STORMWATER UTILITY FEE CREDIT COMPUTATIONS BASED ON BEST MANAGEMENT PRACTICES EFFECTIVENESS

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Introduction

Urban stormwater utilities are becoming an increasingly popular method of funding stormwater programs throughout the United States. Many of these utilities have rate structures that comprise three components: 1) a basic fee and rate concept, 2) secondary funding methods, and 3) rate modifiers. A common method of equitably modifying the rate structure is a fee credit system that reduces the stormwater fee based on a structural control's ability to reduce the impact of runoff from a property to the receiving stormwater system.

On-site structural controls (best management practices or BMPs) can reduce the impacts of runoff to the drainage system caused by development. Therefore, a property owner who owns and maintains a BMP should pay a lower utility fee because of his or her reduced impact on the system.

Fee Credit Structure

A fee credit system should complement the funding base of the stormwater utility. The City of Charlotte selected the impervious area of a parcel as the base utility rate. Factors leading to selection of this base rate methodology were 1) simplicity—impervious area as an indication of the amount of runoff from a property can be easily explained to the general public; and 2) open space—because undeveloped land pays no fee, this structure encourages green space and limited density or clustered development. Therefore, the fee credit system was developed with impervious area as the basis. The theory was that the credit should be based on the extent to which a BMP can reduce the impacts and associated public costs on the stormwater system by reducing the "effective impervious area."

An analysis of the fiscal structure of Charlotte's stormwater management program indicated that the total cost is allocated approximately in proportion to the following three impacts on the drainage system:

- peak flow—50%,
- flow volume—25%, and
- water quality—25%.

Therefore, Charlotte's credit system was structured to grant a fee reduction based on the ability of BMPs on a property to reduce the effect on the receiving water course for each of these three impacts.

The method of computation for fee credit purposes is to determine each of these impacts at the exit of the site for the following conditions:

- existing conditions prior to development,
- developed conditions without controls, and
- developed conditions with controls in place.

An assumption was made that each of these impacts varies linearly with impervious area of the site. Therefore, an "effective" impervious area is computed by the following formula:

$$I2 = I1 + (Q2 - Q1) (I3 - I1) / (Q3 - Q1)$$

where:

I2 = "effective" impervious area;

I1 = impervious area without development (always assumed to be zero);

Q1 = pre-development peak, volume, or pollution runoff;

I3 = post-developed impervious area;

Q3 = post-development peak, volume, or pollution runoff; and

Q2 = post-development with controls for peak, volume, or pollution runoff.

Figure 1 illustrates the "effective imperviousness" concept.

