Evaluating LID for a Development in the Lockwood Folly Watershed

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An alternative Low Impact Development (LID) plan was developed for a 39-acre subdivision in the Lockwood Folly watershed. A sub-catchment of the larger 39-acre development, which was 4.12 acres in size, was specifically selected to be designed as an LID. The existing soils on the site are Mandarin fine sand and Murville fine sand (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) with high infiltration rates suitable for the increased infiltration preferred with Low Impact Development (Figure 1)

Figure 1 Site Conditions

According to the original plan, there were originally 10 homes on approximately 1/4- to 1/3- acre lots. NC State faculty produced an alternative design incorporating LID throughout the 4.12-acre watershed. All the stormwater practices discussed herein were only designed. The changes discussed in this report have yet to be installed. Several types of practices were suggested. Pervious concrete, rain gardens, and grassed swales were used in an effort to reduce the size of, or eliminate the need for, a pre-designed stormwater wet pond.

Permeable pavement is a hard surface with connected gaps or pores that allow stormwater to either infiltrate into an underground storage basin or exfiltrate to the subsoil, providing for groundwater recharge and reducing the overall volume of runoff (Figure 2). Rain gardens are excavated areas filled with an engineered soil, mulch, and plants that store and infiltrate stormwater (Figure 3). Pollutants in the stormwater are removed by filtration through the fill

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soil, plant uptake, and sorption to the mulch. Grassed swales are wide channels with flat bottoms giving a greater surface area to allow for increased infiltration (Figure 4). These channels can be enhanced by introducing small check dams serving as flow barriers.

Figure 2 Permeable Pavement


Figure 3 Rain Garden


Figure 4 Swale

In the original design produced by a local engineering firm, a stormwater pond was designed to mitigate for the 5-year, 6-hour rain event. The wet pond was 8,500 square feet and approximately 3.5 feet deep. To conduct the LID analysis, several engineering assumptions were made. It was assumed that the impermeable roofline of the homes would be approximately 2,300 square feet on 10 of the 11 lots in the drainage area. The 11th lot contained the wet pond. Driveways were assumed to be 10 feet wide at the street and expanded to 20 feet wide at the home and cover approximately 400 square feet. The 4.12-acre, 180,068-square feet, drainage area consisted of 23,037 square feet of roof tops and 3,515 square feet of driveways. The existing design also consisted of 19,110 square feet of road way. The drainage area was 34% impervious and the composite curve number for the neighborhood was approximately 70[2] (SCS, 1986) (Figure 5).

The first step of the analysis involved converting each driveway from standard asphalt to pervious concrete. In addition to the driveway being pervious, runoff from an area of the roof top equal to the area of the driveway could be stored in the pervious concrete driveway. The hamlet adjacent to lots 64 to 67 was also converted to pervious concrete. According to North Carolina State stormwater regulations pervious concrete is considered to be equivalent to 60% grass and 40% asphalt (NC DENR, 2006)[3]. Using the NCDENR standard, the amount of impervious surfaces was reduced to 27%, resulting in a decrease of the watershed's composite curve number to 69. The result of permeable pavement replacing standard asphalt and concrete was a decreased size of the stormwater pond. Its surface area was reduced from 8,500 square feet to 7,900 square feet (Figure 6).

A community rain garden 15 inches deep was designed to be installed in the open space in the hamlet. The rain garden would be able to store approximately 4,375 cubic feet (32,727 gallons) of water. Installing the rain garden would not have any effect on the curve number; however, it provides additional stormwater runoff storage. Volume captured by the rain garden would allow the stormwater pond's surface area to be reduced to 5,900 square feet (**Figure 7**).

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[2] The Curve Number (CN) is a parameter used to predict runoff volumes from large storm events (those exceeding 2.0 inches). The number ranges from ~30 to 100. Higher numbers mean more runoff and less abstraction/ infiltration. For more information, please see: USDA. 1986. Soil Conservation Service. "Urban Hydrology for Small Watersheds." Technical Release No. 55, Washington, DC.

