

INCENTIVE COMPATIBLE POLICES TO PROMOTE VOLUNTARY USE OF ENHANCED STORMWATER BMPs IN NEW RESIDENTIAL DEVELOPMENTS

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Abstract: Stormwater runoff generally increases with the level of urbanization because the percentage of land with impervious surfaces increases. Traditional residential stormwater runoff control practices predominately use regulatory tools such as zoning ordinances and mandatory construction regulations to control runoff. However, the introduction of voluntary incentive based policies can encourage developers to exceed the regulatory control standard when the economic incentive is sufficiently large to encourage voluntarily adoption of low impact Best Management Practices (BMPs). A voluntary stormwater banking program (SBP) is presented that increases both developer profit and regional water quality relative to the existing regulatory policy. Developers participating in the program receive a site density bonus that allows them to construct subdivisions at a higher residential density than allowed under current regulations. The density bonus specifies the maximum number of additional lots that can be developed within a subdivision. Participating developers agree to incorporate low impact BMPs into their stormwater management design and pay a participation fee to the SBP. The SBP specifies the residential runoff level the developer must achieve to receive the density bonus. The value of the density bonus is influenced by the price of the additional lots sold and the additional low impact BMP cost. When the net economic value of the density bonus lots is greater than the additional cost of adopting the required BMPs plus paying the participation fee, the profit maximizing developer will participate in the program. In addition to potentially increasing developer profit, the proposed program benefits regional water quality in two ways. First, developers participating in the SBP provide stormwater runoff control above the minimum regulatory standard on new developments. Second, the collected participation fee can subsequently be used to retrofit outdated and/or poorly functioning BMPs in existing developments to enhance/protect regional water quality.

Introduction

As urbanization density increases, less surface area becomes permeable to water and stormwater runoff from urban development increases. The increased stormwater runoff transports greater amounts of pollutants and nutrient loadings into water supplies. Stormwater control is conventionally addressed using regulatory tools such as imposing residential density limits and open space requirements. Incentive based policies that can achieve more stringent runoff control objectives and are supported by residential developers provide an opportunity to exceed the existing regulatory standard while increasing developer profits and regional water quality. Toward this end, a voluntary stormwater banking program (SBP) is developed that allows residential developers to build at greater densities in exchange for achieving a greater level of stormwater runoff control by incorporating low impact development (LID) stormwater Best Management Practices (BMPs) into their residential developments and paying a participation fee to the SBP. The participation fee is calculated as a share of the profits earned from lot sales resulting from building at the higher density. The proposed density bonus allows the developer to develop additional lots, or bonus lots, on the same amount of land. If the developer chooses to exceed the specified minimum control standard to participate in the SBP by using additional LID BMPs, they receive a percentage-based rebate of the participation fee.

Literature Review

Randall and Taylor (2000) provide an overview of the merits of incentive based environmental policies. They emphasize that incentive based policies provide more flexibility than command and control policies, and have lower compliance costs. Parikh et al. (2005) provide a hydrologic, economic and legal framework for examining incentive and market based instruments to reduce stormwater runoff and illustrate how a voluntary offset program provides an incentive for landowners to

reduce runoff with low impact BMPs. Thurston et al. (2003) examine runoff control using tradable allowances based on impervious surface area. They show that the possibility of earning revenue from selling excess allowances provides property owners with an incentive to build low impact BMPs with greater detention capacity than the minimum regulatory requirement.

Several cost effectiveness studies of stormwater BMPs have been conducted. Brown and Schueler (1997) provide cost estimates for the Mid-Atlantic States. Wossink and Hunt (2003) estimate BMP construction, maintenance and land costs in North Carolina. Hathaway and Hunt (2007) estimate BMP construction costs in North Carolina. Montalto et al. (2007) examined the cost effectiveness of LID for reducing sewer overflow and found that only under high cost, poor design scenarios, is LID not cost-effective relative to common sewer overflow tanks. Landphair (2001) reviewed the cost to performance ratios of several stormwater BMPs and found that infiltration basins tend to be the most cost effective BMPs in terms of cost per pound of total suspended solids (TSS) removed in watersheds larger than 10 acres. Weiss et al. (2007) analyzed cost effectiveness in terms of suspended sediments and total phosphorous control for six stormwater BMPs used to treat urban runoff, and found that if land cost is ignored constructed wetlands are most cost-effective. However, in urban environments where land costs are high, less land intensive BMPs may be more cost effective.

