3.2.2 Small System Considerations

The CSO Control Policy acknowledges that *"...the scope of the long-term CSO control plan, including the characterization, monitoring and modeling, and evaluation of alternatives...may be difficult for some small CSSs"* (I.D). EPA recognizes that smaller communities with limited resources might benefit more than investment in CSO controls than from these aspects of LTCP development (EPA, 1995g). For this reason, at the discretion of the NPDES permitting authority, municipalities with populations of less than 75,000 need not be required to complete each of the formal steps outlined in the CSO Control Policy.

At a minimum, however, the permit requirements for developing an LTCP should include compliance with the NMC, consideration of sensitive areas, a post-construction compliance monitoring program sufficient to determine whether WQS are attained, and public participation in the selection of the CSO controls (EPA, 1995g). In developing a small system LTCP, municipalities should consult with both the NPDES permitting and WQS authorities to ensure that the plan includes enough information to allow the NPDES permitting authority to approve the proposed CSO controls.

3.3 DEVELOPMENT OF ALTERNATIVES FOR CSO CONTROL

Development of alternatives for CSO control is generally based on the following sequence of events:

1. Definition of water quality goals
2. Definition of a range of CSO control goals to meet the CSO component of the water quality goals
3. Development of alternatives to meet the CSO control goals.

Within this general context, this section is organized as follows. Section 3.3.1 presents some general considerations, primarily regarding the relationships between the LTCP and other related aspects of a municipality's collection and treatment system, including the NMC. Section 3.3.2 discusses and highlights an example of possible definitions for water quality goals and corresponding CSO control goals. Section 3.3.3 provides a series of approaches to structuring CSO control alternatives. These approaches are intended to provide a means for focusing or organizing CSO control alternatives and include such categories as evaluation of outfall-specific solutions, local or regional consolidation of outfalls, utilization of POTW capacity (including CSO-related bypass), and special considerations for sensitive areas. Depending on the size of the CSS, different approaches might be appropriate in different parts of the CSS. Having discussed the goals of CSO control and general approaches to structuring alternatives to meet those goals, Sections 3.3.4 to 3.3.9 provide guidance on the scope of initial alternatives development. Section 3.3.4 introduces this topic, while Sections 3.3.5 to 3.3.9 present specific aspects of initial alternatives development, such as identification of control measures or technologies, preliminary sizing considerations, cost/performance considerations, preliminary siting issues, and preliminary operating strategies.

3.3.1 General Considerations

This section presents general concepts that should be considered when developing CSO control alternatives.

3.3.1.1 Interaction with Nine Minimum Controls

Certain minimum control measures developed in conjunction with the CSO system characterization might affect baseline flows and loads. In particular, measures associated with maximizing collection system storage and flows to the POTW might reduce the volume and/or frequency of predicted overflows at specific locations. Minimum control measures associated with the control of solid and floatable material in CSOs might be sufficient in scope to be considered as long-term alternatives. Because minimum controls would be implemented before the completion of the LTCP, the LTCP should incorporate the expected benefits of the minimum controls.

3.3.1.2 Interactions with Other Collection and Treatment System Objectives

Implementation of CSO controls is likely to affect other point and nonpoint source control activities occurring within the same watershed. The CSO Control Policy encourages municipalities to evaluate water pollution control needs on a watershed management basis, and to coordinate CSO control efforts with other point and nonpoint source control activities (see Section 1.6.6). For example, if a municipality evaluates sewer separation as an alternative, it should consider the impact of increased storm water loads on receiving waters. Similarly, the system characterization model should explore the interrelationships between inflow/infiltration removal, interceptor capacity, CSO control alternatives, and POTW capacity. The LTCP provides an opportunity to optimize the operation of new and already-planned components of the treatment system, and to explore new system modifications that affect the operation of these components.

3.3.1.3 Creative Thinking

The initial identification of alternatives should involve some degree of brainstorming and free thinking. CSO control can be a challenging problem, where lack of available sites, potential impacts on sensitive receptors, and stringent water quality goals are common issues. The CSO Control Policy encourages *"Permittees and permitting authorities...to consider innovative and alternative approaches and technologies that achieve the objectives of this policy and the CWA"* (I.F). Some of the more successful urban CSO projects have incorporated original ideas for multiple use facilities and for mitigating impacts on neighboring areas. For example:

- **Rochester, NY**—A tunnel system was designed to cross the Genesee River by way of a conduit suspended across the Genesee Gorge. Crossing the gorge above rather than below the river surface eliminated the need for downstream pumping to the POTW and also allowed the construction of a pedestrian walkway along the suspended conduit, providing access between parks located on either side of the gorge.

- **Newport, RI**—Below-grade, covered storage/sedimentation tanks located on a commercial block were designed to allow parking on the roof slab. Architectural features of the facility were designed to blend in with historic homes in an adjacent neighborhood.

3.3.2 Definition of Water Quality and CSO Control Goals

This section discusses the first two aspects of development of alternatives: identifying water quality goals and identifying CSO control goals to meet the water quality goals.

The CSO Control Policy clearly states that the ultimate goal of the LTCP is "*compliance with the requirements of the CWA*" (II.C). The CSO Control Policy also recommends that a range of control levels be evaluated as part of the LTCP (II.C.4), while State CSO policies sometimes identify specific control goals for evaluation. The initial definition of CSO control goals, however, should be based on an identification of watershed-specific or receiving water segment-specific water quality goals. Water Quality goals are defined without regard to sources of pollution. Examples of water quality goals might include meeting WQS at all times, or meeting WQS except for four times per year. CSO control goals refer to specific levels of pollution control from CSO sources only. Defining a CSO control goal based on a water quality goal means identifying a level of CSO control which will allow attainment of the water quality goal, assuming non-CSO sources of pollution are also controlled to an appropriate level. Once a CSO control goal is defined, CSO control alternatives, comprised of technologies or other control measures, can then be developed to meet the CSO control goal.

For example, a water quality goal of meeting existing WQS at all times might correspond to a CSO control goal of eliminating the CSO impacts on a given receiving water. CSO control alternatives to meet this goal might include sewer separation or CSO relocation. A water quality goal of meeting existing WQS except for four times per year might correspond to a CSO control goal of eliminating the CSO impacts except for four times per year. CSO control alternatives to meet this goal might include, storage or treatment of overflows from storms with a recurrence interval of four times per year. In this second case, the existing WQS would not be attained at all times. The CSO Control Policy recognizes, however, that existing WQS might not be appropriate in all cases for a given receiving water: "*...this Policy allows consideration of... WQS review...*" (II.E). In order for a water quality goal that does not fully support existing WQS to conform with the CWA, either a variance, a partial use designation, or a revision to WQS would have to be obtained, as outlined in Part III of the CSO Control Policy. A review of WQS might also be appropriate if non-CSO sources of pollution are contributing substantially to nonattainment, making the definition of an appropriate water quality goal for an LTCP less clear.

Through the evaluation process, a specific water quality goal might ultimately drive the selection of the recommended plan. For example, a goal of meeting a bacteria criterion that allows unrestricted shellfishing could require a CSO control goal of eliminating CSOs to a particular receiving water containing shellfish beds. While less aggressive CSO control goals might be more cost effectively attained, if stakeholders agree that the goal of unrestricted shellfishing is desired and appropriate, then that goal should govern the selection of a recommended plan. Alternatively, cost-effective analysis in conjunction with a use attainability analysis might identify instances where attainment of an existing WQS is not an appropriate goal. For example, suppose an industrial shipping channel is currently rated for primary contact recreation. The cost of the CSO controls required to achieve that goal might be excessive compared with the benefit gained (e.g., even if the bacteria criterion for swimming were met, swimming would not be allowed in the channel for safety reasons due to ship traffic). Coordination with State WQS authorities regarding the possible revision of the existing WQS (consistent with 40 CFR 131.10) to allow a limited number of wet weather excursions from the standard for primary contact recreation might be an appropriate part of the recommended plan. In this case, determination of the ultimate water quality goal would have been driven by the alternatives development and evaluation process.