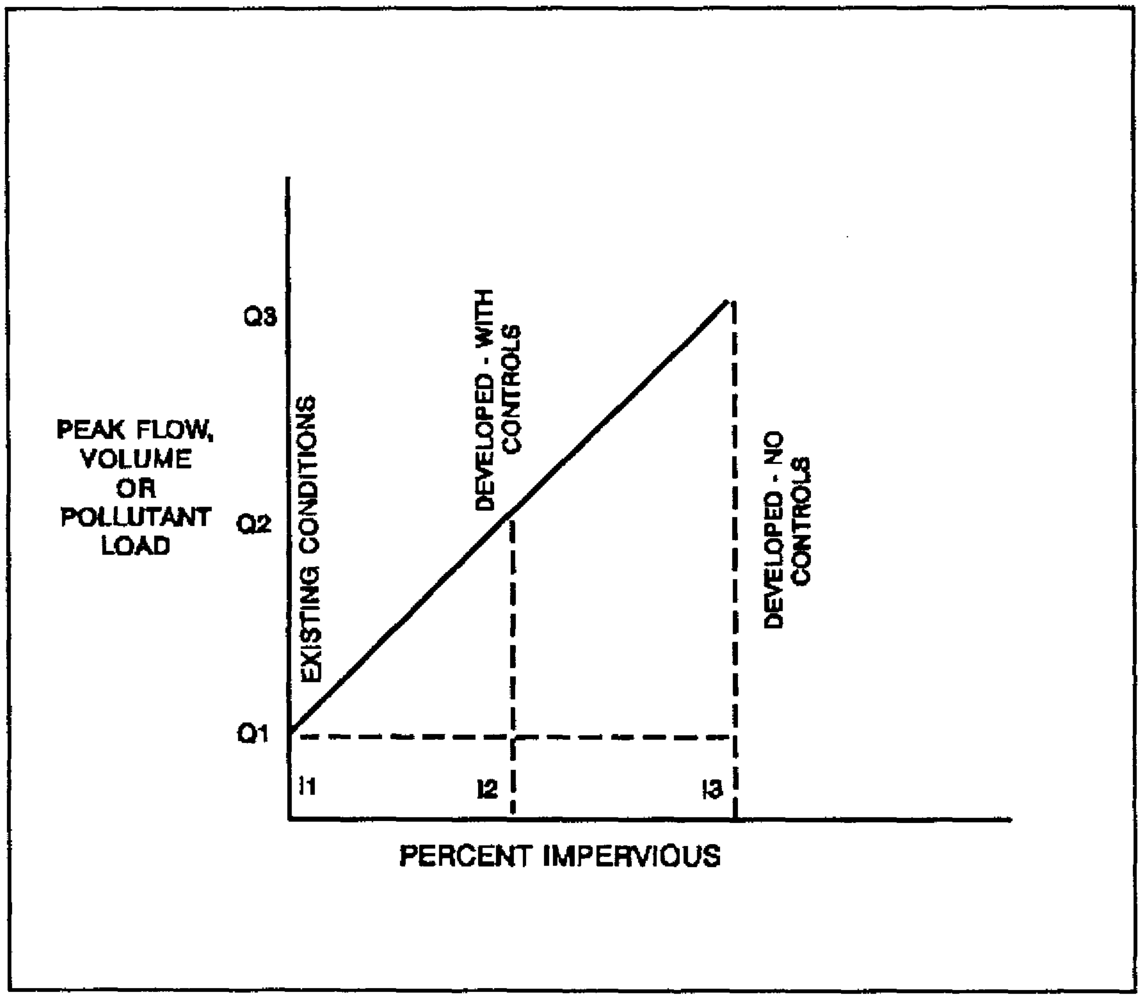

Figure 1. Effective imperviousness diagram.

BMP Design Standards

The City of Charlotte determined that the fee credit system should initially be based on two BMPs: the extended detention basin and the wet pond. Other BMPs were not selected at the onset of the utility due to the inexperience of local engineers in determining the pollution reduction of other BMPs and the inability of the city to actively monitor the maintenance of such facilities. In addition, other BMPs do not provide significant peak flow attenuation in order to achieve peak flow or volume credit. The design standards were developed consistent with the *Charlotte-Mecklenburg Stormwater Design Manual* and are listed as follows:

- Peak flow: 10-year, 6-hour storm event.
- Flow volume: total runoff volume in 12-hours from the start of runoff for the 2-year, 6-hour storm event.
- Pollution: annual loading of lead, BOD5, and total phosphorous.

The 10-year storm was selected for peak flow calculations because it is believed to be the mid-range control for the majority of detention basins in the city. The 2-year storm was selected for flow volume calculations because it is considered to be the "channel forming" event. Channel forming and erosion problems are considered to be a major cause of many of the maintenance problems in Charlotte. The 12-hour period measured for flow volume was estimated to be the time during which the majority of flow can be considered base flow. Both the peak flow analysis storm event and flow volume analysis storm event were based on the 6-hour storm duration due to previous calibration efforts within the city of Charlotte.

Three constituents were chosen for the pollution reduction fee credits: lead, BOD5, and total phosphorous. These three constituents were selected to cover the varied spectrum of possible urban pollutants: lead as a common measure of toxic trace metal production; BOD5 as a common measure of the oxygen demand within the stream system (which typically is a good measure of the overall stream health); and total phosphorous as a measure of nutrient loading. Also considered were: different pollutant protection requirements for different water bodies, the pollutants' different origins, the pollutants' different impacts on the aquatic ecosystem, and the different pollutant removal efficiencies provided by various BMPs.

