APPENDIX A
LOW IMPACT DEVELOPMENT APPROACH

1.0 Introduction

Low impact development (LID) is a comprehensive approach to managing stormwater. It involves designing projects to minimize the amount of runoff generated, and then uses management techniques that utilize natural hydrologic processes to treat the stormwater and moderate the changes in stormwater volume and flow. Specifically, LID techniques enhance infiltration and rely heavily on filtration through vegetation and natural or amended soil for treatment. As much as possible these functions are spread across the landscape, with minimal concentration of the stormwater. The LID approach targets both water quality and hydrology (flow control).

For highway projects, LID is defined as stormwater management techniques within the linear right-of-way that incorporate infiltration, filtration through soil or amended soil, and vegetation. Proprietary and other devices that are confined and depend on mechanical separation or installed filters are not considered LID BMPs, though they may be the best or most appropriate treatment techniques for the situation.

2.0 Advantages and Disadvantages

LID BMPs are generally effective at treating major highway runoff pollutants. The size of conveyance facilities may be able to be smaller than if conventional treatment facilities were used because they are frequently able to promote considerable infiltration of stormwater. Routine maintenance activities are usually fairly simple since LID BMPs do not involve confined spaces, frequent replacement of filters or material, nor orifices, or other devices that can clog or fail. On the other hand, the distributed nature of LID BMPs means that routine maintenance may involve multiple stops, which can be more time consuming than servicing a single, large BMP. Also, long term maintenance requirements of some LID BMPs are not yet entirely understood.

The footprint for some LID BMPs can be large relative to conventional, consolidated stormwater management facilities. This may be counterbalanced by lower construction costs.

Conventional and LID BMPs are not mutually exclusive, and can be components of a treatment train to remove pollutants.

3.0 Elements of LID

The LID approach consists of the following elements:

Minimization: Keeping the amount of impervious area to a minimum reduces the amount of stormwater runoff generated, and therefore reduces the size and extent of management facilities. For highways, minimization is difficult to achieve to any substantial extent. Safety related design standards take precedence over reductions in runoff generation. Minimization can be achieved incidentally when realignment shortens the length of the roadway. Removal of abandoned pavement is also a minimization technique. Pervious pavement is acceptable in certain situations, but generally not for highways. See current ODOT guidance on pervious pavement.

Conservation: Unpaved ground provides water quality and hydrologic functions and can be used to manage stormwater runoff. The capability of the unpaved area depends on multiple factors including soil properties, vegetation cover, and topography. Some features, such as wetlands and forests, are very effective, while previously compacted and modified surfaces may be only slightly better than pavement. Retaining natural conditions is the important first step in LID stormwater management.

Enhancement: The existing right-of-way will not always be well suited for stormwater management due to previous manipulation, poor soils or topography, or inadequate space. Modifications such as soil amendments, reshaping, regrading and plantings can improve conditions enough to meet the stormwater management goals. These enhancements are intended to increase permeability, increase pollutant removal capability, reduce the velocity of flow of stormwater, and provide for increased filtration by vegetation.

Dispersion: Keeping stormwater spread out once it leaves the pavement minimizes flow depth and flow velocity, and increases the amount of infiltration and contact between the water and soil/organic material. Conservation and enhancement are intended to support dispersion as a stormwater management strategy. Ideally, highway runoff will sheetflow from the edge of pavement across the right-of-way and on to its natural course. In some situations, such as at the end of bridges, concentrated flow must be dispersed as much as possible.

Stormwater Control Facilities: Local conditions may preclude the use of dispersion for stormwater management, so engineered BMPs become necessary. LID engineered BMPs emphasize infiltration, filtration through media (amended soils) and, where climate allows, vegetation. Standard LID BMPs include Bioretention facilities and soil-amended vegetated swales. (biofiltration swales) These are differentiated from similar conventional BMPs mostly by size and placing. LID BMPs serve relatively short segments of highway, so they are smaller than conventional BMPs, and there may be several instead of a single large one.

4.0 LID in Project Development

Stormwater management must be a part of project development from project initiation. If it is not, a project may find itself locked into expensive to construct or maintain facilities that, in the worse case, may not meet stormwater management requirements. The project may then face delays and additional expense.

The following sequential steps are recommended for determining how stormwater will be managed on a project:

1. Incorporate project design elements that would reduce total runoff (Minimization).
2. Evaluate the ability of the post construction right-of-way to manage project runoff. If the right-of-way is not capable of completely providing adequate stormwater management, then
3. Identify enhancements of right-of-way. If the right-of-way is still not capable of completely providing adequate stormwater management, then
4. Evaluate the use of LID Structural BMPs. If additional stormwater management is still necessary, then
5. Design conventional BMPs

Projects may use LID BMPs on some segments, conventional BMPs on others, and any combination as needed to treat stormwater.

