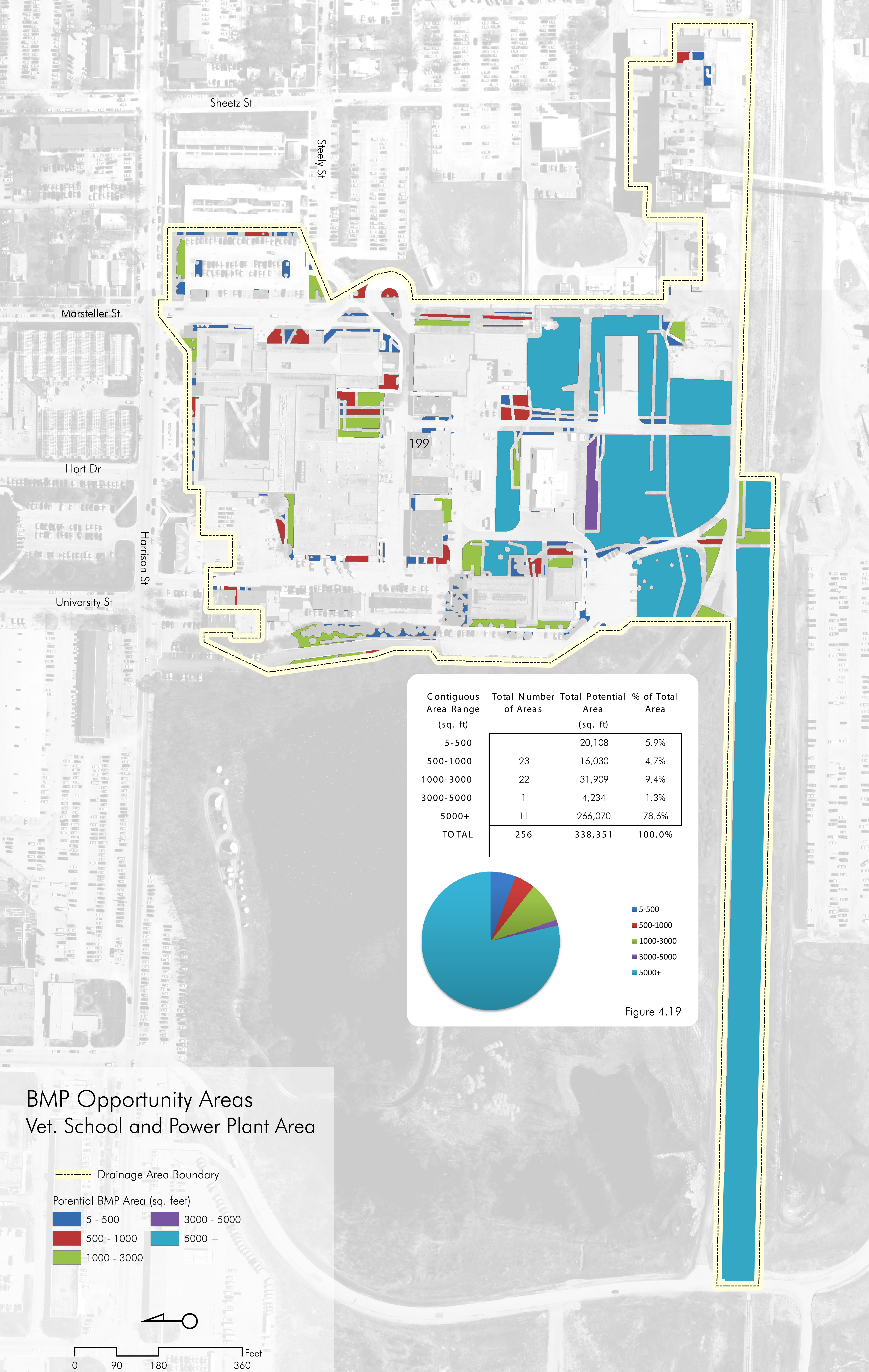


BMP Opportunity Areas
Vet. School and Power Plant Area

Drainage Area Boundary

Potential BMP Area (sq. feet)