Existing Detention Basin Retrofitting

The city of Charlotte investigated the feasibility of private property owners retrofitting their existing detention basin's configuration in order to maximize the available fee credit. The investigation focused on five facilities in Charlotte that had varying physical properties in order to show a diverse set of possible retrofitting opportunities. The property location within the watershed, the contributing watershed size, the property land use, the existing detention basin's storage volume, and the downstream conditions were evaluated during the site selection process so that all hydrologic, hydraulic, site design, and policy issues could be addressed and demonstrated.

All of the detention basins in the study had been designed and constructed under the outdated requirements of the Charlotte Engineering Department, which required the design of the basin with a "Modified Rational" method. Studies have determined that the Modified Rational method typically underestimates the required storage volume of the basin by 20% to 60%. Therefore, it was expected that most of these sites would not receive a full peak flow fee reduction. In addition, it was expected that most of these sites would not receive any flow volume or pollution control fee credit because most of the basins would not provide the required extended detention time or required wet pond volume.

The results of the retrofitting study are presented in Table 1.

Table 1. Results of retrofitting study.

	Total Impervious Acreage	Unadjusted Monthly Fee	Non-Retrofitted Monthly Fee	Retrofitted Monthly Fee	Cost of Retrofit
Site 1	31.4 acres	$1,110	$887	$525	$29,200
Site 2	1.8 acres	$64	$60	$17	$5,600
Site 3	36.3 acres	$1,283	$373	$284	$6,000
Site 4	96.7 acres	$3,418	$3,418	$3,048	$81,685
Site 5	8.2 acres	$290	$221	$124	$30,154

Several conclusions were drawn from the results of the retrofitting study. First, most of the existing detention basin sites received little or no fee credit. The fee credit ranged from 0% to 24%. One site, which contained a large permanent pool facility with additional storage volume above the permanent pool elevation, achieved a 71% fee credit. Second, retrofitting the structures insignificantly increased the fee credit. The range of fee credit shifted to 11% to 78%. However, the cost of retrofitting was excessive for the amount of savings provided by the fee credit. Typical payback periods were computed to range from 5.6 years to 25.8 years.

Conclusion

The fee credit system provides an equitable means of redistributing the costs of a stormwater program to the pro rata share of the properties' impact on the system. The City of Charlotte experienced the effects of two changes within its program that make the evaluation of the fee credit system difficult for existing basins. The implementation of more accurate detention basin design criteria—publication of the *Charlotte-Mecklenburg Stormwater Design Manual,* in July 1993—resulted in many existing detention basins throughout the municipality that did not meet the increased design requirements. In addition, no existing detention basin had been purposely designed for water quality control or flow volume control. Second, the actual publication of the *Credit Application Instruction Manual* initiated a completely new administrative policy and technical procedure.

The fee credit program has been in service for approximately 16 months. During that time approximately 50 fee credit applications for existing sites have been received by Stormwater Services. This number is a small percentage of the estimated 2,000 detention basins constructed during the last 15 years. Generally, existing basins were determined to be eligible for minor fee credit (typical ranges from 0% to 24%). Conversations with many of the property owners and private engineers within Charlotte indicated that the payback period for the engineer design fees will usually range from four years to 15 years. In addition, the property owners must maintain the BMP to city standards to receive a fee credit. Such maintenance is not otherwise required. Therefore, the majority of property owners with existing detention basins have opted to not pursue the fee credit.

However, new developments designed under the updated stormwater detention design regulations ensure that additional design fees will not have to be paid in order to calculate the peak flow fee credit because the majority of the computations would be prepared in conjunction with detention basin design and approval. Therefore, the majority of new developments have applied for the peak flow fee credit. Flow volume and pollution control fee credit are not specific requirements of the Charlotte-Mecklenburg regulations and therefore volume and pollution control have not been used extensively in the new development process. Only in the case where a permanent pool is proposed as an amenity has the property owner constructed a BMP to control pollution or flow volume and applied for the corresponding fee credit. It is expected that as designers become familiar with BMP design, more property owners will take advantage of fee credits.