Under the demonstration approach, the initial system characterization should identify the specific pollutants causing nonattainment of WQS and, where possible, their sources. The CSO Control Policy recognizes that total elimination of the CSO sources of these pollutants might not be technically or economically feasible, nor might it be required to meet the appropriate water quality goals. Determining the appropriate level of control of these pollutants from the point of view of WQS, available technology, cost, and non-monetary factors is one of the goals of the CSO control alternative development and evaluation process. By evaluating a range of control levels, the municipality, NPDES permitting agency, and other stakeholders will be sure that the most cost-effective solution has been developed to address the appropriate level of CSO control.

As an example of one way to derive CSO control goals, consider the following scenario for a particular receiving water segment. System characterization indicates wet weather fecal coliform bacteria counts and floatables are causing nonattainment of WQS, while wet weather dissolved oxygen, TSS, nutrients, metals, and other constituents are within acceptable ranges. In addition, the fecal coliform contributions from storm water alone would continue to cause WQS violations. In this case, elimination of CSOs would not result in attainment of existing WQS. Under the demonstration approach, the appropriate water quality goal would be a level where remaining CSO pollutant loads *"...will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment"* (II.C.b.ii).

To determine an appropriate level of CSO control, a municipality can start by identifying a "reasonable range" of control goals, such as the following:

- Level I: Eliminate the impact of CSOs on receiving water quality.
- Level II: Reduce the CSO fecal coliform load and control floatables to a level that would not alone cause nonattainment of existing WQS and reduce the impact of other CSO constituents on the receiving water segment.
- Level III: Reduce the CSO fecal coliform load and control floatables to a level that would not alone cause nonattainment of existing WQS.

With this range of controls, the constituents contributing to nonattainment of WQS are in all cases targeted for control, while varying levels of control are identified for other constituents that do not directly affect attainment of WQS. General categories of CSO control technologies could be identified that would achieve each particular level of control. Within Levels II and III, controls could be evaluated over a range of design conditions, such as 1 to 3, 4 to 7, and 8 to 12 overflow events per year, as suggested in the CSO Control Policy. Level I would be equivalent to zero overflow events per year.

While this approach is intended to provide flexibility and facilitate cost/benefit analysis, it is clear that even with a fairly simple CSS, the number of possible alternatives can become very large. For example, five outfalls discharge to a receiving water segment and, at each outfall, three technologies are identified as potentially feasible, and each technology could be sized for three different design conditions (i.e., 1-month, 3-month, and 1-year storm). Therefore, cost and performance data would have to be generated for 45 facilities. This point emphasizes the need for iterative screening of alternatives, particularly where multiple CSOs occur to a single receiving water segment. Where a CSS discharges CSOs to receiving water segments in different watersheds, it would be appropriate to at least initially evaluate the alternatives within the different watersheds separately.

This example of developing a range of CSO control goals is intended to be just that—an example. Individual municipalities should develop an approach that is best suited to their own CSS, receiving waters, and control needs. Smaller communities in particular might be able to simplify this process to some degree, but the general concept of defining goals and evaluating a range of controls should be maintained. In all cases, early coordination with appropriate regulatory agencies in the development of the LTCP approach is necessary. Consensus among stakeholders, including the public, on the methodology for developing the LTCP is desirable and contributes to achieving consensus on the recommended plan.

3.3.3 Approaches to Structuring CSO Control Alternatives

A first step in identifying CSO control alternatives to meet the initial range of CSO control goals is to identify ways to structure the alternatives, given the geographic layout of the CSS, as well as hydraulic and other constraints. In other words, how will the alternatives developed for each outfall be related to alternatives developed for other outfalls. This evaluation can be conducted somewhat independently of the specific technologies to be applied to the overflows. For example, the municipality can determine whether local or regional consolidation of outfalls appear to be feasible or whether outfall-specific solutions appear more practical. At this stage, it is not necessary to identify the specific control technologies to be applied. Rather, general categories of projects such as "storage," "treatment," or "in-system controls" would suffice. This "brainstorming" can help focus the initial identification of alternatives, particularly with regard to identifying opportunities for consolidation of outfalls and regional solutions. A given LTCP could ultimately include various combinations of approaches to structuring alternatives. For example, an LTCP featuring regional consolidation of outfalls might also include a number of outfall-specific facilities to control remote outfalls that would not be part of the consolidation system. The following subsections discuss typical approaches to structuring CSO control alternatives. Each of the following approaches should be considered in developing the LTCP. It is possible, however, that for a given collection system, a particular approach might yield no feasible alternatives.

3.3.3.1 Projects Common to All Alternatives

Projects common to all alternatives would be part of the LTCP regardless of the recommendations for other alternatives. These projects might be associated with the NMC or be specific fast-track projects for which the need and the expected benefit have already been defined (perhaps as part of an earlier study). For example, if a previous study recommended modifying the operation of a pumping station to relieve upstream surcharging in a particular interceptor, the project can be incorporated into each alternative for long-term control, whether the alternative be for end-of-pipe treatment or for local or regional consolidation. Subsequent alternatives development should consider the effect of these common projects on predicted system performance and implementation schedules.

3.3.3.2 Outfall-Specific Solutions

These alternatives are intended to control CSOs at individual outfalls. This approach might be appropriate for outfalls that are located remotely from other outfalls. Typical alternatives for single-outfall abatement include localized sewer separation, off-line storage, and end-of-pipe treatment.

3.3.3.3 Localized Consolidation of Outfalls

Where several outfalls are near each other, municipalities should investigate whether to consolidate them to a single location for storage and/or treatment. Consolidation can provide more cost-effective control of CSOs, minimizing the number of sites necessary for abatement facilities, and the institutional benefit of reducing the number of permitted outfalls.

Consolidation conduits between outfalls may present opportunities for in-line storage, which may reduce the required size of the abatement facilities.

3.3.3.4 *Regional Consolidation*

Municipalities with multiple outfalls and limited available space for near-surface facilities should consider consolidation of outfalls on a regional basis using deep tunnels or other appropriate technologies. Depending on the geographic distribution of outfalls, subsurface geological conditions, and other factors, a deep tunnel alternative can include near-surface consolidation conduits or satellite near-surface storage/treatment facilities for remotely located outfalls. Alternatives involving deep tunnels should consider whether the tunnels will serve primarily as storage facilities to be pumped out to the POTW at the end of a storm event or whether they will also serve to convey wet weather flows to the POTW for treatment during a storm event.

3.3.3.5 *Utilization of POTW Capacity and CSO-Related Bypass*

The CSO Control Policy encourages municipalities to consider the use of POTW capacity for CSO control as part of the LTCP. The use of POTW capacity is presented in the CSO Control Policy within three general contexts. First, as a minimum control, maximizing flow to the POTW is intended to ensure that optimum use is made of existing POTW capacity. Second, the CSO Control Policy states that *"...the long-term control plan should also consider expansion of POTW secondary and primary capacity in the CSO abatement alternative analysis"* (II.C.4). In some cases, it might be more cost-effective to expand existing POTW facilities than to site separate facilities for CSO control. Third, the CSO Control Policy addresses the specific case where existing primary treatment capacity at a POTW exceeds secondary treatment capacity and it is not possible to utilize the full primary treatment capacity without overloading the secondary facilities. For such cases, the CSO Control Policy states that at the request of the municipality, EPA may allow an NPDES permit *"...to authorize a CSO-related bypass of the secondary treatment portion of the POTW treatment plant for combined sewer flows in certain identified circumstances"* (II.C.7). Under this provision, flows to the POTW within the capacity of primary treatment facilities but in excess of the capacity of secondary treatment facilities may be diverted around the secondary facilities, provided that *"...all wet weather flows passing the headworks of the POTW treatment plant will receive at least primary clarification and solids and floatables removal and disposal, and disinfection, where necessary, and any other treatment that can reasonably be provided"* (II.C.7). In addition, the CSO-related bypass should not cause exceedance of WQS.