- 5 - 500
- 500 - 1000
- 1000 - 3000
- 3000 - 5000
- 5000 +

Contiguous Area Range (sq. ft)	Total Number of Areas	Total Potential Area (sq. ft)	% of Total Area
5-500		20,108	5.9%
500-1000	23	16,030	4.7%
1000-3000	22	31,909	9.4%
3000-5000	1	4,234	1.3%
5000+	11	266,070	78.6%
TOTAL	256	338,351	100.0%

5-500
500-1000
1000-3000
3000-5000
5000+

Figure 4.19

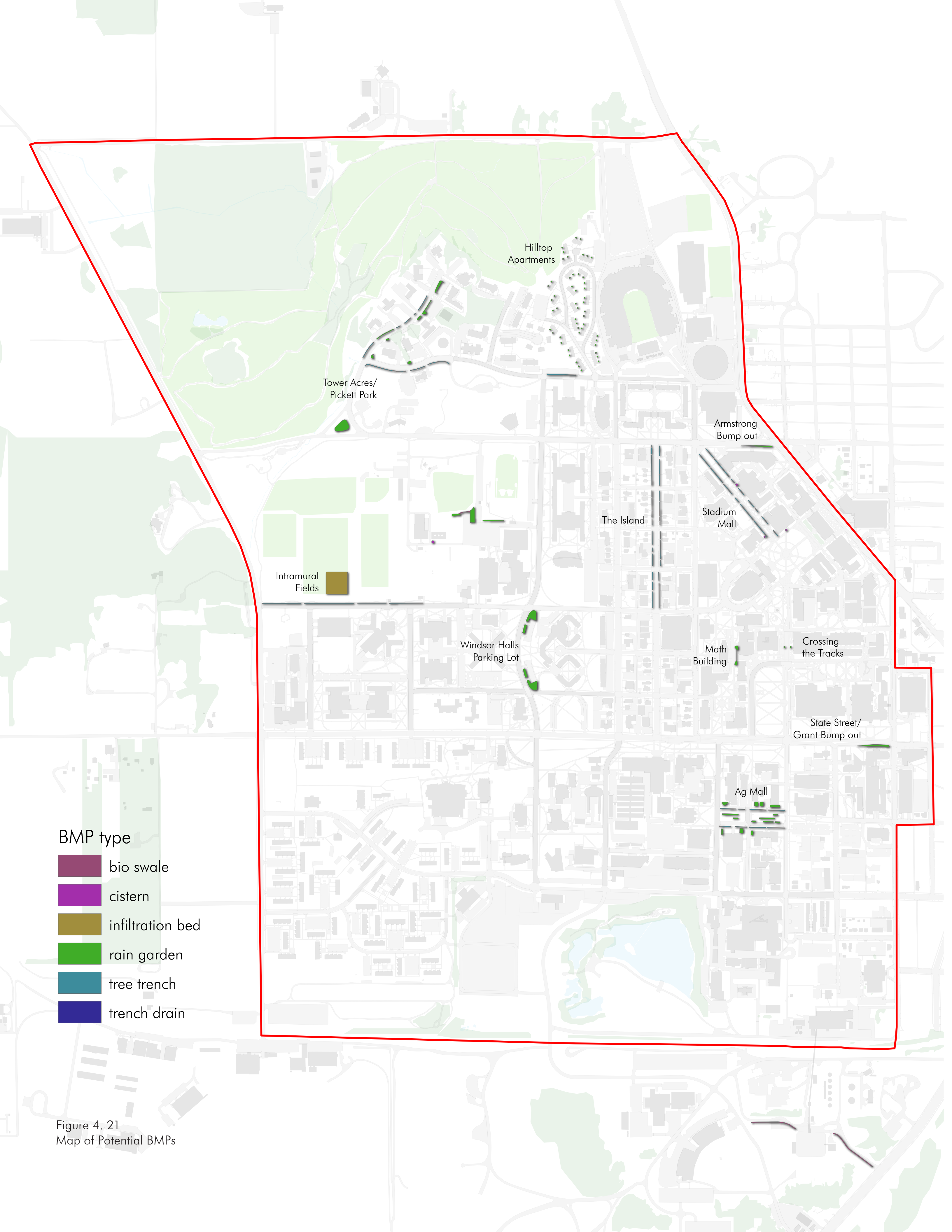


Figure 4. 21
Map of Potential BMPs

4.3 Potential BMP Types and Locations

Deciding what type of stormwater BMP to install and where is a process that involves considering the site location, area draining to the BMP, space constraints, construction costs, and maintenance needs. BMP selection also requires considering the context – a rain garden in the central part of the campus would be more formal in design, plantings, and maintenance than a bioswale at the edge of a remote parking lot.