5.0 Evaluating a Project for LID Opportunities

The type, design, and extent of LID practices that can be incorporated into a project depend on both highway design elements and the characteristics of the existing and prospective right-of-way. The following are the primary considerations:

Highway Features:

- Width of roadway draining to the side of the highway: Filter strips depend on maintaining sheet flow, so the depth of stormwater as it enters the filter strip should not be deep enough to initiate concentrated flow. The ability to infiltrate a design storm also depends on the amount of water flowing across a filter strip, along with the permeability of the soil. Guidance on the ratio between road width and filter strip width, and maximum road width is discussed in Appendix B.
- Curbs and existing/proposed storm drain system: Filter strips are ruled out as a treatment option if curbing is installed to intercept and direct stormwater runoff into drainage features such as inlets and storm drain piping. Instead, localized facilities such as bioretention basins should be considered, along with off-site dispersion, swale, or proprietary facilities.

Physical Characteristics of the Right-of-way:

- Topography:
    - Steepness of the highway embankment and adjacent land: Filter strips, dispersion areas and bioswales all have optimal ranges of slope for pollutant removal performance. Excessive steepness can be compensated for to a certain extent by greater length of the facility and other modifications. Guidance on appropriate slope ranges is discussed in each BMP appendix.
    - Distance to constraining features: This is anything that limits the size and location of a treatment BMP, and includes cliffs, protected natural resources, protected cultural resources, hazmat sites, and property that is not feasible to acquire. Modification of

BMPs can, to a certain extent, compensate for inadequate space. Guidance on length or width requirements is discussed in each BMP appendix.

- Location of surface waters, including streams, lakes, and wetlands: These are a subset of constraining features. If close, they increase the value of on-site stormwater management while possibly constraining what can be done. On the other hand, lakes, ponds, and wetlands can eliminate the need for flow control BMPs (treatment before discharge is still required).

- Soils:
  - Permeability: The area required to infiltrate a design storm is dependent on soil permeability. Hydrologic class A and B soils are well suited for infiltration. C soils are poorly suited and D soils are unsuited for infiltration. For guidance in infiltration and sizing of filter strips and infiltration facilities, see Appendix B and C. Soil amendments increase the ability of the amended layer to capture and hold runoff, but increase infiltration only by providing more time for it to occur.
  - Organic and fines content: The pollutant removal capability of the soil is positively related to the amount of organic material and fines. Sandy soils, particularly hydrologic class A, offer high permeability, but may be lacking in the ability to remove pollutants. Soil amendments can adequately compensate for poor organic content. See Appendix E for guidance on amending or importing a water quality mix.

- Vegetation:
  - Density and type of shrub and overstory: Shrubs and trees, particularly evergreens, can substantially reduce the amount of stormwater runoff compared to even permeable ground covered only by grasses. Their preservation outside of the clear zone is therefore important, particularly when their part of the right-of-way drains to the storm drainage system.
  - Density and type of ground cover: Dense herbaceous ground cover slows overland flow, maintaining sheet flow and allowing for increased infiltration, and traps pollutants. Removal of pollutants seems to be most effective when the ground has 80 percent or greater cover.

- Groundwater:
  - The seasonal high groundwater table should be at least 3 feet below the bed of infiltration BMPs.
  - Infiltration BMPs should be located at least 100 feet (in Type “B” soils) to 200 feet (in Type “A” soils) away from domestic water wells. Contact the municipal drinking water well owner to determine the setback requirements. Groundwater protection areas and Wellhead Protection Zones may have special requirements.

- Geotechnical and geological hazards:
    - Unstable slopes should not receive additional water, therefore BMPs that support infiltration should not be used near these locations
    - Flood prone areas are not well suited for stormwater BMPs because the accumulated pollutants in the BMPs may be washed out, and besides the BMPs may be flooded by the very waters they are intended to protect. If there is no option other than treatment within the floodplain, vegetated BMPs should be used to stabilize accumulated sediment.

6.0 Low Impact Development Techniques

The following sub-sections provide an overview of low impact development approaches used on ODOT projects. These techniques can be implemented as a stand-alone treatment option or combined with other BMPs to meet treatment goals.

6.1 Dispersion

Description

Dispersion relies on maintaining sheet flow across vegetated and permeable ground, which maximizes stormwater contact with soil and vegetation. Only a narrow width of contiguous vegetation is needed for effective attenuation and treatment as long as runoff enters the dispersion area as sheet flow. Concentrated flow may be dispersed with a flow spreader to achieve sheet flow conditions.

