City and County of San Francisco
2030 Sewer System Master Plan

TASK 500
TECHNICAL MEMORANDUM NO. 507
COMBINED VS SEPARATE SEWER AND STORMWATER QUALITY

FINAL DRAFT
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1.0 INTRODUCTION AND HISTORY

Currently approximately one out of every seven Americans is served by a combined sewer system (CSS) (systems which collect sanitary sewage and storm water runoff in a single pipe network). Sanitary sewage is made up of domestic, commercial and industrial wastewater plus infiltration and inflow. Storm water runoff consists of precipitation (rainfall and snowmelt) that does not infiltrate into the ground or evaporate due to impervious surfaces but instead flows onto adjacent land and is routed into drainage systems.

Major cities with combined systems in the United States are located on the east coast and in the Midwest. These would include Boston, New York, Philadelphia, Washington D.C., Atlanta, Cleveland, Detroit, Indianapolis, Chicago and St. Louis. On the west coast, generally only the oldest and largest cities, i.e. San Francisco, Old Town Sacramento, Portland and Seattle have CSSs, In Europe many of the largest and oldest cities also have combined systems, for example, London, Paris, Berlin and Rome. The choice, typically, was based on cost and convenience.

With the advent of indoor plumbing, around the turn of the last century, cesspools and leaching basins soon became overloaded with the new water borne waste and relief was essential. In densely packed urban areas, storm drains had been constructed earlier to keep roads passable and yards free of inundation. Because flow rates to contain and transport the runoff from even modest storms could be very large, pipeline routes were generally selected along the most direct downward route to the nearest water course, whether a brook, stream, river or estuary. Compared to storm runoff, sanitary sewage flows were small and it became expedient to connect the new flows into the drains to hasten their passage to the natural waterways.

As populations grew the waterways became increasingly polluted and foul smelling, especially during the intervals between storms when flushing flow volumes were minimal. Public health concerns led to the virtual abandonment of construction of new combined sewers by the 1920s and 1930s and separate sanitary and storm water systems became the standard of practice for new or expanding communities.

For cities already possessing combined systems, interceptors were constructed parallel to the waterways to intercept a small multiple of the average daily dry weather flow from the drains and convey this volume to areas of greater dilution or to newly constructed treatment facilities. Flows not intercepted continued to discharge directly to the receiving waters as combined sewer overflows (Fair and Geyer, 1954)

Implementation of the Clean Water Act of 1972 (CWA) and subsequent initiatives have led to significant progress in protection of the public health and restoration of the nation's waters. These include the baseline standard of secondary treatment or higher for dry weather flows, the US Environmental Protection Agency's Combined Sewer Overflow (CSO) Policy of 1994 (which became law in the Water Quality Act of 2000) and non-point pollution guidance. The CSO Control Policy represents a comprehensive national strategy to ensure that all stakeholders, including regulatory agencies, municipalities and the public, engage in a comprehensive and coordinated effort to achieve cost effective CSO controls that ultimately meet the goals of the CWA.

The USEPA Report to Congress on "Implementation and Enforcement of the Combined Sewer Overflow Policy" in December 2001 (USEPA, 2001) listed 772 CSS communities nationally, predominantly in the East and Midwest, of which 16, including San Francisco, Portland and Seattle are located in the Pacific coastal states. Of the 772 CSS communities approximately 30 percent have populations greater than 75,000 and approximately 30 percent are very small with populations of less than 10,000. Approximately 95 percent of the communities discharge to fresh waters and 5 percent to oceans, estuaries and bays. Long Term Control Plans (LTCPs) of the surveyed communities usually include a combination of control measures, with sewer separation being the most common component.

Fifteen case studies are detailed in the report and San Francisco is cited as having made exemplary progress in controlling its discharges in compliance with the goals of the CWA. In view of this progress, is sewer separation a viable option in the City's future?

2.0 OVERALL APPROACH

In this Technical Memorandum the option of sewer separation is examined in terms of service to users, receiving water impacts, regulatory guidance and direction, previously committed resources and achievements, options available going forward, their advantages and disadvantages, illustrative case studies and a summary assessment.

2.1 Service to Users

The primary concern of wastewater collection whether in a combined or separate system is the safety and health of the public it is obligated to protect. When properly designed, operated and maintained the results from either system should be indistinguishable to the user: sanitary sewage and runoff are collected rapidly, efficiently and reliably and delivered to points of treatment in a manner and condition which facilitates pollutant removals and operational effectiveness. System failures are evidenced by backups, flooding and/or odors. Flexibility, redundancy, access for inspection/repairs, and ability to respond to emergencies are desirable traits.

Capacity requirements for collection system design for urban areas, whether separate or combined, are dominated typically by the high volume and rate of the storm induced flows. For example, rates of runoff from an average storm intensity of 0.1 in/hr may be expected to be about 5 to 10 times the incremental dry weather flow contribution from the same area. Similarly, a not uncommon rainfall intensity of 1.0 in/hr will produce flow rates of 50 to 100 times the dry weather flow (Lager and Smith, 1974). It is impractical, if not impossible, to design for total capture of extreme storm events, thus overflow points must be provided.

2.2 Receiving Water Impacts

Receiving water impacts of urban wet weather discharges are complex and highly variable. They are dependent upon the intensity, duration and frequency of events and conditions at the point(s) of discharge. The impacts can be beneficial (e.g. flushing, re-aeration, etc) and/or detrimental (solids, trash, floatables, heavy metals, nutrients, pesticides, herbicides, bacteria, etc). Both combined sewer overflows and separate storm water discharges can be significant sources of pollution. Both combined sewer overflows and separate storm water discharges can be significant sources of pollution as shown in the generalized comparisons in Table 1.

Table 1 General Comparison of Wastewater Characteristics
2030 Sewer System Master Plan
City and County of San Francisco

Parameter	Unit	Storm Water Runoff	Combined Wastewater	Sanitary Sewage
Total Suspended Solids, TSS	Mg/L	67-101	270-550	120-370
Biochemical Oxygen Demand	Mg/L	8-10	60-220	120-380
Fecal Coliform Bacteria	MPN/100ml	10^3-10^4	10^5-10^6	10^5-10^7
Total Kjeldahl Nitrogen (as N)	Mg/L	0.43-1.00	4-17	20-705
Phosphorus (total as P)	Mg/L	0.67-1.66	1.2-2.8	4-12

Source: *Adapted from Metcalf & Eddy Wastewater Engineering: Treatment and Reuse, 4th Edition, [2003]*

Absent disinfection, the bacterial content of combined sewer overflows may be one to two orders of magnitude greater than separate storm water discharges; however, storm water alone can have sufficiently high bacterial concentrations so as to require beach closings.

