The Great Sewer Separation Debate

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ABSTRACT

This paper discusses and compares sewer separation and other combined sewer overflow control methods from a variety of perspectives. A comprehensive life cycle analysis and consideration of a wider range of potential benefits and risks is recommended. The paper describes an approach that helps reduce water quality concerns for separate storm sewer systems using green infrastructure and other watershed BMPs focusing on *source control*, while optimizing sanitary sewer system performance.

KEYWORDS: Combined sewer overflow control, storage, conveyance, treatment, sewer separation, stormwater, green infrastructure, source control

INTRODUCTION

Combined sewer systems (CSSs) were first used in the United States in the 1850s to convey sewage and stormwater away from developed areas to local waterways or water bodies, usually downstream of the population center if possible. A single system was used to convey wastewater and stormwater at minimal cost. Since then, State and Federal requirements intended to clean up our waterways have become increasingly restrictive and costly to meet, making control of combined sewer overflows a very costly requirement for combined sewer system (CSS) owners.

Sewer separation has been used to eliminate combined sewer overflows (CSOs) for over 50 years. Separate sanitary sewer and stormwater systems are also used exclusively for all new development. As communities develop long term control plans to eliminate or reduce and treat CSO discharges, sewer separation is one alternative of several considered to control overflows. Sewer separation is often said to be too disruptive, costly, and may result in an increase in pollutant loading to receiving waters as a result of the increased discharge of untreated stormwater. Incomplete sewer separation efforts can also result in poor sanitary sewer system (SSS) performance, including basement flooding and sanitary sewer overflows (SSOs).

Following is a discussion of the problem, the current regulatory framework, a comparison of solutions and how future wet weather flow management may be easier for those who are flexible and plan for change.

THE PROBLEM – A SHORT-TERM VIEW

Sewer systems in many larger/older cities have been designed and constructed over periods often exceeding 100 years, subject to varying regulatory frameworks, local codes and common practices. Public and private systems were typically constructed with good intention and thrift to solve drainage or waste disposal problems, or to extend service for development.

Unfortunately, unintended results such as basement and surface flooding or unacceptable water quality degradation often accompanied system expansion. While these problems were to a large extent predictable, they were either unforeseen, ignored or deemed too costly to deal with at the time. System expansion in outlying areas has also frequently trumped maintenance and rehabilitation of older downstream infrastructure resulting in poor system performance.

Combined and Sanitary Sewer Overflows

Combined sewer systems were typically designed to convey sewage to wastewater treatment plants during dry weather and bypass combined sewage and stormwater flows to local waterways during larger wet weather events. While these systems were an obvious improvement over sewage flowing in the street, the short-term cost savings of constructing the single combined system as opposed to a properly sized separate sewer system is costing ratepayers billions to resolve today.

In many separate sanitary sewer systems the occasional catch basin, “quick fix” cross connections, and previously allowed connection of private property runoff and groundwater drainage to sanitary sewer services are common. These practices, in many cases permitted but undocumented, have caused untold flooding/economic damage to property and business owners, and are similarly costing today’s ratepayers billions for SSO control programs across the country.

Stormwater Contamination

Stormwater pollution sources including illicit discharges, fertilizer over/misuse, soil erosion, vehicle fluids and metal dust, trash, pet and animal waste, and aerial deposition have been identified and quantified for years. Until this contamination is effectively controlled at its source, the requirements and costs for cleanup and stormwater treatment will continue to increase significantly.

REGULATION & POLICY SNAPSHOT

Environmental regulations intended to reduce water pollution, property damage and health risks have become increasingly restrictive and costly, but have not achieved the intended goals of protecting designated uses and achieving water quality standards. Since passage of the Water Pollution Control Act in 1972 (later named the Clean Water Act (CWA) in 1977), it is estimated that over $1 trillion has been spent to achieve compliance with the act (*Liquid Assets 2000*). The primary goals of the CWA were to clean up waters of the United States enough to support fishing and swimming by 1983 and to end discharges of pollutants to surface waters.