The regulatory basis for permitting a CSO-related bypass is included at 40 CFR 122.41(m), which defines a bypass as "...the intentional diversion of waste streams from any portion of a treatment facility." At 40 CFR 122.41(m)(4), bypasses are prohibited except where unavoidable to prevent loss of life, personal injury, or severe property damage and where there were no feasible alternatives to the bypass. "Severe property damage" is defined at 40 CFR 122.41(m)(1) to include "...damage to treatment facilities which causes them to become inoperable...." Under the CSO Control Policy, severe property damage could *"...include situations where flows above a certain level wash out the POTW's secondary treatment system"* (II.C.7).

Thus, the CSO-related bypass provision applies only in situations where the POTW meets the requirements of 40 CFR 122.41(m), as evaluated on a case-by-case basis. The municipality is responsible for developing and submitting the technical justification supporting the request for a CSO-related bypass. As with other aspects of the long-term plan development, coordination between the municipality and the permitting agency on this issue is very important. For the purpose of applying the requirements of 40 CFR 122.41(m) to the CSO-related bypass, the municipality must demonstrate that the following criteria are met:

- The bypass was unavoidable to prevent severe property damage, the definition of which includes damage to the treatment facilities that causes them to become inoperable (i.e., washout of the secondary treatment system)
- There was no feasible alternative to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime.

To satisfy the first criterion, *"...the long-term control plan, at a minimum, should provide justification for the cut-off point at which the flow will be diverted from the secondary treatment portion of the treatment plant"* (II.C.7). Examples of the types of information that support the "no feasible alternative" criterion include:

- Records demonstrating that the secondary treatment system is properly operated and maintained
- A demonstration that the system has been designed to meet secondary limits for flows greater than the peak dry weather flow plus an appropriate quantity of wet weather flow
- A demonstration that it is either technically or financially infeasible to provide secondary treatment for greater amounts of wet weather flow.

In presenting alternatives incorporating the CSO-related bypass in the context of the LTCP, the municipality should also provide *"...a benefit-cost analysis demonstrating that conveyance of wet weather flow to the POTW for primary treatment is more beneficial than other CSO abatement alternatives such as storage and pump back for secondary treatment, sewer separation, or satellite treatment"* (II.C.7).

The permit can include the conditions under which a CSO-related bypass would be approved and can specify appropriate treatment, monitoring, or effluent limitation requirements related to the bypass event. An example of permit language for the CSO-related bypass requirement is included in the permit writer's guidance document (EPA, 1995g).

3.3.3.6 Consideration of Sensitive Areas

The CSO Control Policy states that *"EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas, as determined by the NPDES authority in coordination with State and Federal Agencies, as appropriate..."* (II.C.3). Examples of sensitive areas presented in the CSO Control Policy include designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters supporting primary contact recreation (e.g., bathing beaches), public drinking water intakes or their designated protection areas, and shellfish beds. As described in Chapter 1, the CSO Control Policy (II.C.3) provides a hierarchy of approaches for controlling overflows to sensitive areas. Each of the approaches to developing alternatives could be applied to controlling overflows to sensitive areas, and an awareness of the locations of sensitive areas might guide the development and selection of control alternatives, as well as the identification of priorities for project implementation.

3.3.4 Goals of Initial Alternatives Development

Once a range of CSO control goals has been developed and approaches to structuring CSO control alternatives have been identified, the next step is to develop specific alternatives to achieve the various CSO control goals. As noted previously, in the initial alternatives development steps, the number of alternatives necessary to cover the range of control levels for each CSO can be very large. Judgment is necessary to develop a manageable array of alternatives. It is important to remember that the iterative screening of alternatives is flexible and not a rigid process. Alternatives initially rejected might become more feasible as more information is developed. Similarly, agency interaction and public participation throughout the process might contribute additional alternatives.

Municipalities should generally include the following steps during the initial development of alternatives to meet CSO control goals:

1. Identification of control alternatives (Section 3.3.5)
2. Preliminary sizing of control alternatives (Section 3.3.6)
3. Preliminary development of cost/performance relationships (Section 3.3.7)
4. Identification of preliminary site options and issues (Section 3.3.8)
5. Identification of preliminary operating strategies (Section 3.3.9).

3.3.5 Identification of Control Alternatives

A municipality's LTCP should contain one or a combination of CSO control alternatives to achieve receiving water segment-specific CSO control goals. Each alternative, in turn, will likely consist of one or more control measures. Control measures can include technologies, operating strategies, public policies and regulations, or other measures that would contribute to some aspect of CSO control. Control measures can generally be classified under one of the following categories:

- Source controls
- Collection system controls
- Storage technologies
- Treatment technologies.

Given the number of specific control measures within each of these categories and the range of sizing options for specific measures, initially it might be practical to consider general categories, such as storage or treatment, rather than specific storage or treatment technologies. Alternatively, it might be appropriate to identify "representative" technologies, with the understanding that specific technologies would be considered as part of more detailed evaluations. For example, if the consolidation of three outfalls appears to be feasible, the general categories of alternatives for these outfalls would include consolidation to storage or treatment. Representative technologies could include storage in the consolidation conduit, a storage tank downstream of the conduit, or a storage/sedimentation facility downstream of the conduit. The storage/sedimentation tank could be representative of or a "place-holder" for other treatment technologies, which could be evaluated in more detail once the general feasibility of achieving CSO control goals with the representative technology is established. In general, receiving water-specific CSO control goals will provide a basis for initial screening of CSO control measures. As the feasibility of the general categories of controls is resolved, the concepts will be developed gradually to higher levels of detail, allowing further screening of specific measures within the general categories.

The following discussion briefly introduces some common control measures under the above categories. The list is for general information only and is not intended to be comprehensive or imply EPA endorsement. Municipalities should also be open to evaluating new and emerging control measures. More detailed discussions of specific CSO control measures are given in the *Manual—Combined Sewer Overflow Control* (EPA, 1993a) and *Combined Sewer Overflow Pollution Abatement* (WPCF, 1989).

3.3.5.1 Source Controls

Source controls affect the quantity or quality of runoff that enters the collection system. Since source controls reduce the volumes, peak flows, or pollutant loads entering the collection system, the size of more capital-intensive downstream control measures can be reduced or, in some cases, the need for downstream facilities eliminated. The source controls discussed below include both quantity control and quality control measures:

- **Porous Pavements**—Porous pavements reduce runoff by allowing storm water to drain through the pavement to the underlying soil. Porous pavements, most commonly used in parking lots, require skill and care in installation and maintenance to ensure that the pores in the pavement do not become plugged. The benefits of porous pavements in cold climates might be limited.

- **Flow Detention**—Detention ponds in upland areas and roof-top storage can store storm water runoff temporarily, delaying its introduction into the collection system, and thereby helping to attenuate peak wet weather flows in the collection system. The detention facilities drain back to the collection system when peak wet weather flows subside.

- **Area Drain and Roof Leader Disconnection**—In highly developed areas with relatively little open, pervious space, roof leaders and area drains are commonly connected directly to the combined drainage system. Rerouting of these connections to separate storm drains or available pervious areas can help reduce peak wet weather flows and volumes.

- **Use of Pervious Areas for Infiltration**—Detention of storm flow in pervious areas not only helps attenuate peak wet weather flow in the collection system but also reduces runoff volume through infiltration into the soil. Grassed swales, infiltration basins, and subsurface leaching facilities can be used to promote infiltration of runoff. Infiltration sumps can be used in areas with well draining soils. This type of control might be more appropriate as a requirement for future development or redevelopment and could be implemented through sewer use ordinances and through strict review of proposed development plans.