The Fact Sheet supporting the National Pollutant Discharge Elimination System (NPDES) Determination for San Francisco (CA Regional Water Quality Control Board, San Francisco Bay CA, 2002) states in part "…Shoreline bacteriological levels have been monitored for the past 15 years at 45 locations around the City at a frequency of 8 to 12 times per month at each site; visual observations of overflow debris and recreational uses in the vicinity of the overflow structures are also reported. Monitoring results show that coliform bacteria levels are elevated at shoreline stations near CSO structures during and shortly after CSO events, *but generally return to background levels within one or two tidal cycles following the* *cessation of the overflow"* [emphasis added]. Further a study performed by ESA and reported in the SOFT (Brown and Caldwell, 2004) report "…found very little contact with Bayside water…" along the shores of San Francisco.

Storm water picks up contaminants as rainfall strips particulates from the air, off building surfaces, from streets, parking lots, industrial and construction sites, from vegetation, lawns and parks, and from the conveyance system through which it passes, whether natural or improved channels, separate or combined pipelines and their appurtenances. Pervious surfaces, such as sandy soils, vegetative swales, porous pavements, and depressions, etc encourage infiltration into the ground and thus reduce peak runoff rates, scouring velocities and volume. Typically, the concentration and abundance of pollutants in storm water reflect the "cleanliness" of the watershed; thus runoff from industrial and poorly maintained areas is of greater concern than, say, productive residential and commercial areas. This explains why source controls, such as street sweeping and flushing (heavy metals source), catch basin cleaning, solid waste collection and disposal, chemical use restrictions, erosion controls and illicit connection prohibitions and enforcement can be effective countermeasures.

Surprisingly, perhaps, the primary source of dioxins in San Francisco's wastewater is from storm water inflow (Brown and Caldwell, 2004) These result primarily from emissions from diesel engines and other combustion sources which precipitate on to streets, roofs and other surfaces and are subsequently flushed into the collection system by storm water. If not removed by treatment, as could be the case under a sewer separation project, dioxins would be a receiving water quality concern as they bioaccumulate in the food chain. Under the present combined system, 80 – 95% or more of the dioxins are removed at the City's treatment plants.

3.0 REGULATORY GUIDANCE AND DIRECTION

The options for creating a separate storm sewer system in San Francisco have substantial regulatory hurdles including: maximum extent practicable (MEP) pollutant controls for new development; potential numeric effluent limits; waste load allocations from total maximum daily loads (TMDLs); California Environmental Quality Act (CEQA); compliance with water quality standards; non-degradation; and anti-backsliding. The regulatory environment is evolving such that separation is becoming increasingly unattractive.

The major constraint is that future regulations will likely require treatment for separate storm water discharges. The costs for treatment would be substantial and in addition to the extraordinary cost of separating the pipe networks. These costs would be for services that are largely, if not totally, redundant to those provided by the present system. In addition, the required environmental impact analysis would have difficulty demonstrating that the environmental benefits of separation would offset the negative impacts of the associated construction.

Under San Francisco's current combined system an estimated 60% of the particulate pollutants in the storm water runoff are captured by the treatment facilities. A related factor is the policy of the Regional Water Quality Control Board to prevent any increases in loadings to impaired waters for pollutants listed on the 303(d) list. Storm water contains significant loadings of some pollutants listed for San Francisco Bay including dioxins and mercury. A separate storm water system presumably would need to provide an equivalent level of treatment to that provided by the present system.

Sewer separation regulatory issues can be summarized into the following categories:

1) *Requirements to provide treatment for the stormwater flows if the existing combined sewer system is separated.*

    This memo concludes that a number of regulations and policies will likely require that flows from a separate storm sewer system be treated so that pollutant loading to the Bay and Ocean does not increase as a result of sewer separation. In effect, the City would be required to operate two systems.

2) *Requirements to assess environmental benefits and impacts of separating the existing combined sewers.*

    The California Environmental Quality Act (CEQA) requires decision-makers to weigh the environmental costs and benefits of a project.

3) *Requirements applicable to stormwater discharges from current separated sewer areas and from new developments with separated sewers.*

    Major developments in the City are being constructed with separated sewer and the City, along with regulatory agencies, must determine the appropriate stormwater controls. The requirements applicable to new developments will be impacted by the relatively recent statewide permit for stormwater discharges from small storm sewer systems.

The following sections describe the current system and potential configurations if the sewer system is to be separated. It also identifies the specific regulatory constraints related to the categories above.

3.1 Current system

The advantage of the combined system is that San Francisco is able to provide treatment to the stormwater component, as well as the sanitary sewage. Most separate sewer communities do not currently treat their stormwater. For smaller storms, all the runoff is contained within the storage/transports and directed to the treatment plants and receives secondary level treatment. For intermediate level storms, the combined sewage, including the stormwater is contained with the storage/transports and directed to the treatment plants but portions receive only primary-level treatment. During the largest storms, the storage/transports may discharge partially treated combined sewage at the shoreline. This partial treatment consists of settling within the storage/transports, which removes particles and baffles, which control floatable pollutants.

Combined sewer discharges (CSDs) at the shoreline currently occur from 1 to 10 times per year on average depending on location. These combined sewer discharges (CSDs) are composed of mostly stormwater, however the sewage component of the CSDs potentially contributes to elevated bacteria at the discharge locations compared with a stormwater discharge[1].

San Francisco provides significantly more overall treatment, measured in terms of pollutants removed from sewage and stormwater runoff, than would occur in a comparable city with separated sewers. This is because the regulatory agencies do not currently require treatment for discharges from separated storm sewer systems.

Although the City is served almost exclusively by combined sewers, small areas of the City are served by separate storm sewers. These areas include the Port, Candlestick Point, local drainages around Lake Merced, Lobos Creek, and several other waterways, and the new development at Mission Bay. These areas are described in more detail in Appendix A.

