Bay Area
Stormwater Management
Agencies Association

"White Paper" on Provision C.3 in MRP 2.0

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Introduction

The major urbanized areas in the San Francisco Bay area, including Alameda, Contra Costa, San Mateo and Santa Clara Counties and the Vallejo and Fairfield-Suisun areas, are subject to the requirements of a Phase I stormwater permit known as the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit (MRP)[1]. Countywide and areawide stormwater management programs have collaborated on a regional basis through the Bay Area Stormwater Management Agencies Association (BASMAA) to meet some of the permit requirements.

In 2013, BASMAA Phase I stormwater program managers began discussions with Regional Water Quality Control Board (Water Board) staff about potential requirements in the next permit (known as MRP 2.0). As part of this effort, the BASMAA Development Committee began discussions with Water Board at its regular meetings on future requirements for Provision C.3, New Development and Redevelopment.

In early 2014, the Development Committee proposed, and Water Board staff agreed, to take a "big picture" view of Low Impact Development (LID) implementation in the Bay Area – where we've been and where we are headed in the long term. There was a shared desire to address the following questions: what is the vision for LID in the Bay Area, what is the approach to achieving that vision, and how should permit provisions be designed to follow that approach and achieve the vision? The Committee proposed that BASMAA prepare a white paper to help address these questions and provide the technical support and rationale for future permit requirements. This "White Paper on Provision C.3 in MRP 2.0" is the product of that effort.

Bay Area Approach

The San Francisco Bay Area is California's second-largest metropolitan region, covering about 7,000 square miles across nine Bay Area counties. Regional planning documents estimate that by 2040, the population will increase from 7 million today to around 9 million, the number of jobs will increase by 33% and the number of housing units will increase by 24% (ABAG/MTC, 2013). Much of the expected development in the Bay Area will be

[1] California Regional Water Quality Control Board Order R2-2009-0074, NPDES Permit No. CAS612008, adopted October 14, 2009, revised November 28, 2011. The permit expired on November 30, 2014, but has been administratively extended.

influenced by the strategies and funding mechanisms associated with Plan Bay Area, a long-range integrated transportation and land-use/housing strategy for the Bay Area. Plan Bay Area provides a strategy for meeting 80 percent of the region's future housing needs in Priority Development Areas, where mixed-use residential and commercial development will support the needs of residents and workers in a pedestrian-friendly environment served by transit.

In the coming decades, there will be a steady increase in the number of sites on which LID stormwater treatment and/or flow control facilities are in operation. If the C.3 requirements remain in effect over the very long term, eventually most commercial, industrial, and multi-family residential sites will have such facilities. This is good news for water quality. However, all these facilities will need to be maintained, and their condition will need to be tracked and periodically verified. Within 10-20 years, municipal Permittees will be responsible for tracking the condition of thousands of LID facilities and taking necessary actions to ensure each is operating properly.

This paper proposes a "Bay Area Approach" to implementing new development requirements, based on substantial experience with implementing LID measures on private development projects and expected future challenges, with the aim of using available municipal resources to maximize effectiveness on a regional scale. The key issues that are addressed in this White Paper relative to the Bay Area Approach include the following:

- Regulated project thresholds and applicability;
- Alternative compliance, including Special Projects criteria and requirements;
- LID requirements, feasibility, criteria, and standards;
- Hydromodification management (HM) requirements and integration with LID; and
- Operation and maintenance verification requirements for LID and HM facilities.

Methodology

The general approach taken in this document to evaluating current permit provisions and the key issues follows these four steps:

1. Investigate the origin and justification for the current requirements in Provision C.3;

2. Evaluate the potential beneficial effects of the requirements in terms of regional-scale pollutant load reductions, or benefits to urban hydrology, based on current knowledge (e.g., using the amount of impervious area subjected to LID treatment as a metric);
3. Consult with municipal staff practitioners to understand the costs and staffing resources required for implementation;
4. Consider alternatives that may address the original objective more efficiently and effectively, or may be more suitable to the Bay Area's development patterns in the coming decades.

Findings, Conclusions, and Recommendations

A summary of the findings, conclusions, and recommendations for the key issues presented in this White Paper is provided below and in Table ES-1. These recommendations will be promoted by BASMAA for inclusion in Provision C.3 as part of the continuing MRP 2.0 permit negotiations in the coming year.

Regulated Project Thresholds and Applicability

Findings

The current MRP defines Regulated Projects as: 1) new and redevelopment projects that create and/or replace 10,000 square feet (SF) or more of impervious surface; 2) special land use projects (auto service facilities, retail gasoline outlets, restaurants, and uncovered parking lots) that create and/or replace 5,000 SF or more of impervious surface; and 3) road projects that create 10,000 SF or more of contiguous impervious surface. Water Board staff has suggested reducing the Regulated Projects threshold to 5,000 SF of impervious surface created or replaced for all projects.

BASMAA conducted an analysis of development projects throughout the MRP Permittees' jurisdictions, to determine the relationship between project threshold and the proportion of the total amount of new and replaced impervious surface that would be subject to the requirements, using a previously compiled dataset of 533 projects that received municipal development approvals and were subject to C.3 during 2006-2010. The analysis indicates that reducing the threshold to 5,000 SF for all projects would increase the proportion of total impervious area subject to the MRP Regulated Projects requirements by 0.5%, which is roughly comparable to implementation of C.3 requirements on one large project.

Analysis of more recent data from the Cities of Fremont and San Jose confirmed the previous analysis, and also showed that lowering the threshold would increase the total number of MRP Regulated Projects by approximately 8%. Since smaller projects tend to require more staff time for processing and review, in part because the applicants tend to have less experience with the development review process and have fewer resources to hire land development professionals, the additional municipal staff level of effort resulting from the proposed threshold change could be considerably larger than 8%.

Conclusions and Recommendations

We conclude that the proposed lower threshold would result in a disproportionate and ineffective use of limited municipal staff resources that could otherwise be used to advance strong, pro-active C.3 implementation programs. We recommend that the current MRP thresholds be retained.

C.3 Applicability to Road Projects

In lieu of requiring road replacement or rehabilitation projects to be subject to stormwater treatment requirements, the current MRP requires Permittees to construct ten green street pilot projects within the region (a requirement that is nearly completed). For MRP 2.0, the BASMAA Green Infrastructure (GI) Work Group and Water Board staff have discussed the concept of a GI permit provision that would address the Permittees' potential load allocations for mercury and PCB TMDLs and also contribute to implementation of other permit provisions, including trash reduction requirements. It is BASMAA's understanding, based on discussions with Water Board staff, that implementation of a GI permit provision would allow Permittees to maintain the current C.3 requirements for road projects (i.e., applicable only to creation of new roads and addition of travel lanes)

We support the GI program approach to achieving multiple benefits, including pollutant load and flow reduction, and recommend maintaining the current C.3 requirements for road projects.

Alternative Compliance

Findings

Under the current MRP, Permittees may allow applicants for development project approvals to comply by implementing LID to treat an equivalent amount of runoff at an off-site location, or paying an in-lieu fee to treat an equivalent amount of runoff at a municipal or regional stormwater treatment facility. Over the past decade, few projects have chosen to use alternative compliance and no municipalities have pursued implementation of a regional treatment facility funded by in-lieu contributions from project proponents, for a number of technical, logistical and institutional reasons.

Water Board staff has stated their interest in seeing more alternative compliance projects implemented, especially as part of GI programs. However, some of the barriers to alternative compliance include: 1) limitations on the timing of the offsite treatment project relative to the proposed project; 2) limiting the location of the offsite project to the same watershed as the proposed project; 3) additional costs associated with the offsite project; 4) long term implications for the status of the offsite project; 5) institutional, financial, and legal complexities of regional treatment projects; and 6) long term O&M and funding responsibilities for offsite and regional projects.

Conclusions and Recommendations

The current MRP alternative compliance provisions have proven useful in very limited applications. However, more flexible provisions are essential to expansion of alternative compliance programs and the success of GI and mitigation banking programs.

We recommend that the alternative compliance provision be rewritten to eliminate, or provide more flexibility on, the restrictions as to the timing and location of the alternative compliance project relative to the proposed project. The provision should 1) allow the alternative project location to be anywhere within the municipal jurisdiction, and for regional projects, anywhere within the countywide or area-wide program area; and 2) allow the timing of projects to be consistent with current legal requirements regarding municipalities' use of development funds.

Special Projects

Findings

Current provisions allow development projects that meet certain location, lot coverage, density and parking criteria ("Special Projects") to use tree-box-type high flowrate biofilters or vault-based high flowrate media filters in lieu of LID treatment, for a specified proportion of site runoff. The purpose of allowing these "LID treatment reduction credits" is to facilitate smart growth, infill and transit-oriented development projects, consistent with regional, state and federal plans and policies.

BASMAA's analysis of Permittee data collected for two complete years (FYs 2012-2013 and 2013-2014) indicated that approved Special Projects accounted for about 88 acres of impervious area, or about 3.6% of the total impervious area attributable to Regulated Projects receiving discretionary approval during those years. Implementation of the Special Project provisions resulted in runoff from about 1.3% of the total impervious area associated with approved Regulated Projects being treated by non-LID treatment facilities within the approved Special Projects. This is a very small percentage given the benefits associated with Special Projects, including improved access to transit, reduced automobile-related runoff pollution and greenhouse gas emissions, preservation of open space, and efficient use of previously developed land and existing infrastructure.

The Special Projects provisions have generally been implemented successfully; however two particular criteria related to ground-level plazas and retail components of residential developments have had unintended consequences and need to be fixed (see recommendations).

The reporting requirements related to Special Projects have been burdensome. Permittees are required to track and report when they receive planning applications for Special Projects, twice per year, as well as report when the projects receive discretionary approval. Reports must include a narrative discussion of the feasibility or infeasibility of 100% LID treatment, onsite and offsite. BASMAA developed guidance for preparing the narrative, which recognizes the barriers to offsite alternative compliance.

Water Board staff has suggested that MRP 2.0 explicitly require that Permittees evaluate the feasibility of 100% LID onsite, offsite or at a regional project, payment of in-lieu fees, or a combination of all options before allowing non-LID treatment. This prioritization does not reflect our experience with implementing stormwater treatment on development projects and the difficulties with implementing off-site or regional projects and in-lieu fees, and doesn't recognize the inherent environmental benefit of Special Projects, which was the basis for allowing selective non-LID treatment in the first place.

Conclusions and Recommendations

Based on current trends, maintaining the Special Project provisions will facilitate environmentally-beneficial smart growth projects and result in nearly 99% of the total impervious area subject to Provision C.3 being treated with LID measures. The best strategy for maximizing the use of LID on these projects is to craft LID-appropriate permit criteria and conduct educational outreach to the land development community regarding the advantages of bioretention and strategies for incorporating LID in high density projects. Conducting educational outreach to land development professionals is a more productive use of limited municipal resources than continuing to implement the current reporting requirement.

We recommend that the Special Projects provisions be maintained in MRP 2.0 with the following changes:

- Allow exclusion of ground-level public plaza areas from the calculation of the 85% coverage requirement, and require public plaza areas to drain to LID facilities.
- Allow mixed use projects to use either FAR or residential density criteria to determine Special Projects eligibility and/or allowable LID treatment reduction credits.
- Eliminate the requirements to report any potential Special Projects that have submitted planning applications and to submit semi-annual reports on Special Projects, and include reporting of Special Projects with other approved projects in Annual Reports;
- Eliminate the requirement to evaluate the feasibility of LID treatment offsite or at a regional project or payment of in-lieu fees.
- Encourage Permittees to increase educational outreach to land development professionals on bioretention design and strategies for incorporating LID in high density projects.

LID Feasibility, Criteria, and Standards

Findings

Current MRP provisions require implementation of site design strategies that reduce runoff and LID treatment. In defining LID treatment, the MRP states that "a properly engineered and maintained biotreatment system may be considered only if it is infeasible to implement harvesting and re-use, infiltration, or evapotranspiration at a project site".

The MRP does not contain or reference standards for site design measures, nor does the MRP contain methods for determining the amount of runoff reduced, or the extent to which the site design measures reduce the required size or capacity of treatment measures. For this reason, each of the stormwater programs has created guidance for applicants to follow when integrating site design measures and treatment measures into an overall design to achieve stormwater quality compliance. This guidance promotes dividing the project site into Drainage Management Areas (DMAs), identifying "self-treating" and "self-retaining" areas (including impervious areas that drain to self-retaining areas), and identifying remaining impervious areas that require treatment. These concepts have proven essential for translating LID objectives into verifiable and enforceable criteria, and have become standard practice in stormwater control plans throughout the Bay area.

Since the concept of LID was conceived in the late 1990s. bioretention has been the most commonly used "integrated management practice" across the U.S. When LID became part of MRP Provision C.3 in 2009, LID was redefined such that a biotreatment (i.e., bioretention) facility may be considered only if it is infeasible to implement harvesting and re-use, infiltration, or evapotranspiration. This definition appears to have originated from a 2009 NRDC comment letter on a Tentative Order for an Orange County permit.

BASMAA completed two MRP required reports to address the question of feasibility. The *Harvest and Use, Infiltration and Evapotranspiration Feasibility/ Infeasibility Criteria Report* (2011), presented the results of technical analyses to develop criteria and procedures for Permittees to follow to determine whether harvesting and use, infiltration, or evapotranspiration are feasible or infeasible at a Regulated Project site and when biotreatment may be used. The Permittees subsequently incorporated the criteria in the report into guidance which has been used by applicants for development approvals and by municipal staff when reviewing those applications since

December 1, 2011 (the start date for implementation of LID requirements.)

The *Status Report on the Application of Feasibility/Infeasibility Criteria for Low Impact Development* (2013) conducted a review of Permittee Annual Reports submitted for Fiscal Years 2011-2012 and 2012-2013 to evaluate the results of applying the feasibility/infeasibility criteria. The report found that the application of current feasibility/infeasibility criteria resulted in widespread installation of bioretention facilities that are effectively treating water quality design runoff volumes and are retaining a significant portion of total runoff.

Conclusions of the *Status Report* on LID feasibility/infeasibility were:

- Infiltration of some runoff is feasible on most projects. In the clay soils typical of our Region, the amount of runoff that can be infiltrated is unpredictable and highly variable. On most sites, it is not practical or feasible to design facilities that can reliably and dependably infiltrate the Provision C.3.d.i.(3) amount of runoff (that is, 80% of the total quantity of runoff over a period of 30 years or more).
- Very few development projects create the quantity and timing of non-potable-water demand required to feasibly harvest and use the amount of runoff specified in MRP Provision C.3.d.i.(3). Harvesting and use of a smaller quantity of runoff is technically feasible on some projects. In particular, proponents of some development projects are willing and able to incorporate harvesting and use systems when those systems are sized and designed for cost-effective augmentation of water supply, which requires considerably less storage than would be required to meet current MRP requirements. However, the complexity and operation and maintenance requirements for harvesting and use systems make it inadvisable to require those systems on developments where it cannot be assured that a qualified maintenance staff will be employed on-site at all times during the life of the project.
- Bioretention facilities, when designed according to the criteria in current Permittee guidance, could infiltrate between 40% and 80% or more of total runoff, depending on rainfall patterns and facility size. However, the amount of runoff that would be infiltrated over the life of a particular project is variable and unpredictable because of uncertainty in the near-term and long-term infiltration performance of underlying soils. Infiltration can be maximized by ensuring

project designs adhere to current design criteria and by ensuring facilities are constructed as designed.

Further analyses conducted for this White Paper found that bioretention facilities can approximate the hypothetical pollutant-reduction performance associated with harvest/use and infiltration facilities. When high reductions in pollutant concentration are achieved via biotreatment soil filtration (such as with sediment-bound pollutants like PCBs), the percent retained on-site has little effect on overall pollutant load reduction. Variability in pollutant removal rates is driven mostly by variation in influent concentration rather than actual variation in performance.