At the beginning of the stormwater evaluation for this document, Purdue representatives identified areas of the campus that were experiencing specific stormwater problems such as flooding, surcharging, and erosion. These areas were looked at in detail during site visits and evaluated using the available GIS and mapping information. During these site visits to areas of concern on campus, other areas were noted that were not experiencing immediate stormwater problems, but that presented potential opportunities to implement effective stormwater improvements. Both the areas experiencing problems and the areas identified as potential opportunities were evaluated based on field evaluations, followed by further spatial analysis and mapping using AutoCAD and GIS. Potential BMPs are recommended for these locations based on this information (see location map - Figure 4.21). It should be noted that these BMPs are by no means limiting, it is possible that alternative or additional BMPs could be constructed in these areas. Efforts were also made to identify different types of BMPs. The specific opportunities that were noted and mapped are described briefly below, and a concept level cost (based on potential BMP size and area) is provided in Table 4.22 through 4.36. Cost include standard demolition (pavement, etc.), but do not include design and soft costs. More detailed case studies for specific areas of campus are presented in Chapter 5.

JORDAN CREEK DRAINAGE AREA

Tower Acres / Pickett Park

Large fraternity houses and parking areas create the unmitigated runoff that is contributing to the erosion problems in Pickett Park. Solutions for Pickett Park require reducing the upstream sources of runoff. Within the Tower Acres area, tree trenches and bioswales designed to capture runoff from the parking areas and streets will reduce the runoff volume. The topography is such that these measures could be implemented at a number of locations. This is discussed in detail in chapter 5 as well as mention of projects that have recently been installed in the area.

Figure 4.22
Tower Acres / Picket Park

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	15,729	3,845	$15.87	$249,619	$61,020
Tree Trench w/ Stone	5,827	3,480	$14.57	$84,899	$50,704
SubTotal				$334,519	$111,724
20% Contingency				$66,904	
Total Construction Cost				$401,422	
Estimated Design Cost				$60,213	
Total Project Cost				$461,636	

Erosion in Pickett Park

INTRAMURAL DRAINAGE AREA

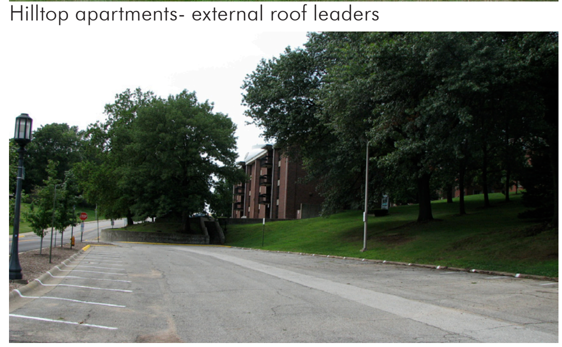
Hilltop Apartments

The Hilltop Apartments are located at the top of the Intramural Drainage Area. This is always an effective location to begin project implementation because it reduces the stormwater burden on downstream areas and infrastructure. The buildings have external roof leaders and provide an opportunity, if disconnected, to create small informal rain garden planting areas designed to receive roof runoff as well as parking and road runoff where topography allows. The large parking lot along Tower Drive is graded in a way that allows a tree trench to be created along the road to receive parking lot runoff and provide additional landscaping.

Figure 4.24
Hilltop Apartments

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	5,993	1,102	$15.87	$95,109	$17,489
Tree Trench w/ Stone	1,973	0	$14.57	$28,747	$0
SubTotal				$123,856	$17,489
20% Contingency				$24,771	
Total Construction Cost				$148,627	
Estimated Design Cost				$22,294	
Total Project Cost				$170,921	


Hilltop apartments- external roof leaders


Tower Drive parking lot

Intramural Gold Fields

An infiltration bed with pretreatment bioswales combined with tree trenches could alleviate localized flooding and improve the capacity of this area. This area is also adjacent to the existing University well field. These measures would serve to increase infiltration and groundwater recharge.