3.2 Treatment Options for Separate Sanitary And Storm Sewers

Nearly every street in the City has a combined sewer. Separation of this sewer into sanitary sewer and storm sewer systems would require the construction of an additional sewer system. Typically, the sanitary sewer lines are much smaller than storm sewers. Most likely, the streets would be excavated to install a new sanitary sewer system.

The non- treatment option – If treatment were not required for the stormwater, then it could be discharged at the shoreline in a similar manner to how stormwater is managed in communities with a separate storm sewer system. In this case, the storage/transports would be bypassed or possibly used for the sanitary sewage. This option would greatly increase pollutant loadings to local waters since the current system directs much of the stormwater runoff to the treatment plants. In addition, the storage/transports, themselves, provide some treatment through settling of solids and skimming of floatables.

The treatment option – As discussed later, current regulations will likely require that the stormwater receive treatment more or less equivalent to that provided to the stormwater component by the current wastewater system. If the stormwater has to be treated, the previous combined sewer system including the shoreline storage/transports would then be used exclusively for stormwater. Additional construction would include interceptor sanitary sewers to convey the sanitary sewage to the treatment plants. The former combined

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1 Stormwater discharges typically contain bacteria levels that exceed standards when measured at the point of discharge. Combined sewer discharges would be expected to have higher levels of bacteria due to the presence of sewage.

sewers (now storm sewers) would release the stormwater into the storage/transports. The storage/transports would be used to contain the stormwater for eventual treatment at the treatment plants.

The North Point plant would treat stormwater instead of combined sewage and stormwater. On the Oceanside, some stormwater would be discharged directly from the Westside Storage/Transport to the Ocean Outfall.

During the largest storms, the capacity of the storage/transports would be exceeded, as occurs now, and the excess stormwater would be discharged at the shoreline. This is because the hydraulic loading during wet weather mostly results from stormwater, especially during the major storms causing shoreline discharges. However, these discharges would likely have lower bacteria loadings due to the absence of sanitary sewage. Urban stormwater runoff does typically carry substantial loadings of bacteria but this loading would be less than that from a combined sewer system discharge. The loadings of other runoff pollutants in the discharges (copper, dioxin, etc.) would remain essentially the same under this scenario.

3.3 Water Quality Standards and Potential Treatment Requirements for the Stormwater Flows

The specific requirements are listed bellow.

3.3.1 Maximum Extent Practicable (MEP) Pollutant Controls for New Development

The evolving, flexible, and advancing concept of *maximum extent practicable* (MEP) pollutant removal is the basic stormwater permit requirement for separate storm sewers. It means that, at a minimum, new development projects and renovations meeting certain criteria need to provide runoff treatment.

3.3.2 Potential Numeric Effluent Limits for Existing Runoff

The State Water Resources Control Board has formed a Blue Ribbon panel to assess whether it is technically feasible to establish numeric effluent limitations, or some other objective criteria, for inclusion in stormwater permits for separate sewer systems. Typically, such requirements are imposed on new systems first. At some future date, numeric limits may be part of MEP controls and could potentially require treatment for existing stormwater runoff.

3.3.3 Wasteload Allocations from *Total Maximum Daily Loads* (TMDLs)

San Francisco's current wastewater system provides treatment to the stormwater runoff component of the combined sewer flows. This is because most of the stormwater is directed to the treatment plants and receives primary or secondary-level treatment. As discussed previously, the storage/ transports also provide some treatment. The City has estimated that approximately 60% of the particulate pollutants in the runoff are captured by the treatment facilities. The TMDLs in development for San Francisco Bay will allocate significant reductions for stormwater. For example, the proposed mercury allocation for municipal stormwater runoff will require an approximately 50% reduction in loading. San Francisco's combined system may already be achieving this reduction because of the treatment provided to the stormwater component. (The San Francisco Bay Mercury TMDL assumes most mercury in runoff is attached to sediment, i.e., particulates.) A separate storm sewer system would potentially be required to provide collection and treatment facilities to achieve the allocations from the mercury and other upcoming TMDLs.

A related factor is the policy of the Regional Board to prevent any increases in loadings to impaired waters for pollutants listed on the 303(d) list of impaired waters. Stormwater contains significant loadings of some pollutants listed as causing impairment for San Francisco Bay including dioxins and mercury. A separate stormwater system presumably would need to provide an equivalent level of treatment to that provided by the current combined sewer system and associated treatment facilities.

3.3.4 Compliance with Water Quality Standards

If the sanitary and stormwater sewers are separated, pollutants in untreated stormwater runoff would likely exceed water quality standards, see Table 2. The intent is to theoretically assess potential compliance problems if San Francisco sewers were to be separated and the stormwater discharged without treatment. Several typical constituents of storm water, including copper, zinc, and bacteria, are likely to frequently exceed water quality standards at the point of discharge. Dioxin and mercury are also likely to frequently exceed standards although the available data set is limited. Adequate information is not available for constituents such as PCB.

Most of the stormwater runoff data in the following table is taken from a large-scale multi-year stormwater sampling effort by Caltrans[2]. Runoff data for dioxin and mercury were estimated from other sources. Municipal runoff shows wide variation in pollutant concentrations depending on location and such factors as the antecedent dry period, upwind sources, etc. The Caltrans data is assumed to generally approximate expected values for urban runoff. The large standard deviations are indicative of the variability in runoff data.

Municipal stormwater discharges in California are prohibited from causing an exceedance of water quality standards. The standards are specified in the Basin Plans, Ocean Plan, and California Toxics Rule (CTR). The current stormwater permits provide an "iterative process" for compliance with this requirement. Permittees are required to monitor, report

2 *Stormwater Monitoring & Data Management Discharge Characterization Study Report,* CTSW-RT-03-065.51.42, November 2003, California Department of Transportation, Table 3-18, Page 60

Table 2 Comparison of Typical Stormwater Runoff with Water Quality Standards
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Parameter	Units	Mean	Standard Deviation	CTR Acute(3)	CTR Chronic(3)	Non-CTR objective
Cu, total	μg/L	39	262	-	-	
Cu, dissolved	μg/L	14	15	4.8	3.1	
Zn, total	μg/L	207	286	-	-	
Zn, dissolved	μg/L	75	128	90	81	
Pb, total	μg/L	49	142	-	-	
Pb, dissolved	μg/L	4.5	21.3	210	8.1	
Ni, total	μg/L	13	67	-	-	
Ni, dissolved	μg/L	4.2	5.3	74	8.2	
*Mercury, total (1)	μg/L	3.8 est.	na	-	-	0.025 (chronic); 2.1 (acute) *BP*
*Dioxin (2)	pg/L	0.8 - 68	na	-	0.014 HH	
Fecal Coliform Bacteria	MPN/100 ml	1415	3029	-	-	400 *OP SS*
Total Coliform Bacteria	MPN/100 ml	9,169	25,975	-	-	10,000 *OP SS*
PCBs and other possible POCs	Adequate information is not available on stormwater discharge concentrations					

Notes:

The Caltrans data includes many additional constituents. This table is limited to those constituents most likely to exceed standards.