[3] For more information, please see: http://h2o.enr.state.nc.us/su/bmp_forms.htm

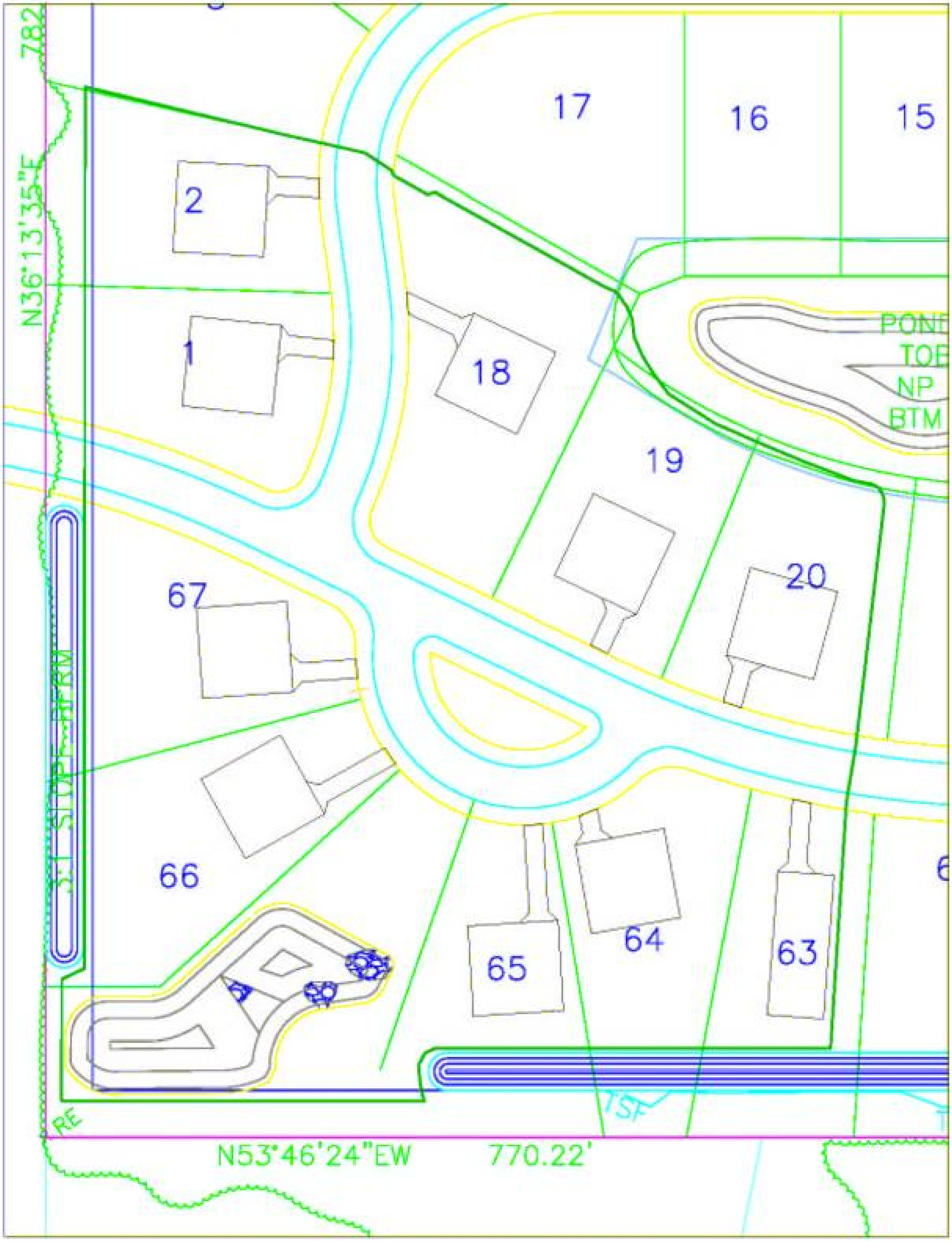

Figure 5. Initial Conditions

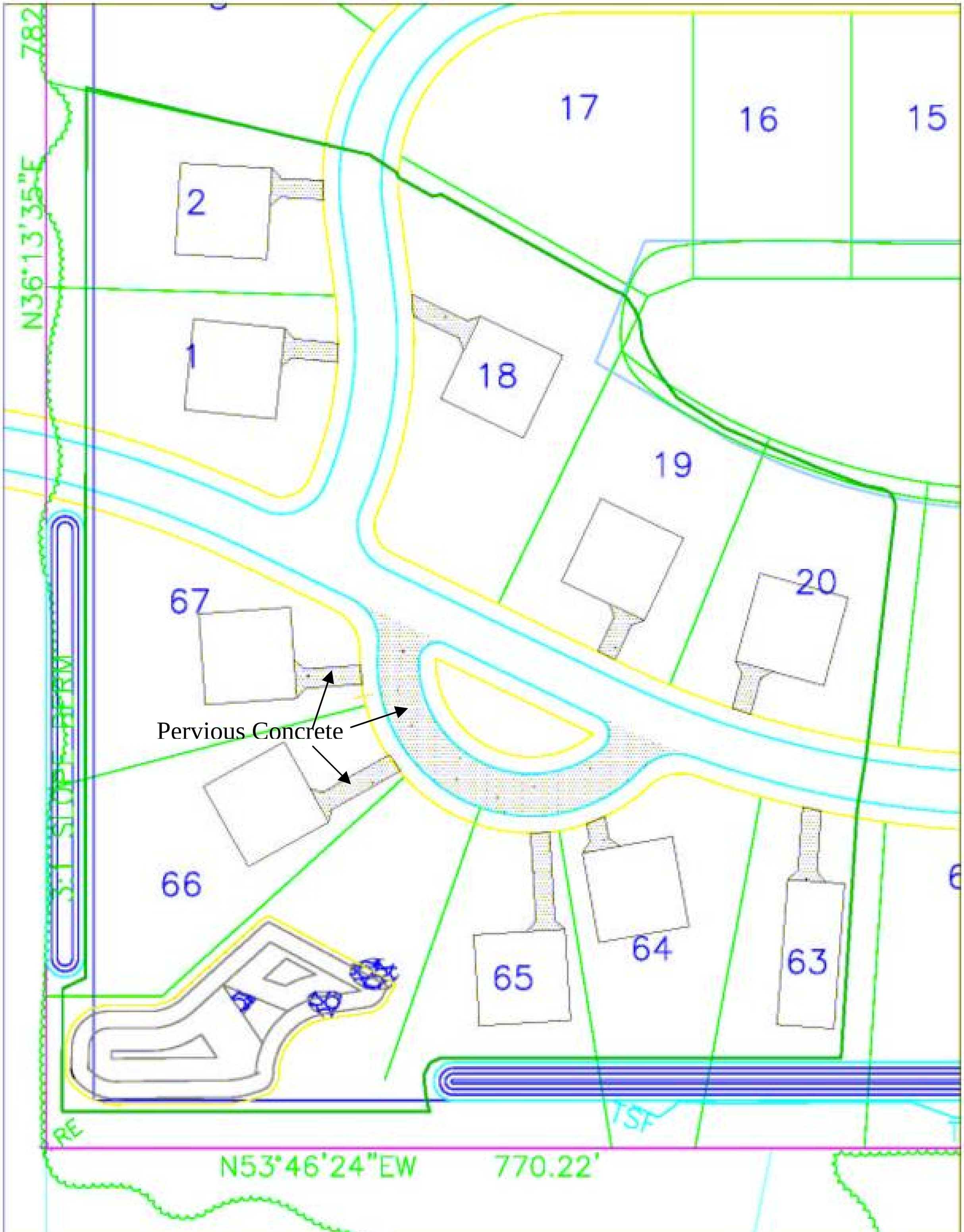

Figure 6. Conversion of Driveways and Hamlet Roadway to Pervious Concrete

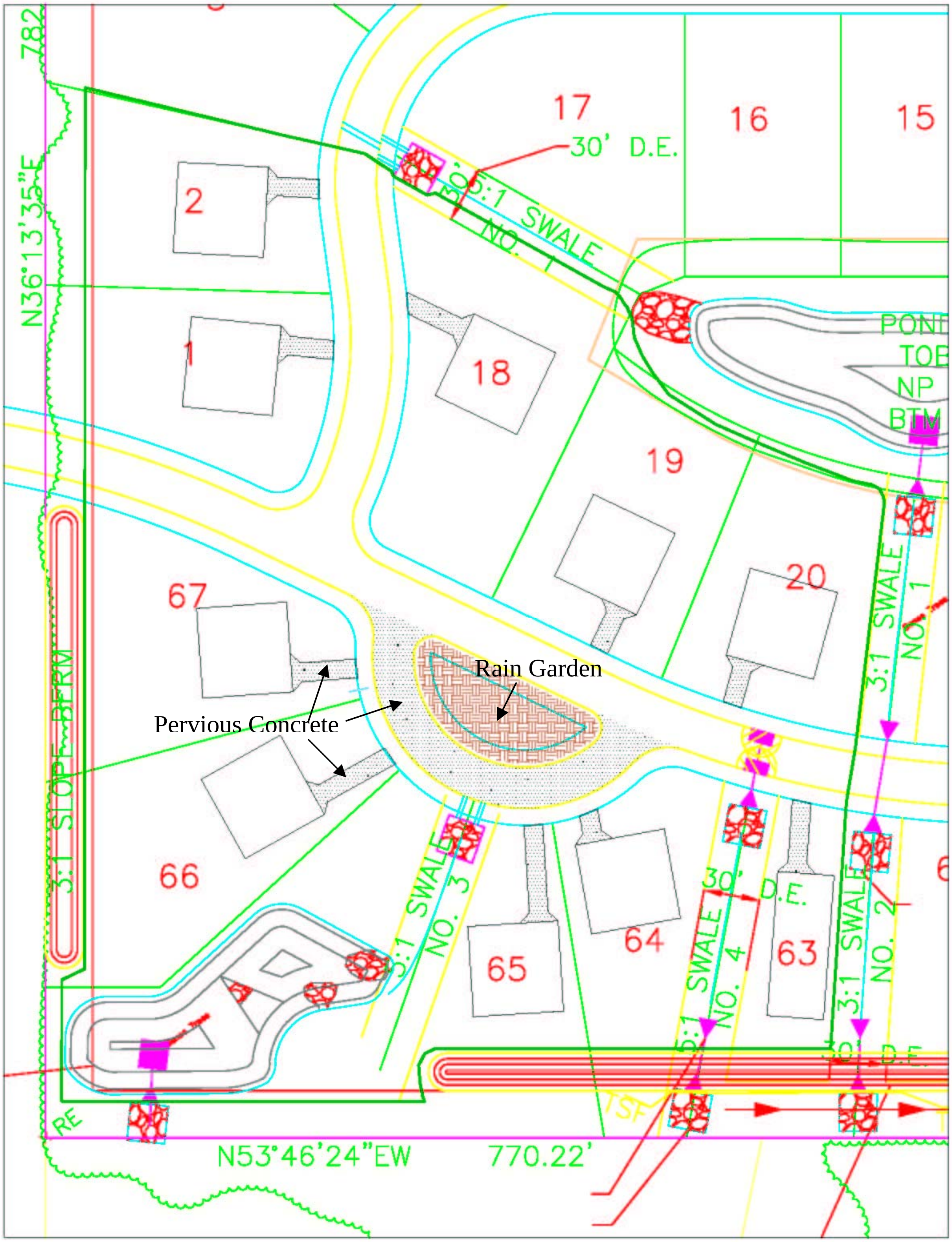

Figure 7 Conversion of Hamlet Open Space to Community Rain Garden

Grassed swales were already planned for stormwater conveyance to the wet pond. All the swales are in drainage easements between adjoining properties. Swales are "community" properties with respect to stormwater management. Moreover, simple swale modifications were possible that would make the swales work more efficiently. Some water can be stored in the grassed swale if check dams are installed to detain portions of the water. Three grassed swales as