Stormwater Banking Program

The fundamental idea behind the design of the SBP is to align the incentives of stormwater control authorities and developers so that stormwater runoff is reduced beyond the current regulatory standard to jointly increase developer profit and improve regional water quality. The proposed economic incentive is to allow residential builders to build at a higher density if they achieve a target control goal beyond the regulatory minimum. Greenville, South Carolina specifies area specific density limits for new developments. In exchange for relaxing the density limit and allowing more housing lots to be constructed on the same acreage, bonus lots, the developer must reduce stormwater runoff below the current regulatory standard by incorporating low impact BMPs into the development. The developer pays a participation fee to the SBP, calculated as a percentage of profit on bonus lot sales. The participation fee is subsequently used to retrofit outdated and/or poorly functioning BMPs in existing developments to enhance/protect regional water quality.

The metric used to determine the level of stormwater runoff reduction is the Site Runoff Index Score (site

score). The site score is a complex function of factors impacting runoff such as impervious cover, soil factors, infiltration factors, sediment factors and particulate runoff factors. Each individual factor is scored on a scale from zero to ten and weighted based on its relative importance in determining the amount and severity of runoff. A site score of zero implies that all runoff eventually leaves the subdivision and adversely impacts regional water quality. A site score of 100 implies that almost all runoff and particulates are trapped within the subdivision and water quality impacts are minimal.

For Greenville, South Carolina, a site score of 40 is consistent with the effectiveness of the current minimum regulatory standard. Alternative combinations of low impact BMPs were introduced into various subdivision stormwater management designs to estimate the effect of the BMPs on the site score using the IDEAL simulation model (Barfield et al, 2005). An iterative simulation procedure is used to determine both the appropriate combination of low impact and traditional BMPs, and the scale of the identified BMPs to meet a specific site score. Once the combination of BMPs and the associated scale level of implementation is determined to achieve a specific site score, the data is combined with a BMP cost data set to estimate the cost of increasing the site score from the regulatory baseline score of 40 to the targeted higher site score (Huber et al., 2010).

Given the uncertainty regarding the type of single family residence likely to be built on any subdivision lot and/or the final selling price of the house, together with the reality that the developer needs to know the economic benefit of participating in the SBP before any houses are constructed, expected lot price instead of house price is used to estimate likely developer profit from participating in the SBP. Developer participation profit before considering the additional low impact BMP costs and any participation fee rebate is specified in equation 1:

$$(1) \pi = [L_B \cdot P_B \cdot \% \pi_B - (P_{NB} - P_B) \cdot L_{NB}] \times (1 - c),$$

where,

π : program profit before possible program rebate and additional BMP costs,

L_{NB} : number of original subdivision lots,

L_B : number of bonus lots,

P_{NB} : original lot price,

P_B : new lot price at bonus density,

$\% \pi_B$: percent profit on bonus lot sales, $\frac{P_b - Cost_b}{P_b}$,

$$0 \leq \% \pi_B \leq 1,$$

c: fraction of density profits paid to the SBP as the participation fee, $0 \leq c \leq 1$.

The first term on the right-hand side of equation 1, measures developer profit from selling bonus lots. The second term reflects potential lost profit to the developer on the original lots if lot price decreases at the higher building density. When there is no price decrease, the bonus lots sell for the same price as the original lots and the second term in equation 1 equals zero. The lost profit on the original non-bonus lots is not scaled by percent profit because the cost of constructing the original non-bonus lots has not changed. Since the cost to construct the original lots did not change with the changing density the only thing that changes is revenue, that is the change in lot price times the number of original lots. After any lost profit on the original lots is subtracted from the profit on the bonus lot sales, this density profit is multiplied by the third term, one minus the fraction of density profit paid to the SBP (1-c). The overall value is developer profit before any possible rebate on the participation fee and the additional LID BMP costs are considered.

Given space limitations, for simplicity, we assume that the percent profit on the bonus lots is equal to the percent profit on the original lots ($\% \pi_B = \% \pi_{NB}$). However, profit on the bonus lots is likely to be higher because the primary infrastructure costs (engineering and site design, permits and impact fees, clearing and grading, sewer and water infrastructure, and roads) to construct the subdivision have already been incurred. The largest cost incurred in constructing the additional subdivision lots, is connecting the lots to sewer and water services. Since the costs to construct the bonus lots are much lower, it is likely the percent profit on these lots to be higher than for the original lots.

If the developer chooses to exceed the target site score, the minimum score needed to participate in the SBP, through more intensive low impact BMP use, the SBP provides a rebate on the original participation fee that assumed the developer only achieved the minimum target score. The rebate provides the developer with an economic incentive to voluntarily incur additional LID BMP costs to exceed the target site score when it is profitable. The rebate is calculated using equation 2:

$$(2) \quad A = a \cdot (SC - TSC) \cdot \{(L_B \cdot P_B \cdot \% \pi_B - (P_{NB} - P_B) \cdot L_{NB})\} \cdot c$$

where,

- A: rebate on the participation fee,
- TSC: target site score for SBP participation,
- SC: site score achieved by the developer, $SC \geq TSC$,

a: percent rebate on participation fee for every point SC exceeds TSC.