In summary, the policy requires a significant effort to determine the appropriate credit for previously developed properties and BMPs, resulting in a limited number of such applications. However, the additional effort to apply for credit in conjunction with the approval of new development plans is very small. In fact, the engineer of new development has an opportunity to refine the design of required on-site BMPs to maximize credits for the site, which will benefit the owner indefinitely.

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VALUE ENGINEERING
COST CONTROL FOR FLOOD CONTROL

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Introduction

This paper describes how value engineering was used on a large flood control project designed by the Los Angeles District of the U.S. Army Corps of Engineers. The project is the modification of an existing flood control system in the Los Angeles County Drainage Area (LACDA). It is designed to increase the flood control capacity of the lower Los Angeles River and the Rio Hondo Diversion Channel to compensate for the urban development that has occurred since the original system was constructed. The paper first gives an overview the value engineering process. Then it tells how value engineering was applied to the project, the results that were achieved, and the impact of the recommendations on the design and the designers. Finally, the paper will discuss how even greater results can be achieved by performing the studies before finalizing the feasibility study.

Value Engineering Process Overview

Value engineering (VE) can be defined as a systematic study of functions using teamwork and creativity to identify alternatives with the lowest life cycle cost without sacrificing the required functions or appropriate quality.

In today's environment of escalating project costs and diminishing budgets, VE must be an essential element of the design and construction process. VE is the most effective tool available to obtain the required functions at the minimum cost without sacrificing the needed quality of the project. The time has come to recognize that money is a precious commodity that must be considered thoughtfully.

The VE job plan or process consists of pre-workshop preparation, the workshop, and post-workshop activities. The specific process is described in more detail below.

Before the Workshop

The pre-workshop period is a time to get prepared for the actual workshop. During this time, the team leader will assemble the study team. This will be accomplished after reviewing the project material and interviewing key owner and designer staff about the project. This gives the team leader insight on the issues and concerns on which the team should focus. From this information, the team leader will determine the disciplines necessary for the team and the workshop duration, i.e., three, four, or five days. This is followed by a coordination effort on the workshop logistics.

Also during the pre-workshop phase, the team leader will review the cost data on the project and begin assembling a cost model. The cost model helps the team to focus on areas of the project where most of the money is being spent. The results of these cost models often surprise the owner and even the designer.

Other activities during this phase include an independent review of the project cost estimate by the VE team's estimator and project document review by other VE team members.

Workshop

The workshop is the focus of the VE study effort. It is then that the VE study team analyzes the project functions and generates alternatives to the designer's concept for accomplishing those functions. The workshop is broken into five distinct phases: information; creative; judgment; development; and presentation.

Information Phase. The objective of the information phase is to give the VE team a thorough understanding of the project. This education will begin with presentations about the project from the owner and designer. After the presentations, the team will spend some time reviewing the project documents in more detail and tour the actual project site, if possible. The review is followed by an intense function analysis of the project.

Function analysis is the heart of the VE process. During function analysis, the team dissects the project into distinct elements. It is from this that the VE study team develops the unique perspective of the project that can only be accomplished through this process.

Creative Phase. The next phase of the process is the creative phase, which is used to generate a large number of ideas without regard to their practicality. The intent is quantity of ideas, not quality. The technique most often used for the idea generation is brainstorming.

Judgment Phase. This phase is used to evaluate the ideas generated during the creative phase, and to select those worthy of further consideration. Several group evaluation techniques are available, but this project used a voting process followed by a brief discussion. This allows the top 20% of the ideas, often 200-300 in number, to be evaluated in about two hours. The ideas remaining at the end of the judgment phase are carried on to the next phase.

Development Phase. The purpose of this phase is to turn the ideas into a recommendation supported by engineering calculations, sketches, cost estimates, and life cycle cost analysis. Approximately half of the workshop is dedicated to this phase.

Presentation Phase. This phase is used to present the recommendations developed by the VE study to the project decisionmakers. This time is used for further explanation of the recommendations, not for debating the acceptability of the idea. For this project, this phase actually occurred a few weeks after completion of the development phase. In most cases, however, it will immediately follow the previous phase.