- **Air Pollution Reduction**—One way to control pollutant loadings from combined sewer areas is to limit the amount of pollutants contributed to local air. Particulate and gaseous pollutants in air are carried to the ground by rainfall and airborne particulates also settle to the ground during dry weather. It is extremely difficult, however, to quantify the potential reduction in storm water pollution associated with air quality improvement.

- **Solid Waste Management**—Although littering is generally prohibited everywhere, it is a common problem in many communities. Street litter typically includes metallic, glass, and paper containers; cigarettes; newspapers; and food wrappers. If not removed from the street surfaces by cleaning equipment, some of these items often end up in combined sewer overflows, creating visible pollution due to their floatable nature.

  Enforcement of anti-litter ordinances is generally given a relatively low priority by law enforcement agencies due to the limited availability of personnel and funds, as well as the difficulty of identification and conviction of violators. Both public education programs and conveniently placed waste disposal containers might be effective, low-cost alternatives, especially in urban business areas. The proper disposal of leaves, grass clippings, crankcase oil, paints, chemicals, and other such wastes can be addressed in a public education program. Because the results of such a program depend on voluntary cooperation, the level of effectiveness can be difficult to predict.

- **Street Sweeping**—Street sweeping may be evaluated as a best management practice (BMP) for CSO pollution control. Frequent street sweeping can prevent the accumulation of dirt, debris, and associated pollutants, which may wash off streets and other tributary areas to a combined collection system during a storm event. Current sweeping practices can be analyzed to determine whether more frequent cleaning will yield CSO control benefit. The overall effectiveness of street sweeping as a CSO control measure has been debated and depends on a number of factors, including frequency of sweeping, size of particles captured by sweeping, street parking regulations, and climatic conditions, such as rainfall frequency and season.

- **Fertilizer and Pesticide Control**—Fertilizers and pesticides washed off the ground during storms contribute to the pollutant loads in storm water runoff. The municipal parks department is probably the user easiest to control. It is important, therefore, that these departments follow proper handling and application procedures. The use of less toxic formulations should also be encouraged. In highly urbanized areas, the use of these chemicals by the general public is not likely to be a major source of pollution. Because most of the problems associated with these chemicals are a result of improper or excessive usage, however, a public education program might be beneficial.

- **Snow Removal and De-Icing Control**—This abatement measure involves limiting the use of chemicals for snow and ice control to the minimum necessary for public safety. This, in turn, would limit the amount of chemicals (normally salt) and sand washed into the collection system and ultimately contained in CSOs. Proper storage and handling measures for these materials might also reduce the impacts of runoff from material storage sites.

- **Soil Erosion Control**—Properly vegetated and/or stabilized soils are not as susceptible to erosion and, thus, will not be washed off into combined sewers during wet weather. Controlling soil erosion is important in relation to CSOs and water quality for a number of reasons: soil particles create turbidity in the receiving water, blocking sunlight and causing poor aesthetics; soil particles carry nutrients, metals, and other toxics which may be released in the receiving water, contributing to algal blooms and bioaccumulation of toxics; and eroded soil can contribute to sedimentation problems in the collection system, potentially reducing hydraulic capacity. Like fertilizer and pesticide control, an educational program may be useful in controlling soil erosion, and implementation and enforcement of erosion control regulations at construction sites can also be effective.

- **Commercial/Industrial Runoff Control**—Commercial and industrial lands, including gasoline stations, railroad yards, freight loading areas, and parking lots, contribute grit, oils, grease, and other pollutants to CSSs. Such contaminants can run off into CSSs. Installing and maintaining oil and grease separators in catch basins and area drains can help control runoff from these areas, while pretreatment requirements can be identified as part of the community's sewer use regulations.

- **Animal Waste Removal**—This measure refers to removing animal excrement from areas tributary to CSSs. As with air pollution control, the impact of this control measure is difficult to quantify; however, it might be possible to achieve a minor reduction in bacterial load and oxygen demand. This BMP can be addressed by a public information program and "pooper-scooper" ordinances.

- **Catch Basin Cleaning**—The regular cleaning of catch basins can remove accumulated sediment and debris that could ultimately be contained in CSOs. In many communities, catch basin cleaning is targeted more toward maintaining proper drainage system performance than pollution control.

3.3.5.2 Collection System Controls

Collection system controls and modifications affect CSO flows and loads once the runoff has entered the collection system. This category of control measures can reduce CSO volume and frequency by removing or diverting runoff, maximizing the volume of flow stored in the collection system, or maximizing the capacity of the system to convey flow to a POTW and includes the following control alternatives:

- **Sewer Line Flushing**—Sediments that accumulate in sewers during dry weather can be a source of CSO contaminants during storm events. Periodically flushing sewers during dry weather will convey settled materials to the POTW. A 2-year study conducted in Boston, Massachusetts, addressed the cost-effectiveness and feasibility of sewer line flushing as part of a CSO management program (EPA, 1976a). The study determined that flushing combined sewer laterals removed pollutant accumulations. The cost effectiveness of such a program, however, depends on treatment, labor costs, physical sewer characteristics, and productivity.

  Sewer cleaning usually requires the use of a hydraulic, mechanical, or manual device to resuspend solids into the waste flow and carry them out of the collection system. This practice might be more effective for sewers with very flat slopes. Cleaning costs increase substantially for larger interceptors due to occasional accumulations of thick sludge blankets in inverts.

- **Maximizing Use of Existing System**—This control measure involves maximization of the quantity of flow collected and treated, thereby minimizing overflows. It involves ongoing maintenance and inspection of the collection system, particularly flow regulators and tidegates. In addition, minor modifications or repairs can sometimes result in significant increases in the volume of storm flow retained in the system. Strict adherence to a well-planned preventive maintenance program can be a key factor in controlling dry and wet weather overflows.

- **Sewer Separation**—Separation is the conversion of a CSS into separate storm water and sanitary sewage collection systems. This method has historically been used by many communities as a way to eliminate CSOs and their effects altogether. Separation has been reconsidered in recent years because it typically results in increased loads of storm water runoff pollutants (e.g., sediments, bacteria, metals, oils) being discharged to the receiving waters, is relatively expensive, and can disrupt traffic and other community activities during construction. Sewer separation is a positive means of eliminating CSOs and preventing sanitary flow from entering the receiving waters during wet weather periods, however, and might still be applicable and cost-effective. It also can be considered in conjunction with the evaluation of sensitive areas in accordance with the CSO Control Policy, although storm drain discharges will likely still remain. In some cases, municipalities that separate their combined sewers might be required to file for NPDES storm water permit coverage.

- **Infiltration/Inflow Control**—Excessive infiltration and inflow (I/I) can increase operations and maintenance costs and can consume hydraulic capacity, both in the collection system and at the treatment plant. In CSSs, surface drainage is by design the primary source of inflow. Other sources of inflow in CSSs might be appropriate to control, including tidal inflow through leaking or missing tidegates and inflow in separate upstream areas, which might be tributary to a downstream combined system.

  Infiltration is ground water that enters the collection system through defective pipe joints, cracked or broken pipes, manholes, footing drains, and other similar sources.

Infiltration flow tends to be more constant but of lower volume than inflow. The control of infiltration is difficult and often expensive, since infiltration problems are usually difficult to isolate and reflect a more general sewer system deterioration. Significant lengths of sewers usually must be rehabilitated to effectively remove infiltration, and the rehabilitation effort often must include house laterals. Controlling infiltration might have minimal impact on CSO volume due to its small magnitude compared to inflow.

- **Polymer Injection**—Polymers can increase the hydraulic capacity of pipelines by correcting specific capacity deficiencies in a transport system. The injection of polymer slurries into sewers is intended to increase pipe capacity by reducing pipe friction. In certain cases, this increase can be significant and might reduce system surcharging and backups during wet weather. This method has mostly been tested in relatively small sanitary sewers during dry weather.