Figure 4.25
Intramural Fields

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Infiltration Bed	36,809	36,809	$11.36	$418,150	$418,150
Tree Trench w/ Stone	6,647	3,097	$14.57	$96,847	$45,123
SubTotal				$514,997	$463,274
20% Contingency				$102,999	
Total Construction Cost				$617,996	
Estimated Design Cost				$92,699	
Total Project Cost				$710,696	


Intramural Fields

Recreation Sports Center

The area adjacent to the Recreational Sports Center parking lot provides an opportunity to manage runoff from the parking lot through a series of informal bioswales and rain gardens located in the lawn areas adjacent to the parking lot (north of parking). The existing large parking area currently drains towards the north and with simple modifications to the curb line, runoff could be captured by these vegetative BMPs to increase infiltration and groundwater recharge, while reducing the burden on downstream storm infrastructure, particularly the intramural fields where existing flooding is a problem.

Figure 4.26
Recreational Sports Center

BMP Type	**Area (sq. ft.)**		**Cost/SF**	**Construction Cost**	
	Max	**Min**		**Max**	**Min**
Bio Swale	780	2,778	$8.88	$6,926	$24,669
Cistern	406	67	$11.22	$4,555	$752
Rain Garden	7,313	4,284	$15.87	$116,057	$67,987
SubTotal				$127,539	$93,407
20% Contingency				$25,508	
Total Construction Cost				$153,047	
Estimated Design Cost				$22,957	
Total Project Cost				$176,004	


Parking lot along N. Martin Jischke Drive

Windsor Halls

Currently under renovation, the parking lots adjacent to N. Intramural Drive (in front of Wood Hall) could be retrofitted to manage stormwater runoff from the parking areas and potentially from Intramural Drive. Rain gardens and bioswales could be incorporated in the lawn areas between the parking and the street. This retrofit lends itself to creating an entrance sequence to the dormitories and would provide additional landscaping. This intervention has wide application throughout campus and could provide an excellent demonstration of stormwater retrofit techniques for existing surface parking areas.

Figure 4.27
Windsor Halls Parking Lot

BMP Type	**Area (sq. ft.)**		**Cost/SF**	**Construction Cost**	
	Max	**Min**		**Max**	**Min**
Rain Garden	13,788	4,375	$15.87	$218,816	$69,431
SubTotal				$218,816	$69,431
20% Contingency				$43,763	
Total Construction Cost				$262,579	
Estimated Design Cost				$39,387	
Total Project Cost				$301,965	

Windsor Hall aerial

UNIVERSITY DRAINAGE AREA

Agricultural Mall

The Agricultural Mall is currently under redesign to transform the area to a pedestrian only mall with access for emergency vehicles. Limiting vehicular access and creating designs that work within the educational context of the surrounding academic buildings makes this an exciting opportunity to demonstrate sustainable stormwater management techniques. Various BMPs could be implemented including tree trenches and bioswales/rain gardens, which could be located along the right-of-way to manage runoff from the existing Agricultural Mall. Although not included in the cost estimate, the use of porous pavements with subsurface infiltration beds could be incorporated on the Mall where utility conflicts allow. In addition to measures that manage runoff from the streets and sidewalks, some existing buildings with external roof leaders provide an opportunity to disconnect from the storm sewers. These roof leaders could be diverted to rain gardens located in existing landscaped areas or directed to cisterns for non-potable irrigation.

Figure 4.28
Agricultural Mall

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	12,916	7,422	$15.87	$204,984	$117,789
Tree Trench w/ Stone	4,971	658	$14.57	$72,428	$9,582
SubTotal				$277,411	$127,371
20% Contingency				$55,482	
Total Construction Cost				$332,894	
Estimated Design Cost				$49,934	
Total Project Cost				$382,828	


Agricultural Mall


Horticulture Building with external roof leaders

Crossing the Tracks

This area, important to the student culture of Purdue University, is currently experiencing problems associated with winter icing of the walkway due to poor surface drainage. Pervious pavers were installed at this location to alleviate the problem, however icing persists. It is recommended that a new rain garden be installed in the adjacent landscaped area in order to provide positive drainage from the subsurface stormwater storage bed installed under the pervious pavers.