A necessary component of utilizing bioretention as a “top tier” LID treatment measure is the development of consistent design, installation and maintenance guidance and standards for bioretention facilities. This information is provided in Bay Area stormwater program guidance manuals and used by nearly all Permittees. Design guidance and standards, including soil specifications, are best developed and maintained by Permittees and not specified in the Permit, so that guidance can continue to be adjusted and fine-tuned with experience.

Conclusions and Recommendations

Based on the White Paper analysis, the pollutant removal performance of bioretention facilities, overall and on average, is equivalent or better than the likely real-world performance of harvest/use facilities—and as good as the likely performance of infiltration facilities when considered over the long term. There is no water-quality-based justification for preferring infiltration systems or harvest/use, even in the rare cases where such systems are feasible on Bay Area development sites. It is also important to consider that bioretention facilities require less maintenance and are less prone to failure than harvest and use facilities, and in some case, are also preferable to direct infiltration facilities.

Implementation of the recommendation to make bioretention facilities—built according to the recommended design to maximize infiltration where allowed—a “first-tier” option under the MRP is also consistent with the State Water Board’s Phase II permit and would create a consistent standard for stormwater treatment for new development throughout the Bay Area Region.

In summary, the following are recommended for MRP 2.0:

- Site Design Requirements
  - Require Regulated Projects to show the site delineated into DMAs, and make explicit how self-treating areas and self-retaining areas may be used to reduce the amount of runoff that must be treated.
  - Require Permittees to adopt and implement design requirements for self-treating and self-retaining areas, including pervious pavements and green roofs.
  - Allow Permittees to keep site design requirements and specifications in guidance manuals and do not include specific design requirements in the Permit.
- LID Treatment
  - Omit the feasibility test and allow bioretention as an equivalent “first tier” option for LID treatment.
  - Omit the criteria for biotreatment soil media (Attachment L). Generally, for design criteria, state the objectives to be met, and require Permittees to develop and implement criteria, but do not incorporate criteria into the permit.
  - Continue to include performance criteria for LID treatment in the Permit, and allow Permittees to maintain guidance and standards for bioretention design and construction outside of the permit.

Hydromodification Management Requirements

<u>Findings</u>

C.3 provisions added to Bay Area Phase I permits during 2001-2003 required development of Hydromodification Management Plans (HMPs), to be “implemented so that post-project runoff shall not exceed estimated pre-project rates and/or durations, where the increased stormwater discharge rates and/or durations will result in increased potential for erosion or other significant adverse impacts to beneficial uses, attributable to changes in the amount and timing of runoff.” Studies conducted in the Pacific Northwest and by Bay Area Permittees as part of development of their HMPs demonstrated that flow duration control at the project level, i.e., limiting the duration of flows to that which existed prior to development, and to allow increased durations of flow only for flows below the threshold at which sediment movement is likely to occur, would protect downstream channels from increased erosion.

Additional studies defined “erosion potential” (E_P) as the ratio of the post-project effective “work” (erosive force over time on channel bed or banks) to the pre-project effective work. The hydromodification management (HM) standard in the current MRP is that post-project stormwater discharges shall not cause an increase in the erosion potential of the receiving stream over the pre-project condition, i.e., an E_P of 1.0 must be achieved.

An evaluation of the range of flows that are the most important for stream channel erosion and hydromodification impacts in Santa Clara Valley was performed as part of preparation of the Santa Clara Program HMP submittal, based on field-based watershed assessments conducted for three subwatersheds in Santa Clara Valley. This evaluation and subsequent HMP submittals established criteria that HM controls be designed such that post-project flow durations match pre-project flow durations from 10 percent of the 2-year peak flow (0.1Q2) to the 10-year peak flow (Q10) for these programs. The Fairfield-Suisun Program was assigned a design low flow threshold of 20 percent of the 2-year peak flow (0.2Q2) based on local, stream-specific studies. The Contra Costa Program was allowed to meet a low flow threshold of 0.2Q2 when Integrated Management Practices (IMPs, or LID facilities), sized using established sizing factors, are used. Attachments B, C, D, E, and F to the MRP describe the different sets of criteria and exemptions that apply to each area-wide program.

Hydromodification management requirements have been primarily met with on-site controls, including 1) site design and treatment measures that help reduce flow; and 2) flow duration control measures as needed. The most commonly used flow duration control measures include detention/infiltration basins, underground vaults (or large diameter storm drain pipes), and modified bioretention facilities. The flow duration control design approach requires the use of a continuous simulation hydrologic model to analyze the runoff flows resulting from a long term rainfall record. Several tools have been developed and are currently used to facilitate the design and review process: 1) the Bay Area Hydrology Model (allowed to be used by the Santa Clara, San Mateo and Alameda Programs); 2) sizing factors for bioretention facilities (used by the Contra Costa Program); and 3) sizing curves for bioretention and detention basins (specific to Fairfield-Suisun watersheds).

Recently, additional studies have been done to evaluate facility sizing criteria. The Contra Costa Program conducted *in situ* monitoring of some bioretention facilities and then used the monitoring results to calibrate the continuous simulation model used to develop its sizing factors. Observed values for the rate of infiltration into subsurface soils were about eight times higher than were assumed in the model—0.24 inches per hour vs. the previously assumed (textbook) rate of 0.03 inches per hour. Another study by the Contra Costa Program analyzed the relationships between required facility size and different low flow thresholds for flow duration curve matching, as well as different curve matching criteria. A current study being performed for BASMAA is evaluating the erosion potential (E_P) resulting from discharge from bioretention facilities sized according to existing and alternative flow-duration-control curve-matching criteria, and also analyzing whether an E_P control standard could be used to develop more efficient sizing factors.

Conclusions and Recommendations

The current Provision C.3.g containing the HM requirements (and associated attachments) represents one of the few sections of the MRP where there are different requirements for each area-wide program. Based on experience implementing this provision, Permittees desire a consistent and more flexible set of requirements that gives project proponents options for cost-effective solutions and better integrates HM and LID approaches.

To achieve this goal, we recommend the following:

- Eliminate the attachments with separate HM requirements and create one consistent set of requirements for all Permittees, including consistent exemptions, while allowing some variation in low flow thresholds based on stream-specific studies if available.
- Allow Permittees to utilize any of the available tools, including the BAHM, IMP sizing factors, and sizing curves, as applicable and calibrated to the particular hydrologic and geologic conditions of the project site.
- Allow flexibility in the numerical control standard for hydromodification management in order to meet an overarching erosion potential management objective. The sizing methodology should be allowed to be based on either a flow duration control standard, an Ep Control standard, or a flow duration curve matching criterion that more closely approximates an Ep Control standard (to be explored in future studies).

Operation and Maintenance (O&M) Verification

Findings

The current MRP requires Permittees to:

- Have a means to make owners of facilities responsible for O&M.
- Have the authority to inspect privately-owned facilities.
- Conduct inspections of privately-owned facilities at a prescribed frequency.
- Conduct O&M and inspections of the facilities they own.
- Maintain records and submit annual reports.

After a decade of C.3 implementation, some municipalities' O&M verification programs are organized on a small scale to address a limited number of facilities. However, other municipalities have large numbers of facilities, both LID and non-LID, that have been installed over the years, and have developed detailed tracking systems and databases as well as permitting and fee recovery programs.

As the number of facilities that have been built and are subject to O&M verification requirements continues to increase each year, all municipalities will need to shift additional resources toward the oversight of thousands of facilities distributed across the urban landscape. It is essential that MRP 2.0 anticipate this shift, by allowing flexibility in the frequency of O&M verification inspections, eliminating unnecessary and nonproductive requirements from within Provision C.3, and promoting the planning, design, and construction of robust and easily inspected facilities.

Conclusions and Recommendations

The Permittees' O&M verification programs have become institutionalized over the past decade and have been relatively successful. There are no compelling reasons to make major changes to the current O&M verification requirements. However, based on our experience with implementation of the current requirements, we make the following recommendations for improvement:

- Eliminate the requirement to annually inspect 20% of the total number of installed stormwater treatment systems and HM controls, but maintain the requirement to inspect facilities at least once every five years.

- Allow Permittees options and flexibility to make O&M verification programs more efficient, such as utilizing third party inspectors and allowing responsible property owners to self-certify by submitting self-inspection reports and proof of maintenance.
- Pervious pavements should not be required to be tracked and inspected, but permittees should include them in maintenance agreements and provide educational information on proper maintenance of pervious pavement to the property owner.
- Reduce annual reporting requirements for O&M verification programs, but require Permittees to continue to track ownership, status, and inspection history of each facility and maintain detailed records.
- Eliminate unnecessary and nonproductive requirements from other sections of Provision C.3 and promote the planning, design, and construction of robust and easily inspected facilities.

Table ES-1 Findings, Conclusions and Recommendations for Key C.3 Issues

Key C.3 Issue	Findings / Conclusions	Recommendations
C.3.b. - Regulated Project Size Thresholds <u>Current requirement</u>: Defines Regulated Projects as: 1) new and redevelopment projects that create and/or replace 10,000 square feet (SF) or more of impervious surface; 2) special land use projects (auto service facilities, retail gasoline outlets, restaurants, and uncovered parking lots) that create and/or replace 5,000 SF or more of impervious surface; and 3) road projects that create 10,000 SF or more of contiguous impervious surface. <u>Issue</u>: Water Board staff has suggested threshold for all projects be lowered to 5,000 SF impervious area created/replaced.	Analysis of past Permittee data showed an insignificant amount of additional impervious area (0.5% of total subject to C.3) would be regulated, but with significant additional Permittee effort. The proposed lower threshold would result in a disproportionate and ineffective use of limited municipal staff resources that could otherwise be used to advance strong, pro-active C.3 implementation programs	• Maintain current Regulated Project thresholds. • Maintain current exemption for road reconstruction projects.
C.3.e. - Alternative Compliance <u>Current requirement</u>: Permittees may allow applicants for development project approvals to comply by implementing LID to treat an equivalent amount of runoff at an off-site location, or paying an in-lieu fee to treat an equivalent amount of runoff at a municipal or regional stormwater treatment facility. <u>Issue</u>: Water Board staff has stated their interest in seeing more alternative compliance projects implemented, especially as part of green infrastructure (GI) programs. However, numerous barriers to alternative compliance exist.	Barriers include: 1) limitations on the timing of the offsite treatment project relative to the proposed project; 2) limiting the location of the offsite project to the same watershed as the proposed project; 3) additional costs associated with the offsite project; 4) long term implications for the status of the offsite project; 5) institutional, financial, and legal complexities of regional treatment projects; and 6) long term O&M and funding responsibilities for offsite and regional projects. More flexible provisions are essential to expansion of alternative compliance programs and the success of GI and mitigation banking programs.	• Rewrite the alternative compliance provision to eliminate, or provide more flexibility on, the restrictions as to the timing and location of the alternative compliance project relative to the proposed project. The provision should: o Allow the alternative project location to be anywhere within the municipal jurisdiction, and for regional projects, anywhere within the countywide-program area; and o Allow the timing of projects to be consistent with current legal requirements regarding municipalities' use of development funds.

Table ES-1 Findings, Conclusions and Recommendations for Key C.3 Issues

Key C.3 Issue	Findings / Conclusions	Recommendations
C.3.e. – Special Projects Current requirement: Development projects that meet certain location, lot coverage, density and parking criteria ("Special Projects") may use tree-box-type high flowrate biofilters or vault-based high flowrate media filters in lieu of LID treatment, for a specified proportion of site runoff. Current reporting requirement: Track and report potential Special Projects that have submitted planning applications, twice per year, as well as report when the projects receive discretionary approval. Reports must include a narrative discussion of the feasibility or infeasibility of 100% LID treatment, onsite and offsite. Issues: Water Board staff has suggested that Permittees should evaluate the feasibility of 100% LID onsite, offsite or at a regional project, payment of in-lieu fees, or a combination of all options before allowing non-LID treatment. Current reporting and feasibility analysis are burdensome and non-productive. Two particular criteria related to ground-level plazas and retail components of residential developments have had unintended consequences and need to be fixed (see recommendations).	Maintaining the Special Project provisions will facilitate environmentally-beneficial smart growth projects and result in runoff from nearly 99% of the total impervious area subject to Provision C.3 being treated with LID measures. Runoff from the remaining 1-2% of impervious area would be treated by higher-rate filtration measures. Prioritization of offsite LID over limited non-LID does not reflect our experience with the difficulties of implementing off-site or regional projects and in-lieu fees, and doesn't recognize the inherent environmental benefit of Special Projects. The best strategy for maximizing the use of LID on these projects is to craft LID-appropriate permit criteria and conduct educational outreach to the land development community regarding the advantages of bioretention and strategies for incorporating LID in high density projects. Conducting educational outreach to land development professionals is a more productive use of limited municipal resources than continuing to implement the current reporting requirement.	Maintain Special Projects provisions, with the following changes: • Allow exclusion of ground-level public plaza areas from the calculation of the 85% coverage requirement, and require public plaza areas to drain to LID facilities. • Allow mixed use projects to use either FAR or residential density criteria to determine Special Projects eligibility and/or allowable LID treatment reduction credits. • Eliminate the requirements to report any potential Special Projects that have submitted planning applications and to submit semi-annual reports on Special Projects, and include reporting of Special Projects with other approved projects in Annual Reports. • Eliminate the requirement to evaluate the feasibility of LID treatment offsite or at a regional project or payment of in-lieu fees. • Encourage Permittees to increase educational outreach to land development professionals on bioretention design and strategies for incorporating LID in high density projects.
C.3.c – Feasibility of Infiltration and Harvesting/Use Current requirement: Implement site design strategies that reduce runoff and LID treatment. LID is defined such that a biotreatment (i.e., bioretention) facility may be considered only if it is infeasible to implement harvesting and re-use, infiltration, or evapotranspiration. Issue: Current permit does not describe how site design measures can be used to reduce the amount of impervious area needing treatment.	Countywide program guidance promotes dividing the project site into Drainage Management Areas (DMAs), identifying "self-treating" and "self-retaining" areas (including impervious areas that drain to self-retaining areas), and identifying remaining impervious areas that require treatment. These concepts have proven essential for translating LID objectives into verifiable and enforceable criteria and have become standard practice. Stormwater program guidance also contains design, installation and maintenance guidance and standards for bioretention and other LID facilities.	Site Design Requirements: • Require Regulated Projects to show the site delineated into DMAs, and how self-treating areas and self-retaining areas may be used to reduce the amount of runoff that must be treated. • Require Permittees to adopt and implement design requirements for self-treating and self-retaining areas, including pervious pavements and green roofs. • Allow Permittees to keep site design requirements and specifications in guidance manuals and do not include specific design requirements in the Permit.