Mean and standard deviations are from Caltrans statewide monitoring except for mercury and dioxin marked with an asterisk.

HH indicates constituent objective is based on the human health objective for consumption of organisms. **OP SS** stands for Ocean Plan Single Sample maximum. **BP** = San Francisco Bay Basin Plan

(1) The SF Bay Mercury TMDL uses a value for Hg in sediment carried by stormwater runoff of 0.38 ppm. This value is multiplied by an assumed 100 mg sediment per liter of runoff to yield the 3.8 ug/L for the table.

(2) This range is from the San Francisco Regional Water Quality Control Board survey of Bay Area waterways completed in 1997.

(3) The corresponding “total” objective for each metal can be estimated using the conversion table in the State Implementation Policy, App. 3. The conversion factor for copper in saltwater is 0.83, zinc – 0.95, lead – 0.95, nickel – 0.99. In other words, the corresponding calculated total value is generally fairly close to the dissolved objective. The conversion factors are used in calculating water quality-based effluent limits, which must apply to “total” concentrations. Some locations have site specific conversion factors.

Source: California Toxics Rule (CTR) criteria and other relevant water quality objectives exceedances, and improve their stormwater best management practices (BMPs) to address the exceedances. However, municipal stormwater dischargers are not required to treat their runoff. Thus, the State Water Boards have not generally applied numeric effluent limitations to municipal storm water in the municipal permits.[3] However, the municipal stormwater permits require municipalities to design their stormwater management plans (SWMP) to comply with standards. In addition, permittees are required to report exceedances to the Regional Board and implement improvements to the SWMP. In practice, however, runoff monitoring is somewhat limited and water quality standards are mostly disregarded.

One complicating issue is that the Water Boards have not developed guidance for how runoff data should be compared with standards. For example, it has not been determined if data should compared to the chronic (long-term) or to the acute (short-term) criteria in the California Toxics Rule. In some locations there is also a question of whether a dilution factor should be applied. In practice, these requirements are more or less overlooked, possibly because municipal stormwater runoff generally exceeds standards at the point of discharge (e.g., bacteria, metals, toxic organics such as dioxin)[4].

3.3.5 <u>Nondegradation</u>

SWRCB Resolution No. 68-16 describes the nondegradation policy, which is part of the State's water quality standards. The policy requires that existing high quality waters be maintained without degradation. This policy would likely prevent the issuance of a permit for a new San Francisco storm sewer system that did not include the level of pollutant control equivalent to that achieved by the current system.

3.3.6 <u>Anti-backsliding</u>

This provision of the Clean Water Act is intended to prevent the issuance of permit requirements that are less restrictive than prior permit requirements, which have been attained by the permittee. The issuance of a permit to San Francisco to allow the discharge of untreated stormwater could be interpreted as backsliding.

3.3.7 <u>California Environmental Quality Act (CEQA) Review of Treatment Options</u>

CEQA requires that whenever a proposed project will result in potential significant adverse environmental impacts, measures must be taken which will limit or avoid that impact. Separating San Francisco's sewers without adding treatment would result in the release of stormwater constituents potentially with adverse affects on San Francisco Bay. Stormwater is a significant source of Bay pollution and is currently being targeted by TMDLs being prepared for the Bay. Under CEQA, the project proponents would need to identify

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3 This may be changing: a recently issued draft permit for Ventura County does have numeric performance-based limitations, which force treatment for some discharge locations.

4 The SWRCB has not clarified how to assess stormwater compliance with water quality standards. If runoff concentrations are compared directly with water quality objectives (excluding dilution factors), stormwater consistently exceeds standards. This is evident from sampling completed by the permitted Municipal Separate Storm Sewer Systems (MS4) as well as studies done by EPA and others.

alternatives or methods to mitigate this discharge. One obvious mitigation measure is to provide treatment.

3.4 CEQA Requirements to Assess Environmental Impacts of Sewer Separation

The City, as well as the regulatory agencies, will need to assess the environmental impacts of separating the sewers. As described above, CEQA will impact the decision on whether to treat the stormwater runoff from a separate storm sewer system. CEQA also is relevant for the broader question of whether the sewer system should be separated.

If the sewers are separated, virtually every street in the City would need to be excavated during separation and reconstruction. Interceptor sewers would also need to be built. The aggregate construction impacts would be significant and difficult to fully mitigate.

Even assuming stormwater is treated using the current facilities, it will be necessary to assess and compare the other environmental benefits and adverse impacts. A separated sewer system would still have a similar frequency of shoreline discharges. These stormwater discharges may carry less bacteria since sewage would not be present but otherwise would be similar in pollutant loading to the current CSDs, which are mostly stormwater. Shorelines would still potentially need to be posted because stormwater carries substantial amounts of bacteria from street runoff. Thus the CEQA document would potentially identify substantial impacts from sewer separation.

3.5 Regulatory Constraints on Existing Stormwater Discharges

The areas in San Francisco currently discharging from separate storm sewers are subject to the *General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems* (commonly known as the *Small MS4 General Permit*). More details on these requirements are included in Appendix B. The City has two Stormwater Management Plans to address the permit: one covers the Port area and the other covers the remaining separately-sewered areas.

The main compliance challenges resulting from the permit include the following:

- **Implement the specified six *Minimum Control Measures***. These include such activities as public education and control of illegal discharges to storm sewers. These measures require establishment of a stormwater administration program but are relatively inexpensive to implement.

- **Provide *maximum extent practicable* (MEP) pollutant removal**. The permit describes this as an evolving standard. For regulated communities or areas with greater than 50,000 population, MEP can have significant financial impacts. In these larger areas, the permittee must implement a program to ensure that new projects or major renovations meeting certain criteria implement structural controls for runoff.

