy, 33-cm (13-in.) diameter Raywood ash (Fraxinus 'Raywood') (good tolerance, young age):

\[0.06 \text{ m} \times 33 \text{ cm} = 1.98\text{-m radius tree protection zone}\]
\[0.5 \text{ ft} \times 13 \text{ in.} = 6.5\text{-ft radius tree protection zone}\]

(Right) A healthy 60-year-old, 76-cm (30-in.) diameter black walnut (Juglans hindsii) (poor tolerance, mature age):

\[0.15 \text{ m} \times 76 \text{ cm} = 11.4\text{-m radius tree protection zone}\]
\[1.25 \text{ ft} \times 30 \text{ in.} = 37.5\text{-ft radius tree protection zone}\]
TREES: Tree Protection Zone

Tree Protection Barriers

- Protection zone that covers the trees optimum rooting zone
- Use plywood, chain-link or sheet metal fence
- Fines and penalties for violating the area demarcated by the barrier (included in the contract or specifications)
- Location of the barrier determined by the certified arborist based on species tolerance, condition, and age
- Barrier placement should also account for working space
TREES: Tree Protection Zone

1. Standard scaffold poles
2. Uprights to be driven into the ground
3. Panels secured to uprights with wire ties and where necessary, standard scaffold clamps
4. Weldmesh wired to the uprights and horizontals
5. Standard clamps
6. Wire twisted and secured on inside face of fencing to avoid easy dismantling
7. Ground level
8. Approx. 0.8 m driven into the ground
# TREES: Construction Impacts

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
<th>Methods to minimize damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stripping site of organic surface soil</td>
<td>Root loss</td>
<td>• Restrict stripping of topsoil around trees</td>
</tr>
<tr>
<td>• Clearing unwanted vegetation</td>
<td>Root loss</td>
<td>• Install fences to protect trees from injury</td>
</tr>
<tr>
<td>• Demolishing existing structures</td>
<td></td>
<td>• Any woody vegetation to be removed adjacent to trees remain should be cut at ground level and not pulled out by equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Otherwise root injury to remaining trees may result</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Arborist may be needed for adjacent tree removal if crowns are intertwined</td>
</tr>
<tr>
<td>• Lowering of grade, scarifying</td>
<td>Root loss</td>
<td>• Before grading, root prune tree at edge of excavation to a depth required</td>
</tr>
<tr>
<td>• Preparing sub-grade for fill and structures</td>
<td></td>
<td>• Spoil beyond cut face can be removed by equipment sitting outside the drip line of the tree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use retaining walls with discontinuous footings to increase the distance that natural grade is maintained from trunk</td>
</tr>
</tbody>
</table>

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*Statewide LID Training Program*
# TREES: Construction Impacts

<table>
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<tr>
<th>Activity</th>
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</tr>
</thead>
</table>
| Trenching for utilities, stormwater system, drains | Root loss                   | • Avoid open trenching in rooting area  
• Tunnel under roots, if possible. If not, within root area, dig trench by hand, bridging roots greater than 1 inches / 254 mm  
• Consolidate utilities into one trench |
| Compacted surface soils                       | • Unfavorable conditions for root growth  
• Chronic stress from reduced root systems | • Fence trees to keep traffic and storage out of root area  
• Provide a storage area and traffic route/area for construction activity away from trees  
• Where traffic cannot be diverted, protect soil surface |
# TREES: Construction Impacts

<table>
<thead>
<tr>
<th>Tree diameter</th>
<th>Auger / Trenchless distance from tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9 inches</td>
<td>5 feet</td>
</tr>
<tr>
<td>10-14 inches</td>
<td>10 feet</td>
</tr>
<tr>
<td>15-19 inches</td>
<td>12 feet</td>
</tr>
<tr>
<td>over 19 inches</td>
<td>15 feet</td>
</tr>
</tbody>
</table>

![Diagram showing the minimum distance for tree protection during construction.](image)
**TREES: Integrating Stormwater Management**

- **Soil depth**
  - 30-48” extended for a 10’ radius around tree in lawn areas

- **Soil volume**
  - Recommendations vary
    - Urban: 0.38 m³ soil per 1 m² canopy projection for loam, no irrigation with 30” annual rainfall
    - Lindsey and Bussuk: 0.24 m³ per 1 m² canopy projection
  - Structural Soils require volume for structural component => less available soil
  - CU Structural Soil ™ has ~ 20% available soil
1. Rigid cell systems
   • Modular frames
   • Support high loads
   • Most volume available for soil and tree roots
2. **Structural soil**