Table ES-1 Findings, Conclusions and Recommendations for Key C.3 Issues

Key C.3 Issue	Findings / Conclusions	Recommendations
Current permit contains design specifications (e.g., for biotreatment soil) that cannot be changed. Current permit requires feasibility analysis for harvesting/use, infiltration and evapotranspiration for every project before bioretention, a proven and effective LID treatment measure, can be used.	The application of current LID feasibility/infeasibility criteria has resulted in widespread installation of bioretention facilities that are effectively treating water quality design runoff volumes and are retaining a significant portion of total runoff. The pollutant removal performance of bioretention facilities, overall and on average, is equivalent or better than the likely real-world performance of harvest/use facilities—and as good as the likely performance of infiltration facilities when considered over the long term. There is no water-quality-based justification for preferring infiltration systems or harvest/use, even in the rare cases where such systems are feasible on Bay Area development sites. Bioretention facilities require less maintenance and are less prone to failure than harvest and use facilities, and in some case, are also preferable to direct infiltration facilities.	LID Treatment: • Omit the feasibility test and allow bioretention as an equivalent "first tier" option for LID treatment. • Omit the criteria for biotreatment soil media (Attachment L). Generally, for design criteria, state the objectives to be met, and require Permittees to develop and implement criteria, but do not incorporate criteria into the permit. • Continue to include performance criteria for LID treatment in the Permit, and allow Permittees to maintain guidance and standards for bioretention design and construction outside of the permit.
C.3.g. Hydromodification Management Current requirement: Hydromodification management (HM) controls must be implemented so that post-project runoff shall not exceed estimated pre-project rates and/or durations, where the increased stormwater discharge rates and/or durations will result in increased potential for erosion or other significant adverse impacts to beneficial uses. Issue: Low flow threshold for compliance, "goodness of fit" criteria, exemptions, and acceptable sizing tools vary among Permittees.	The current provision for HM requirements (and associated attachments) represents one of the few sections of the MRP where there are different requirements for each area-wide program. Based on experience implementing this provision, Permittees desire a consistent and more flexible set of requirements that gives project proponents options for cost-effective solutions and better integrates HM and LID approaches.	• Eliminate the attachments with separate HM requirements and create one consistent set of requirements for all Permittees, including consistent exemptions, while allowing some variation in low flow thresholds based on stream-specific studies if available. • Allow Permittees to utilize any of the available tools, including the BAHM, IMP sizing factors, and sizing curves, as applicable and calibrated to the particular hydrologic and geologic conditions of the project site. • Allow flexibility in the numerical control standard for HM in order to meet an overarching erosion potential (Ep) management objective. The sizing methodology should be allowed to be based on either a flow duration control standard, an Ep control standard, or a flow duration curve matching criterion that more closely approximates an Ep control standard (to be explored in future studies).

Table ES-1 Findings, Conclusions and Recommendations for Key C.3 Issues

Key C.3 Issue	Findings / Conclusions	Recommendations
C.3.h. – O&M Verification Current requirement: Permittees must have a means to make owners of facilities responsible for O&M; have the authority to inspect privately-owned facilities; conduct inspections of privately-owned facilities at a prescribed frequency; conduct O&M and inspections of the facilities they own; and maintain records and submit annual reports. Issues: Water Board staff have suggested increasing requirements for O&M and inspections of pervious pavement and other site design features. Number of facilities and inspections is increasing, and reporting is burdensome.	Permittees' O&M verification programs have become institutionalized over the past decade and have been relatively successful. There are no compelling reasons to make major changes to the current O&M verification requirements. However, as the number of facilities that are subject to O&M verification requirements continues to increase each year, all municipalities will need to shift additional resources toward the oversight of thousands of facilities distributed across the urban landscape. Permit requirements need to allow flexibility in the frequency of O&M verification inspections, eliminating unnecessary and nonproductive requirements from within Provision C.3, and promoting the planning, design, and construction of robust and easily inspected facilities.	• Eliminate the requirement to annually inspect 20% of the total number of installed stormwater treatment systems and HM controls, but maintain the requirement to inspect facilities at least once every five years. • Allow Permittees options and flexibility to make O&M verification programs more efficient, such as utilizing third party inspectors and allowing responsible property owners to self-certify by submitting self-inspection reports and proof of maintenance. • Pervious pavements should not be required to be tracked and inspected, but Permittees should include them in maintenance agreements and provide educational information on proper maintenance of pervious pavement to the property owner. • Reduce annual reporting requirements for O&M verification programs, but require Permittees to continue to track ownership, status, and inspection history of each facility and maintain detailed records. • Eliminate unnecessary and nonproductive requirements from other sections of Provision C.3 and promote the planning, design, and construction of robust and easily inspected facilities.

1. Introduction

1.1 Background

The major urbanized areas in the San Francisco Bay area, including Alameda, Contra Costa, San Mateo and Santa Clara Counties and the Vallejo and Fairfield-Suisun areas, are subject to the requirements of a Phase I stormwater permit known as the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit (MRP)[2]. The countywide and area-wide stormwater management programs representing those areas, comprising a total of 76 permittee agencies, have collaborated on a regional basis through the Bay Area Stormwater Management Agencies Association (BASMAA) to meet some of the permit requirements.

In 2013, BASMAA Phase I stormwater program managers began discussions with Regional Water Quality Control Board (Water Board) staff about potential requirements in the next permit (known as MRP 2.0). As part of this effort, the BASMAA Development Committee began discussions with Water Board at its regular meetings on future requirements for Provision C.3, New Development and Redevelopment (as well as Provision C.6, Construction Site Control).

Initially, the discussions of Provision C.3 were focused on permit implementation details and did not take into account the geographical and historical context for implementation and the experiences and accomplishments during the current permit term. Permittees disagreed with Water Board staff on a number of issues and discussions were becoming unproductive. Then in early 2014, the Development Committee proposed, and Water Board staff agreed, to take a step back and look at the big picture of Low Impact Development (LID) implementation in the Bay Area – where we've been and where we are headed in the long term. There was a shared desire to address the following questions: what is the vision for LID in the Bay Area, what is the approach to achieving that vision, and how should permit provisions be designed to follow that approach and achieve the vision?

[2] California Regional Water Quality Control Board Order R2-2009-0074, NPDES Permit No. CAS612008, adopted October 14, 2009, revised November 28, 2011. The permit expired on November 30, 2014, but has been administratively extended.

The Committee proposed that BASMAA prepare a white paper to help address these questions and provide the technical support and rationale for future permit requirements. BASMAA approved and funded the effort in April 2014. This "White Paper on Provision C.3 in MRP 2.0" is the product of that effort.

1.2 Context: The Bay Area Approach

1.2.1 Bay Area Population, Land Use, and Economic Trends

The San Francisco Bay Area is California's second-largest metropolitan region, covering about 7,000 square miles across nine Bay Area counties. The Association of Bay Area Governments (ABAG) and Metropolitan Transportation Commission (MTC) regional planning document "Plan Bay Area" anticipates that the Bay Area's population will grow from about 7 million today to some 9 million by 2040. In addition, the Bay Area's healthy economy is expected to provide a 33% increase in the number of jobs region-wide by 2040. During this same time period, the number of housing units is expected to increase by 24% to 660,000. Demand for multi-unit housing in urban areas close to transit is expected to increase, as aging baby boomers downsize and seek homes in more urban locations, and younger generations are attracted to urban life and affordability (ABAG/MTC, 2013).

Much of the expected development in the Bay Area will be influenced by the strategies and funding mechanisms associated with Plan Bay Area, a long-range integrated transportation and land-use/housing strategy for the Bay Area. Plan Bay Area provides a strategy for meeting 80 percent of the region's future housing needs in Priority Development Areas (PDAs). PDAs are areas identified by local governments where mixed-use residential and commercial development will support the needs of residents and workers in a pedestrian-friendly environment served by transit. To meet the State's goals for reducing greenhouse gas emissions (per SB 375), future development in these areas is planned to be walkable and bike-able and close to public transit, jobs, schools, shopping, parks, recreation and other amenities.

1.2.2 Implications for Stormwater Requirements

In the coming decades, as existing developed sites are redeveloped, and undeveloped infill sites and peripheral areas are built out, there will be a steady increase in the number of sites on which LID stormwater treatment and/or flow control facilities are in operation. If the C.3 requirements remain in effect over the very long term, eventually most commercial, industrial, and multi-family residential sites will have such facilities.

This is good news for water quality. However, all these facilities will need to be maintained, and their condition will need to be tracked and periodically verified. Within 10-20 years, municipal Permittees will be responsible for tracking the condition of thousands of LID facilities on private (and public) properties and taking necessary actions to ensure each is operating properly. This is a substantial municipal responsibility—even if the fiscal effects can be mitigated through fees imposed on property owners.

In addition, municipalities must consider the effects that wide-scale implementation of LID may have on the quality of urban life—on economic vitality, on where and when development projects are proposed, on urban design, on neighborhood aesthetics, and on the sustainable use of resources.

Based on the past decade of experience reviewing the design, construction, and maintenance of stormwater treatment facilities, municipal staffs have found that LID features and facilities, and bioretention facilities in particular, are robust and low-maintenance. Most potential long-term maintenance problems can be avoided through well-informed design and construction (See discussion in Sections 4.2 and 4.3).

This paper proposes a "Bay Area Approach" to implementing new development requirements. This approach anticipates the many opportunities and challenges involved in wide-scale implementation of LID over the coming decades, based on expected trends in land development, and also recognizes that municipalities have limited capacity and resources to take advantage of the opportunities and to meet the challenges.

In MRP 2.0, Provision C.3 should be updated with the following three observations in mind:

- In our experience implementing the new development requirements of stormwater NPDES permits over two decades, municipal staff have found that some current requirements contribute significantly to improved LID implementation, while others miss the mark or have unintended negative consequences. Among our objectives in this White Paper are to review the present MRP requirements and to systematically investigate and explain why each requirement contributes to, or detracts from, successful wide-scale LID implementation.

- To effectively implement LID, municipalities have adopted their own requirements, standards, or procedures as adjuncts to the permit requirements. (These are represented, primarily, in the guidance published by each stormwater program.) Our present goal is to preserve that flexibility, while also carefully considering instances where a permit requirement could promote regional consistency.
- To meet the challenges of wide-scale LID implementation in the coming decades, municipalities may need to develop—individually or collectively—new policies, procedures or tools. In some cases, a permit requirement may be helpful to ensure wide Permittee participation in that effort—and/or to create a "level playing field" among Permittees.

We call it the "Bay Area Approach" because, after reviewing many other California stormwater NPDES permits, we note those permits—like the current MRP—incorporate what can be characterized as an earlier generation of new development requirements. That earlier generation of requirements was based, necessarily, on assumptions and best guesses regarding how implementation would play out in the land development arena. In this White Paper, we examine those assumptions and best guesses against current knowledge.

The Bay Area Approach is our attempt to advance new development requirements, based on substantial experience with implementing LID on private development projects and with the aim of using available municipal resources to maximize effectiveness on a regional scale. The key issues that are addressed in this White Paper relative to the Bay Area Approach include the following:

- Regulated project thresholds and applicability;
- Alternative compliance, including Special Projects criteria and requirements;
- LID requirements, feasibility, criteria, and standards;

- Hydromodification management (HM) requirements and integration with LID; and
- Operation and maintenance verification requirements for LID and HM facilities.

1.2.3 Evaluation Methods

The general approach taken in this document to evaluating current permit provisions and key issues follows these four steps:

First, investigate the origin and justification for the current requirements in Provision C.3. What was the original objective of the provision? Why is this requirement, threshold, or criterion thought to be effective? What technical investigations or reports are referenced in the record?

Second, evaluate the potential beneficial effects of the requirement in terms of regional-scale pollutant load reductions, or benefits to urban hydrology, based on current knowledge. (Often, the amount of impervious area subjected to LID treatment or otherwise disconnected from direct discharge to receiving waters is a useful substitute measure—for both pollutant load reduction and for protection of streams from hydrologic impacts of urbanization.)

Third, consult with municipal staff practitioners to understand the costs and staffing resources required for implementation. Often, these costs and resources vary from municipality to municipality, depending on size, urban characteristics, and watershed characteristics, but also depending on existing staffing and modes of organization.

Fourth, consider alternatives that may address the original objective (see the first step) more efficiently and effectively, or may be more suitable to the Bay Area's development patterns in the coming decades.

2 · Regulated Project Thresholds and Applicability

In this section, we consider the current definition of Regulated Projects in MRP Provision C.3.b, and the benefits and costs of reducing the size thresholds for Regulated Projects, with the goal of applying Permittee project review efforts most effectively.

2.1 Current Provisions Related to Thresholds and Applicability

2.1.1 Regulated Projects

The current MRP defines the following categories of Regulated Projects:

- Special land use categories, including auto service facilities, retail gasoline outlets, restaurants, and uncovered parking lots that create 5,000 square feet or more of impervious surface (C.3.b.ii.(1)).
- Other (new) development projects that create 10,000 square feet or more of impervious surface (C.3.b.ii.(2)).
- Redevelopment projects that create and/or replace 10,000 square feet or more of impervious surface (C.3.b.ii.(3)).
- Road projects that create 10,000 square feet or more of newly constructed contiguous impervious surface (C.3.b.ii.(4)).

The category definitions include various qualifications and exclusions, including single-family homes not part of a larger plan of development.

2.1.2 Requirements for Sub-threshold Projects

Provision C.3.a.i.(6) requires Permittees, on all projects subject to their review that are not regulated by Provision C.3, to "encourage the inclusion of adequate site design measures that may include minimizing land disturbance and impervious surfaces (especially parking lots); clustering of structures and pavement; directing roof runoff to vegetated areas; use of micro-detention, including distributed landscape-based detention; preservation of open space; protection and/or restoration of riparian areas and wetlands as project amenities…"

Provision C.3.a.i.(7) requires Permittees to encourage the inclusion of source control measures and includes a list of appropriate measures. Source control measures are addressed in Section 4.1.

Provision C.3.i requires all development projects that create and/or replace between 2,500 and 10,000 square feet of impervious surface, and detached single family home projects which create or replace 2,500 square feet or more of impervious surface to install one of six site design measures.

2.2 Proposed Changes to Regulated Project Threshold

Water Board staff has suggested reducing the Regulated Projects threshold to 5,000 square feet of impervious area created or replaced for all projects. Although no rationale accompanied the suggestion, it is presumed that the proposal was motivated by a belief that extension of the lower 5,000-square-foot threshold to all land uses would result in a significant reduction in pollutant loading.

Our search of permit findings related to project thresholds did not find any instances where a Water Board, prior to adoption, considered the effectiveness of different thresholds on a watershed scale or the effort required to implement different thresholds.

The following sections contain an analysis of the potential effectiveness of changing the threshold, and of the potential additional resources required to implement a reduced threshold.

2.3 Potential Benefits and Costs of a Reduced Threshold

2.3.1 Potential Benefits of a Reduced Threshold

Reducing the Regulated Project threshold could expand the proportion of total development that is subject to C.3. To quantify this benefit, BASMAA conducted an analysis of development projects throughout the Permittees' jurisdictions to determine the relationship between project threshold and the proportion of the total amount of new and replaced impervious surface that would be subject to the requirements. The method and results were presented to the MRP 2.0 Steering Committee on September 5, 2013.

BASMAA used a previously compiled dataset of 533 projects that received municipal development approvals and were subject to C.3 during 2006-2010. These data were compiled to assess the effects of allowing "Special Projects" to implement non-LID treatment (BASMAA, 2010). The data were representative of development throughout the Region during this period. The projects were ranked by amount of impervious area created or replaced, and total impervious area was summed by percentile. Results are shown in Table 2-1.

Within this dataset, 95% of total impervious area created or replaced was attributable to projects with an acre or more of impervious created or replaced. For projects smaller than an acre, total impervious area was summed for 5,000-SF increments between 10,000 and 45,000 SF.

As shown in Table 2-1, each 5,000-SF increment in this range was associated with between 0.5% and 0.8% of the total impervious area of all projects in the dataset.

Table 2-1. Impervious Surface Analysis 2006-2010

Range (Sq. ft. impervious area created or replaced)	No. of Projects	Percent of Total Projects	Sq. Ft. of Impervious Area Created or Replaced	% Total Impervious Area Created or Replaced
10,000-14,999	39	7.3%	455,670	0.5%
15,000-19,999	39	7.3%	680,607	0.7%
20,000-24,999	35	6.6%	766,145	0.8%
25,000-29,999	27	5.1%	732,989	0.7%
30,000-34,999	24	4.5%	764,744	0.8%
35,000-39,999	17	3.2%	648,254	0.6%
40,000-45,000	18	3.4%	768,722	0.8%
Total < 1 acre	199	37.3%	4,817,131	4.8%
Total > 1 acre	334	62.7%	95,749,954	95.2%
Total All Projects	533	100%	100,567,085	100%

By extrapolation, we estimate that the proportion of total impervious area created by projects with between 5,000 and 10,000 SF impervious area is between 0.5% and 0.8%. Because some portion of projects in this size range are already Regulated Projects (including auto-related businesses, restaurants, and parking lots), we estimate that reducing the threshold to 5,000 SF for all projects would increase the proportion of total impervious area subject to the Regulated Projects requirements by 0.5%.