In practice this generally means that the projects must include treatment controls for stormwater. In addition, this requirement may also mean that the volume and rate of stormwater runoff must be maintained at close to pre-development levels (hydromodification management). Both of these requirements can result in significant costs for new projects or redevelopment projects.

The Small MS4 General Permit also states that the MEP-based best management practices (BMPs) "will be expanded or better-tailored in subsequent permits."

> The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility. As knowledge about controlling urban runoff continues to evolve, so does that which constitutes MEP…. the MEP standard in California is applied so that a first-round stormwater permit requires BMPs that will be expanded or better-tailored in subsequent permits. [*General Permit Fact Sheet pg. 9*]

Thus, the requirements on stormwater permittees related to MEP may become more restrictive in the future.

- **Comply with water quality standards using an iterative approach**. Permittees with a population greater than 50,000 are also required to comply with water quality standards. Taken at face value, this requirement would present a financially insurmountable hurdle to stormwater programs since possibly all stormwater exceeds standards at the point of discharge. However, the State Board has significantly reduced the effect of this requirement by providing an iterative process for compliance. The basic requirements are:
    - Design the Stormwater Management Plan (SWMP) to achieve compliance with water quality standards
    - If exceedances of standards occur, the permittee notifies the Regional Board and submits a report including new BMPs to reduce the pollutants causing the exceedances.
    - The permittee modifies the report as necessary, and once the report is approved, implements the modified SWMP.
    - Unless otherwise directed by the Board, permittees have to implement this process only once during the permit cycle.

As discussed earlier, this requirement has not yet had a significant impact on municipal stormwater dischargers.

- **Implement TMDL allocations**. Permittees subject to TMDLs are required to achieve the reductions in pollutant loading specified in the TMDLs. These reductions in loadings can be significant; for example, the draft mercury TMDL for San

Francisco Bay assigns a nearly 50% reduction in stormwater loadings of mercury to the agencies responsible for urban runoff.

3.6 Regulatory Constraints on New Stormwater Discharges

New discharges from major development projects would need to comply with the requirements for existing discharges as listed above, and in addition may need to address the following, which were described previously.

- Prohibition on increases of 303(d) listed pollutants
- California Environmental Quality Act (CEQA) requirements for mitigation
- Nondegradation requirements in the water quality standards
- Anti-backsliding provisions of the Clean Water Act

3.7 Regulatory Constraints of Sanitary Sewer Overflows

Separate sanitary sewers are also subject overflows (bypassing of treatment facilities) termed Sanitary Sewer Overflows (SSOs). SSOs may be caused by (1) the entrance of excessive amounts of storm water, (2) pipe blockages, or (3) structural, electrical or mechanical failures. On May 2, 2006, the CA State Water Resources Control Board (SWRCB) adopted a General Waste Discharge Requirement (WRD) for all publicly owned sanitary sewer systems in California with more than 1 mile of sewer pipe. The goal of the WRD is to provide a consistent statewide approach for reducing SSOs. The WRD requires that:

- In the event of an SSO, all feasible steps be taken to control the released volume and prevent untreated wastewater from entering storm drains, creeks, etc.
- If an SSO occurs, it must be reported to the SWRCB using an online reporting system developed by the SWRCB.
- All publicly owned collection system agencies with more than 1 mile of sewer pipe in the State must develop a Sewer System Management Plan (SSMP). The WDR specifies mandatory elements that must be included in the SSMP, which must be made publicly available.

4.0 SAN FRANCISCO'S COMMITTED RESOURCES AND ACHIEVEMENTS

Over the past two decades the City has moved aggressively to upgrade its treatment facilities, implement best management practices (BMPs), and reduce combined sewer overflows (CSOs). A network of transport/storage chambers have been constructed around the City's perimeter to intercept both dry and wet weather flows and convey them to one of three locations for treatment and discharge. Instantaneous flows during storm events in excess of peak treatment capacity are "stored" in the chambers and subsequently processed through the treatment facilities as capacity becomes available. Rare flows, which exceed the combined storage-treatment capacity receive "flow through" treatment (by sedimentation and floatables retention in the chambers through baffling) prior to discharge to the receiving waters. The City was recognized in 1993 with a First Place Award for Combined Sewer Overflow Control through the EPA National Wastewater Excellence Awards.

The upgrades have achieved full secondary treatment for all dry weather flows and a substantial portion of wet weather flows; primary treatment and disinfection of additional wet weather flows; a reduction in average annual CSO events from 40-80 occurrences to fewer than 10 (prioritized by location); and a reduction in CSO volume in excess of 85%. On an average annual flow basis 82.4% of the combined wet and dry weather flow receives secondary treatment, an additional 8.5% receives primary treatment, and the balance, 9.1%, receives flow through treatment (Water Infrastructure Partners, 2003). Dry weather overflows (referred to as SSOs in separate systems) have been eliminated.

NPDES Permits, authorization to discharge to State and Federal waters, were issued by the California Regional Water Quality Control Board, San Francisco Bay Region to the City in June 2002 for Bayside discharges (CA Regional Water Quality Control Board, San Francisco Bay Region, 2002) and in October 2003 for Westside discharges (CA Regional Water Quality Control Board, San Francisco Bay Region, 2003). The permits establish numerical limits and operational, monitoring and reporting requirements for the City's treatment and wet-weather control facilities. The requirements include public notification and posting of warning signs at beach locations whenever there is a CSO discharge in the vicinity. These signs remain posted until water sampling indicates the bacteria concentration has dropped below the level of concern for water contact recreation. Beach postings have dropped from an average of 80 days per year before control to 12 days per year after control (USEPA, 2001).

The City continues to operate in full compliance with the terms of these permits, which will be up for review/renewal in 2007 and 2008, respectively.

5.0 OPTIONS GOING FORWARD

Three basic options pertaining to sewer separation are available to the City as it moves forward into the 2030 Sewer System Master Planning period: (1) continue its combined system with BMPs and controls; (2) separate its collection system and address issues of sanitary and separate storm water discharges independently; or (3) pursue a hybrid solution by watershed or sub-watershed basis or by disconnecting only downspouts, yard drains, etc.