If the site score equals the target site score, then the rebate is zero. Equation 3 is the sum of equations 1 and 2 and estimates developer profit before considering the additional BMP costs (π^*):

$$(3) \quad \pi^* = \pi + A.$$

When the additional LID BMP costs (C_{BMP}) are subtracted from π^* net program profit (Net π^*) is derived as shown in equation 4:

$$(4) \quad Net \pi^* = \pi^* - C_{BMP}.$$

If Net π^* is positive, the developer has an economic incentive to participate in the SBP and will seek to maximize net program profit subject to the conditions imposed by the SBP. A comprehensive Excel based spreadsheet program has been developed to provide the developer with an estimate of the economic benefit of program participation. The working name of the developed program is the Decision Making Tool (DMT). The tool is based on the logic discussed above, but also provides the developer with additional benefits (site score points) for incorporating regional and neighborhood smart growth options into the location and design of a subdivision. Because of space limitation the empirical illustration is restricted to on-site adoption of LID BMPs. Cost data from the Greenville, South Carolina area was collected to estimate construction and maintenance costs of the traditional stormwater management tools of dry ponds and wet ponds, as well as the following stormwater BMPs: bioretention cells, buffer strips, bioswales, infiltration trenches, porous pavement, rain barrels, green roofs, wetlands, and sand filters. A cost equation is developed for each BMP. Revenue and cost data is incorporated into a spreadsheet model to determine whether the additional revenue from the lot density bonus is sufficiently large to offset the cost of adopting the enhanced BMPs plus paying the SBP participation fee. Engineering formulas are used to determine the mix of BMPs that most cost-effectively achieve the runoff standard.

Empirical Illustration

Ansley Crossing, a 39 acre residential development in Greenville, South Carolina, is used to illustrate the developer benefit of initially entering the SBP at the minimum target site score level, and then deciding to exceed the target site score. Ansley Crossing has 11

buildable acres and under current density requirements, 38 lots can be built on the 11 acres. The remaining 28 acres consist of an unbuildable floodplain which serves as a natural filtration area. The natural filtration area is maintained in all illustrative comparisons. If the Ansley Crossing developer achieves the minimum target site score of 70, the developer can construct an additional 26 bonus lots within the subdivision. A participating developer must pay 50% (c in equations 1 and 2) of the density related profit from the sale of the additional 26 bonus lots to the SBP as the participation fee.

Table 1 summarizes the economic cost and benefits for optimal BMP combinations for four illustrative scenarios. IDEAL in combination with the DMT was used to determine the lowest cost BMP combination to achieve a given site score in each Ansley Crossing scenario. The top half of the table summarizes the cost of the onsite BMP practices needed to achieve alternative site scores for the four illustrative scenarios. The baseline scenario uses traditional stormwater BMPs, consisting of a combination of 28 acres of natural filtration area and two dry ponds that total two-tenths of an acre, to achieve the minimum regulatory required site score of 40. Scenario 2 achieves the target site score of 70, the minimum score necessary to participate in the SBP for the original 38 lot subdivision but assumes no density bonus is available. The higher site score is achieved by reducing the baseline dry pond area by half, and replacing the lost dry pond area with 18 100 square-foot bioretention cells on 18 lots, and a 50 square-foot infiltration trench on the remaining 20 lots. This results in a total of 1,800 square feet of bioretention cells and 1,000 square feet of infiltration trenches within the development. Scenario 3 achieves the minimum target site score of 70 to participate in the SBP for the same subdivision, but at the bonus density development level of 64 lots. With the addition of the 26 bonus lots, the BMP plan developed for Scenario 2, must be modified to achieve a site score of 70 at the higher building density. The higher site score is achieved by using three-fourths of the baseline dry pond area and adding a 90 square-foot bioretention cell on 32 lots and a 50 square-foot infiltration trench on the remaining 32 lots, for a total of 2,880 square-feet of bioretention cells and 1,600 square-feet of infiltration trenches within the development. Scenario 4 was developed to illustrate one set of changes in BMP selection and/or intensity that would motivate a developer to achieve a site score of 80, 10 points higher than the minimum site score required for SBP participation if the subdivision is built to the 64 lot density bonus maximum. In this situation, three-quarters of the original baseline dry pond area is retained and a 150 square-foot bioretention cell is incorporated into 32