To put this quantity in perspective, each of the largest 40 projects in the 533-project dataset accounted for more than 0.5% of the total impervious area created or replaced.

BASMAA also obtained and analyzed more recent data available from the Cities of Fremont and San Jose that appear to confirm the previous analysis. Twenty applicable projects, each with between 5,000 and 10,000 SF of impervious area created or replaced, were approved by the two cities in 2009-2013. The impervious area of these projects accounted for 0.3% and 0.4% of the total impervious area of Regulated Projects approved 2009-2013 by Fremont and San Jose, respectively (see Table 2-2).

Table 2-2. Impervious Area Analysis for FY 09/10 - FY 12/13

Projects with 5,000-10,000 SF of Impervious Area Created/Replaced	Fremont	San Jose
No. of Projects	7	13
Percent of Regulated Projects	10%	8%
Impervious Area (SF)	52,573	112,236
Percent of Regulated Project Impervious Area	0.3%	0.4%

2.3.2 Implementation Issues and Costs of a Reduced Threshold

Table 2-1 also shows the percentage of total projects within each project size increment. By extrapolation, we estimate that the number of projects in the range of 5,000 to 10,000 square feet of impervious area would be approximately 8% of the total number of Regulated Projects. Table 2-2 shows that a similar analysis on the more recent Fremont and San Jose data yielded similar results.

Municipal staff directly involved in project review noted that smaller projects tend to require more staff time for processing and review, in part because the applicants tend to have less experience with the development review process and have fewer resources to hire land development professionals. Therefore the additional municipal staff level of effort resulting from the proposed threshold change could be considerably larger than 8%.

2.3.3 Conclusion and Recommendation

The data show that the proposed lower threshold could provide a small water-quality benefit. Over the permit term, this benefit would be comparable to effective implementation of the C.3 requirements on one large project.

The cost in municipal staff resources, however, would be disproportionate. We conclude the proposed lower threshold would result in an ineffective use of limited municipal staff resources that could otherwise be used to advance strong, pro-active C.3 implementation programs. We recommend that the current MRP thresholds be retained.

2.4 C.3 Applicability to Roads Projects

2.4.1 Current Requirements for Roads Projects

Provision C.3.b.ii.(4) limits regulated road projects (creating 10,000 SF or more of newly constructed contiguous impervious surface) to the following types of projects:

- New roads, including sidewalks and bike lanes built as part of the new roads; and
- Widening of existing roads with additional traffic lanes;

Sidewalks and bike lanes associated with new roads that direct runoff to adjacent vegetated areas or are constructed with permeable surfaces are specifically excluded. Sidewalks and bike lanes along existing roads are also excluded due to the greater benefits that they provide by encouraging reduced use of automobiles.

In lieu of requiring road replacement or rehabilitation projects to be subject to stormwater treatment requirements, the current provisions require Permittees to construct ten green street pilot projects within the region. These projects are nearly completed, and are described in the BASMAA *Green Street Pilot Projects Summary Report* (2013).

2.4.2 Future Green Infrastructure Permit Provision

Through the MRP 2.0 development process, the BASMAA Green Infrastructure Work Group and Water Board staff have discussed a potential Green Infrastructure permit provision. On November 14, 2014, the Work Group provided Water Board staff with proposed draft language[3]. The permit provision would address the Permittees' load allocations for mercury and PCBs, and would also contribute to implementation of other permit provisions, including trash reduction requirements, through a multi-decadal strategy for disconnecting public and private streets and storm drainage from direct discharge to creeks and the Bay.

It is BASMAA's understanding, based on discussions with Water Board staff, that implementation of a Green Infrastructure permit provision would allow Permittees to maintain the current

[3] The proposed draft language was provided to Water Board staff as a draft Work Group product that had not been vetted by all permittees.

C.3 requirements for road projects (i.e., applicable only to creation of new roads and addition of travel lanes).

The current C.3 provisions for road projects tie treatment requirements to specific projects (and therefore specific locations). However, in practice municipalities have and will continue to use the alternative compliance approach to treat runoff from equivalent amounts of impervious area at locations where it is most cost-effective and feasible to do so. For example, the C.3 requirement for treatment of a road widening project on steep slopes within a limited right-of-way might be met, under alternative compliance, by retrofitting a public parking lot in a flatter area.

Under the current alternative compliance provisions, municipalities can "bank" impervious area disconnected/treated to be credited as mitigation for future projects. Under such a banking arrangement, the long-term minimum total amount of impervious surface a municipality would be required to disconnect/treat would be equivalent to the total amount of impervious surface of projects subject to the C.3 roads requirement.

We expect that the impervious surface disconnection and stormwater treatment achieved through a green infrastructure program would be substantially greater than the amount needed to mitigate for road reconstruction projects alone. In addition, a coordinated and prioritized green infrastructure program would result in projects being strategically located to achieve the most benefits, rather than limited to locations where roads need repair.

In conclusion, we support the green infrastructure program approach to achieving multiple benefits, including pollutant load and flow reduction, and recommend maintaining the current C.3 requirements for road projects (i.e., applicable only to creation of new roads and addition of travel lanes).

3 ▪ Alternative Compliance

In this section, we consider provisions whereby Permittees may allow applicants for development project approvals to comply by:

- Implementing LID to treat an equivalent amount of runoff at an off-site location (Provision C.3.e.i.(1))
- Paying an in-lieu fee to treat an equivalent amount of runoff at a municipal or regional stormwater treatment facility (Provision C.3.e.i.(2)
- Qualifying, based on project location and characteristics, as a "Special Project," and then to implement non-LID facilities (or a combination of LID and non-LID facilities, depending on project location and characteristics) for stormwater treatment (Provision C.3.e.ii.).

These provisions are considered here—directly following the section on thresholds and applicability—because both sections involve the determination of which stormwater requirements will apply to a project, based on project characteristics.

3.1 Implementation of Alternative Compliance to Date

Alternative compliance options have been in effect since C.3 started a decade ago. Yet during that time, few C.3 projects have chosen to use alternative compliance. Nevertheless, the option has proven to be very helpful for some projects.

Here are some examples where alternative compliance has been used on private developments:

- Some redevelopment projects—which were not subject to the "50% rule"[4]—have treated runoff from an already developed portion of the same site, in lieu of treating a portion of impervious area that was new or replaced.
- Some development projects have treated runoff from impervious surfaces on an existing adjacent (upgradient) site with facilities located on their site, in lieu of treating runoff from a (downgradient, hard-to-treat) part of their own site.
- In lieu of treating some or all site runoff on-site, a few development projects have agreed to help fund green

[4] This refers to the requirement in C.3.b.ii.(3)(a) that where a redevelopment project results in alteration of more than 50 % of the impervious surface of that previously existed on-site, runoff from the entire site must be treated.

streets retrofits on nearby streets that were already slated for transportation improvements.

- Some development projects have considered treating some street runoff with facilities on-site, in lieu of treating runoff from a portion of their site (again because of the locations of available flat areas suitable for bioretention).

In summary, the current MRP alternative compliance provisions have proven useful in limited applications that were specific to site characteristics.

(Note regarding road projects: If MRP 2.0 requires C.3 applicability to road reconstruction projects, Permittees believe they will need to invoke alternative compliance for many of these projects. The issue of applicability of C.3 to roads and our recommendations are discussed in Section 2.4.)

There have been few, if any, instances where a substantial portion of site runoff for a private development project was not treated on site, and instead an equivalent amount of runoff was treated at another site not adjacent to the project site. In addition, no municipalities have pursued implementation of a "Regional Project," a stormwater treatment system funded by contributions from project proponents made in lieu of providing on-site treatment, for a number of technical, logistical and institutional reasons.

3.2 Barriers to Implementation of Alternative Compliance

In MRP 2.0 Steering Committee discussions, Water Board staff has stated their interest in seeing more alternative compliance projects implemented. In response to this expression of interest, Permittee representatives cited the following barriers to alternative compliance:

- Timing - Current MRP provisions require that construction of offsite treatment projects be completed by the end of construction of the Regulated Project, or incur a penalty of a 10% annual increase in the amount of runoff treated. In any case, alternative compliance projects must be completed within 3 years. Regional Projects must be completed within 3 years, or up to 5 years with Executive Officer approval.
- Location within the same watershed – Provision C.3.e requires the alternative compliance project to be within the same watershed as the regulated project. Although "watershed" is not defined, it is generally assumed to

mean within the same major creek watershed. This has not been a significant barrier to date, but could be an issue in the future if municipalities want to implement jurisdiction-wide green infrastructure projects and have flexibility to use these projects as "mitigation banks" for any regulated project.

- Increased cost – Providing treatment measures on another site often results in significant additional costs, for the following reasons:
    - Costs for on-site compliance using bioretention are low, and costs are generally absorbed into the project budgets for grading and landscaping. In contrast, off-site grading and landscaping directly increase project costs.
    - Expanding the "whole of the project" to include two sites rather than one site complicates planning and zoning review, design review, and CEQA review of a project, increasing the proponent's risk of encountering delay or denial of needed approvals.
    - Even if construction on the two sites is approved as one project, costs for contractor mobilization and construction inspection will increase significantly over implementing LID on-site.
- Long-term implications - The long-term status of an off-site project with regard to C.3 is unclear. For example, if a developer retrofits drainage from an existing parking lot in lieu of providing treatment for the newly developed or redeveloped site, what happens if that developer (or a subsequent owner) later wants to redevelop the existing parking lot? Must the developer now provide treatment for runoff from that redevelopment, and also find a new site on which to retrofit drainage for new off-site compliance for the first project? Developers are generally unwilling to tie up privately-owned property as a stormwater mitigation site that cannot be redeveloped in the future.
- Complexities of Regional Projects - Most municipalities lack the means, as well as the incentive, to create Regional Projects. The process of planning, permitting, funding, and constructing such a project would typically take 5 years or more—considerably longer than the horizon for private developments that might pay into

such a project. Municipalities would need to build the regional projects on speculation that developments would later be proposed. This creates a financial risk. In addition, setting up in-lieu fee programs and establishing fee amounts is complicated and there are significant legal restrictions regarding municipalities' use of development funds. Finally, all of the efforts described above require significant municipal staff resources that may not be available.

- O&M and funding responsibilities for offsite and regional projects – Defining the O&M and funding responsibilities can be challenging when treatment facilities are located on two different sites that may have different owners and uses. If a homeowners' association does not exist, typically a community facilities district or other instrument has to be created to assign responsibility and collect funds, which also requires significant staff resources.

3.3 Recommendations for the Alternative Compliance Provision

We recommend that the alternative compliance provision be rewritten to eliminate, or provide more flexibility on, the restrictions as to the timing and location of the alternative compliance project relative to the proposed project. More flexible provisions are essential to the success of green infrastructure and mitigation banking programs. Specific recommendations include:

- Allow the alternative project location to be anywhere within the municipal jurisdiction, and for regional projects, anywhere within the countywide or area-wide program area.
- Allow the timing of projects to be consistent with current legal requirements regarding municipalities' use of development funds (e.g., the Quimby Act[5]).

In addition, the requirements should make explicit that the practice of retrofitting existing impervious area on-site, in lieu of treating an equivalent or smaller amount of new or replaced impervious area, is an acceptable form of alternative compliance.

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[5] California Government Code Sec. 66447 states that a city or county may, by ordinance, require the dedication of land or impose a requirement of the payment of fees in lieu thereof, or a combination of both, for park or recreational purposes as a condition to the approval of a tentative map or parcel map. Any fees collected under the ordinance must be committed within five years after the payment of the fees.

The challenges and barriers to implementing alternative compliance at off-site or regional projects should also be recognized if the requirement for a feasibility analysis for Special Projects' LID treatment reduction credits is continued, as is discussed in Section 3.4.3.

3.4 Special Projects

3.4.1 Current Criteria for Special Projects

MRP Provision C.3.e.ii.(1), effective December 1, 2011, allows development projects that meet certain criteria ("Special Projects") to use tree-box-type high flowrate biofilters or vault-based high flowrate media filters in lieu of LID treatment, for a specified proportion of site runoff.

The project criteria are defined in three categories:

- Category A – Lot-line-to-lot-line project creating and/or replacing 0.5 acres or less of impervious surface that is located in a designated central business district, downtown core area or pedestrian-oriented commercial district, etc., has no surface parking, and has at least 85% coverage of the entire site by permanent structures.
- Category B – High density project creating and/or replacing greater than 0.5 acres but no more than 2 acres of impervious surface that is located in a designated central business district, downtown core area or pedestrian-oriented commercial district, etc., has no surface parking, and has at least 85% coverage of the entire site by permanent structures. A minimum density of either 50 dwelling units per acre (for residential projects) or a Floor Area Ratio (FAR) of 2:1 (for commercial or mixed use projects) is required to get LID treatment reduction credits.
- Category C – High density, transit-oriented project for which at least 50% of the project area is within 1/2 mile of an existing or planned transit hub or 100% within a planned Priority Development Area, and is characterized as a non-auto-related use. A minimum density of either 25 dwelling units per acre (for residential projects) or a Floor Area Ratio (FAR) of 2:1 (for commercial or mixed use projects) is required to get LID treatment reduction credits.

The Special Project categories, criteria and corresponding amount of allowed non-LID treatment are summarized in Appendix A.

Provisions C.3.e.v and C.3.e.vi require Permittees to track and report when they receive planning applications for Special Projects. This is in addition to reporting discretionary approval of these projects, which is required by Provision C.3.b.

3.4.2 Significance of Special Projects to Water Quality

As stated in the BASMAA Special Projects Proposal (2010), Special Projects facilitate viable smart growth, infill and transit-oriented development, consistent with regional, state and federal plans and policies. Smart growth, infill, and transit-oriented development increase population density and improve access to transit, both of which reduce annual auto mileage per capita and consequently reduce automobile-related runoff pollution and greenhouse gas emissions. These types of development also preserve open space and make efficient use of previously developed land and existing infrastructure[6].

In the current MRP, tree-box-type high flowrate biofilters and vault-based high flowrate media filters were selected as allowable non-LID alternatives. This is because, as stated in the Special Projects Proposal:

> The two methods have proven capable of providing good stormwater treatment. Both remove fine particles and particle-bound pollutants and produce consistent effluent quality. Data are inconclusive on whether effluent quality is as good as, or better than, effluent quality from a bioretention facility. Bioretention is considered superior because of its robust design, low maintenance requirements, and self-renewing characteristics and because a portion of the influent flow is infiltrated or evapotranspirated where site and project conditions allow.

The disadvantages of these two non-LID methods, as compared to bioretention, can be mitigated through regular inspection and maintenance of the non-LID facilities. Because of the nature of Special Projects, including the intensity of use characterized by each of the categories, municipalities are finding that owners and operators of Special Projects sites usually have the institutional capability to assure regular maintenance of non-LID

[6] For additional discussion of the environmental benefits of smart growth projects, see BASMAA's Special Projects Proposal (2010), Chapter 4.

facilities over the long term. (Typically, these development projects have building management and maintenance staff that can also operate and maintain elevator, heating/ventilation, and electrical systems.)

3.4.3 Special Projects Categories—Experience and Proposed Changes

The Permit's LID requirements, and the accompanying Special Projects requirements, have been in effect for less than three years. Data for two complete years (2012-2013 and 2013-2014) have been collected, analyzed and summarized in Table 3-1.