There are approximately 900 miles of sewers in the present collection system ranging in size from eight-inch diameter pipes to multi-chambered box structures up to 44 feet wide and 25 feet deep. Seventy-one percent of the collection system is over 65 years old and one-third of all sewers are more than 100 years old. As the “normal” life expectancy of sewer pipes is 50-100 years, a pro-active repair and replacement program is essential in all future programs. The City estimates the on-going sewer repair and replacement costs to be on the order of $1 million per mile and projects a necessary total replacement cycle target of 70-100 years. Sewer replacement costs for 70 miles of undersized sewers in backlog as of 2003 was estimated to cost $143 million or approximately $2 million per mile (Water Infrastructure Partners, 2003).

House and building laterals (service connections) connected to the CSS also carry both sanitary sewage and storm water and would be a major cost component in any separation project. There are approximately 200,000 service connections within the City with an estimated total length of 2,000 miles. For most of the buildings and especially residential homes with flat roofs the connection for the roof drainage is internal to the building; thus greatly increasing retrofit costs. Separation of storm and sanitary flows on private property presents significant legal and social challenges: Who would perform and pay for the work? How would timely compliance be assured? In a USEPA sponsored Sanitary Sewer Overflow Workshop (USEPA, 1995) it was concluded that “…laterals tend to have more problems in older neighborhoods where residents are on fixed incomes or economically disadvantaged…” and that “…repair costs of failed laterals may vary from $3-4,000 to $18,000…” What if the private owner lacks the necessary funds?

Although the City is almost entirely served by combined sewers (>90%), there have been and will continue to be small areas that are served by separate storm sewers (see Appendix A). These areas include the Port of San Francisco, Golden Gate Park, Lobos Creek, Lake Merced and other smaller parks. Other separately sewered areas that may be operated by the City in the future include Treasure Island/Yerba Buena Island, Mission Bay-South, and the Hunters Point Shipyard.

Separate sanitary and storm sewers are advantageous for the Port as the sanitary sewage disposal requirements are small and the piers and warehouses are located on or adjacent to the Bay facilitating direct storm discharge. Similarly, the park sanitary sewer requirements are small and the park environment, excluding the major thoroughfares, is well suited for flow retention and infiltration.

5.1 Continue the Present Combined System

There are several advantages and some disadvantages associated with continuing with the present system with phased improvements prioritized by need and opportunity. Most important among these are:

Advantages:

1) Proven system that is working and in regulatory compliance

2) Preserves scarce resources for higher level needs (flood relief, system renewal and repair, further reductions in overflow volume and events, low impact development (LID) opportunities, etc.)

3) Eliminates dry weather overflows

4) Provides primary or higher level of treatment for majority of storm water flows and associated environmental benefits

5) Provides reserve transport/storage capacity (up to two days) to help sustain wastewater system operations during catastrophic events, such as earthquakes and/or security breaches

6) Facilitates a proactive, not reactive, approach to scheduling system improvements

7) Requires minimal neighborhood and service disruptions

8) Takes the least time to implement

Disadvantages:

1) Potentially greater public health risks from system backup and flooding

2) Odors emanating from vented manhole covers, malfunctioning catch basins, broken lines, etc

3) Higher disinfection requirements for treated flows

4) Reliance on an aging infrastructure

5.2 Separate Sanitary and Storm Water with a System-wide, Dual Pipe System

Advantages:

1) Potentially reduced infiltration and inflow (assuming the new pipelines would convey sanitary flows, only) and as a result marginally reduced treatment operating costs

2) Reduced odor potential (sanitary sewers typically utilize non-vented manhole covers)

3) Potentially reduced public health risks from line backups (although backups may be more frequent due to the smaller pipe sizes)

4) Easier line maintenance (smaller pipes are better suited to jet flushing)

Disadvantages:

1) Regulatory risks associated with permitting new separate storm water discharges, as described above

2) High cost associated with separation (on the order of $2 to $4 billion based on recent cost experience in comparable cities)

3) Highly invasive and environmentally disruptive construction required (impacting virtually every street, sewer easement and connected private property) and disruption of services (including public and emergency access, utility services, traffic flow, etc)

4) High burden, both cost and disruption, on homeowners and businesses to effect complete separation including interior piping changes on their property

5) Public/private legal and social issues for lateral system improvement affordability, maintenance and enforcement

6) Competition for space to install the new lines in existing streets and easements while maintaining separations required by Code from other utilities

7) Further constrained future access for maintenance and repair

8) Inordinate length of time required to complete, test and accept the work (frequently decades, not years) and the associated delays in achieving measurable environmental benefits

9) Increased opportunity for, and high probability of, cross connections and resultant sanitary sewer overflows (SSOs)

5.3 Hybrid Solutions

Separation on a watershed or sub-watershed basis and partial separation alternatives also may be considered. Urban renewal and redevelopment projects are typical of opportunities for separation on a watershed or sub-watershed approach. When buildings are leveled and streets realigned over broad areas, existing utility alignments and sizes may be rendered obsolete and the disruption factor for separation is marginalized within the perspective of the total project. In these cases, such as the Mission Bay-South project, sewer separation may be viable, subject to the conditions for the treatment and permitting of the separate storm water discharge. Partial separation projects, including LID projects, are being investigated under a separate task in the WWMP effort. Rainfall runoff, which is contained or delayed in upstream watersheds may reduce, marginally, the downstream conveyance and treatment needs.

6.0 CASE STUDIES

Virtually all major cities served by combined sewers have considered sewer separation as an alternative control measure at one time or another. A selected few are highlighted below to provide added insight for the City's decision makers and stakeholders.

Columbus, GA – Columbus is typical of many mid-sized communities, which have mixed CSS and separated systems. The old downtown area includes 2,600 acres served by combined sewers. The earliest surrounding development began with CSS service areas which gave way to fully separated systems as the population grew and spread to the suburbs. The city's LTCP, completed in 1995, was based on the demonstration approach of the CSO Control Policy and included treatment plant upgrades, sewer separation in the outer areas, a diversion structure, collector and transport conduits, pumping stations, two CSO treatment facilities, an associated river walk, trail and parks and a five year technology testing program.

"Sewer separation was focused mainly in the upstream catchments *where this type of solution made economic sense or had a high benefit-to-cost ratio. One strategically placed relief line eliminated half of the sanitary flow that entered the CSS"* [emphasis added] (US EPA, 2001*)*.