Figure 4.29
Crossing the Tracks

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	312	0	$15.87	$4,951	$0
SubTotal				$4,951	$0
20% Contingency				$990	
Total Construction Cost				$5,942	
Estimated Design Cost				$891	
Total Project Cost				$6,833	


The "Tracks" in the pavement

State Street / Grant Street

This area currently includes a raised and curbed hardscape (concrete) "island" along the street. Runoff is directed to this area by the existing grading along the street and enters via a trench drain to an inlet. This area could be modified to depress the grading in the "island" area and capture this water into infiltration elements or more formal planting areas designed to receive runoff. The planting design could visually enhance this area as well as capture stormwater.

Figure 4.31
State Street/Grant Bump-Out

BMP Type	**Area (sq. ft.)**		**Cost/SF**	**Construction Cost**	
	Max	**Min**		**Max**	**Min**
Rain Garden	3,572	0	$15.87	$56,688	$0
SubTotal				$56,688	$0
20% Contingency				$11,338	
Total Construction Cost				$68,025	
Estimated Design Cost				$10,204	
Total Project Cost				$78,229	

Enlarged sidewalk - Bump-out along State Street facing Grant

The Island

The Island is comprised primarily of properties that are not owned by Purdue. However, this area drains to Harrison Pond and is of concern to the University and is also highlighted in the recent master plan *Purdue Strategic Plan: New Synergies*. Within this area, the sidewalk and area along the street could be modified to include tree trenches that could receive street and sidewalk runoff, potentially combined with porous sidewalks. Although not included in the cost estimate, the on-street parking lends itself to conversion to porous pavement parking. Implementation of this project would require partnering with both West Lafayette and the property owners, but could serve as a joint demonstration pilot project regarding stormwater improvements in the right-of-way.

Figure 4.32
The Island

BMP Type	**Area (sq. ft.)**		**Cost/SF**	**Construction Cost**	
	Max	**Min**		**Max**	**Min**
Tree Trench w/ Stone	11,690	11,248	$14.57	$170,323	$163,883
SubTotal				$170,323	$163,883
20% Contingency				$34,065	
Total Construction Cost				$204,388	
Estimated Design Cost				$30,658	
Total Project Cost				$235,046	

Street view within the Island

UNIVERSITY CSO

Armstrong Bump-out

Located along Stadium Avenue at the intersection with Northwestern Avenue, the recently constructed Armstrong Hall of Engineering includes a very wide sidewalk, grassed areas, and tree plantings along Stadium Avenue. The area is graded such that drainage from Stadium Avenue drains toward this area, which is curbed. This area lends itself to conversion to a street bump-out that could collect this runoff via modifications to the curb to create curb cuts or depressions. With additional modifications to the grading in this area, combined with soil improvements and plantings, this area serves as a potential street bump-out demonstration site. Depending on underlying conditions, the bump-out could be designed for infiltration or to slow and evaporate the runoff.

Figure 4.33
Armstrong Bump-Out

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	2,182	982	$15.87	$34,628	$15,584
SubTotal				$34,628	$15,584
20% Contingency				$6,926	
Total Construction Cost				$41,554	
Estimated Design Cost				$6,233	
Total Project Cost				$47,787	

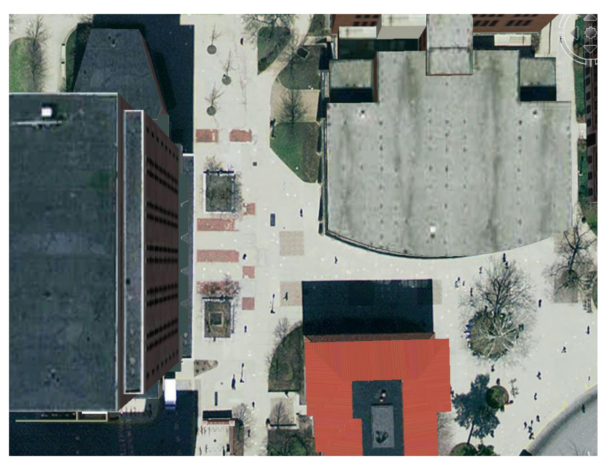

Bump-out along Stadium Ave.