Per the EPA's *National Water Quality Inventory: Report to Congress* (2004 reporting cycle, released in 2009):

In 2004, states reported that about 44% of assessed stream miles, 64% of assessed lake acres and 30% of assessed bay and estuary square miles were not clean enough to support uses such as fishing and swimming. Less than 30% of U.S. waters were assessed by the states for this report. Leading causes of impairment included pathogens, mercury, nutrients, and organic enrichment/low dissolved oxygen. Top sources of impairment included atmospheric deposition, agriculture, hydrologic modifications and unknown or unspecified sources.*

*this value was 36% in the 1996 Report to Congress

CSO Control

Current EPA CSO control policy includes technology-based and water quality based requirements as detailed in the CWA, and other policy and guidance documents. The technology-based requirements are also known as the nine minimum controls which all CSO communities must implement in conjunction with their NPDES permits. They include:

1. Proper operation and maintenance of the sewer system and CSOs;
2. Maximum use of the collection system for storage;
3. Review and modification of pretreatment requirements to minimize CSO impacts;
4. Maximization of flow to the POTW;
5. Prohibition of dry weather CSOs;
6. Control of solid and floatable materials in CSOs;
7. Pollution prevention;
8. Public notification of CSOs and resulting impacts; and
9. Monitoring to characterize CSO impacts and efficacy of CSO controls

NPDES permittees with CSOs must also develop and implement a long-term CSO Control Plan (LTCP) that must ultimately meet the requirements of the CWA. This process may be completed on a watershed scale or at the municipal level, and may include a Total Maximum Daily Load (TMDL) analysis to assess all the sources of pollution contributing to water quality impairment. EPA's CSO Control Policy allows for consideration of two approaches in developing CSO control plans:

Presumption Approach – This approach includes three performance criteria that are presumed to provide an adequate level of control to meet water quality standards (WQS), such as a maximum of 4 untreated overflow events per year, elimination or capture for treatment of 85% by volume of the combined sewage collected during precipitation events on a system-wide annual average basis, or the elimination or removal of no less than the mass of pollutants identified as causing water quality impairment through the sewer system characterization, monitoring and modeling effort for volumes that would be captured for treatment above.

Demonstration Approach – In this approach, the permittee must demonstrate that the selected program will meet water-quality based requirements of the CWA. Table 1 summarizes CWA recommended water quality requirements for bacteria:

Table 1. Summary of EPA-Recommended Water Quality Criteria for Bacteria

	Steady State, 30-day Geometric Mean Indicator Density (cfu/100ml)	Single Sample Maximum (cfu/100ml)			
		Designated Beach Area	Moderate Full Body Contact Recreation	Lightly Used Full Body Contact Recreation	Infrequently Used Full Body Contact Recreation
Freshwater					
enterococci	33	61	89	108	151
E. coli	126	235	298	406	576
Marine Water					
enterococci	35	104	124	276	500

Retrofitting

EPA requires both approaches to develop controls that allow for cost-effective expansion and/or retrofitting as may be required to meet CWA requirements.

SSO Control

Sanitary sewer overflows are illegal. Sanitary sewage generally must be treated to secondary treatment standards prior to discharge per the CWA. The NPDES permit program develops site specific effluent limits for secondary treatment processes. Typical municipal secondary treatment limits are summarized in Table 2.

Table 2. Secondary Treatment Standards

Parameter	30-Day Average	7-Day Average
5-Day BOD	30 mg/l	45 mg/l
Total Suspended Solids (TSS)	30 mg/l	45 mg/l
pH	6 – 9 s.u.	-
Removal	85% BOD5 and TSS	-

Stormwater Management

Stormwater pollution control was brought into the NPDES program and made part of the CWA in 1987. To comply with the NPDES program, industrial permittees must develop and implement stormwater pollution prevention plans, while operators of municipal separate storm sewer systems (MS4s) must develop and follow stormwater management plans. The program, while mandatory, is largely developed in detail by the permittees who also monitor compliance.

While most current stormwater management focuses on pollution prevention and practices to prevent contamination of stormwater, some communities have elected to provide some level of stormwater treatment. Stormwater treatment ranges from floatables control to capture, settling and filtration of runoff for some design rainfall amount, typically less than one inch.

SOLUTIONS – COST, RISK AND OPPORTUNITY

Long-term planning for CSO control typically includes system monitoring and characterization, identification of water quality goals, and analysis of alternatives to control or eliminate CSOs as required to achieve WQ goals and be compliant with the CWA. Because the cost of compliance is so high for CSO communities and rate payers, long-term planning and cost-effectiveness analyses may tend to focus on the lowest cost alternatives without adequate consideration for future trends and project risks that may significantly alter long-term obligations and cost. Permit and enforcement schedules usually seek to achieve compliance as quickly as possible, and may also drive alternatives selection toward control options that can be most quickly implemented, but that may not provide the best long-term value to the environment or rate payers.