Table 3-1. Analysis of Regulated Project and Special Project Impervious Area Data from FY 12-13 and FY 13-14 Permittee Annual Reports

	Regulated Projects
County	Total Created and Replaced Impervious Area (ac)
Alameda	1,186
Contra Costa	134
San Mateo	135
Santa Clara	942
Solano	80
Bay Area-wide Total	2,477

	Special Projects (Approved)
County	Total Created and Replaced Impervious Area (ac)
Alameda	10
Contra Costa	2
San Mateo	12
Santa Clara	64
Bay Area-wide Total	88
Percent of Impervious Area in Special Projects:	3.6%
Percent of Impervious Area Receiving Non-LID Treatment[7]:	1.3%

The analysis indicated that approved Special Projects accounted for about 88 acres of impervious area, or about 3.6% of the total impervious area attributable to Regulated Projects receiving discretionary approval during those years, a proportion that is

[7] Of the total created/replaced impervious area in approved Special Projects, approximately 57% of the area will be treated with LID and 43% will be treated with non-LID measures.

generally in line with the predictions in BASMAA's Special Projects Proposal. Implementation of Special Project provisions resulted in runoff from about 1.3% of the total impervious area associated with approved Regulated Projects being treated by non-LID treatment facilities within the approved Special Projects.

Experience implementing the Special Projects provision has revealed unintended consequences of two particular criteria. These are detailed below, with recommendations for proposed changes to the criteria.

1) Category B: Building Coverage Requirement

   To qualify for Category B, a project must:

   > Have at least 85% coverage for the entire project site by permanent structures. The remaining 15% portion of the site is to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping, and stormwater treatment.

   Municipal staff have found that this requirement acts as a disincentive for developers to incorporate public plazas into their proposed development plans. It is recommended that this disincentive be rectified by allowing applicants to omit the portion of the project dedicated to ground-level public plazas from the calculation of the 85% coverage requirement, and requiring the public plaza area to drain to LID facilities.

2) Category C Mixed Use Projects: Applicability of FAR Criterion to Mostly Residential Projects

   Provision C.3.e.ii.(4)(a) states the required minimum densities for projects to qualify:

   > (ii) If a commercial or mixed-use development project, achieve at least an FAR of 2:1.
   >
   > (iii) If a residential development project, achieve at least a density of 25 DU/Ac.

   The corresponding LID credits for density in Provision C.3.e.ii.(4)(d) likewise lump commercial and mixed-use projects.

   These thresholds inadvertently penalize projects that are mostly residential but include a small amount of ground-floor commercial space. Municipal agencies typically encourage high density residential projects to include ground-floor retail in order to provide services to residents on-site and reduce automobile trips. However, some of these high density, smart growth residential projects do not meet the minimum FAR requirement of 2:1 due to the project design (e.g., designs that include public plazas or central courtyards on podiums). It is recommended that mixed-use projects be eligible for Category C, and/or be eligible for density credits, based on meeting either the FAR or residential density criteria.

3.4.4 Reporting Issues Related to Special Projects

Provision C.3.e.vi requires Permittees to track *potential* Special Projects that have submitted planning applications but that have not received discretionary approval, and to report these projects semi-annually (once on March 15, and again with the Annual Report due September 15).

This semi-annual reporting requirement was intended to be temporary, to allow Water Board staff the opportunity to assess the effect of the new provision as implementation began. The reporting requirement has fulfilled its purpose, and should be discontinued.

Provision C.3.e.vi.(2) requires that Permittees incorporate in their reports a narrative discussion of the feasibility or infeasibility of 100% LID treatment, onsite and offsite. To assist Permittees with this requirement BASMAA's Development Committee developed guidance for conducting the required analysis and preparing the narrative. The guidance directs a systematic review of constraints on the locations of bioretention facilities and constraints on the flow of runoff from impervious areas to those facilities. For consideration of offsite feasibility, the guidance proposes as a framework that the narrative describe whether the project proponent owns or otherwise controls land within the same watershed that can accommodate in perpetuity adequate off-site bioretention facilities, or whether any regional in-lieu program is available. These feasibility criteria for offsite LID (i.e., alternative compliance) were based on the actual barriers to implementation of alternative compliance described in Section 3.2.

Water Board staff has suggested that MRP 2.0 "explicitly require that Permittees evaluate the feasibility or infeasibility of all of the following prior to invoking any Special Projects LID credits:

- 100% LID treatment onsite
- 100% LID treatment offsite or at a regional project
- Payment of in-lieu fees equivalent to 100% LID treatment,

- A combination of LID treatment onsite, offsite, and at a regional project, and payment of in-lieu fees, the total of which is equivalent to 100% LID treatment."

In essence, this would mean that any option that includes LID treatment should be required over any non-LID treatment option, in all cases.

We disagree with this prioritization, as it: a) doesn't reflect the relative advantages and disadvantages of bioretention vs. non-LID treatment; b) doesn't reflect our knowledge of and experience with implementing stormwater treatment on development projects and the difficulties with implementing off-site or regional projects and in-lieu fees (as discussed in Section 3.2); and c) doesn't recognize the inherent environmental benefit of Special Projects, which was the basis for allowing selective non-LID treatment in the first place.

For most Special Projects, some on-site bioretention is feasible, and some portion of runoff (as identified in criteria for categories A, B, or C) is allowed to be directed to on-site tree-box-type high flow rate biofilters and/or vault-based high flowrate media filters. Applicants should be able to balance the pros and cons of incorporating bioretention facilities vs. the allowed non-LID systems, within the framework established by the categories. This is the best way to promote proper design, construction, installation, and long-term maintenance of treatment facilities. A "one-size-fits-all" prioritization will just lead to unfortunate compromises when facilities are designed and built.

That said, some applicants for projects that qualify for Special Projects submit proposals to use non-LID treatment (typically vault-based high flowrate media filters) to treat runoff in locations where there are flat landscaped areas that could be used for bioretention facilities. Using bioretention to treat this runoff would clearly have a lower capital cost and much lower long-term costs for maintenance.

Based on experience working with applicants and municipal reviewers, we believe the primary reason this occurs is land development engineers' lack of familiarity with the advantages of bioretention and lack of experience designing bioretention on high density projects with space constraints. There is also a tendency for engineers to develop the stormwater control plan to utilize the maximum amount of non-LID treatment allowed without fully evaluating all on-site options. The best remedy is more efforts to inform and educate the Bay Area community of land development professionals.

3.4.5 Conclusions and Recommendations for Special Projects

The preceeding sections can be summarized as follows:

- The Special Project provisions have generally been implemented successfully; however two particular criteria have had unintended consequences and need to be fixed.
- Maintaining Special Project provisions will result in runoff from nearly 99% of the total impervious area subject to Provision C.3 being treated with LID measures (based on data for projects approved during FY 12-13 and FY 13-14).
- Tree-box-type high flowrate biofilters and vault-based high flowrate media filters will provide treatment for around 1% of the total impervious area subject to Provision C.3. These facilities can be effective for protecting water quality when properly operated and maintained. The principal disadvantages of these systems are less robust operation, higher capital costs, and higher maintenance costs.
- Some Permittees report success in convincing applicants to use bioretention where feasible because—compared to the non-LID options—bioretention has lower initial costs and lower anticipated long-term operating costs.
- The best strategy for maximizing the use of bioretention is to craft LID-appropriate Permit criteria and conduct educational outreach to the land development community regarding the advantages of bioretention and strategies for incorporating LID in high density projects.
- Conducting educational outreach to land development professionals is a more productive use of limited municipal resources than continuing to implement the current reporting requirement.

Based on the points above, it is recommended that:

- The current Special Project categories and criteria be maintained, with the addition of the following changes:
  - Allow exclusion of ground-level public plaza areas from the calculation of the 85% coverage requirement, and requiring public plaza areas to drain to LID facilities.
  - Allow mixed use projects to use either FAR or residential density criteria to determine Special Projects eligibility and/or allowable LID treatment reduction credits.

- The requirement to report any potential Special Projects that have submitted planning applications not be included in MRP 2.0;
- The requirement to submit semi-annual reports on Special Projects be discontinued;
- In Annual Reports, reporting of Special Projects that have been granted discretionary approval should be integrated with reporting for Regulated Projects that are not Special Projects; and
- Special Projects not be required to evaluate the feasibility of LID treatment offsite or at a regional project or payment of in-lieu fees.
- Permittees be encouraged to increase educational outreach to land development professionals on bioretention design and strategies for incorporating LID in high density projects.

4 ▪ Low Impact Development

In this section, we review the outcomes of implementation, from December 2011 to now, of Provision C.3.c, with an emphasis on the requirements in Provision C.3.c.i.(2)(b)(ii), which states:

> A properly engineered and maintained biotreatment system may be considered only if it is infeasible to implement harvesting and re-use, infiltration, or evapotranspiration at a project site.

We also address the following issues pertinent to the implementation of the Provision C.3.c. LID requirements:

- Technical specifications for site design measures, including pervious pavement.
- Technical specifications for treatment facilities and biotreatment soils.

4.1 Site Design Measures and Runoff Reduction

MRP Provision C.3.c.i.(2) requires implementation of site design strategies that reduce runoff. However, as has been the Permittees' experience since the mid-1990s (when *Start at the Source* was being developed and published) specific measures cannot be reasonably mandated, and the extent of measures on any particular site is dependent on both site characteristics and the individual designer's knowledge and creativity.

The MRP does not contain or reference standards for site design measures, nor does the MRP contain methods for determining the amount of runoff reduced, or the extent to which the site design measures reduce the required size or capacity of treatment measures. For this reason, each of the stormwater programs has created guidance for applicants to follow when integrating site design measures and treatment measures into an overall design to achieve stormwater quality compliance. Many of the concepts of this guidance were created during 2003 with the development of a *Stormwater C.3 Guidebook* for the City of Milpitas (and later, an identically titled publication for Contra Costa County), and the publication that same year of BASMAA's *Using Site Design Techniques to Meet Development Standards for Stormwater Quality: A Companion Guide to Start at the Source.*

These documents, and current Permittee guidance, contain the following key concepts:

- Applications for development project approvals must include complete information, including drawings, showing how site drainage is managed to comply with Permit requirements.

- A drawing must show the entire project site divided into distinctly delineated Drainage Management areas (DMAs). This is critical to ensuring appropriately sized site design and treatment measures.
- DMAs may include self-treating areas, which are natural or landscaped areas that treat direct rainfall by infiltration and/or evapotranspiration, do not receive runoff from other areas, and drain excess runoff directly off-site. (In some stormwater program guidance manuals, a properly designed pervious pavement area or green roof can also be considered self-treating).
- DMAs may include self-retaining areas (called zero-discharge-areas in the BASMAA document), which are natural or landscaped areas that retain and infiltrate the first 1 inch of rainfall without producing runoff. A properly designed pervious pavement area or green roof can also be a self-retaining. Impervious areas may be drained to self-retaining areas in a specified manner.[8]
- In general, roofs and pavement are assumed to be entirely impervious; natural and landscaped areas, pervious pavement, and green roofs are assumed to be (for the range of storm sizes corresponding to the criteria in Provision C.3.d.) entirely pervious.
- Impervious areas that do not drain to self-retaining areas must drain to treatment facilities.

These concepts have proven essential, and workable, for translating LID objectives into verifiable and enforceable criteria, and have become standard practice throughout the Bay Area. They have been tested in review of hundreds of development projects by the staffs of dozens of Permittees. Having these concepts in Permittee guidance documents (i.e., outside of the permit) facilitates updates and improvements based on experience with implementation and lessons learned.

To support implementation of functional site design measures MRP 2.0 should make clear how site design measures—delineated and documented as self-treating areas and self-

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[8] Current guidance specifies a maximum 2:1 ratio of impervious to pervious area, consistent with a rule of thumb put forward in *Start at the Source* and verified with modeling studies done for the BASMAA *Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report* (2011).

retaining areas—may be used to reduce the amount of runoff that must be treated. Furthermore, MRP 2.0 should explicitly state that municipalities must require applicants for approvals of Regulated Projects to show the site delineated into DMAs. As mentioned above, this is essential to ensuring correct site design and treatment facility sizing.

Most Permittees have adopted self-treating and self-retaining design requirements through stormwater program guidance manuals. To advance this effort, MRP 2.0 should also require that all Permittees adopt and implement design requirements for self-treating areas and for self-retaining areas, including pervious pavements and green roofs. However, we recommend against including specific site design measure design requirements in the Permit itself, because it is then difficult to correct errors or update requirements based on subsequent experience.

Some considerations for design of pervious pavement are discussed in the following section.

4.1.1 Design Criteria and Runoff Factors for Pervious Pavement

Start at the Source contains recommended runoff factors for small storms; these include recommended factors for pervious pavements. The factors implicitly assume that some portion of runoff will be absorbed by the pervious pavement and the remainder discharged. BASMAA's 2003 *Using Site Design Techniques…* identified designation of "runoff reduction areas," that is, areas to which runoff factors could be applied.

More recently, stormwater program guidance has given greater attention to design criteria for pervious pavements, including maximum slopes where pervious pavement may be used, subgrade preparation, minimum depths of base courses and types of aggregate, the width of interstices when solid pavers are used, and the material to be used when filling interstices. Where appropriate, guidance has been developed with input from the Interlocking Concrete Pavement Institute, the Concrete Promotion Council of Northern California, and the California Asphalt Pavement Association, or referrals made to these organizations.

When these criteria are implemented successfully, all runoff from the storm sizes specified in Provision C.3.d can be expected to be retained within the pervious pavement and base course and then infiltrated into the subgrade. Therefore the appropriate runoff factor is zero, and the pervious pavement becomes, effectively, a self-treating or self-retaining area.

This is consistent with the MRP, which defines pervious pavement as “pavement that stores and infiltrates rainfall at a rate equal to immediately surrounding unpaved, landscape areas, or stores and infiltrates the rainfall runoff volume described in C.3.d.” This is a good example of the type of performance criteria that should be specified in the permit. We recommend keeping these performance criteria for pervious pavement in MRP 2.0 and allowing the design requirements for achieving this performance to be provided in stormwater program guidance documents. Permittees should require development project applicants to provide calculations and design details in stormwater control plans to demonstrate that proposed pervious pavement systems meet the design requirement and can be considered self-treating or self-retaining.

4.2 Feasibility of Infiltration and Harvesting/Use

This section will demonstrate that the feasibility test for the use of bioretention (biotreatment) should be omitted from MRP 2.0 because:

- New information about bioretention systems—presented below—shows that they can achieve pollutant reduction that is comparable to retention, while also being less prone to failure and easier to maintain than harvest/use or below-ground infiltration systems.
- BASMAA studies mandated under the current MRP demonstrated that few developable sites have sufficient soil permeability to support infiltration of the specified amount of runoff and even fewer sites have sufficient on-site non-potable water demand to use the specified amount of runoff for harvest/use.
- In cases where infiltration is feasible—that is, where runoff will infiltrate to subsurface soils at a rate of 1.6 inches per hour or higher—the standard bioretention system design (with a surface area meeting the 4% sizing criterion) will infiltrate the C.3.d volume.
- In cases where rainwater harvesting/use is feasible, sufficient economic and other incentives exist to ensure their consideration and application, and a permit mandate is not needed.

4.2.1 Background

The concept of “Low Impact Development” (LID) was developed by staff at the Prince Georges County, Maryland, Department of Environmental Resources during the late 1990s. “Low Impact Development Design Strategies: An Integrated Design Approach,” published with USEPA support in 1999, was the foundation document for LID and has been widely used and referenced throughout the US. BASMAA’s “Start at the Source,” published in 1997 and updated in 1999, does not use the LID terminology but contains many of the same concepts and promotes the same design approach.