Dispersion uses existing vegetation, soils, soil amendment, and topography to provide stormwater runoff treatment and some level of flow control. The pollutant-removal processes include infiltration, sorption by soils and organic material, and filtration by vegetation. Moderation and reduction of storm flows results from infiltration or retention in the soil, and to a lesser extent evapotranspiration. Dispersion areas can consist of preserved native habitat and can provide visual buffering of the roadway.

The filter strip, where runoff sheet flows from the highway pavement over vegetated shoulders, side slopes and right-of-way, is the most common form of dispersion. In cases where conditions do not allow dispersion adjacent to the highway, stormwater can be collected and conveyed to a dispersion area. Energy dissipation and flow spreaders are required at the outfall into the dispersion area.

While dense vegetation is desirable in dispersion areas, in some climates this is not possible. In those locations it is important to ensure that the soils, amended or natural, are protected from both wind and water erosion.

Applications

- Ideal for highways with wide linear, undeveloped right of way.
- Is applicable for non-roadway projects (e.g. parking lots, maintenance yards), as long as sheet flow conditions can be achieved, i.e. impervious and pervious areas graded to avoid concentrating flows.

Design Criteria

Utilize the design criteria for filter strips outlined in Appendix B to meet requirements for:

- Siting of facility
- Groundwater separation
- Soil suitability
- Facility geometry (slope, width, length)
- Water quality mix
- Planting requirements, and
- Field markers

6.2 Low Impact Development Bioretention

Description

LID bioretention areas are landscaped depressions or cells with water quality mix, grass, and/or plants adapted to the local climate. Its function is to mimic natural conditions where the soils and plants store, treat, infiltrate and slow stormwater runoff. It also has been referred to as a "rain garden" in other stormwater management design manuals.

Applications

- Treat and infiltrate stormwater runoff from building rooftops, driveways, pedestrian/bike paths, loop roads, cul-de-sacs, parking lots, and maintenance yards.
- Retrofit landscaped area or impervious areas to treat stormwater runoff.
- Can be implemented along sites with lower infiltration rates by installing an underdrain system to bypass water not able to infiltrate.

Design Criteria

Utilize the design criteria for bioretention facilities outlined in Appendix C to meet requirements for:

- Siting of facility
- Groundwater separation
- Soil suitability
- Pretreatment

- Facility geometry (side slopes, depth, volume, and freeboard)
- Berm embankments
- Maintenance access
- A bottom marker
- Water quality mix
- Planting requirements
- Field markers
- Sub surface drainage, and
- Protective treatment

6.3 Soil Amending to Establish a Water Quality Mix

Water Quality Mix is used to retain stormwater to allow for infiltration into the underlying soils and to improve pollutant removal capabilities. It is comprised of a mix of inorganic materials and organic matter.

Utilize water quality mix in dispersion areas (filter strips), biofiltration swales, bioretention facilities, and extended dry detention facilities.

See the Water Quality Mix Section in Appendix E for additional discussion and design guidance.

7.0 Design Guidelines

7.1 Adaptation for Climate

LID BMPs have traditionally incorporated vegetation as an integral component. Dry or cold climates present challenges to rapid or dense establishment or sustainability of vegetation, so BMPs dependent on dense growth may fail. The pollutant removal capability of vegetation can be replaced by the use of amended soil or compost, but poor vegetative cover will leave the soil vulnerable to erosion. Protection of the soil is therefore important. In climates where vegetation establishment is feasible but slow, temporary ground cover may be adequate. Arid region BMPs may need permanent cover, such as the placement of coarse drain rock on top of amended soil. Irrigation to ensure dense plant growth is recommended only where the vegetation will survive on its own after the establishment period.

Innovative and modified LID BMPs to meet local conditions are encouraged, but are to follow the hydraulic design deviation process (Chapter 3) so they can be tracked and evaluated for future formal design guidance.

7.2 LID in Urban Situations

Many LID approaches to stormwater management developed by other agencies have been focused on the urban and suburban environment. However, popular LID BMPs such as rain gardens and porous pavement, that are appropriate and useful on low volume and low speed roads need modification or are not realistic for high volume or high speed highways.

Space is the biggest challenge for LID techniques for urban highways. Some freeways have wide, unpaved rights-of-way, but urban highways that function as city streets are frequently bordered by buildings and pavement on all sides. Bioretention rain gardens and some proprietary systems do support the LID approach, but urban constraints will affect their design and placement. Infiltration may be precluded by the presence of adjacent buildings with basements that could be damaged by water seepage. Pedestrian movement should not be obstructed by the placement of BMPs. Bulb-outs for traffic calming can house BMPs, but they are not acceptable on high speed roads.