The primary reason communities undertake a CSO control program is to meet regulatory requirements and the schedule written into permits, consent orders or legal settlements. At the conclusion of an expensive program, it is important that the rate payers who bear the burden of the costs see a direct benefit for themselves and their community. In addition to meeting legal requirements for overflow control, rate payers, collection system owners and operators may also seek to:

- Minimize long-term system costs (the next 100 years)
- Hedge against stricter future regulations and effluent limits
- Simplify O&M activities and minimize O&M costs
- Eliminate combined and sanitary sewage overflows
- Improve level of service - mitigate basement flooding
- Maximize public support during project planning
- Minimize property/business owner disruption during construction
- Provide infrastructure renewal and upgrades (roads, water, electric, voice/data, etc.)
- Improve system structural integrity and reliability
- Improve property values and development potential
- Improve stormwater runoff quality and reduce peak rates and total volume
- Provide groundwater recharge
- Shorten program schedule and move on with life
- Lengthen program schedule and spread costs over longer time and more rate payers
- Minimize surface flooding
- Minimize risks associated with emerging contaminants of concern
- Continuously improve water quality and public perception of water quality and viability for recreation and development
- Increase neighborhood/ratepayer awareness and participation in pollution reduction
- Minimize receiving waterway erosion
- Provide neighborhood improvements (new driveway approaches, curb and gutter, sidewalks, rain gardens, tree canopy, multi-use space atop underground storage basins)

CSO Control Alternatives

The alternatives analysis required for long-term control planning develops and considers several CSO control alternatives including storage, conveyance, treatment and source controls that may be applicable and feasible for a given CSS. Following are considerations for various CSO control alternatives.

Storage, Conveyance and Treatment (SCT)

Combined sewage is frequently stored and/or conveyed for treatment prior to discharge. Storage alternatives commonly developed include in-line storage provided by oversized combined sewers, off-line storage basins, retention/treatment basins and deep tunnel storage/conveyance. These facilities store combined sewage during runoff events and typically provide the equivalent of primary treatment for a design overflow rate in excess of the storage volume. Flows above the design overflow rate (up to four events annually, or 15% annually by volume per the presumptive approach) may receive something less than primary treatment.

The flow volume stored is typically conveyed back to the POTW for full secondary treatment after wet weather flows have subsided. Primary treatment of combined sewage overflows typically includes settling of solids, removal of floatables and disinfection in some cases, depending on local waterway conditions and designated uses.

Screening Facilities - George Kuhn Drain CSO Basin
Oakland Co. MI, Photo by Tetra Tech

High rate treatment (HRT) technologies use physical and chemical treatment either with or without storage elements to treat CSOs directly. The process uses screening, chemical coagulants and flocculants and ballast material for solids removal and often includes sodium hypochlorite for disinfection. Dechlorination may also be required.

Coarse/Fine Screening - George Kuhn Drain CSO Basin
Oakland County, MI, photo by Tetra Tech

Storage and treatment alternatives are frequently attractive, particularly for congested urban areas because they are usually cost-effective based on standard analysis procedures/design periods, and tend to minimize disruption during construction. Storage, conveyance and treatment alternatives can also be constructed in relatively short schedules, if land and/or easements are readily available for facility sites and pipeline routes. From a water quality perspective, SCT/HRT alternatives are attractive because most of the runoff generated in the tributary area receives at least primary treatment prior to discharge.

Some of the potential negatives associated with SCT alternatives may include the following:

Risk of Long-term Cost Increases
The long-term trend is for environmental regulation and wastewater/combined sewage treatment requirements to become more restrictive, and therefore more costly. Treatment requirements for emerging contaminants of concern may also lead to more costly treatment. CSO control options that capture and treat large volumes of combined sewage will be most sensitive to this trend.

Storage and treatment options also tend to require increased operations and maintenance activities and personnel, energy for pumping and treatment and chemicals which may also experience higher than expected cost increases.