currently sized with check dams would store approximately 5,524 cubic feet (41,322 gallons) of water, further reducing the size of the stormwater pond to 5,150 square feet. Using pervious concrete, a community rain garden, and grassed swales reduced the original stormwater pond's surface area enough to allow an additional home to be constructed on the lot (**Error! Reference source not found.**). This is considered the **Community LID option** as all the treatment outside of the permeable driveways was located in public spaces.

It was possible to further treat stormwater runoff by putting more practices on individual properties. This second, more intensive, LID scenario is called the **Community and Residential LID option**. Rain gardens installed on each lot can reduce or eliminate runoff from the site. Homes on lots 1, 2 18, 19, and 20 would each have a 1,500 square foot rain garden installed as a landscape feature. Rain gardens would be installed on the remaining lots and would average 600 square feet. Installing the rain gardens on each individual lot would reduce stormwater runoff such that the 5,150 square feet stormwater pond could be converted into a 2nd community rain garden 15 inches deep and approximately half the size of the original pond (Figure 9). Installing the rain gardens would eliminate all stormwater runoff from the drainage areas up to the 5-year, 6-hour storm. The calculations used to determine runoff and storage capacity do not consider infiltration. The soils in the drainage area are very sandy which would allow for high rates of infiltration and increased storage capacity, making all of our estimates conservative.