Mathematical Sciences Building

The hardscape (concrete) area at the entrance to the Mathematical Sciences Building provides an opportunity to demonstrate techniques to manage runoff within the Campus Core, where many small interventions that can be "fit in" to the landscape are required. Here, the hardscape at the building entrance could be managed by small rain gardens located in existing landscape areas down gradient from the impervious plaza area. This demonstrates measures that provide a dual use – stormwater management and enhanced landscape beds with passive irrigation.

Figure 4.34
Math Building

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Rain Garden	1,501	246	$15.87	$23,821	$3,904
Trench Drain	210	181	$7.79	$1,636	$1,410
SubTotal				$25,457	$5,314
20% Contingency				$5,091	
Total Construction Cost				$30,548	
Estimated Design Cost				$4,582	
Total Project Cost				$35,130	


Mathematical Sciences Building entrance

Stadium Mall

Stadium Mall has been recently renovated with new walkways and landscaped areas, however, opportunities remain to incorporate stormwater management measures along the pedestrian mall and adjacent to academic buildings. The high profile location makes this an excellent demonstration area for stormwater measures in a high-density campus location. Care must be taken to avoid impacts to existing trees and utility infrastructure in this area. However, where space is available in lawn areas new stormwater tree trenches could be incorporated. The tree trenches could be designed to infiltrate or be lined (where utilities exist) and could manage the adjacent walkway areas. Although it has not been included in the cost estimate, additional opportunities may be possible to capture runoff from academic buildings having external roof leaders. Roof leaders may be connected to flow-through planter boxes or cisterns where in close proximity to building foundations and other subsurface infrastructure.

Figure 4.35
Stadium Mall

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Cistern	659	73	$11.22	$7,394	$819
Tree Trench w/ Stone	7,869	942	$14.57	$114,651	$13,725
SubTotal				$122,045	$14,544
20% Contingency				$24,409	
Total Construction Cost				$146,454	
Estimated Design Cost				$21,968	
Total Project Cost				$168,423	

View of Stadium Mall

View of Stadium Mall

Front Lawn @ Johnson Hall of Nursing

BELOW OFFSITE

Coal Storage Area

The Coal Storage Area serves the Wade Power Plant and is an industrial area which requires very specialized runoff management conforming to local, state and federal regulations, and it does have its own stormwater pollution prevention plan. That being said, several general recommendations are put forward in this report to provide concepts that could meet stringent water quality requirements while advancing the sustainability goals of this Plan. Due to the nature of the contaminants present at the Coal Storage area, it is recommended that a bioswale or other vegetative BMP be designed to provide water quality management for additional surface drainage through phytoremediation of contaminated runoff, prior to infiltration or entrance into inlets. Additionally, a permanent water quality treatment unit should be installed to replace temporary filters currently installed on the west side of the storage area.

Figure 4.36
Coal Storage

BMP Type	Area (sq. ft.)		Cost/SF	Construction Cost	
	Max	Min		Max	Min
Bio Swale	6,079	0	$8.88	$53,982	$0
SubTotal				$53,982	$0
20% Contingency				$10,796	
Total Construction Cost				$64,778	
Estimated Design Cost				$9,717	
Total Project Cost				$74,494	


Coal delivery


Temporary filtration structure


Open air coal storage

4.4 Recommended Stormwater Policy: Requirements for New Projects, Campus Improvements, and Redevelopment

The existing stormwater conveyance system at Purdue has been implemented over a long period of time with the on-going growth and evolution of the campus. Changing the way stormwater is managed at the University - to reduce stormwater runoff and pollutants, to provide groundwater recharge and to implement a landscape-based green infrastructure - will also require time. Additionally, in order to truly be sustainable, this policy cannot be based simply on preventing additional stormwater impacts for new development, but must instead focus on a program that will eventually "retrofit" the campus to achieve the goals of pollutant reduction, volume reduction, and groundwater recharge. There will never be sufficient funding to address all the needed stormwater changes at once. But Purdue can continue the process by creating a greater awareness of stormwater needs and opportunities, by engaging a policy that encourages the integration of stormwater into new projects, into general campus capital improvements, and into redevelopment efforts.