These trends are often not adequately addressed in alternative cost-effectiveness analyses, and may have a significant effect on future operating costs

Political Opposition

CSO storage and treatment basins can be difficult to locate in some areas because property owners may feel that having a waste /storage treatment facility nearby may cause odor problems, and may involve dangerous chemicals and operations at odd hours. Property values may be decreased, or at least that perception may arise. If the location is near a waterway, waterfront property values may be decreased in the vicinity of the facility and downstream for some distance.

Public opinion may also be negative because once people understand the concept of a CSO event, they may feel that even infrequent overflows of partially treated human waste are unacceptable.

A third problem may arise with politicians and other stakeholders who see the huge public dollars being committed to projects and facilities that when completed are essentially unseen - "*You've spent $300 million, and I can't see any of it above ground.*"

Collection System Performance

Many combined sewer systems lack adequate capacity for runoff generated during larger rainfall events, resulting in system surcharging and possible basement flooding. This common occurrence is sometimes largely ignored in alternatives analyses because some regulators and permit writers still do not view basement flooding as a treatment bypass or overflow. To many, particularly those who experience it, it is the worst possible system performance.

CSO SCT options provide relief points at which surcharged sewers can discharge into the conveyance or storage element. This helps reduce the system hydraulic grade line and reduces the frequency of overflows to waterways. In many cases, however, upstream/local combined sewer capacity is also inadequate for larger rainfalls, resulting in local surcharging and basement flooding in these areas. Solving the local combined sewer capacity issues is not always adequately addressed in CSO control programs, and if included, can significantly change the cost-effectiveness analysis.

Some CSS operators have restricted runoff capture at catch basins to reduce surcharging and basement flooding in combined sewers during rainfall. This concept uses the street cross-section to temporarily store stormwater in the roadway, and if acceptable to the community can often help solve local CSS capacity problems (Skokie, Illinois).

In-system storage and real-time controls are also used to maximize storage of flow in the existing collection and conveyance system, if pipe volume is available beyond the conveyance capacity required. Controlling storage in the system helps minimize the need for additional offline storage, and can also help prevent downstream system performance problems. Real-time control systems often use a system of gates and weirs, flow and depth sensors, rain gages, and a computerized system model to track, predict and control the system hydraulic grade line and flow rates. Real-time control systems tend to increase system operational complexity, and may require extensive testing and experience to achieve projected results.

Infrastructure Rehabilitation Needs

Most SCT options tend to be located in downstream portions of the CSS, and are designed to avoid interference with existing infrastructure. This helps reduce alternative costs for the work proposed, but tends to ignore the condition of existing sewers and other utility infrastructure, which in many cases is 50-150 years old, and nearing the end of its useful life. While this can be viewed as a separate problem, large public works efforts like CSO control programs provide a rare opportunity for a joint program to update many infrastructure elements simultaneously, at a significant savings compared to individual projects. This potential savings and investment in infrastructure renewal is generally not available with SCT alternatives, and this benefit is often not quantified in alternatives comparisons.

Groundwater Recharge and Streambank Erosion

Storage and treatment alternatives are most often designed to capture, convey, treat and dispose of treated water to a local stream or water body as efficiently as possible. In some communities the lost groundwater recharge can reduce the availability of fresh water supplies. Increased wet weather streamflow can cause increased streambank erosion if the local wet weather flow increases are a significant portion of the local average streamflow.

Source/Collection System Controls

The idea of source control is common in many environmental programs from solid waste and Industrial Pollution Prevention (IPP) to stormwater Best Management Practices (BMPs), sewer separation and sewer system infiltration/inflow (I/I) removal. The concept is to permanently remove or separate an element or contaminant from the larger waste stream at its source, thereby eliminating the cost and complexity of dealing with it downstream.

In the context of CSO control and stormwater management, there are several source control methods available including sewer separation, stormwater BMPs such as street sweeping, control of surface pollutants such as fertilizers and pet waste, solid waste management, soil erosion control, stormwater detention, infiltration and harvesting.

Sewer separation has been used for over 70 years to eliminate CSOs, and most new sewer systems have been constructed as separate sewer systems since the 1940s. As wastewater treatment requirements have increased, treatment costs have risen significantly. Wastewater treatment is simpler, more reliable and much less expensive when stormwater is not mixed with sewage. Sewer separation projects can be challenging to design and construct, but if implemented properly, provide a permanent, reliable, low-risk, low-maintenance solution to CSOs and basement flooding.