- **Regulating Devices and Backwater Gates**—Flow regulating devices have been used for many years in CSSs to direct dry weather flow to interceptors and to divert wet weather combined flows in excess of interceptor capacity to receiving waters. The following discussion of regulators was adapted from the *Manual—Combined Sewer Overflow Control* (EPA, 1993a).

  In general, regulators fall into two categories: static and mechanical. Static regulators have no moving parts and, once set, are usually not readily adjustable. They include side weirs, transverse weirs, restricted outlets, swirl concentrators (flow regulators/solids concentrators), and vortex valves. Mechanical regulators are adjustable and might respond to variations in local flow conditions or be controlled through a remote telemetry system. They include inflatable dams, tilting plate regulators, reverse-tainter gates, float-controlled gates, and motor-operated or hydraulic gates.

  Many of the older float-operated mechanical regulators have proven to be erratic in operation and require constant maintenance. In Saginaw, Michigan, many existing float-operated regulators were replaced by vortex valves, due to the unreliability and excessive maintenance associated with the mechanical regulators. In Boston, Massachusetts, many float-operated regulators have been replaced over the years with static regulators.

  The following types of regulators and gates have been installed in more recent CSO control projects or have been used to replace older, less reliable types:

  - **Vortex Valves**—Vortex valves are static regulators that allow dry weather flow to pass without restriction but control higher flows by a vortex throttling action. Vortex valves have been used to divert flows to CSO treatment facilities, control flow out of storage facilities, and replace failed mechanical regulators. They have the following advantages over standard orifices:

-- The discharge opening on the vortex valve is larger than the opening on a standard orifice sized for the same discharge rate, thereby reducing the risk of blockage.

-- The discharge from the vortex valve is less sensitive to variations in upstream head than a standard orifice (Urbonas and Stahre, 1993).

- **Inflatable Dams**—An inflatable dam is a reinforced rubberized fabric device that, when fully inflated, forms a broad-crested transverse weir. When deflated, the dam collapses to take the form of the conduit in which it is installed. Inflatable dams can be positioned to restrict flow in an outfall conduit or combined sewer trunk. The dams, when fully inflated, can act as regulators by directing flow into an interceptor and preventing the diversion of flow to an outfall until the depth of flow exceeds the crest of the dam. Alternatively, when installed upstream of a regulator, dams can be inflated during wet weather to create in-system storage. Inflatable dams are controlled by local or remote flow or level sensing devices, which regulate the height of the dam to optimize in-line storage and prevent upstream flooding. The dam height is controlled by the air pressure in the dam. Because inflatable dams are typically constructed of rubber or strong fabric, they are subject to puncturing by sharp objects. These devices generally require relatively little maintenance, although the air supply should be inspected regularly (WPCF, 1989).

- **Motor- or Hydraulically Operated Sluice Gates**—Similar to the inflatable dams, motor- or hydraulically operated gates typically respond to local or remote flow or level sensing devices. Normally closed gates can be located on overflow pipes to prevent overflows except under conditions when upstream flooding is imminent. Normally open gates can be positioned to throttle flows to the interceptor to prevent interceptor surcharging or to store flow upstream of regulators. Controls can be configured to fully open or close gates, or to modulate gate position. The level of control and general reliability of motor-operated gates make them well suited for use with real-time control systems.

- **Elastomeric Tidegates**—While not actually regulators, tidegates are intended to prevent the receiving water from flowing back through the outfall and regulator and into the conveyance system. Inflow from leaking tidegates takes up hydraulic capacity in the downstream interceptors and increases the hydraulic load on downstream treatment facilities. Elastomeric tidegates provide an alternative to the more traditional flap-gate style tidegates, which are prevalent in many CSO communities. Tidegates have historically required constant inspection and maintenance to ensure that the flaps are seated correctly and that no objects or debris are preventing the gate from closing. Warpage, corrosion, and a tendency to become stuck in one position are also characteristic of flap-gate style tidegates. Elastomeric tidegates are designed to avoid the maintenance problems associated with the flap gates. In particular, the elastomeric gates are designed to close tightly around objects which might otherwise prevent a flap gate from closing (Field, 1982).

Several documents provide detailed descriptions of other regulator types (WPCF, 1989; Metcalf & Eddy, 1991; and Urbonas and Stahre, 1993).

- **Real-Time Control**—System-wide real-time control (RTC) programs can provide integrated control of regulators, outfall gates, and pump station operations based on anticipated flows from individual rainfall events, with feed-back control adjustments based on actual flow conditions within the system. Computer models associated with the RTC system allow an evaluation of expected system response to control commands before execution. Localized RTC might also be provided to individual dynamic regulators, based on feedback control from upstream and/or downstream flow monitoring elements. As with any plan for improving in-line storage, to take the greatest advantage of RTC, a CSS should have relatively flat upstream slopes and sufficient upstream storage and downstream interceptor capacity (EPA, 1993a).

- **Flow Diversion**—Flow diversion is the diversion or relocation of dry weather flow, wet weather flow, or both from one drainage basin to another through new or existing drainage basin interconnections. Flow diversion can relieve an overloaded regulator or interceptor reach, resulting in a more optimized operation of the collection system. Flow diversion can also be used to relocate combined sewer flow from an outfall located in a more sensitive receiving water area to an outfall located in a less sensitive one.

3.3.5.3 Storage Technologies

Wet weather flows can be stored for subsequent treatment at the POTW treatment plant once treatment and conveyance capacity have been restored. Technologies include the following:

- **In-Line Storage**—In-line storage is storage in series with the sewer (Urbonas and Stahre, 1993). In-line storage can be developed in two ways: (1) construction of new tanks or oversized conduits to provide storage capacity or (2) construction of a flow regulator to optimize storage capacity in existing conduits. The new tanks or oversized conduits are designed to allow dry weather flow to pass through, while flows above a design peak are restricted, causing the tank or oversized conduit to fill. A flow regulator on an existing conduit functions under the same principle, with the existing conduit providing the storage volume. Developing in-line storage in existing conduits is typically less costly than other, more capital-intensive technologies, such as off-line storage/sedimentation, and is attractive because it provides the most effective utilization of existing facilities. The applicability of in-line storage, particularly the use of existing conduits for storage, is very site-specific, depending on existing conduit sizes and the risk of flooding due to an elevated hydraulic grade line. Examples of flow regulating technologies used to develop in-line storage were discussed previously.

- **Off-Line Near Surface Storage**—This technology reduces overflow quantity and frequency by storing all or a portion of diverted wet weather combined flows in off-line storage tanks. The storage arrangement is considered to be parallel with the sewer. Stored flows are returned to the interceptor for conveyance to the POTW treatment plant once system capacity is available. In some cases, flows are conveyed to a CSO treatment facility.

- **Deep Tunnel Storage**—This technology provides storage and conveyance of storm flows in large tunnels constructed well below the ground surface. Tunnels can provide large storage volumes with relatively minimal disturbance to the ground surface, which can be very beneficial in congested urban areas. Flows are introduced into the tunnels through dropshafts, and pumping facilities are usually required at the downstream ends for dewatering.

3.3.5.4 Treatment Technologies

Treatment technologies are intended to reduce the pollutant load in the CSO to receiving waters. Specific technologies can address different pollutant constituents, such as settleable solids, floatables, or bacteria. Where treatment facilities are to be considered, the LTCP should contain provisions for the handling, treatment, and ultimate disposal of sludges and other treatment residuals. The following list highlights selected treatment technologies:

- **Off-Line Near Surface Storage/Sedimentation**—These facilities are similar to off-line storage tanks, except that sedimentation is provided for flows in excess of the tank volume. Coarse screening, floatable control, and disinfection are commonly provided as part of these facilities.