Bay Area municipalities began adopting and implementing LID as conditions for development project approvals during the 1990s. The Water Board began adopting C.3 Provisions into NPDES permits in 2001-2003. The C.3 Provisions required that development projects include treatment facilities meeting specified volume-based and flow-based sizing criteria. The criteria were developed for extended detention basins and for facilities using filtration. The C.3 Provisions included no specific criteria for designing LID facilities.

The Permittees adapted the Water Board’s sizing criteria for application to LID facilities, publishing design guidance, including sizing criteria, beginning in 2003. As in Prince George’s County and other US municipalities implementing LID, implementation began with an emphasis on bioretention as the most commonly used “integrated management practice.”

In 2009, the Water Board shifted direction and required LID in MRP Provision C.3. However, in doing so, the Board also redefined the term “Low Impact Development” to be different from what had been in use in the Bay Area, and nationally, for (at that time) a decade. The Water Board’s new definition, expressed in the new Provision C.3.c.i.(2)(b)(ii), included the caveat that a bioretention facility (redubbed “biotreatment system”) may be considered only if it is infeasible to implement harvesting and re-use, infiltration, or evapotranspiration.

MRP Provision C.3.c.i.(2)(b)(iv) required the Permittees to submit a report on criteria and procedures used to determine feasibility or infeasibility at project sites. This report (BASMAA, 2011) was prepared and submitted by the May 1, 2011 due date. MRP Provision C.3.c.i.(2)(b)(v) required the Permittees to submit a report on their experience with determining infeasibility. This report (BASMAA, 2013b) was submitted by December 1, 2013 as required. The two reports address the question of feasibility. Key conclusions and recommendations are recapped and discussed in Section 4.3.3.

4.2.2 Origin of, and Rationale for, Retention Requirements

Development of the MRP LID requirements mimicked a parallel process by staff at the Santa Ana Regional Board, which was developing a Municipal NPDES Stormwater Permit for Orange County municipalities during mid-2009.

The key concepts and specific language in MRP Provision C.3.c.i.(2)(b)(ii) were developed by David Beckman and Bart Lounsbury of NRDC and are clearly expressed in their April 8, 2009 letter commenting on the second draft Tentative Order for the Orange County permit. Beckman and Lounsbury state:

> The Tentative Order, and our advocacy for LID practices that retain stormwater onsite through infiltration, harvesting and reuse, or evapotranspiration, thus ensuring that pollutant loads do not reach receiving waters, is most consistent with LID principles and goals. Others have advanced interpretations of "LID" that include the use of treat-and-discharge systems, but these systems are not as effective as retention practices because the discharged water may still contain pollution, even if it is attenuated. Our interpretation of "LID" is consistent with USEPA's: "LID comprises a set of approaches and practices that are designed to reduce runoff of water and pollutants from the site at which they are generated. By means of infiltration, evapotranspiration, and reuse of rainwater, LID techniques manage water and water pollutants at the source and thereby prevent or reduce the impact of development on rivers, streams, lakes, coastal waters, and ground water."[9]

The Beckman/Lounsbury language—requiring retention of a design volume "through infiltration, evapotranspiration, or harvesting and reuse"—was subsequently included in the September 24, 2009 MRP Final Draft Tentative Order and was adopted by the San Francisco Bay Water Board. This shift away from standard LID practice in the Bay Area and nationally (which arguably, was already consistent with EPA's

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[9] In the original, at this point Beckman and Lounsbury cite USEPA's December 2007 report, *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices.* However, Beckman and Lounsbury fail to note that, in the USEPA report, the quote introduces case studies that rely heavily on filters, bioswales and other "treat and discharge" LID systems.

interpretation of LID quoted above) was not evaluated for application in the Bay Area and caused significant changes in Permittees' LID requirements.

4.2.3 Experience with Feasibility of Infiltration and Harvesting/Use

The BASMAA *Harvest and Use, Infiltration and Evapotranspiration Feasibility/ Infeasibility Criteria Report* presented the results of technical analyses to develop criteria and procedures for Permittees to follow to determine whether harvesting and use, infiltration, or evapotranspiration are feasible or infeasible at a Regulated Project site and when biotreatment may be used. The Permittees subsequently incorporated the criteria in the report into guidance which has been used by applicants for development approvals and by municipal staff when reviewing those applications since December 1, 2011 (the start date for implementation of LID requirements).

The BASMAA *Status Report on the Application of Feasibility/Infeasibility Criteria for Low Impact Development* conducted a review of Permittee Annual Reports submitted for Fiscal Years 2011-2012 and 2012-2013 to evaluate the results of applying the feasibility/infeasibility criteria. The report found that the application of current feasibility/infeasibility criteria resulted in widespread installation of bioretention facilities that are effectively treating water quality design runoff volumes and are retaining a significant portion of total runoff.

Of the 554 regulated development projects approved during those two fiscal years, the majority of projects required to implement LID treatment measures used variations of bioretention facilities (identified as "bioretention", "bioinfiltration", flow-through planters, etc.) as the selected treatment measure. There were approximately 22 projects that reported the use of infiltration treatment facilities[10]. In addition, there were 256 projects (46% of the total) that reported using infiltration-based site design measures, 69 projects (12.5% of the total) that reported using pervious pavement, and many projects using biotreatment facilities that infiltrated a significant portion, if not all, of the water quality design volume.[11]

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[10] There may have also been other projects for which it was feasible to infiltrate the water quality design volume but chose to design a biotreatment facility to accomplish infiltration of that volume, and reported the treatment as "bioretention".

[11] The proportion of biotreatment facilities proposed to be unlined vs. lined, and the amount of infiltration achieved in the unlined facilities, is

The *Status Report* also reported that there were no regulated projects during FYs 11-12 and 12-13 that used rainwater harvesting as a means to achieve compliance with Provision C.3.c.i.(2)(b). However, the *Status Report* and *Criteria Report* did document a number of projects constructed in the past several years that are using rainwater harvesting to meet non-potable water demands on-site, for reasons other than stormwater permit compliance (e.g., obtaining LEED points or serving as examples of sustainability).

Based on the information presented in the *Status Report*, the Permittees concluded the following:

- Infiltration of some runoff is feasible on most projects. In the clay soils typical of our Region, the amount of runoff that can be infiltrated is unpredictable and highly variable. On most sites, it is not practical or feasible to design facilities that can reliably and dependably infiltrate the Provision C.3.d.i.(3) amount of runoff (that is, 80% of the total quantity of runoff over a period of 30 years or more).
- Very few development projects create the quantity and timing of non-potable-water demand required to feasibly harvest and use the amount of runoff specified in MRP Provision C.3.d.i.(3). Harvesting and use of a smaller quantity of runoff is technically feasible on some projects. In particular, proponents of some development projects are willing and able to incorporate harvesting and use systems when those systems are sized and designed for cost-effective augmentation of water supply, which requires considerably less storage than would be required to meet current MRP requirements. However, the complexity and operation and maintenance requirements for harvesting and use systems make it inadvisable to require those systems on developments where it cannot be assured that a qualified maintenance staff will be employed on-site at all times during the life of the project.
- Bioretention facilities, when designed according to the criteria in current Permittee guidance, could infiltrate between 40% and 80% or more of total runoff, depending on rainfall patterns and facility size. However, the amount of runoff that would be infiltrated over the life of a particular project is variable and unpredictable because of uncertainty

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unknown. However, stormwater program guidance manuals require that, where infiltration is allowed on-site, bioretention areas be unlined and that underdrains be designed to discharge near the top of the gravel layer in order to maximize infiltration from bioretention facilities.

in the near-term and long-term infiltration performance of underlying soils. Infiltration can be maximized by ensuring project designs adhere to current design criteria and by ensuring facilities are constructed as designed.

- Bioretention is, on balance, equal in water-quality effectiveness to harvesting/use or infiltration. It has the following advantages over harvesting/use and infiltration:
  - Applicable to nearly all development sites;
  - Proven to be practical, affordable, and acceptable to applicants;
  - Robust and very low maintenance;
  - Provides ancillary benefits of heat island mitigation, evapotranspiration of some runoff, aesthetics, air quality, and habitat.
- The maximum water-quality benefit would be obtained by adopting policies that allow project proponents to choose among effective options, so that they can effectively integrate LID treatment with other project objectives and features.

Accordingly, the Permittees proposed eliminating the feasibility/infeasibility criteria. The Permittees also proposed to continue to promote infiltration to the degree achievable on each development site via site design and bioretention, in order to achieve the maximum practical amount of infiltration collectively over all development sites on a watershed scale.

4.2.4 Relative Pollutant-Removal Effectiveness of Bioretention

This section presents information developed since MRP adoption, and accompanying updates to design guidelines, showing that bioretention facilities can approximate the hypothetical pollutant-reduction performance associated with a retention requirement. When operability, reliability, and other practical considerations are taken into account, bioretention appears to be at least as effective.

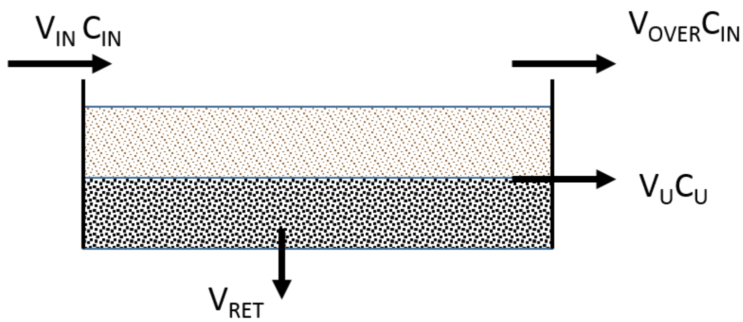
Two Mechanisms for Pollutant Load Reduction

MRP Provision C.3.d contains criteria that aim for retention or treatment of 80% of the total influent volume. A treatment facility designed according to these criteria will bypass or overflow the remaining 20%.

Influent reaching a harvest/use or infiltration system divides into two paths: Some portion (80% or more) is retained, and the remainder (20%) is bypassed or overflows the system.

Influent reaching a bioretention system divides into three paths: Some portion is retained (infiltrated and evapotranspirated), some portion is treated by filtration (through the biotreatment soil mix) and discharged, and some portion (typically 20% by design) is bypassed or overflows the system. See Figure 4-1.

Figure 4-1. Bioretention Inflows and Outflows



In a bioretention system, pollutant load reduction is accomplished by two mechanisms: retention and biofiltration. These two mechanisms are represented by Equation 4-1 below.

$$Load\,Reduction = \frac{V_{RET}}{V_{IN}} + \left(\frac{V_{IN} - V_{OVER}}{V_{IN}} - \frac{V_{RET}}{V_{IN}}\right) \times \frac{(C_{IN} - C_{U})}{C_{IN}}$$

Where:

V_{IN} = total volume of inflow

V_{RET} = total volume retained by infiltration and evapotranspiration

V_{OVER} = total volume of overflow

C_{IN} = pollutant concentration in influent

C_{U} = pollutant concentration in underdrain discharge

The first term on the right side of Equation 4-1 is the fraction of pollutant load reduction achieved by retention, which can be evaluated as the volume retained divided by the influent volume.

The remainder of the equation represents the additional pollutant load reduction achieved by filtration through biotreatment soil, i.e., the fraction of influent volume discharged by the underdrain, V_U, multiplied by the reduction achieved by treatment, or $(C_{IN} - C_U)/C_{IN}$. (Based on Figure 4-1, V_U is represented as the influent volume (V_{IN}) minus the volume overflowed (V_{OVER}) minus the volume retained (V_{RET})).

In Equation 4-1, these terms are grouped to correspond to the way retention and pollutant removal are typically referenced and reported. $(V_{IN} - V_{OVER})/ V_{IN}$ is the percentage volume to be treated (a minimum of 80% is mandated by Provision C.3.d.). Removal rates are typically reported as the discharge concentration divided by the influent concentration (multiplied by 100%). For bioretention facilities, the discharge is sampled at the underdrain.

Relative Effects of Retention and Treatment on Pollutant Load

Hypothetically, facilities that infiltrate or harvest/use 80% of total runoff would achieve an 80% reduction in pollutant load, with the remaining pollutant load being discharged in untreated runoff that overflows or bypasses the facility.

Table 4-1 and Figure 4-2 show how, in a bioretention facility, infiltration performance and reduction in pollutant concentration combine to achieve total pollutant load reduction. A range of infiltration percentages ("Retention") and percent reduction in pollutant concentration (pollutant removal through biotreatment soil filtration) are shown. The maximum percent retained on-site is assumed to be 80%.

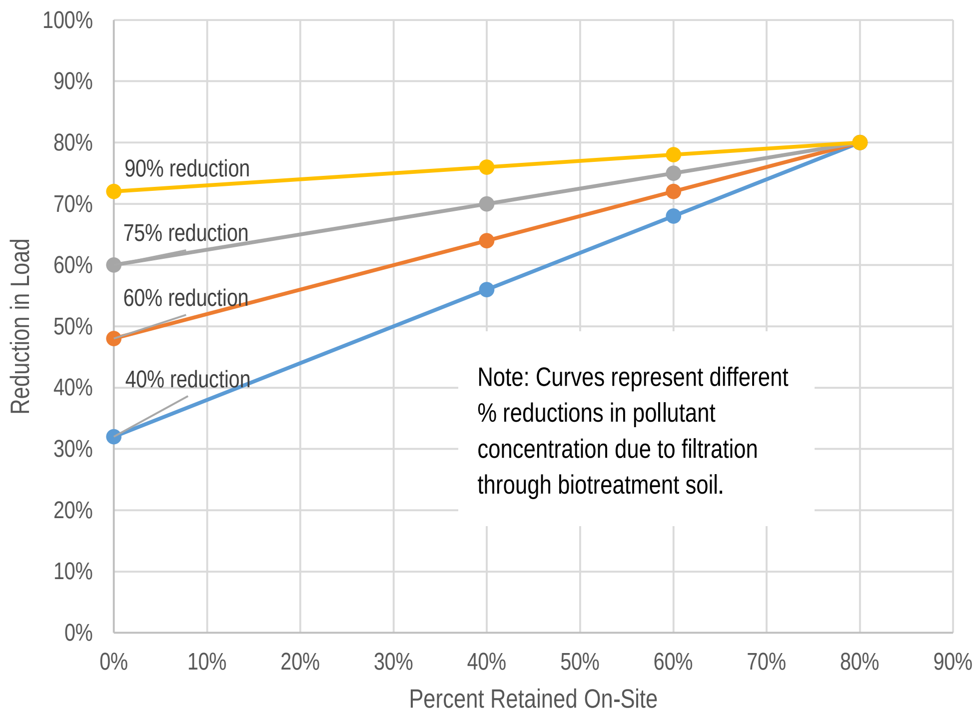
Table 4-1. Percent Load Reduction Achieved By Bioretention

Percent retention ↓ / Percent reduction in pollutant concentration →	40%	60%	75%	90%
0%	32%	48%	60%	72%
40%	56%	64%	70%	76%
60%	68%	72%	75%	78%
80%	80%	80%	80%	80%

As Table 4-1 and Figure 4-2 demonstrate, for lower reductions in pollutant concentration, increasing the percent retained on-site has a moderate but potentially significant effect on overall pollutant load reduction. If a system achieves 40% reduction in pollutant concentration through biotreatment soil filtration, achieves 40% on-site retention, and bypasses 20% of inflow, the overall load reduction is 56%. Boosting on-site retention to 80% (with 20% bypass) would increase overall pollutant load reduction to 80%, a relative increase of 24%.

However, at higher reductions in pollutant concentration, the percent retained on-site has little effect on overall pollutant load reduction. If a system achieves 90% reduction in pollutant concentration through biotreatment soil filtration, achieves 40% on-site retention, and bypasses 20% of inflow, then the overall pollutant load reduction is 76%. In this case, boosting the percentage of on-site retention from 40% to 80% increases the overall pollutant load reduction from 76% to 80%—a considerably less significant relative increase of 4%.