Sewer separation projects provide the rare opportunity to assess and renew other infrastructure elements cost-effectively. Rehabilitation or replacement of other aging infrastructure in the project area including water mains and services, gas and electric utilities, communications systems, roadways, curb and gutter, driveway approaches and even sidewalks can be included in one project.

Sewer Separation Basics

The separation approach to be used depends heavily on the configuration and condition of the existing system. New sanitary and/or storm sewers and service leads are constructed to separate sewage and stormwater flows at their sources. Most of the construction is located in roadways or alleys, but work on private property may also be required.

In areas where the existing combined sewer system provides adequate drainage, construction of new sanitary sewers may be recommended. Although construction of new sanitary sewers can be a more costly sewer separation approach, it offers valuable benefits. New sanitary sewer materials and construction methods result in a water-tight system that minimizes infiltration/exfiltration, maximizes reliability and provides a new useful life. If the new sewers are sized properly for post-separation flow rates, basement flooding can be eliminated. The project should include assessment of the existing system condition for any rehabilitation or replacement that may be required to provide a structurally sound storm sewer system.

If the existing system is significantly undersized for peak stormwater runoff, it may be desirable to use existing sewers for the new sanitary sewer system and construct new storm sewers. This can result in a lower construction cost because of the shallower trench depths typically required for storm sewers. This savings is partially offset by the larger pipe sizes required. Assessment of the existing system slope and condition is even more important in this case, to help insure a trouble-free, self cleansing sanitary sewer system.

Other important separation elements include detailed investigation of existing service connections and disconnection of runoff and groundwater sources on private and public property from the sanitary sewer system. Homes and buildings with basements are often constructed with footing drains to drain water away from the soil near the foundation. Until approximately 1980, many building codes allowed footing drains to discharge by gravity or sump pump to sanitary/combined sewer service connections. In some locales, footing drain flows can exceed 5 gallons per minute (gpm) for a typical residential home. If significant footing drain flows or direct inflow sources are present, stormwater service leads can be included in the project.

A comprehensive and continuous public information effort is critical for sewer separation support and success. Information should begin at least one year before construction, in as many mediums as possible to help insure coverage of the system users.

Green Separation

An emerging CSO control alternative using a combination of sewer separation and green infrastructure (GI) is worth considering. EPA defines GI as *systems and practices that use or mimic natural processes to infiltrate, evapotranspirate (the return of water to the atmosphere either through evaporation or by plants), or reuse stormwater or runoff on the site where it is generated.* (*Managing Wet Weather with Green Infrastructure* EPA website)

Green Separation (GS) uses sewer separation and GI to eliminate CSOs, reduce stormwater runoff, and improve stormwater quality. Sewer separation projects provide an excellent opportunity to restore the road right-of-way (ROW) using GI. In this approach the ROW cross-section is modified to allow construction of bioswales and bioretention areas between the traveled roadway and private property. Permeable pavements can be used in parking lanes and driveway approaches, and GI can also be encouraged, and perhaps even funded on private property to further reduce runoff. Green separation may negate the need for storm sewer system capacity increases, and can eliminate or reduce the potential for future end-of-pipe stormwater treatment requirements.

Green infrastructure has the potential to provide many other benefits including increased property values, increased groundwater recharge, urban heat island mitigation, improved air quality, improved streetscaping and improved human health. See EPA's website *Managing Wet Weather with Green Infrastructure* for more information.

Modification of the roadway and ROW cross-section to accommodate GI would likely require a program to educate residents and seek input on preferred GI types and locations. In many cases, local ordinances and traffic codes would need review and revision to allow the proposed construction of these systems. The following photographs from Ann Arbor and Lansing, Michigan and Portland, Oregon show examples of green infrastructure in residential and dense urban ROWs.

Easy Street, Ann Arbor, Michigan
Showing Roadside Permeable Pavers and Swales
Photo by Tetra Tech