The costs for each individual practice are outlined in Table 1. The "cost" for the hamlet permeable pavement is the difference in the cost of asphalt and pervious concrete. Because the hamlet would have been asphalt in the traditional development design, only the additional cost to make it pervious concrete is considered. The savings associated with using LID practices are outlined in Table 2. The existing design, from which the analysis was made, already utilized many LID concepts including narrowed roads and grass swales. Because grassed swales are used to convey water rather than a traditional stormwater conveyance system, stormwater inlets, piping, and curb and gutter systems are not required. These cost savings in Table 2 are provided

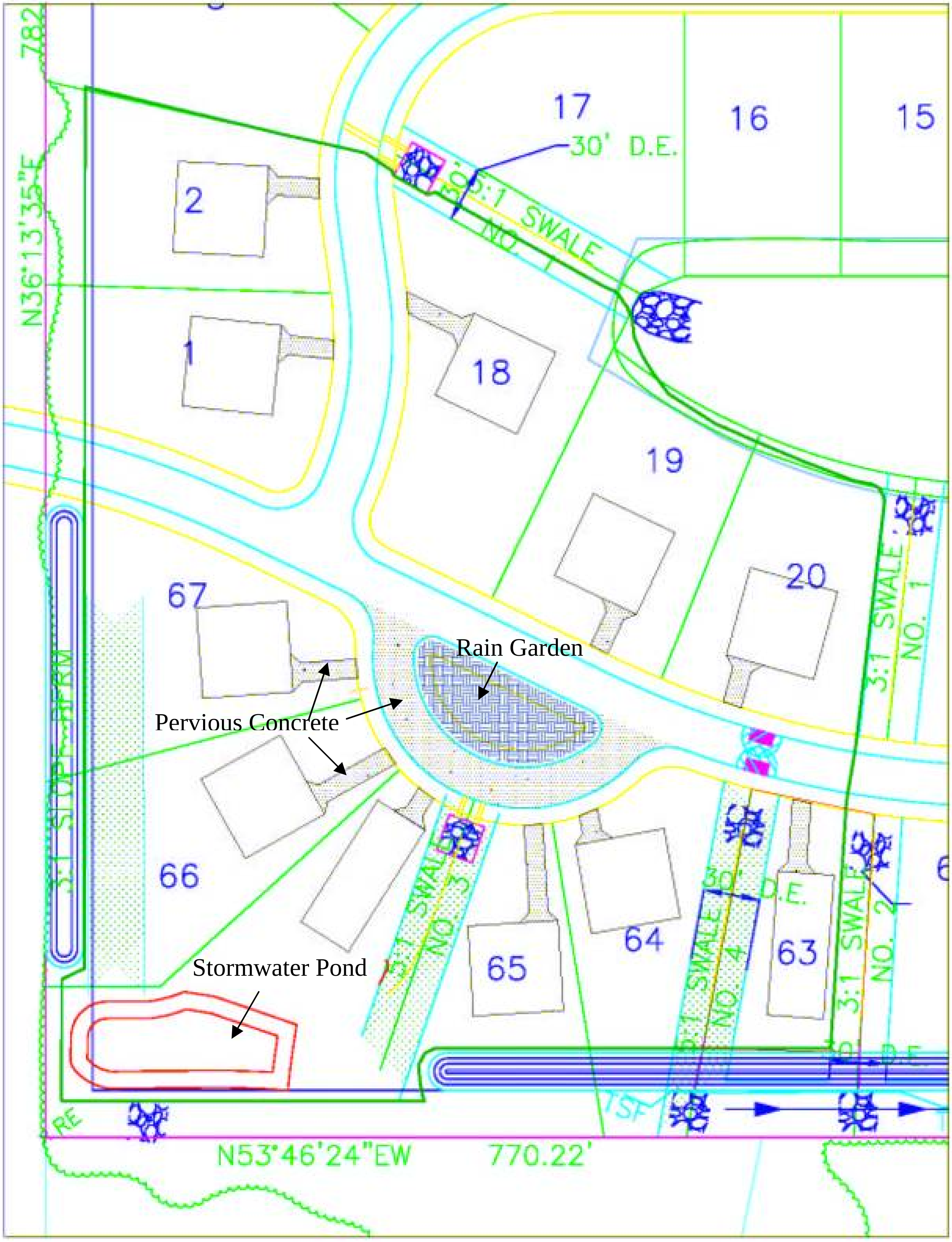

Figure 8 Community Rain Garden, Swales, and Additional Home

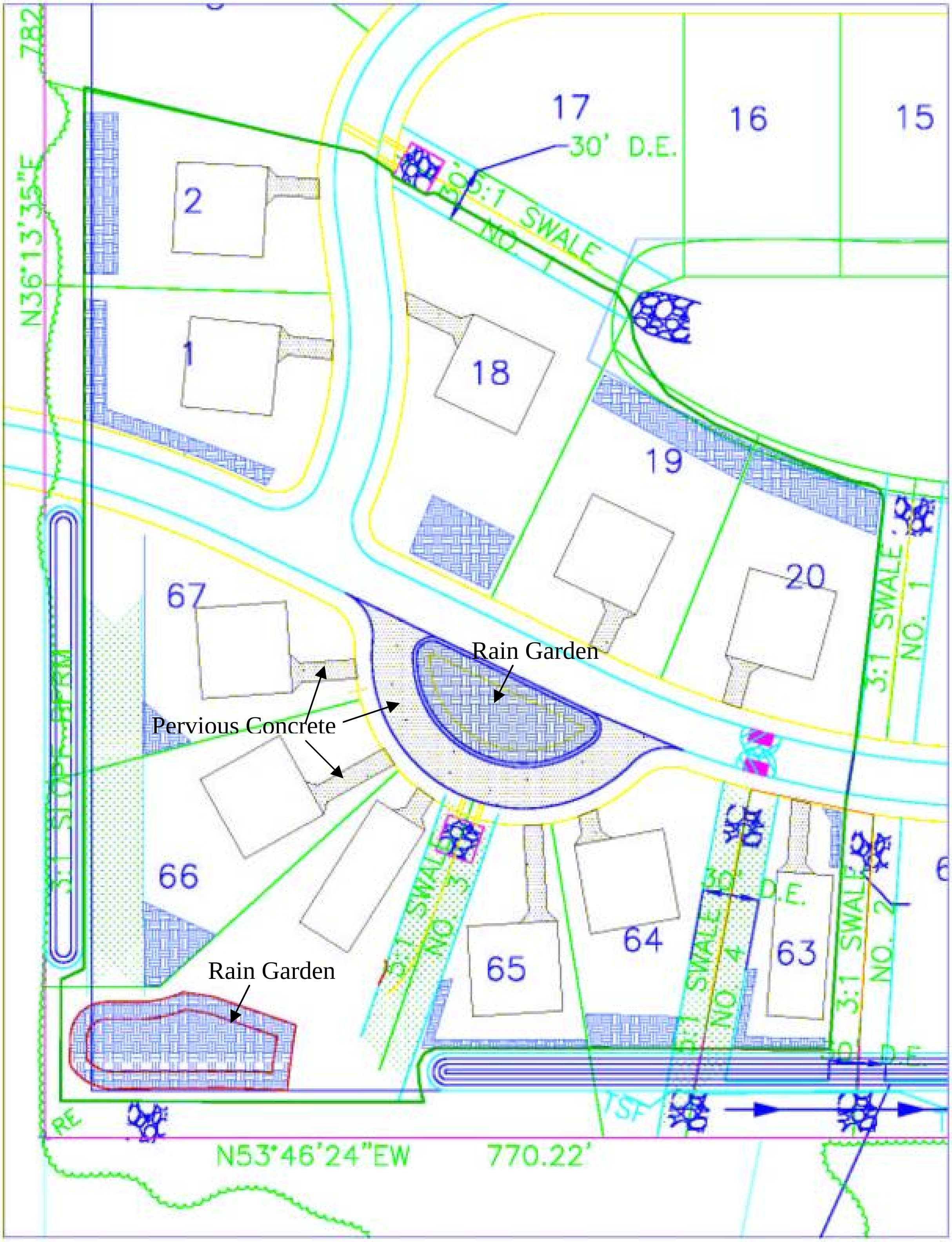

Figure 9 Individual Rain Gardens

Table 1 LID Costs
Community LID Option

	Area		Unit Costs		Total
Driveways	3,515	per ft^2	$4.00	per ft^2	$14,060
Hamlet	4,606	per ft^2	$2.50	per ft^2	$11,515
Community Rain Garden	3,500	per ft^2	$4.00	per ft^2	$14,000
Swale (12 check dams)	6,367	per ft^2	$1.00	per ft^2	$6,367
				Total	$45,942