Figure 4-2. On-Site Retention and Load Reduction



How do these observations apply to real-world bioretention facilities?

As stated earlier, bioretention facilities exhibit consistently low pollutant concentrations in underdrain discharge, especially for pollutants, such as PCBs, that associate readily with sediments. Variability in pollutant removal rates is driven mostly by variation in influent concentration rather than actual variation in performance (Wright Water Engineers/Geosyntec, 2007).

This effect can be seen in the data collected by the San Francisco Estuary Institute at the San Pablo Avenue Rain Gardens in El Cerrito (SFEI, 2012[12]). The data are shown in Table 4-2.

Table 4-2. SFEI San Pablo Avenue Rain Gardens Data

	Storm 1	Storm 2	Storm 3	Storm 4	Average*
PCBs (picograms/L)					
Inlet	226,373	9,587	9,795	4,520	
Underdrain	1,366	1,615	1,290	954	
% Reduction	99%	83%	87%	79%	98%
Methylmercury (ng/L)					
Inlet	.296	.261	.243	.330	
Underdrain	.130	.154	.155	.178	
% Reduction	56%	41%	36%	46%	45%

*Sum of inlet concentrations/Sum of underdrain concentrations

For higher influent concentrations of pollutants that associate with sediments, bioretention is very effective, and that effectiveness is not significantly affected by differences in the proportion of runoff that is retained on-site. As influent concentrations approach irreducible levels, and for pollutants that associate less readily with sediments, treatment is somewhat less effective, and retention provides some additional benefit.

Bioretention facilities constructed to meet current criteria actually perform somewhat more effectively than what is represented in Figure 4-2. The figure assumes bioretention facilities are designed to treat 80% of runoff (without overflow) based on the minimum allowable percolation rate for bioretention treatment soils and the minimum allowable treatment surface area. In reality, the typical bioretention facility

[12] Additional information provided by Alicia Gilbreath, SFEI, September 18, 2014.

has both higher percolation rates and additional capacity. Therefore more than 80% of runoff is captured for treatment and/or retention. This offsets, to some degree, any actual advantage of facilities that retain 80% of runoff onsite and discharge the remaining 20% untreated.

It is also important to consider that bioretention facilities require less maintenance and are less prone to failure than harvest and use facilities, and in some case, are also preferable to direct infiltration facilities. Decades of experience with bioretention facilities in the U.S.—and a decade of experience with such facilities here in the Bay Area—shows that they will reliably continue excellent treatment with minimal maintenance. By contrast, harvest/use facilities work only as long as on-site water demand continues to provide reliable drawdown, and require significant maintenance of pumps and filtration and disinfection systems, and distribution piping, all of which have higher risk of failure than bioretention facility components.

Facilities capable of infiltrating 80% or more of runoff are feasible only on sites with relatively permeable soils. Bioretention facilities on these permeable sites will infiltrate a higher proportion of runoff than similar facilities on sites with clay soils, further narrowing any presumed advantage in overall pollutant removal.

Based on this information and analysis, the pollutant removal performance of bioretention facilities, overall and on average, is equivalent or better than the likely real-world performance of harvest/use facilities—and as good as the likely performance of infiltration facilities when considered over the long term. There is no water-quality-based justification for preferring infiltration systems or harvest/use, even in the rare cases where such systems are feasible on Bay Area development sites.

Implementation of the recommendation to make bioretention facilities—built according to the recommended design to maximize infiltration where allowed—a “first-tier” option under the MRP would be consistent with the State Water Board’s Phase II permit and would also create a consistent standard for stormwater treatment for new development throughout the Bay Area Region.

4.3 Design Criteria for Bioretention Facilities

A necessary component of utilizing bioretention as a "top tier" LID treatment measure is the development of consistent design, installation and maintenance guidance and standards for bioretention facilities. This information is provided in Bay Area stormwater program guidance manuals and used by nearly all Permittees. This section describes the current criteria and standards and makes the case that design guidance and standards are best developed and maintained by Permittees and not specified in the Permit.

4.3.1 Sizing—Minimum Surface Area

MRP Provision C.3.c.i.(2)(b)(vi) states that bioretention systems shall be designed "to have a surface area no smaller than what is required to accommodate a 5 inches/hour stormwater runoff surface loading rate, and infiltrate runoff at a minimum of 5 inches per hour during the life of the facility."

In practice, this design criterion has been combined with the 0.2-inch-per-hour intensity flow-based criterion (Provision C.3.d.i.(2)(c)) to arrive at a sizing factor of 0.04, or 4% (0.2/5 = 0.04). The 4% sizing criterion was first developed in guidance for the City of Milpitas (2003), was subsequently adopted by Contra Costa municipalities, and is now referenced in municipal stormwater NPDES permits and guidance for new developments in many locations throughout California.

Guidance published by the Santa Clara, San Mateo, and Alameda programs also recommend the use of the 4% sizing criterion wherever possible, in order to maximize infiltration of treated runoff from bioretention facilities. However, from a surface loading standpoint, the 4% criterion is conservative in that it does not account for any storage provided in the surface ponding area. For projects on sites where infiltration should be avoided, or where space constraints at high density projects require bioretention areas to be lined (e.g., flow-through planters), the guidance for these countywide programs suggests that municipalities may allow the use of a combination flow and volume design basis (allowed per MRP C.3.d.i.(3)). The combination flow/volume approach routes a rectangular hydrograph with a height of 0.2 in/hr and a duration equal to the unit basin storage volume divided by 0.2 in/hr through a bioretention facility with a surface reservoir volume equal to the facility surface area times a depth of six inches. This results in a facility size that meets both the flow-based and volume-based sizing criteria in C.3.d but has a smaller surface area (typically about 3% of the contributing impervious area).

Contra Costa permittees, in developing their guidance in 2004-2005, considered that bioretention facilities might be affected by high-intensity bursts of rainfall with short duration over a small area (this phenomenon would not be taken into account in the criteria, which were intended to be applied to larger drainage areas). The surface reservoir offsets this effect by retaining short-duration peak flows long enough to allow percolation into the bioretention planting medium.

4.3.2 Bioretention Planting Medium Specification and Depth

Provision C.3.c.i.(2)(b)(vi) in the 2009 MRP (prior to the 2011 revision) required the Permittees to submit "for Water Board approval, a proposed set of model biotreatment soil media specifications and soil infiltration testing methods to verify a long-term infiltration rate of 5 to 10 inches/hour." During 2010, the Permittees retained WRA, Inc. and held a roundtable discussion, which Water Board staff attended, to develop an appropriate specification.

The outcome of the roundtable and WRA's work was to use a bioretention soil specification already in use by Contra Costa municipalities, with a minor modification (specifying particle distribution of the compost fraction). The specification was submitted to the Water Board by BASMAA on December 1, 2010.

The November 28, 2011 amendment to the MRP revised Provision C.3.c.i.(2)(b)(vi) to state that bioretention facilities must "infiltrate runoff at a minimum of 5 inches per hour during the lifetime of the facility. The soil media for… bioretention systems shall be designed to sustain healthy, vigorous plant growth and maximize stormwater runoff retention and pollutant removal. Permittees shall ensure that Regulated Projects use… soil media that meet the minimum specifications set forth in Attachment L." Attachment L included the submitted specification.

Water Board staff's decision to include the complete bioretention soil specification in Attachment L created a situation in which the specification cannot be modified to reflect experience with its application. For example, the following issues with the specification have come up since it was adopted:

- Compost available in the Bay Area does not always meet every criterion in the specification, due to factors beyond the contractor's control;

- In drier climates, drought tolerant or native plants do not thrive in the fast-draining sand/compost mix because it does not retain moisture as well as native soil and require increased irrigation;
- Some testing requirements have become unavailable or outdated;
- Permittees are currently experimenting with soil media additions that could enhance removal of pollutants (specifically for PCBs); these additions would not be in compliance with the Permit if used on C.3 Regulated Projects.
- Although the MRP does allow “alternative” soil mixes to be used, it is difficult for Permittees to verify that the mix is acceptable.

Lessons from the Permittees’ experience with the soil specification may be valuable when considering the inclusion of engineering specifications in MRP 2.0 permit requirements generally. Some of these lessons are:

  - Development of specifications is best done by Permittees using their implementation experience.
  - Permit requirements can be helpful when they endorse the use of a regional specification. This helps bring all Permittees up to the same level.
  - Permit requirements need to include flexibility. This can be done by stating the objective and mandating that Permittees adopt specifications that fulfill the objective.
  - Where there is consensus around a design standard, it can be useful to identify that design standard as a reference point (that is, by stating that facilities must be “as effective as” a facility built to the design standard).

Based on the Permittees’ experience implementing MRP Attachment L, it is recommended that MRP 2.0 retain the existing statement of objectives for bioretention planting media, and identify the need for Permittees to have a specification, but omit Attachment L and references thereto. This would ensure bioretention planting media meets permit objectives while allowing improvements to soil specifications to be readily implemented (regionally) based on Permittee experience. For example, if healthy, low water use plants are expected to populate bioretention facilities and the mandated reduction in water use continues, then a soil specification that allows for greater moisture retention may be needed.

4.3.3 Bioretention Physical Configuration and Underdrain Elevation

The current bioretention design evolved, over more than a decade, from early guidance and specifications for "landscape-based" treatment facilities, which once included vegetated filter strips and conventional swales (sometimes called "grassy swales" or "bioswales"). Lack of detailed specifications sometimes resulted in the design and construction of ineffective facilities. Here are some of the factors that contributed to the evolution of bioretention design criteria:

- Landscape-based facilities constructed from on-site clay soils often retained ponded runoff, resulting in vector concerns, and macrophyte growth.
- Filtration through porous media is a more reliable and effective mode of treatment than allowing runoff to flow overland through vegetation.
- Bioretention facilities, although somewhat more expensive and difficult to construct than conventional swales, do not require more land area than other landscape-based facilities, and can be shaped to fit the same footprint as conventional swales.
- Bioretention facilities, unlike conventional swales, can have inlets any point around their perimeter (and may have inlets at more than one point) without compromising runoff quality.

MRP Provision C.3.c.i.(2)(b)(ii) refers to "a properly engineered and maintained biotreatment system," and MRP Provision C.3.c.i.(2)(b)(vi) states that bioretention facilities shall be designed to have a surface area no smaller than what is required to accommodate a 5 inches/hour surface loading rate.

Beginning in 2004, the stormwater programs developed and specified, in their guidance manuals, a configuration for bioretention facilities. The current design standard, consistent among the stormwater program manuals, include the following components:

- 6-inch-deep surface reservoir
- 18-inch-deep planting media (specified biotreatment soil mix)
- 12-inch-deep gravel layer
- Open interface of the gravel layer to underlying soils (where infiltration is allowed)

- A “raised” underdrain with the discharge elevation set near the top of the gravel layer to maximize infiltration (where allowed).
- Where infiltration is not allowed (e.g., due to high groundwater, contaminated soils, close proximity to buildings, location on podium structure, etc.), the facility may be lined and the underdrain placed at the bottom of the gravel layer.

4.4 Summary of Recommendations for Low Impact Development

In summary, the following are recommended for MRP 2.0:

- Site Design Requirements
  - Require Regulated Projects to show the site delineated into DMAs, and make explicit how self-treating areas and self-retaining areas may be used to reduce the amount of runoff that must be treated.
  - Require Permittees to adopt and implement design requirements for self-treating and self-retaining areas, including pervious pavements and green roofs.
  - Allow Permittees to keep site design requirements and specifications in guidance manuals and do not include specific design requirements in the Permit.
- LID Treatment
  - Omit the feasibility test and allow bioretention as an equivalent “first tier” option for LID treatment.
  - Omit the criteria for biotreatment soil media (Attachment L). Generally, for design criteria, state the objectives to be met, and require Permittees to develop and implement criteria, but do not incorporate criteria into the permit.
  - Continue to include performance criteria for LID treatment in the Permit, and allow Permittees to maintain guidance and standards for bioretention design and construction outside of the permit.

5 · Hydromodification Management

In this section, we first review the Hydromodification Management (HM) requirements and their applicability, and summarize the technical concepts of hydromodification management, flow duration control, erosion potential, and low flow threshold. We then discuss ways to better integrate LID requirements and HM requirements to—and size facilities more efficiently—in MRP 2.0.

5.1 Background

5.1.1 Hydromodification Management Requirements

Water Board Region 2 staff introduced Hydrograph Modification Management (the term was later condensed to “Hydromodification Management”) as part of the C.3 provisions added to the countywide permits in 2001-2003. Similar requirements were later included in municipal NPDES permits throughout California.

The Water Board’s original C.3 Provisions required the Permittees to submit a Hydromodification Management Plan (HMP), to be “implemented so that post-project runoff shall not exceed estimated pre-project rates and/or durations, where the increased stormwater discharge rates and/or durations will result in increased potential for erosion or other significant adverse impacts to beneficial uses, attributable to changes in the amount and timing of runoff. The term duration… is defined as the period that flows are above a threshold that causes significant sediment transport and may cause excessive erosion damage to creeks and streams.”

The hydromodification management (HM) requirements were continued as part of the MRP, with specific attachments to the MRP based on the HMPs submitted by the Permittees (typically by county or region). The current HM Standard, consistent for all Permittees, is that “stormwater discharges from HM Projects shall not cause an increase in the erosion potential of the receiving stream over the pre-project (existing) condition”.

HM is required for projects that create or replace an acre or more of impervious area. Projects may comply, or are exempted, by showing that there is no net increase in impervious area (that is, no increase in runoff as compared to the pre-project condition).

Projects located so that downstream runoff affects only pipes, hardened channels and tidal or aggrading channels are exempted. In Santa Clara and San Mateo Counties and the City of Vallejo, projects located in catchments or subwatersheds that are 65% or more impervious are also exempted; this exemption does not currently apply in Contra Costa or Alameda.

5.1.2 Flow Duration Control

Flow duration is defined as the number of hours in a long term flow record that a particular flow rate occurs. The concept of flow duration control was developed in the Pacific Northwest in the 1990s, stimulated by advances in hydrogeomorphology and by the availability of computing power to calculate hour-by-hour stream flows over many years (continuous simulation).