To this end, it is recommended that Purdue implement a Stormwater Policy for development and improvement projects that requires the following:

- For all new development projects and for redevelopment projects over 1,000 square feet of disturbance, all stormwater runoff from impervious surfaces should be captured and managed within the context of the project for all rainfall events of 1-inch or less. "Management" is considered to be any stormwater measure that captures the water and prevents its release from the project site, including infiltration, re-use, and landscaped-integrated measures.

- Whenever feasible, this same goal should be applied for campus improvements to existing landscape and hardscape (i.e., replacement of sidewalks, planting of street trees, etc.) to identify potential opportunities for stormwater reduction. Within the public portions of campus, these improvements should be evaluated to maximize the amount of water managed. For example, the improvement may be able to capture water beyond the disturbance footprint of the improvement.

- For new and redevelopment projects, where runoff cannot be captured due to site constraints, stormwater must at a minimum be addressed by approved BMP measures that improve water quality before release to Harrison Pond or other surface waters for the first 1" inch of rainfall.

- Within a project area (i.e. the area necessary to build the project), the opportunity to reduce impervious area or to change land surfaces to reduce stormwater runoff is encouraged; this would include the creation of land cover specifically to reduce stormwater (i.e., reducing lawn and increasing planting beds, converting turf areas to meadows and establishing multi layered landscapes). Opportunities to reduce stormwater sources should always be considered.

- Where a project is unable to implement sufficient stormwater improvements within the project footprint, the project shall provide compensation in the form of the implementation of a stormwater retrofit measure in another portion of the campus, or in the form of a monetary compensation to a stormwater fund in coordination with the Office of the University Architect. These project compensations shall then fund stormwater management improvements in concert with campus wide Master Plan efforts.

In addition to a Stormwater Policy for improvement projects, there are considerations for the University and its approach to stormwater. Individual projects may implement stormwater measures, but it is essential that the University provide comprehensive coordination and implementation on a campus basis. Specifically, it is recommended that:

- A process should be developed to evaluate projects and improvements to encourage awareness and implementation of stormwater opportunities through the review and support of the Office of the University Architect, and to provide Project Managers and designers with recommendations, guidelines, and supporting stormwater information as needed.

- In implementing stormwater measures in all areas, especially drainage to Harrison Pond, the capture and treatment of water from the most pollutant-laden surfaces is encouraged as having the highest priority.

- The University should work with the privately held properties within campus, especially those that drain to Harrison Pond, to implement this stormwater policy or to address the runoff from these properties with the campus stormwater improvements.

- The improvements and projects implemented under this policy should contribute to the recognition of the campus fabric as an educational resource. Projects should be encouraged to include educational signage, and post-construction evaluation and visual monitoring to allow the University to gauge the effectiveness of the stormwater management plan. Detailed water quality monitoring of BMPs by University research teams should be encouraged.