Boston, MA – The Massachusetts Water Resources Authority (MWRA) provides wastewater services to the City of Boston and the surrounding metropolitan area. The CCS area covers 14 sq mi, with a service population of 550,000 people. The separate sewer service area is 393 sq mi, with a service population of ~2,000,000 people. Implementation under the CSO Control Policy is proceeding in two phases. The first involves more than 100 system optimization projects that can be implemented immediately at relatively low cost to maximize wet weather conveyance and in-system storage to improve capture and treatment. The second constitutes the LTCP and involves 25 projects of which 18 were complete or under construction by May 2001. All projects are to be completed by November 2008.

The key performance measures used by MWRA in developing the plan and monitoring achievement of plan goals are frequency and volume of CSO discharges for a "typical rainfall year." (US Environmental Protection Agency, Report to Congress, *Op cit)*

Three of the projects involved sewer separation. *In each case, sewer separation was not the first choice as a control measure, but rather a compromise option to resolve site constraints and/or public opposition to constructing CSO treatment facilities in "their neighborhood."* It was acknowledged that sewer separation would result in higher bacteria loads to the receiving waters than the originally proposed screening and disinfection facilities. Detailed cost estimates made for one of the projects (Reserved Channel Sewer Separation Project in South Boston) indicated an estimated capital cost of $48 million for separation of approximately 355 acres (~$135,000/acre) (USEPA, 2001*)*.

Nashua, NH – USEPA, Region 1, issued an Administrative Order in 1999 that required the city to separate its CSS (approximately 25% of its total service area) by 2019 in order to mitigate its CSO problem and related water quality impacts. After completion of several early separation projects, the experienced high costs (more than twice the pre-construction estimates) led the city to reassess its options. The city now estimates the cost of sewer separation to be on the order of $2.3 million per mile (~$70,000/acre) (Personal communication from D. Walker, Metcalf & Eddy, 2006). The estimate includes costs associated with construction of new sewers and/or storm drains as well as costs to reconstruct curbs and sidewalks, repave streets, and realign adjacent utilities disrupted during the work.

In addition to cost, the early construction proved to be unacceptably disruptive to neighborhoods and businesses. The estimate above *does not reflect the economic impacts to the community caused by having the streets torn up for significant amounts of time, nor does it address the logistical problems that often arise when major thoroughfares are blocked* [emphasis added]. The City also recognized that sewer separation would create a new source of wet weather pollution as the storm water discharged to the rivers would increase substantially. With a CSS, much of this urban storm water is captured and treated

The adopted and approved alternative includes optimization of inline storage, expansion of the WPCP with ballasted sedimentation to treat excess wet weather flows, and two remote CSO treatment facilities, all at a capital cost of less than one-fifth of the separation program. In addition, *the time required to implement the program would be reduced by eight years* [emphasis added].

Rouge River (Detroit), MI – The Rouge River watershed occupies 438 sq mi in southeastern Michigan. The south and east portions of the watershed are highly urbanized and include parts of Detroit and its suburbs. Approximately 20% of the area is served by CSSs. In 1992 the Rough River National Wet Weather Demonstration Project, a joint federal, state and local agency project, was initiated to manage wet weather pollution to restore the water quality of the river.

By 1999, six CSS communities had committed to complete sewer separation projects and 11 had committed to retention/treatment controls. The retention/treatment basins capture most of the flows for later conveyance to the Detroit POTW for treatment. Flows from very large wet weather events that are not captured in the basins receive screening, skimming, settling and disinfection prior to discharge. These projects have effectively eliminated or controlled the discharge of untreated sewage from approximately half of the watershed's CSOs.

Implementation of the projects to date has resulted in significant improvement in river conditions. Exceedances of the dissolved oxygen standard have been almost eliminated, the bacteria levels have been greatly reduced, and visual evidence of raw sewage has been eliminated. *However, completion of the LTCP will not result in complete compliance* *with water quality standards due to other pollution sources within the watershed. …Other sources include storm water, non-permitted discharges, failing septic systems, leaching dumps and possibly air deposition* [emphasis added] (USEPA, 2001*)*.

Minneapolis-St. Paul, MN – The Twin Cities embarked on one of the largest sewer separation projects starting around 1980. The project involved pipe separation in more than 21,000 acres. By 1996, approximately 189 miles of new storm sewers and 12 miles of sanitary sewers had been installed. The full sewer separation option was *selected based on local needs to eliminate sewage backups into basements, reduce street flooding, and reconstruct aging portions of the sewer system* [emphasis added] (USEPA,1999).

Water quality monitoring performed by the Twin Cities and regulatory agencies from 1976 to 1996 indicated a fecal coliform concentration reduction in the affected reaches of the Mississippi of 70%. In conjunction with the separation program, *streets were paved, handicapped ramps were added to sidewalks, gas and water mains were installed, gas services were renewed or replaced, lead water services connections were replaced, and street lights were installed* [emphasis added].

7.0 CONCLUSION

Many of the largest and oldest cities in the United States and Europe continue to use combined sewers to collect their sanitary sewage and storm water runoff. In the United States these cities are largely concentrated in the Northeast and Midwest. The sizing of conveyance conduits are dominated by the storm water component which may be 50 or more times the sanitary component from the same urban area. Receiving water impacts of urban wet weather discharges are complex and highly variable; however, both components, if untreated, can have significant detrimental effects.

The options for creating a separate storm sewer system in San Francisco have substantial regulatory hurdles and the regulatory environment is evolving such that separation is becoming increasingly unattractive. The City has moved aggressively through the past few decades in capturing and treating all of the dry weather and most of the wet weather flows. All of the dry weather flows receive secondary treatment and, on an average annual basis, more than 80% of the combined wet weather flows receive secondary treatment and more than 90% primary treatment or better. The City's operations are in full compliance with its NPDES permits issued by the Regional Water Quality Control Board.

Continuing with the present combined sewer system offers many advantages and few disadvantages. Most importantly it preserves scarce resources to support phased improvements prioritized by need, opportunity and cost-effectiveness. Full sewer separation would be very costly, extremely invasive and disruptive to construct, require an inordinate length of time to complete, and it would provide few measurable benefits. Separation on a watershed or sub-watershed basis and partial separation alternatives may be worthy of consideration on a case-by-case basis.

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REFERENCES

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APPENDIX A – AREAS CURRENTLY WITH SEPARATE STORM SEWERS

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(Adapted from San Francisco PUC *Stormwater Management Plan*)

Although the City is served almost exclusively by combined sewers, there are small areas of the City that are served by separate storm sewers. This area will increase as the City assumes jurisdiction over former Federal government lands and the associated storm sewer systems.