- **Coarse Screening**—This technology removes coarse solids and some floatables. Coarse screening is typically provided upstream of other control technologies, such as storage facilities or vortex units, and is also used in end-of-pipe treatment applications.

- **Swirl/Vortex Technologies**—These devices provide flow regulation and solids separation by inducing a swirling motion within a vessel. Solids are concentrated and removed through an underdrain, while clarified effluent passes over a weir at the top of the vessel. Types of swirl/vortex devices include the EPA swirl concentrator and commercial vortex separators. Conceptually, the EPA swirl concentrator is designed to act as an in-line regulator device. In addition to flow routing or diversion, it removes heavy solids and floatables from the overflow. The commercial vortex separators are based on the same general concept as the EPA swirl concentrator but include a number of design modifications intended to improve solids separation. The commercial designs have been applied as off-line treatment units. Each type of swirl/vortex unit has a different configuration of depth/diameter ratio, baffles, pipe arrangements, and other details designed to maximize performance.

- **Disinfection**—This process destroys or inactivates microorganisms in overflows, most commonly through contact with forms of chlorine. Various disinfection technologies are available both with and without chlorine compounds. Some of the more common technologies include gaseous chlorine, liquid sodium hypochlorite, chlorine dioxide, ultraviolet radiation, and ozone. For disinfection of CSOs, liquid sodium hypochlorite is the most common of the above technologies.

- **Dechlorination**—A major disadvantage of chlorine-based disinfection systems is that the residual chlorine concentration can have a toxic effect on the receiving waters, due either to the free chlorine residual itself or to the reaction of the chlorine with organic compounds present in the effluent. With the relatively short contact times available at many CSO control facilities, disinfection residuals can be of particular concern and can require consideration of dechlorination alternatives. Two of the more common means for dechlorinating treated effluent are application of gaseous sulfur dioxide or liquid sodium bisulfite solution.

- **Other Treatment Technologies**—A number of other treatment technologies have been identified as applicable to CSOs and have been studied in pilot tests, but have not been widely implemented in operating facilities. These technologies include dissolved air floatation, high-rate filtration, fine screens and microstrainers, and biological treatment. Fine screens and microstrainers have been used in full-scale facilities but, in some cases, have been unreliable due to mechanical complexity and blinding of the screens. Biological treatment at a POTW treatment plant of pump back flows from a CSO storage facility is a common practice, but a biological treatment facility dedicated solely to CSO treatment would not likely be successful due to the impact of prolonged dry periods on the biological media.

3.3.6 Preliminary Sizing Considerations

The preliminary sizing of CSO control alternatives will likely depend on the following factors:

- Predicted CSO flow rates, volumes, and pollutant loads under selected hydraulic conditions

- Level of abatement of predicted CSO volumes and pollutant loads necessary to meet CSO control goals

- Design criteria for achieving the desired level of abatement with the selected control measure or technology.

The collection system hydraulic model developed for system characterization is an appropriate tool for predicting CSO flow rates and volumes (EPA, 1995d). The design hydrologic conditions can include historical storms of specified recurrence intervals, a continuous simulation based on a statistical year or multiple years of rainfall data, or both. The system model should be used to define a baseline condition, which will serve as a basis for evaluating reductions in CSO impacts resulting from the implementation of minimum technologies or other currently planned, short-term projects that are likely to be implemented before the major components of the LTCP. A "future planned conditions" baseline, incorporating short-term projects as well as design year base flows, would provide the basis for evaluating the impacts of the CSO control alternatives proposed as part of the LTCP. The future planned conditions baseline would be equivalent to a "future no-action condition" in facilities planning, although, in the case of CSOs, this nomenclature is misleading because near-term actions, such as implementation of minimum controls, are generally required and would be incorporated into the model.

The level of abatement of predicted flows necessary to meet CSO control goals depends on the definition of the specific goals. A goal of CSO elimination means that discharges from a given CSO location would be eliminated under all possible hydraulic and hydrologic conditions. This goal essentially dictates either sewer separation or CSO relocation, in which the relocation conduit is sized for the absolute peak flow from the CSO outfall. This peak flow can be determined by analyzing increasingly larger storm events (e.g., 5-year, 10-year, 20-year storms) until a storm is reached above which the peak flow from the CSO outfall does not increase. At this point, the collection system is at absolute capacity, and additional runoff cannot enter the collection system.

Sizing to meet goals of providing storage for 1 to 3, 4 to 7, and 8 to 12 overflows per year can be estimated initially by capturing the volumes from the 1-year, 3-month, and 1-month storms, respectively. Similarly, sizing to provide treatment over that range can be estimated using the peak flow rates from the range of storms, in conjunction with sizing criteria for treatment, which are usually based on flow rates. As CSO control alternatives are further developed, the basis for sizing should be evaluated against a long-term simulation, which would incorporate the impacts of dewatering rates and antecedent storms, particularly if the CSO control goals are tied to average annual overflow frequencies.

It is also important to evaluate the impact of remaining overflows on the receiving waters. A receiving water model might be required, for example, to evaluate whether the remaining overflow from the 6-month or 1-year storm would cause exceedances of WQS if a storage tank is sized to capture the volume from a 3-month storm. This evaluation might indicate whether flow in excess of the capacity of the tank should continue to pass through the tank receiving a level of treatment or whether excess flows should be diverted upstream of the tank.

As is evident from this discussion, the issues of sizing and performance are closely related. The relationships between sizing criteria and expected performance might not be as clearly defined for CSO treatment as they are for sizing of POTW treatment plant unit processes. This latter issue was addressed earlier in the discussion of the definition of equivalent primary treatment under the presumption approach. For the purposes of initial alternatives development, reasonable assumptions regarding design criteria should be made to allow a preliminary sizing and estimate of performance. These assumptions can then be revisited during further steps or refinements in the alternatives development and evaluation process, as more information becomes available and as the general feasibility of alternatives becomes better defined.

3.3.7 Cost/Performance Considerations

The CSO Control Policy states that cost/performance evaluations should be "*...among the other considerations used to help guide selection of controls*" (II.C.5). These analyses typically involve estimating costs for a range of control levels, then comparing performance versus cost and identifying the point of diminishing returns, referred to as the "knee" of the curve. Cost/performance analyses, used for the evaluation of alternatives, are discussed in more detail in Section 3.4. For the development of alternatives, it is likely that more than one alternative will be identified to achieve each level of control. During the alternatives development, a simpler cost/performance approach might be appropriate to eliminate non-cost-effective alternatives. For example, a computation of capital cost per gallon controlled might provide a reasonable basis for screening certain alternatives. During the more detailed alternatives evaluation process described later, present worth costs, incorporating annual O&M costs, would be developed for the remaining alternatives.