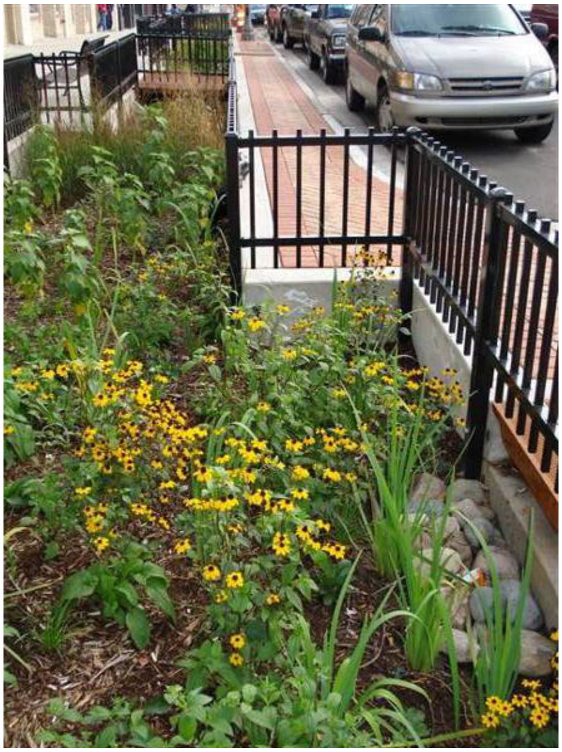
Rain Garden on Michigan Avenue, Lansing, Michigan
Photo by Tetra Tech

NE Siskiyou Green Street Project, Portland, Oregon
Photo by Kevin Robert Perry, City of Portland Environmental Services

SW 12th Avenue Green Street Project, Portland, Oregon
Photo by Kevin Robert Perry, City of Portland Environmental Services

NE Siskiyou Green Street Project, Portland, Oregon
Photo by Kevin Robert Perry, City of Portland Environmental Services

Urban Rain Garden, Washington Avenue, Lansing, Michigan
Photo by Tetra Tech



Urban Rain Garden
Michigan Avenue, Lansing, Michigan
Photo by Tetra Tech

Other Separation Approaches

Shallow Separation

Other sewer separation approaches may offer significant cost savings. In some communities or neighborhoods, it is feasible to discontinue gravity sanitary sewer service to basement-level fixtures. In this approach, a new gravity or vacuum sanitary sewer system would be installed only as deep as required to serve fixtures at ground level or above. Shallow, watertight sanitary service leads would be constructed for existing properties with existing basement service and deep service leads. The existing service lead can be retained to drain footing water or runoff to the storm sewer system if required, or abandoned if not needed. Existing basement-level fixtures would either be abandoned, or the flow pumped to the new service lead. For example, most washing machines have pumps capable of pumping to the new service lead elevation. This separation approach would eliminate sewage flooding of basements, and would essentially eliminate I/I flows from public and private property. This in turn would make existing system and treatment capacity available for new development.

Selective Separation

Selective sewer separation can be combined with SCT alternatives to minimize new wet weather storage, conveyance and treatment capacities required to control overflows. This concept seeks to identify portions of the CSS where significant stormwater tributary areas can be easily removed from the CSS and directed via storm sewers or overland flow to local waterways. Green infrastructure can also be used in this approach to reduce and improve runoff to be discharged, and to make streetscape improvements in project areas. Selective separation can also help reduce basement flooding in portions of the CSS prone to surcharging. Examples of selective separation include diversion of open channel drains away from the CSS, and separation of roadway, parking lots and roof drains in areas with positive slope to the local waterway.

Phased Separation

CSO control analyses usually conclude that sewer separation is impractical in dense urban/downtown areas because of the high capital cost, disruption and difficult construction. Over longer periods of time, however, urban redevelopment and required infrastructure renewal can make a phased sewer separation and GI program attractive and cost-effective. This approach requires advanced planning to develop interim CSO controls that can dovetail with the separation plan. A likely approach would be to develop a plan for a new sanitary sewer system to be constructed as major projects are completed in the CSS tributary area. The new system would likely need to focus on the shallow separation approach so that the new sanitary system could discharge into the CSS until eventual separation is complete.

Potential sewer separation negatives include the following:

Cost

Sewer separation construction costs can range from approximately $20,000 to over $300,000 per acre depending on location, development density, separation approach, existing utilities and construction standards. As a result, separation may be significantly more costly to construct in comparison to many SCT alternatives. Long-term phased separation may become attractive in these cases.

Stormwater Management Challenges
In some locations, separated stormwater may be heavily polluted, and may increase runoff to local streams, causing increased erosion and other water quality problems. In such areas, effective stormwater BMPs may be impractical in the near term, and stormwater may need to be treated prior to discharge. Eventual site cleanup and improvement in source controls may make separation a feasible long-term goal.