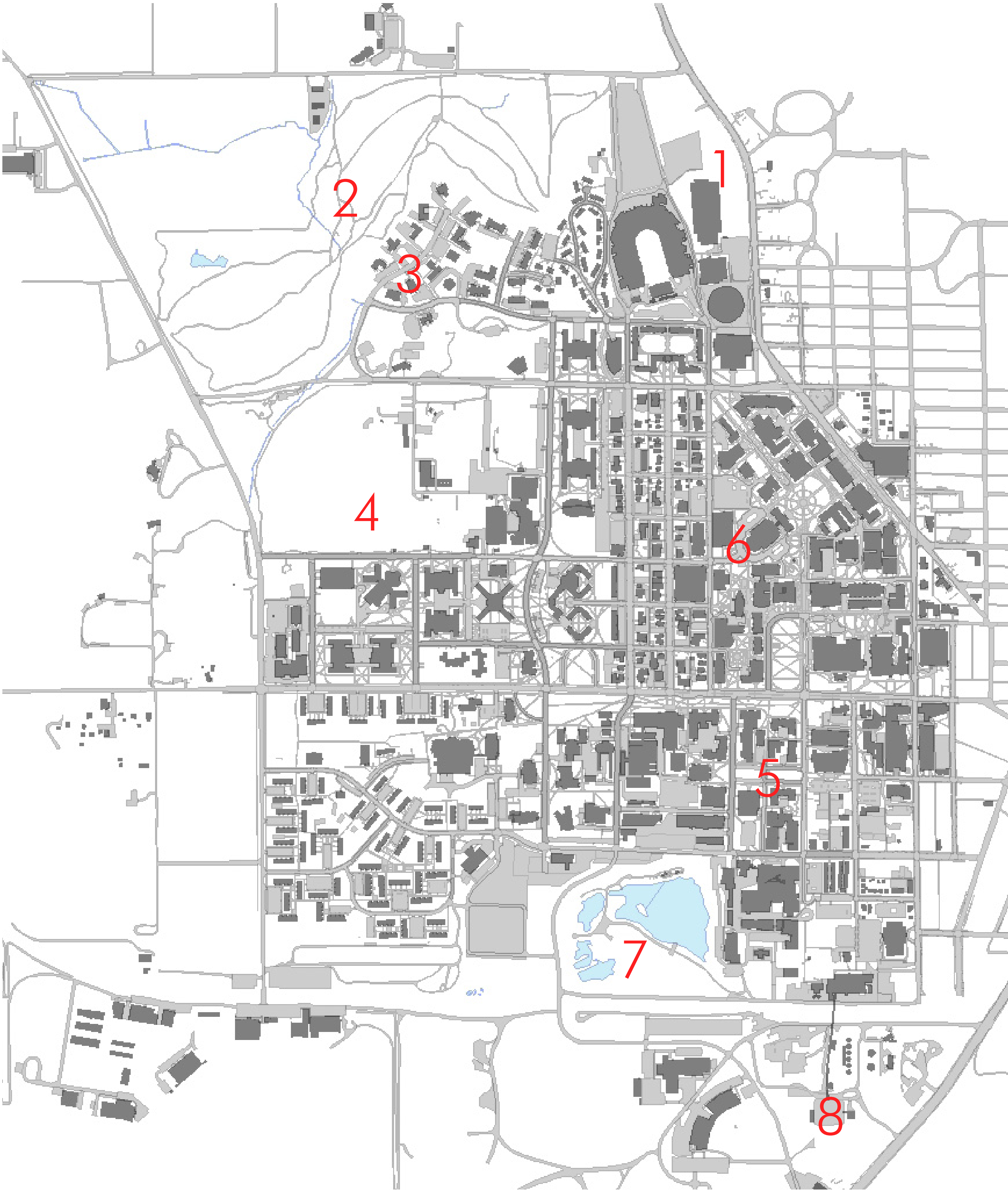
- The University should create a land maintenance program including guidelines and proper maintenance techniques for BMPs, pesticide and fertilizer use, non-structural measures such as street sweeping, and coordination with regulatory permitting to document positive measures.

- The University should establish a documentation process to record the location and type of stormwater measures as they are implemented. This will also provide positive documentation for regulatory permitting and add to the existing Purdue University Stormwater BMP Tour.

The University should also engage with West Lafayette to coordinate the implementation of stormwater improvements. Within the University CSO area, these measures will directly reduce the burden on the combined sewer system. For stormwater streetscape improvements along sidewalks and right-of-ways within the campus, coordination with West Lafayette will be essential. The opportunity exists for the University to set examples and develop designs that can be applied beyond the campus held properties. Purdue's role in the creation and adoption of the Tippecanoe County Stormwater Technical Standards Manual is recognized, and it is suggested that this report be taken into consideration when revisions of the manual occurs.

Finally, it must be recognized that implementing a sustainable approach to stormwater is part of a design process where decisions are informed by many considerations. For every stormwater improvement, the proposed project should be:

- Cross-checked for consistency with the Campus Master Plan.
- Designed for the specifics of each site.
- Developed with the needs and requirements of the specific users in mind.
- Considered in terms of maintenance needs and the ability to provide required maintenance.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