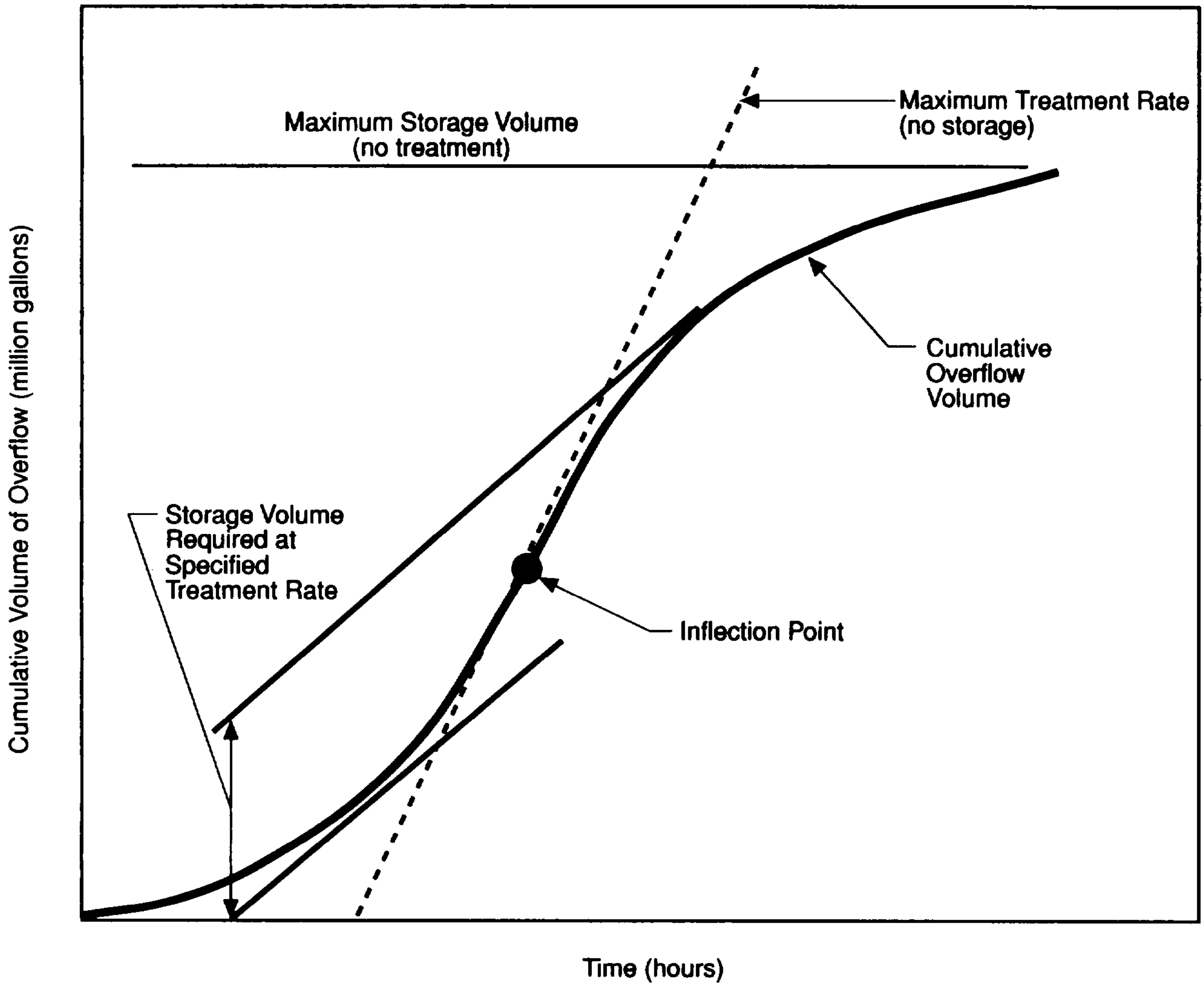
During alternatives development, non-monetary factors can also be defined and compared. For example, siting and environmental impacts and construction-related issues can be identified and used as a basis for the preliminary screening of alternatives. While at a more detailed level of alternatives development and evaluation, it might be appropriate to assign dollar values to some of these factors, in the initial development phase, qualitative assessments might be sufficient to eliminate certain alternatives from further consideration.

Thus, more formal cost/benefit analyses are appropriate during the detailed alternatives evaluation phase. For municipalities with larger or more complex CSSs where more initial screening of alternatives is necessary to make the alternatives evaluation analyses more manageable, simpler cost/benefit relationships provide an appropriate basis for that screening.

Another approach to cost-performance evaluations is the optimization of combinations of storage and treatment facilities. Given a design condition, the desired level of control could be achieved by providing storage of the entire CSO volume, sedimentation/treatment based on a maximum overflow rate for the peak CSO flow, or a combination of storage and treatment. Providing sufficient storage volume to capture all of the CSO or sufficient surface area to meet the maximum overflow rate at peak flow might not be feasible due to site or cost constraints. A more feasible alternative might be to size a sedimentation tank for a maximum flow that is less than the peak and provide storage for flows between the design maximum and the actual peak flows.

A mass diagram for the selected design storm (Exhibit 3-2) can be used to determine the range of combinations of storage and treatment to meet a given control goal. The mass diagram consists of a plot of cumulative volume of overflow versus time, based on a hydrograph developed by a collection system hydrologic/hydraulic model, such as SWMM. The slope at any given point on the curve represents the flow rate (change in volume with respect to time) at that point in time, and the end of the storm is indicated where the slope of the curve approaches zero (flow equals zero). The total volume at the end of the storm represents the storage volume required if no treatment is provided. The inflection point on the curve, where the slope is at a maximum, represents the peak flow rate to be treated if no storage is provided. The intermediate combinations of storage and treatment required to achieve a level of control between all-storage and all-treatment can be determined from the mass diagram. The changing slope of the curve represents the increase then decrease in CSO flow rate during the storm event. If a given flow rate (less than the peak) is selected as the maximum design flow rate for treatment, then flows above this maximum rate must be stored. Graphically, the selected maximum flow rate can be identified as two points on the curve, one above and one below the inflection point. All points between these two points on the curve represent flow rates greater than the design maximum. The vertical distance between the tangents at these two points, therefore, represents the volume of flow occurring while the flow rate is greater than the maximum design flow rate and, thus, represents the necessary storage volume.

Exhibit 3-3 is an alternative representation of this approach. In this figure, the predicted CSO flow rate to a facility is plotted against time. A horizontal line is drawn at the selected maximum flow rate for treatment, corresponding to a peak hydraulic loading rate. The volume of flow associated with flow rates in excess of the design maximum, which is to be captured for storage, is represented by the area of the curve above the maximum treatment rate. To optimize the storage/treatment combinations, cost estimates are developed for the all-storage, all-treatment, and selected intermediate combinations, and then the points are plotted and the minimum cost alternatives identified. Alternatives for the intermediate combinations of storage and treatment would require separate tankage for treated flows and for stored flows, with a regulator to limit peak flows to the treatment tanks. Flow would be introduced into the treatment tanks first. When the influent flow exceeded the design maximum, flow to the