After the Workshop

The post-workshop activities are to determine acceptability of the recommendations, define the implementation procedures, and document the study effort. After the conclusion of the workshop, the VE team leader provides the owner and designer with a copy of the workshop materials. This is reviewed and an implementation meeting scheduled. At this meeting, decisions are made about which recommendations will be implemented into the design. After this meeting a final report is developed to document the study and decisions.

VE Study: Los Angeles County Drainage Area

Project Background

This project was designed to increase the flood control capacity of an existing system located in the Los Angeles County Drainage Area (LACDA). The work is primarily focused on the lower reaches of the Los Angeles River, the Rio Hondo Diversion Channel, and Compton Creek. The proposed fix by the Corps of Engineers' Los Angeles District involves constructing parapet walls on top of existing levees. Due to clearance problems, 27 bridges were originally scheduled for reconstruction at a higher elevation. After significant physical modeling performed by the Waterways Experiment Station, the Corps determined that only 10 needed to be reconstructed and the other 16 could be modified with pier extensions. Other significant elements of the work included changing the large trapezoidal channel at the confluence of the Los Angeles and Rio Hondo to a rectangular cross section.

The overall project was aimed at increasing the flood protection level to a 133-year event. Economic factors in this highly urbanized area justified a higher level of protection, but this would require reconstruction of the Century Freeway Bridge, which substantially lowered the benefit-cost ratio, to the point at which it was not cost effective.

The VE team consisted of a CVS team leader, two hydraulic engineers, two civil/structural engineers, and a structural/bridge engineer. This team was tailored to the project based on information obtained from the cost model developed for the project. The model showed that the project costs were concentrated on concrete parapet walls, bridge modifications, and the confluence modification. After the team was assembled, each team member was given eight hours to study the project documents before the workshop began.

In the information phase, the VE team was informed that the project cost had been significantly reduced as a result of the extensive physical modeling. The modeling allowed the designer to test more economical modifications to the bridges. However, some parts of the project had not been modeled, for example, the confluence and the lower reaches of the project where the flows went subcritical.

During the creative phase, the VE team generated over 150 ideas for project improvements and cost reductions. During the judgment phase this number was reduced to the best 35 ideas. This number was based on the number of ideas the team was capable of developing in the time given for the development phase. After the team performed its evaluation, the owners/designers were invited in to review the short list of ideas. This is done to ensure that the VE team has not missed an important issue that would make an idea totally unworkable and therefore not worthy of further effort. The Corps only removed two ideas from the VE team's list but replaced them with two other ideas that they wanted to see developed.

The Corps chose to combine the presentation of the recommendations and the decisionmaking process into one meeting. The result of this meeting was the acceptance of several proposals, which offered alternatives to the standard L-shaped parapet wall in the project design. The designers did not feel that any one of the proposed alternatives was appropriate for the entire project but they saw benefits to each design alternative that they could apply where appropriate. This saved an estimated $10 million. Another suggestion was made to detour traffic rather than construct temporary bridges for those being reconstructed. This idea saved the project over $8 million. The Corps and county accepted other ideas related to the bridges totaling another $9 million in construction savings. The Corps is performing some further studies to evaluate a VE recommendation to physically model the entire project, which the VE team estimated could save the project over $30 million. Another significant proposal that the Corps is still evaluating concerns reducing the level of protection at selected bridges to postpone reconstruction until the end of the bridges' useful life. While the Corps and the county can see merit to this proposal it may not be implemented because it would require resubmitting the feasibility report for approval. Depending on the current political priorities of the Corps' division office, headquarters, or Congress, the project could be delayed or canceled.

Achieving Greater Results

Although the results of this study were phenomenal, far greater results could have been achieved if the study had been planned for and conducted early in the planning and design process. Any time you are looking at a project with the intent of identifying design changes, the earlier it is done the better. For a project of this size, a study should be done at the conclusion of the planning effort, before finalizing the feasibility report. Once the feasibility report is approved, it becomes a significant effort to make changes. Particularly difficult are those that result in changes to criteria, such as the level of flood protection provided or the method by which protection will be provided.