Areas historically with separate sewer systems - The major areas historically served by separate storm sewers in the City urbanized area include:

- **Port of San Francisco** – The Port of San Francisco manages approximately 7 ½ miles of San Francisco's waterfront, from Hyde Street Pier in the north to India Basin in the south. The majority of the Port is served by separate sanitary and storm drain systems. (The Port has its own Stormwater Management Plan, separate from the PUCs.)

- **Lobos Creek Area** – The dead ends of a few municipal streets north from Lake Street drain to the slope above Lobos Creek.

- **South Beach Harbor** – A portion of the parking lot and some landscaping drains to the Bay via catch basins. The Port's NOI and SWMP will cover this area as well.

- **Golden Gate Park** – At least three of the park's 12 lakes have some type of separate storm sewer system, although in each case the system is quite limited. These lakes are: Stow Lake, Middle Lake, and Elk Glen Lake.

- **Stern Grove / Pine Lake Park** – Pine Lake receives landscaping and sheet runoff via a curbed asphalt path along the southern edge of Pine Lake Park and its parking lot, just west of Stern Grove.

- **Lake Merced** –Lake Merced receives runoff from various roads and facility parking lots via catch basins and asphalt paths that double as drainage channels. SFPUC and Daly City are investigating the feasibility of diverting, treating, and discharging stormwater from the Vista Grande Stormwater Canal in Daly City to Lake Merced.

The SFPUC plans to continue its investigation to identify all separate storm sewer areas owned by the City.

New separate sewer areas - Areas over which the City has recently assumed or is in the process of assuming jurisdiction of the separate storm sewers:

- **Treasure Island / Yerba Buena Island** - Treasure Island and Yerba Buena Island are served by separate stormwater and wastewater systems. Naval Station

Treasure Island complies with the statewide Industrial General Permit through a Notice of Intent and Stormwater Pollution Prevention Plan (SWPPP) that covers the entire base as a single industrial site.

- **Mission Bay–South (areas as built)** - Although the drainage at this redevelopment will be a separated sewer system, the vast majority of that system has not been built. The redevelopment of Mission Bay is planned to occur over the next 15-20 years. Currently, Mission Bay–North is in a combined sewer system area. The rest of Mission Bay–South is a construction site, subject to the Construction General Permit and the Stormwater Pollution Prevention Plan (SWPPP) developed for the project by the property owner – Catellus Development Corporation.
- **Hunters Point Shipyard** - Unlike most of San Francisco, Hunters Point Shipyard is served by separate stormwater and wastewater systems. The U.S. Navy complies with the statewide Industrial General Permit through a NOI and SWPPP that covers industrial activities at the former shipyard.

Federal/State jurisdiction areas - It is important to note that both the State and Federal government own and operate separate storm sewer systems within the definition of an urbanized area within San Francisco including:

- **Golden Gate National Recreation Area (GGNRA)** including:
  - Alcatraz
  - Fort Mason
  - Presidio National Park
- **Lake Merced –** Highway 35 (Skyline Boulevard)
- **Candlestick Point**

Industrial-type facilities - In addition, there are a number of industrial facilities that are not owned by the City and County of San Francisco that have obtained coverage under the State's Industrial General Permit including:

- Golden Gate Bridge
- Naval Station Treasure Island
- US Coast Guard Group – Yerba Buena Island
- Fort Mason

The separate storm sewer systems in these areas are not connected to the City's separate or combined sewer systems and therefore are not part of SFPUC's SWMP.

APPENDIX B – SUMMARY OF KEY REQUIREMENTS OF SAN FRANCISCO'S STORMWATER PERMIT (*SMALL MS4 GENERAL PERMIT*)

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The areas currently discharging from separate storm sewers must comply with the stormwater regulatory program created by the 1987 amendments to the Clean Water Act (CWA, section 402(p)). The amendments and implementing regulations established a two-phase program requiring permits and stormwater management plans for municipalities and other urban areas. Municipal separate storm sewer systems (MS4s) serving a population of 100,000 people or more were part of the Phase I program. Communities with populations less than 100,000 that meet certain designation criteria are part of the Phase II program.

San Francisco applied for coverage under the Phase II program because only very limited areas are served by a separate storm sewer system. (Combined sewer systems are addressed by other requirements in the CWA.) Consequently, in the separate sewer areas, San Francisco must comply with the provisions of the General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (generally known as the *Small MS4 General Permit*).

The key requirements of the Small MS4 General Permit include the following:

- Prepare and submit a Stormwater Management Program or Plan (SWMP), including the following elements (six Minimum Control Measures)
    - Public Education
    - Public Participation
    - Illicit Discharge Detection and Elimination
    - Construction Site Stormwater Runoff Control
    - Post Construction Stormwater Management
    - Pollution Prevention/Good Housekeeping for Municipal Operations
- Implement, maintain, and enforce an effective SWMP (the program must be fully implemented in 5 years).
- Provide maximum extent practicable (MEP) pollutant removal:

    The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility. As knowledge about controlling urban runoff continues to evolve, so does that which constitutes MEP…. the MEP standard in California is applied so that a first-round stormwater permit requires BMPs that will be expanded or better-tailored in subsequent permits. [*General Permit Fact Sheet pg. 9*]

- Ensure that the storm sewer system discharges only stormwater and “authorized non-stormwater.”

  Supplemental provisions for larger (>50,000) and fast growing regulated Small MS4s, which must be implemented by the expiration date of the General Permit:

- Implement design standards as part of a *post-construction program* or a functionally equivalent program. These design standards focus on mitigating the impacts caused by increased impervious surfaces through establishing minimum BMP requirements that stress (i) low impact design; (ii) source controls; and (iii) treatment controls. The design standards include minimum sizing criteria for treatment controls and also include maintenance requirements.

  Comply with water quality standards through implementing better-tailored BMPs in an iterative process. Regulated Small MS4s must begin to comply with the receiving water limitations iterative process once their plans are fully implemented. The receiving water limitations in the General Permit do not require strict compliance with water quality standards but rather require that SWMPs be designed to achieve compliance with water quality standards over time, through an iterative approach requiring improved BMPs (described previously). Exceedances of water quality standards must be addressed through the iterative process.