Source: Camp, Dresser & McKee, 1989

Exhibit 3-2. Typical Mass Diagram

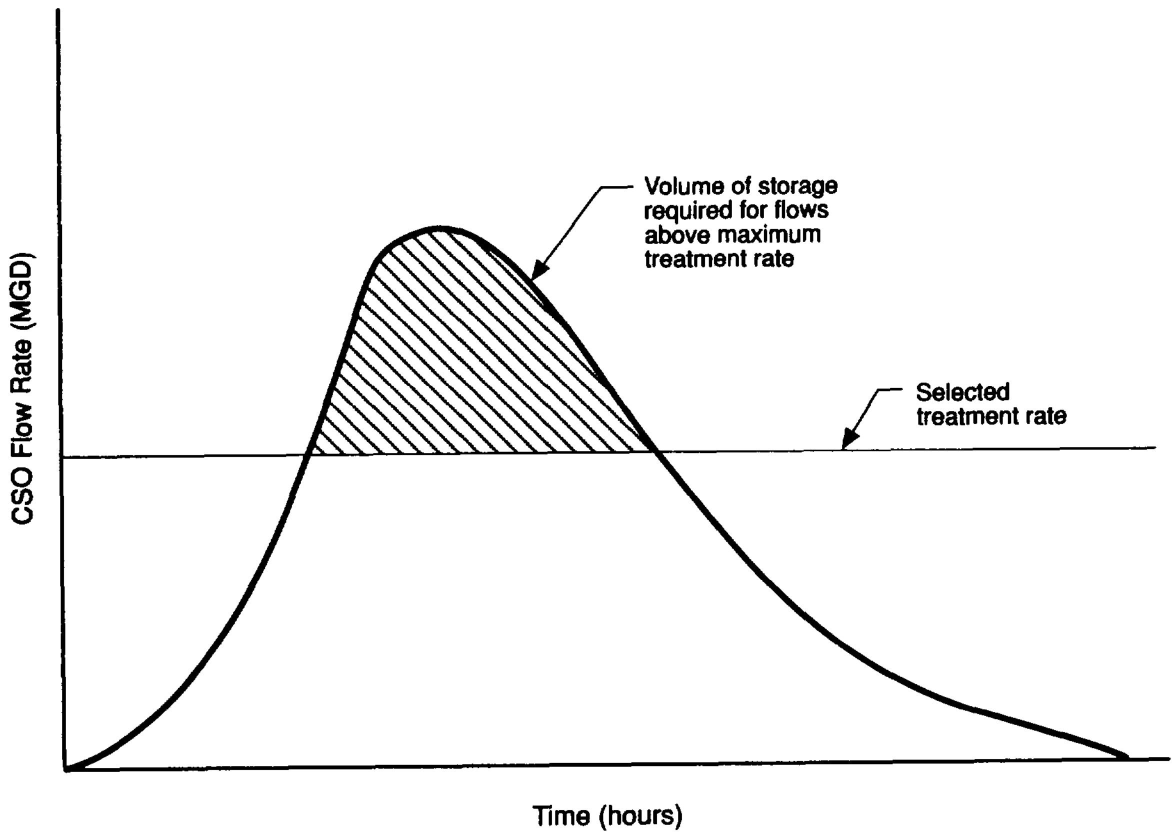


Exhibit 3-3. Typical Representation of Interaction Between Storage and Treatment Needs

treatment tanks would be throttled, with flows in excess of the design maximum diverted to the storage tanks. Once flows subsided to below the design maximum, the diversion of flow to the storage tanks would cease, and all flows would again be diverted to the treatment tanks. A vortex valve with an upstream overflow weir is an example of the type of regulator device that could be used to achieve the necessary flow control. The vortex valve would limit flow into the treatment tanks to a design maximum, with the excess flows diverted over the upstream weir to the storage tanks.

The mass diagram approach might be most applicable where an existing tank is available for CSO sedimentation. If the tank is not big enough to meet the maximum allowable overflow rate at peak flow, the size of a new storage facility to work in conjunction with the existing tank can be readily determined from the mass diagram, using the procedure described above.

One drawback to the mass diagram analysis is that the level of CSO control provided by each alternative is not equal. Storage of the full volume of CSO from a given storm for subsequent pumpback to a POTW treatment plant will likely provide a higher level of control than providing the equivalent of primary treatment at a satellite facility, particularly if pumpback occurs once secondary treatment capacity is available at the POTW treatment plant. A second drawback is that this analysis does not consider the storage volume available in the sedimentation tank. Depending on the total volume, peak flow, and hydrograph shapes for the selected design storm, the volume of the sedimentation tank might have more or less of an impact on performance. It is possible that the peak influent flow to a sedimentation facility will occur before the tank volume is full, so that the actual peak overflow rate occurs on the falling leg of the influent hydrograph, at a value less than the peak influent flow. The mass diagram could be used to estimate the total CSO volume associated with the point of maximum flow for comparison with the volume of the sedimentation tank.

In general, the evaluation of storage/treatment optimization can provide an additional level of information from which to identify potential alternatives. The analysis does not predict the performance or impact on water quality, other than that the performance will be between the boundary conditions of all-storage and all-treatment. In addition, questions of reliability, operability, and increased maintenance needs associated with maintaining separate tankage for storage and treatment should be considered in evaluating such alternatives.

3.3.8 Preliminary Siting Issues

One of the key considerations in assessing the overall feasibility of a CSO control alternative is the identification of an appropriate site. Siting issues can overshadow technical and even financial issues in the process of gaining public acceptance of a CSO control program. As with other aspects of the alternatives development process, identifying and evaluating potential sites calls for iterative screening. The objective of preliminary site development is to identify potential locations for the range of facilities identified based on the sizing procedures. Common sense and engineering judgement are used at the preliminary siting level to identify possible locations for facilities.

Initial criteria for screening potential sites can include:

- Availability of sufficient space for the facility on the site
- Distance of the site from CSO regulator(s) or outfall(s) that will be controlled
- Environmental, political, or institutional issues related to locating the facility on the site.

Recent aerial photographs or relatively small-scale maps, such as USGS topographic maps, are useful for the initial identification of potential sites. To assess whether sufficient space is available on a site, however, larger-scale maps, such as 100-scale sewer maps, are more useful. It is helpful to develop an estimate of the footprint of the proposed facility, then lay the footprint over an assessor's map, or other larger-scale plan view of the site. Consolidation or connecting conduits, where required, should also be located on the preliminary site plans. Site inspections are extremely valuable to confirm geographic information and to identify obvious features that might not appear on the available maps or aerial photographs.

If possible, it is usually beneficial to identify more than one potential site for each facility. Later evaluation of alternate sites may involve tradeoffs and comparisons between sites. Public participation through public meetings and workshops provides key input for the evaluation of these trade-offs, as well as to other aspects of preliminary site development.

Deciding whether a site is within a reasonable distance of the required point of control requires engineering judgment, particularly if an apparently ideal site is located further from the point of control than an apparently less-ideal site. The tradeoffs between distance and other factors can be evaluated during the detailed alternative evaluation process described in the next section. During alternatives development, however, initial comparisons might eliminate some options from further consideration.

Detailed analysis of the environmental, political, and socioeconomic impacts of locating a facility at a particular site is also part of the detailed alternative evaluation process. In some areas, however, a municipality might have specific knowledge of the history or existing plans for a particular site, which would preclude that site for consideration as a location for a CSO control facility. For example, a vacant lot might be known to contain contaminated soil or might to be already committed to commercial development. In such a case, a more detailed analysis of the site would not be worthwhile, unless perhaps no other feasible sites were available.

The municipality also needs to consider issues of "environmental justice" at the preliminary siting level. If the initially identified sites for CSO control facilities are all in low-income neighborhoods, the municipality should attempt to identify alternative sites in other areas to balance perceived inequities in project siting. If no other sites are technically feasible, then the municipality should recognize the need for additional effort in public participation, such as public meetings with concerned members of the community or multilingual fact sheets about the proposed facility. Development of multiple-use facilities with special architectural considerations or linkage with neighborhood improvement projects can also foster public acceptance of the proposed plan.

3.3.9 Preliminary Operating Strategies

Once a preliminary size and location have been identified for an alternative, the municipality should develop conceptual operating considerations to ensure that the alternative can function reasonably in the context of its geographic location and relationship to the collection system. For an off-line storage/treatment facility, the preliminary operating considerations might include the location of regulators and conduits for diverting flow into the facility, identification of influent or effluent pumping needs, route of a dewatering force main and facility outfall, identification of solids handling needs, and coordination of dewatering rates with POTW capacity. For a deep tunnel, the alternative development process might include preliminary identification of diversion structures, consolidation conduits, dropshaft, access and work shaft locations, screening facilities, and pumping requirements.

3.4 Evaluation of Alternatives for CSO Control

The evaluation of CSO control alternatives can be a complex process, and no one methodology is appropriate for all CSO control programs. Certain general considerations, however, apply to most evaluation approaches. In general, evaluations focus on cost, performance, and non-monetary factors. Cost evaluations are quantitative, performance evaluations can be both quantitative and qualitative, and non-monetary factor evaluations are generally qualitative. One of the challenges to alternatives evaluation is how to assess the relative importance of cost, performance, and non-monetary factors in selecting a preferred alternative. The following sections present discussions and examples of ways to evaluate these issues.

3.4.1 Project Costs

Project costs include capital costs, annual O&M costs, and life-cycle costs. Capital cost, the cost to build a particular project, includes construction cost, engineering costs for design and services during construction, legal and administrative costs, and typically a contingency. The contingency is usually developed as a percentage of the construction cost, and the engineering, legal, and administrative costs are usually combined as a percentage of the construction plus contingency. Annual O&M costs reflect the annual costs for labor, utilities, chemicals, spare