Community and Residential LID Option

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Swale (12 check dams)	6,367	per ft^2	$1.00	per ft^2	$6,367
Individual Rain Gardens	10,653	per ft^2	$3.00	per ft^2	$31,960
				Total	$77,902

Table 2 LID Costs Savings
Community LID Option

Curb and Gutter*	1,314	ft	$11.00	per ft	$14,454
Asphalt (28 ft wide)*	3,941	ft^2	$1.79	per ft^2	$7,054
Drop Inlets*	3		$1,500.00	per	$4,500
18" RCP Pipe*	750	ft	$28.56	per ft	$21,420
Pond Partially Eliminated	3,350	ft^2	$7.00	per ft^2	$23,450
				Total	$70,878

* 2006 RS Means Building Construction Cost Data 64th edition

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Pond Partially Eliminated	3,350	ft^2	$7.00	per ft^2	$23,450
Remaining Pond Replaced with RG	5,150	ft^2	$3.00	per ft^2	$15,450
				Total	$86,328

* 2006 RS Means Building Construction Cost Data 64th edition

$380,000.00	home	approximate 30% profit	$114,000
		Total Profit	$114,000

as a reference. Cost savings associated with LID practices include shrinking the pond, narrowing the roads, eliminating drop inlets and pipe, and eliminating curb and gutter. By decreasing the surface area of the wet pond, room was created for another home on the lot. *This is perhaps the greatest benefit to the developer* as comparable homes in the area have sold for approximately $380,000. Assuming a profit of 30% for the lot and the home, an additional $114,000 of profit would be associated with full-scale LID implementation. The costs of installing Community LID practices would be approximately $45,942, and the costs would increase to $77,902 for the Community and Residential LID option. The savings associated with the Community LID option would be $70,878, while $86,328 is saved using the Community and Residential option. When *NOT* including the sale of the new, 11th, home, the profit from the community LID option would be $24,937; the Community and Residential LID option would result in a smaller profit of $8,427. The Community and Residential LID option would not be as profitable indicating that there is an "optimum" level of LID implementation that will result in a cost savings. However, if the profit of the sale of the new 11th home were considered, the total profit for implementing the Community LID option rather than traditional development would be $138,937. The Community and Residential LID option would also produce a savings of $122,427 for the developer if the new home is accounted for. These findings are summarized in Table 3.

Table 3 LID Profit

Community LID Profit

Community LID Cost Savings		$70,878.00
Community LID Costs		-$45,941.00
	Total	$24,937.00
$380,000.00 home approximate 30% profit		+$114,000.00
	Total	$138,937.00

Community and Residential LID Profit

Community and Residential LID Cost Savings		$86,328.00
Community and Residential LID Costs		-$77,901.00
	Total	$8,427.00
$380,000.00 home approximate 30% profit		+$114,000.00
	Total	$122,427.00

Summary

Both LID options save the developer money. The Community LID option is approximately 15% more profitable than the Community + Residential LID option. This indicates that there is an optimum level of LID from the developer's perspective. An additional advantage of the Community LID option is long term maintenance. It is probable that practices like swales and bioretention in public rights-of-way are more likely to be maintained than practices solely on a homeowner's property. This cost analysis does not account for the ease and cost of maintenance, but the Community LID option is probably superior.

While there was a cost savings associated with replacing conventional stormsewer utilities (such as curb and gutter, narrowing of street widths, and elimination portions of the wet pond), and these cost savings were greater than the extra costs associated with implementing LID practices (permeable concrete versus asphalt, the addition of rain gardens, etc.), *the major financial factor for the developer is the creation and sale of an additional property*. Savings were quintupled when the profit of the extra home was added to the bottom line.

Coastal North Carolina, especially portions of Brunswick County's Lockwood Folly watershed, appears to be an ideal location for LID to be implemented. This is particularly true in the sandier in situ soils regions of the county, similar to where this development was proposed. The use of LID, such as the design discussed herein, can provide an economic benefit to the developer while at least matching, if not improving, water quality and flood control from conventional designs.

Acknowledgements

Funding for this study was provided by the North Carolina Coastal Federation in cooperation with Brunswick County and the North Carolina Department of Environment and Natural Resources.