Table 1. BMP Cost, Effective Participation Fee and Profit by Scenario

BMP Practice	Scenarios			
	Baseline	SC 2	SC 3	SC 4
Bioretention Cell	\$0	\$10,015	\$15,469	\$25,053
Natural Filtration	\$0	\$0	\$0	\$0
Infiltration Trench	\$0	\$4,629	\$7,290	\$10,837
Buffer Strip	\$0	\$0	\$0	\$0
Bioswale	\$0	\$0	\$0	\$0
Dry Pond	\$10,060	\$5,030	\$7,545	\$7,545
Wet Pond	\$0	\$0	\$0	\$0
Wetland	\$0	\$0	\$0	\$0
Porous Pavement	\$0	\$0	\$0	\$0
Sand Filter	\$0	\$0	\$0	\$0
Green Roof	\$0	\$0	\$0	\$0
Rain Barrel	\$0	\$0	\$0	\$0
Total Cost	\$10,060	\$19,674	\$30,303	\$43,436
Site Score	40	70	70	80
Additional BMP Cost	NA	\$9,614	\$20,243	\$33,376
Number of Lots	38	38	64	64
Lot Price	\$46,500	\$46,500	\$46,500	\$46,500
Participation Fee	---	NA	\$151,125	\$151,125
Rebate	---	NA	NA	\$30,225
Effective Fee	---	NA	\$151,125	\$120,900
Program Profit before Rebate and Additional BMP Cost	---	NA	\$151,125	\$151,125
Net Profit	---	-\$9,614	\$130,882	\$147,974

Note: All cost, benefit and profit measures are calculated relative to the baseline scenario. Scenario 2 has a zero program profit before subtracting additional BMP cost to the achieve the target site score of 70 because there is no SBP in place to reward developers that implement management plans beyond the minimum regulatory requirements to achieve a site score of 40. In scenarios 3 and 4, Net Profit is calculated as the profit from the sale of additional lots, minus the participation fee and Additional BMP Costs incurred, plus any rebate the developer qualifies for. The Effective Participation Fee is the Participation Fee less any Rebate.

housing lots, and a 75 square-foot infiltration trench is included in the stormwater management plan for the remaining 32 lots. In total, 4,800 square feet of

bioretention cells and 2,400 square feet of infiltration trenches are used in Scenario 4 to achieve the site score of 80. Other BMP combinations which achieve a given site score were found, but are not reported due to space limitations. As the number of residential lots increases, impervious surface increases and the scale of BMPs necessary to achieve a given site score will increase.

The bottom half of Table 1 summarizes developer profit in each scenario. No net profit is reported for the baseline scenario because under the baseline the developer is not in the SBP. A total BMP cost of \$10,060 is incurred to achieve the regulatory minimum site score of 40. Scenario 2 illustrates why the density bonus is necessary to encourage developers to voluntarily adopt LID BMPs. When the optimal combination of LID BMPs are used to attain the target site score of 70, total BMP cost is \$19,674, \$9,614 higher than in the baseline. Scenario 3 illustrates the economic benefit of participating in the SBP. Based on a review of 700 lots sold in Greenville South Carolina between 2007 and 2009, an average lot price of \$46,500 is used in this illustration. Average profit per lot sold is assumed to be 25% based on discussions with eight Greenville real estate developers. Despite the higher BMP cost incurred to achieve the target site score of 70, the 26 lot density bonus increases net developer profit by \$130,882 even though BMP cost is \$20,243 higher than in the baseline and \$10,629 higher than they are in scenario 2. The increased BMP cost in scenario 3 relative to scenario 2 results from the fact that additional BMPs must be installed at the higher building density to control runoff. In scenario 4 a site score of 80 is achieved. To achieve this higher site score additional LID BMPs must be used. To encourage a developer to design a stormwater management plan that achieves the higher site score a percentage rebate on the participation fee is used as the carrot. In this illustration, for every point the development site score exceeds the minimum target site score of 70, the developer receives a 2% rebate on the participation fee. After receiving the rebate and paying the additional BMP cost, developer net program profit is \$147,974. Thus, with the rebate incentive, a profit maximizing developer would both voluntarily enter the SBP and design to the higher site score of 80 because the rebate exceeds the additional LID BMP cost incurred in increasing the site score from the minimum site score of 70 required to participate in the SBP.

Conclusion

Incentive based policies hold promise to reduce stormwater runoff in urban areas and improve regional water quality by aligning the incentives of regulators and residential developers. The proposed incentive based

SBP allows developers to build at a higher density in exchange for adopting low impact stormwater best management practices. An example development in Greenville, South Carolina was used to demonstrate how a policy of this type could both increase developer profit and reduce stormwater runoff beyond current regulatory standards. Moreover, the collected participation fee can be used to retrofit substandard stormwater control measures elsewhere in the community to improve regional water quality.

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