- Crushed aggregate (typ. 0.75-1.5” fine grained soil and polymer).
- Good porosity (25-30%) and permeability (>20in/hr), load bearing. Lower soil availability (~20%).
3. **Sand-based structural soil**
   - Medium to coarse uniformly graded sand with compost
   - (2-3% by volume) and 2-4in/hr Ksat typical.
   - Typically 30” deep
   - Non-proprietary.
Soil and rooting volume strategies

4. Root paths
   • Guide roots out of confined planting areas.
   • Do not add much soil volume, but interconnect planting areas.

Figure 2.6.8. Root path detail.
1. Strip drain.
2. 4-inch-wide by 12-inch-deep trench backfill with loam topsoil. Compact sides of trench.
3. Extend strip drain 12 inches into tree opening.

Soil Volume
Tree Opening - 140 CF
Root Paths - 30 CF
170 CF
5. Root trenches
   • Increase soil and rooting volume.
   • Typically 5” wide filled with topsoil or designed mix.
   • Reinforce sidewalk to span trench.

Figure 2.6.13. Soil trench detail.
1. Loam topsoil compacted to 80 percent.
2. Slope sides of trench. Assure soil beyond trench is compacted to 95 percent.
3. Drain line.
4. Perforated water line in gravel layer.
5. Gravel base course (#57 stone).
6. Concrete paving. Thicken the concrete over the trench and for a minimum of 18 inches past the edge of the trench. Concrete reinforcing per project engineer.
TREES: Stormwater Management Performance

Interception and evaporation

• Xaio (2000)...Mediterranean climate
  • Deciduous: 15% annual precip intercepted and evaporated.
  • Evergreen: 27% annual precip intercepted and evaporated.

• Asadian (2009)...Vancouver, BC
  • Evergreens
  • Seven events, 377mm total precip.
  • Interception and evaporation ranged from 17-89%.
  • Note that 89% is high...authors speculate high rate due to increased temps in urban area.
TREES: Stormwater Management Performance

Infiltration

• Bartens (2008)
  • Black oak (course root structure) and red maple (finer root structure).
  • Both penetrated soils in containers with bulk densities of 1.3 and 1.6 g/cm³.
  • Infiltration rates were 63% higher in lower compaction soil and 153% higher in higher compaction soil compared to control with no plants.
AGENDA

1. Introduction and regulations
2. Principles of LID site design
3. LID site design process
4. Site assessment and layout
5. Site planning and infrastructure
6. Trees
7. Exercises
8. Wrap up
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OTHER COURSE OFFERINGS

INTRODUCTORY

1.0 Introduction to LID for Eastern Washington

2.1 Introduction to LID for Inspection & Maintenance Staff

2.2 Introduction to LID for Developers & Contractors: Make Money be Green

INTERMEDIATE

3.1 Intermediate LID Topics: NPDES Phase I & II Requirements

3.2 Intermediate LID Design: Bioretention

3.3 Intermediate LID Design: Permeable Pavement

3.4 Intermediate LID Design: Site Assessment, Planning & Layout

4.1 Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs

4.2 Intermediate LID Design: Hydrologic Modelling

ADVANCED

5.1 Advanced Topics in LID Design: Bioretention

5.2 Advanced Topics in LID Design: Permeable Pavement

5.3 Advanced Topics for Long-term LID Operations: Bioretention

5.4 Advanced Topics for Long-term LID Operations: Permeable Pavement

6.0 Advanced Topics in LID Design: Hydrologic Modeling

7.0 Advanced Topics in LID Design: Site Assessment, Planning & Layout

8.1 Advanced Topics in LID Design: Rainwater Collection Systems & Vegetated Roofs

8.2 Advanced Topics in LID Design: Bioretention Media

TRAIN THE TRainers

9.1 Service Providers

9.2 LID Topic Experts
Statewide LID Training Program

Low Impact Development Training Program

2014-2015 COURSE CATALOG

http://www.wastormwatercenter.org/lidswtrainingprogram/
An on-line evaluation will be sent to you within 5 days following this training.
Two certificates:

• Stay tuned for decisions on certificate
• LID Design certificate
• Long-term LID Operations certificate

Sign out!
For information on training and other resources, visit the Washington Stormwater Center website:

http://www.wastormwatercenter.org

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