Disruption During Construction
Sewer separation can be very disruptive for local businesses, residents and commuters. This is a significant issue for the separation approach, and requires constant attention by the owner, engineer and contractor to adequately address it. Successful separation programs have developed comprehensive communication plans to keep stakeholders informed of upcoming work and traffic detours. Individual projects may also need to be segmented to minimize disruption. This generally means that properties must have ready access for all but short periods of time, and that major traffic routes must allow for efficient detours. The owner and contractor must also be attentive to property owner needs and be willing to accommodate reasonable requests that may not be in the design drawings.

Extended Schedule
Because of the added construction complexity and need to minimize disruption during construction, sewer separation programs can require significantly more time to implement than some other alternatives. This can be positive and negative. The positive side is that the program cost is likely spread out over a longer period, which helps to reduce rate increases, and spread the cost over more rate payers. The primary negative of the extended schedule is that the challenges associated with the program are extended as well.

THE FUTURE – PLAN TO ADAPT

The American Society of Civil Engineers (ASCE) has estimated that over $1 trillion will be needed over the next two decades to bring America’s drinking and wastewater infrastructure systems to good condition (*Report Card for America’s Infrastructure)*. With approximately 50% of our nation’s assessed surface waters remaining impaired, and WQ degradation continuing in some categories, it is likely that our approaches to clean water will undergo significant change. Based on the trend to date, treatment requirements and costs will likely continue to increase. Following are some unscientific, projected trends that may affect wastewater treatment and stormwater management approaches:

- Energy, labor and health care costs will tend to increase.
- Effluent requirements will tend to become more restrictive.
- New contaminants such as antibiotics, endocrine disruptors and other pharmaceuticals and are being detected in surface waters and may need to be removed from effluent.
- Climate changes will likely increase rainfall in some locations, and decrease it in others.
- Hopefully, EPA and state environmental efforts will continue to reduce the sources of common environmental contaminants such as fertilizers, heavy metals, floatables etc.

It appears that a long-term strategy to minimize the volume of wastewater and stormwater requiring treatment would help minimize overall cost. Over a period of several decades, a source control approach to separate combined sewer systems, dry up sanitary sewer systems and treat stormwater onsite may be the most cost-effective and politically acceptable path to clean water.

CONCLUSIONS AND RECOMMENDATIONS

The Clean Water Act has revolutionized wastewater treatment and stormwater management in the United States, but it has not achieved its original goals. While significant progress has been made in many communities, some surface water degradation has actually increased. Federal and State environmental agencies need to continue to explore alternatives to reduce the sources of pollutants and other WQ impairments.

While end of pipe treatment for CSOs and stormwater can produce excellent effluent quality, reducing the volume of stormwater runoff, and controlling pollutants at their source may produce better results at a lower long-term cost.

Sewer separation can be costly and disruptive, but offers a rare, cost-effective opportunity to assess and rehabilitate failing infrastructure and eliminate basement flooding.

Green Separation combines *s*ewer separation with restoration of the road ROW using green infrastructure. Green separation can help maximize sewer system performance, minimize stormwater runoff and improve the quality of discharged stormwater.

A *Shallow Separation* approach may be considered in areas where basement level gravity sanitary service is not required. Shallow separation reduces sanitary sewer system depth by providing gravity or vacuum sanitary service to first floor and higher building levels only. Basement sanitary fixtures are either abandoned or pumped to the elevated service lead. Where feasible, this approach may provide significant cost savings due to reduced system depth. Public and private property I/I would also be eliminated.

Selective Separation may be used with CSO storage, conveyance and treatment (SCT) alternatives to reduce the design storage volume and peak rates to be treated. Selective separation seeks to identify significant stormwater tributary areas that can be easily separated and discharged via storm sewers or overland flow to local waterways. Green infrastructure may also be used in this approach to reduce runoff and improve runoff quality.

Phased Separation may be used in areas where sewer separation is not presently considered cost effective. Phased separation uses a long-term plan, perhaps 50 years or more, to implement sewer separation in conjunction with other major urban renewal and infrastructure replacement projects. Phased separation may be combined with the other separation approaches above to minimize cost and maximize benefits to rate payers and the environment.

The future of wastewater treatment and stormwater management appears costly and increasingly restrictive. Over a period of several decades, a source control approach to separate combined sewer systems, dry up sanitary sewer systems and treat stormwater onsite may be the most cost-effective and politically acceptable path to regulatory compliance, social benefit and clean water.

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