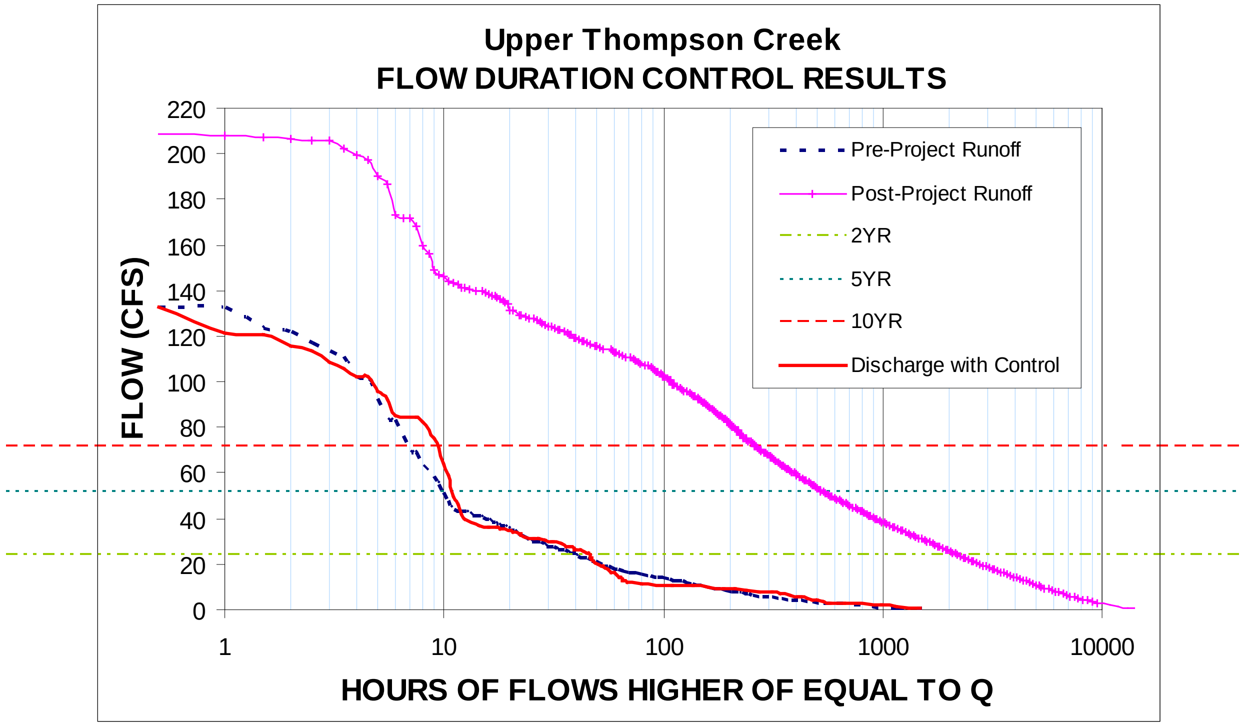
Flood control requirements, already common at that time, required on-site detention to reduce peak runoff from infrequent, large storm events (with recurrence intervals of 10 to 100 years). In some jurisdictions, these requirements were augmented to provide peak-flow controls for more frequent, smaller runoff events (typically the 2-year event). However, studies showed that peak flow control, even for smaller events, was not sufficient to protect receiving stream channels from erosion (MacRae, 1996). In between storm events, flood detention facilities were drawn down, and the discharge rates from these facilities were sometimes high enough to move sediment in receiving streams. Because the drawdown had occurred over many hours, the erosive effects accumulated over time.

The proposed solution—flow duration control—involves limiting the duration of such flows to that which existed prior to development, and to allow increased durations of flow only for flows below the threshold at which sediment movement is likely to occur. The first HMP in the Bay Area (submitted by the Santa Clara Valley Program) utilized flow duration control as one method for achieving the erosion potential management objective, which became the model for subsequent HMPs.

Typically this method of hydromodification control is demonstrated by a flow duration curve, i.e., a plot of flow rates versus the number of hours the flow rate is exceeded, for the pre-project and post-project conditions. The plots are generated by continuous simulation models, using hourly rainfall data from a period of 30 years or more. The continuous-simulation model tracks rainfall, runoff, routing through a basin or other facility, drawdown of the facility, drying of soils between storms, etc.

An example plot is shown in Figure 5-1.

Figure 5-1. Example Flow Duration Curves from Continuous Simulation Modeling (SCVURPPP, 2005)



5.1.3 Erosion Potential

Erosion potential (E_P) can be expressed as the ratio of the post-project effective "work" (erosive force over time on channel bed or banks) to the pre-project effective work. Beginning with flow duration curves for the pre-project and post-project condition, E_P can be assessed as follows:

1. Divide the range of flow rates into "bins" representing a narrow range of flows (e.g., 0-5 cfs, 5-10 cfs, etc).
2. For each flow-rate "bin," determine the resulting depth and velocity of flow in a channel section.
3. For each flow rate "bin," determine the resulting excess shear stress (the increment in shear stress over the shear stress at the flow threshold below which no sediment movement is likely to occur) for the stream bed and bank.
4. For each flow rate "bin," multiply the excess shear stress times the duration of flow. This is the incremental effective "work" done on the stream bed and bank for that flow rate "bin".

5. Sum up the effective "work" for all flow rate "bins".
6. Compare this sum of effective work for the pre-project and post-project condition. This ratio of the post-project to the pre-project effective work is described as E_P.[13]

Since the HM standard in the MRP is that post-project stormwater discharges shall not cause an increase in the erosion potential of the receiving stream over the pre-project condition, an E_P of 1.0 must be achieved.

For any given stream flow rate, the depth and velocity of flow—and the resulting shear stress—will be different for each section in a stream channel. For any calculated shear stress, the potential to move sediment depends on the characteristics of the soil making up the stream bed and bank.

Stream channels that are incised experience higher velocities and shear stresses. Streams with sand beds and banks are highly prone to erosion; those with cohesive (clay) soils somewhat less so; those with rock or cobble beds and banks are considerably more resistant.

5.1.4 Range of Flows for Hydromodification Management

An evaluation was performed of the range of flows that are the most important for stream channel erosion and hydromodification impacts in Santa Clara Valley as part of preparation of the Santa Clara Program HMP submittal (Geosyntec, 2004, TM#4). The evaluation was based on field-based watershed assessments conducted for three subwatersheds in the Valley.

The lower limit of the range is based on the flow threshold in each stream reach that initiated erosion of the stream bed or bank. The flow threshold was evaluated at 14 stream cross-sections within the three subwatersheds, and ranged from 3 to 40 cfs[14]. The values were normalized by relating the flows to the 2-year peak flow for the stream section under pre-development conditions; the resulting normalized thresholds ranged from 2 to 18% of the 2-year pre-development peak flow, with an approximate average of 10% of the 2-year pre-development peak flow for the three subwatersheds. To partition this flow threshold among contributing land areas, an on-site project design criteria of 10% of the pre-project 2-year peak flow (abbreviated as 0.1Q2)

[13] Current practice for assessing E_P takes into account additional factors such as sediment supply.

[14] The largest value (40 cfs) was observed in two cross-sections that were located in a section of channel engineered with grade controls.

was proposed as the allowable low flow from a HM facility. This became the standard low flow threshold for the current MRP.

The upper limit of the range of flows was determined by analyzing the cumulative "work" (erosive hydraulic force) exerted by stream flows in various stream sections before and after development. The analyses indicated that 90-95% of the total work done on the channel bed and banks is associated with flows up to the pre-development 10-year peak flow in the stream. Flows higher than the 10-year peak flow perform a very small percentage (5-10%) of the total work because they occur relatively infrequently over the period of record. Thus, the upper limit of the range of flows for flow-duration matching was proposed to be the pre-development (i.e., pre-project) 10-year peak flow, consistent with a "knee of the curve" cost-effectiveness approach for controlling erosive flows (SCVURPPP, 2005).

5.1.5 Flow Duration Control Design Criteria

As a result of the Santa Clara, Alameda, and San Mateo Program HMP submittals (and the subsequent Vallejo Program submittal), MRP Provision C.3.g.ii(1) established that HM controls be designed such that post-project flow durations match pre-project flow durations from 10 percent of the 2-year peak flow (0.1Q2) to the 10-year peak flow (Q10) for these programs. The Fairfield-Suisun Program was assigned a design low flow threshold of 20 percent of the 2-year peak flow (0.2Q2) based on local, stream-specific studies. The Contra Costa Program was allowed to meet a low flow threshold of 0.2Q2 when Integrated Management Practices (IMPs, or LID facilities), sized using established sizing factors, are used. MRP Provision C.3.g.ii.(2) also specified a "Goodness of Fit" criterion as follows: "The post-project flow duration curve shall not deviate above the pre-project flow duration curve by more than 10 percent over more than 10 percent of the length of the curve corresponding to the range of flows to control." The "goodness of fit" criterion was developed in Washington State; as far as is known, the specific limits were identified to accommodate a reasonable level of precision for the designers of flow-duration control basins to achieve.

Developments in Contra Costa are subject to an additional flow-control criterion, proposed in the CCCWP Hydromodification Management Plan, as follows (MRP Attachment C):

> For flow rates from 0.5Q2 to Q2, the post-project peak flows shall not exceed pre-project peak flows. For flow rates from Q2 to Q10, post-project peak flows may exceed

pre-project peak for by up to 10 percent for a 1-year frequency interval. For example, post-project flows could exceed pre-project flows by up to 10 percent for the interval from Q9 to Q10 or from Q5.5 to Q6.5, but not from Q8 to Q10.

The criterion does not apply outside of Contra Costa.

Attachments B, C, D, E, and F to the MRP describe the different sets of criteria and exemptions that apply to each area-wide program.

5.2 Experience with Implementation of HM Standards

Hydromodification management requirements have been primarily met with on-site controls, including 1) site design and treatment measures that help reduce flow; and 2) flow duration control measures as needed. The most commonly used flow duration control measures include detention/infiltration basins, underground vaults (or large diameter storm drain pipes), and modified bioretention facilities. The MRP also allows the use of regional facilities and instream controls to meet HM requirements, but these options are rarely implemented.

5.2.1 Flow Duration Control Measure Design

As discussed above, the flow duration control approach requires the use of a continuous simulation hydrologic model to analyze the runoff flows resulting from a long term rainfall record. To make this design process easier for development applicants to perform and municipal staff to review, several tools were developed:

- The Santa Clara, San Mateo and Alameda Programs jointly funded the Bay Area Hydrology Model, based on the Western Washington Hydrology Model and calibrated to local watersheds, to simulate pre- and post-project hydrology on-site (including the presence of LID measures) and automatically size facilities that meet the flow duration matching criteria;
- The Contra Costa Program developed sizing factors for IMPs (including bioretention) using a continuous simulation model, and a tool for applying the sizing factors to a specific project;
- The Fairfield-Suisun Program, as part of its HMP, developed sizing curves for bioretention and detention basins specific to its watersheds.

Conventional (non-LID) flow-duration-control basins are equipped with a low-flow outlet orifice designed to limit the discharge rate to the specified low-flow threshold. Above the low-flow outlet orifice, one or more larger-diameter outlet orifices or weirs are provided. The number, size, and elevation of the outlet orifices/weirs are designed so that the post-project flow duration curve matches, as closely as possible, the pre-project flow duration curve.

Bioretention facilities rely on retention of runoff in the planting medium and underlying gravel layer, and on infiltration to native soils, to mimic pre-development hydrology. These processes are less controllable and predictable than the construction of basins and outlet structures. A bioretention facility designed for HM control typically has a raised underdrain with orifice control to limit discharge to the low flow criterion.

5.2.2 Contra Costa Model Calibration and Verification Project

CCCWP's *Stormwater C.3 Guidebook* includes factors for sizing bioretention facilities to meet the HM criteria. The factors were presented in the 2005 HMP and used the curve-matching procedure with a low-flow threshold of 0.5Q2. The factors were updated in February 2009 using a low-flow threshold of 0.2Q2. Later that year, the latter criterion was incorporated into MRP Provision C.3.g.ii.(1).

CCCWP's continuous-simulation model of bioretention performance used textbook values for some model parameters. As required by MRP Attachment C, CCCWP conducted *in situ* monitoring of some bioretention facilities and then used the monitoring results to calibrate the model used in the 2005 HMP. The results were submitted to Water Board staff, as required, in a September 2013 report (CCCWP, 2013).

Observed values for the rate of infiltration into subsurface soils were about eight times higher than were assumed in the 2005 model—0.24 inches per hour vs. the previously assumed (textbook) rate of 0.03 inches per hour.

Assessing the current sizing factors using the calibrated model, CCCWP consultants concluded that facilities built using these criteria would meet the criterion using a 0.2Q2 threshold and would also meet, with current design requirements or slight changes to design requirements, the criteria using a 0.1Q2 threshold.

5.2.3 Effects of Design Criteria on Sizing of Facilities

The historical development of HM and LID criteria—which were added to the permit in stages between 2001 and 2011—created practices in the design process that may cause facilities to be sized larger than is needed to fully protect water quality and maintain stream channel integrity.

This oversizing can generate significant costs for projects using LID measures to meet HM criteria. When development project sites are laid out, it is harder to arrange space efficiently. This works against current public agency efforts (including ABAG's Plan Bay Area) to increase density and walkability of neighborhoods, and slows the trend to reverse sprawl. When bioretention sizing factors exceed 4%, designers tend to move the bioretention facilities to the periphery of a development rather than integrating the facilities into the landscaping distributed throughout the site. This works against LID principles of mimicking predevelopment hydrology within the site. In addition, there are indirect environmental impacts associated with excavation and gravel backfill to create unneeded runoff storage. Gravel is mined from stream beds and mountainsides and is transported in diesel-fueled trucks.

In this section, we will discuss two criteria that have a significant impact on the sizing of HM facilities – low-flow thresholds and the "goodness of fit" criterion.

Low-Flow Thresholds

The 0.1Q2 criterion was developed to be protective of Santa Clara Valley streams that may or may not be representative of streams in other parts of the Bay Area. A less stringent criterion may be applicable in Bay Area watersheds that have less constrained creek cross-sections and/or more resistant bed and bank material. For example, a 0.2Q2 criterion was proposed and accepted for Fairfield-Suisun Permittees, based on analyses of specific stream conditions in the Fairfield-Suisun watersheds, and is included in MRP Attachment D. Low-flow criteria in Sacramento County are 0.25Q2 or 0.45Q2, and in San Diego County may be 0.1Q2, 0.3Q2, or 0.5Q2.

Alameda and Santa Clara Permittees are allowed, as part of their specific HM provisions, to prepare a "User Guide" with instructions for assessing stream stability and proposing a less stringent low-flow threshold that might be applicable for a particular development project. However, those Permittees have not prepared these instructions or allowed this option to date. Reliable determination of criteria for individual watersheds would likely require too much public investment if done in advance, and too much lead time (and possibly too much cost accruing to one project) if done project-by-project.

A second cause of oversizing may be the application of in-stream low-flow thresholds to individual project sites. There are a number of factors that may mitigate the discharge of flows from HM facilities before they reach a receiving stream. Some of these factors are:

- *The area tributary to the HM facility is only a portion of the stream's watershed at the discharge point.* In-stream low-flow thresholds are set to accommodate very long durations of flow as HM facilities drain following a storm. In some steep, "flashy" watersheds where HM is needed, HM facilities drain long after runoff from surrounding areas (whether built or natural) has ceased.
- *Watershed position of the discharge.* Below headwaters areas, the drainage areas from newly developed sites typically account for a small portion of the entire watershed at the discharge point. Even if the site's low-flow discharge coincided with other stream flows, the increment may be too small to increase the risk of erosion.
- *Losses between the HM facility discharge and the stream discharge point.* The low-flow discharges for HM facilities are very low flows, and a significant portion can be expected to be lost in piped or channel flow between the HM facility and the receiving stream. This is especially true for development projects that incorporate LID design, which emphasizes the use of many small facilities within a site. Typical HM bioretention facilities discharge through orifices less than an inch in diameter. It is also especially true for development project sites that discharge to the MS4 rather than directly to the stream, allowing for additional losses to occur between the site and the stream.

"Goodness of Fit" Criterion

As noted in Section 5.2 above, the "goodness of fit" criterion in MRP Provision C.3.g.ii.(2) allows designers of flow duration control basins reasonable leeway to facilitate the sizing and placement of the orifices and weirs controlling discharge.

The "goodness of fit" criterion is more difficult to meet with bioretention facilities and other LID facilities that rely, to a greater extent, on a simple outlet configuration and infiltration to mimic pre-development hydrology. Being dependent on natural processes, and having fewer options for controlling outflow, these facilities are less amenable to minute adjustments in performance.

LID facilities tend to control higher-rate flows (in the vicinity of Q2, or the 2-year pre-development peak flow) to well below the pre-project condition. However, because of the way the "goodness of fit" criterion is written, this control cannot be credited to offset any exceedance of pre-project low flows.

The intent of the flow-duration-control criteria is to limit the additional "work" done by increased flow durations on stream beds and banks. The current "goodness of fit" criterion is based on the flow duration control curve matching approach; a direct evaluation of E_P control would more closely approximate the total "work" done on the streambed.

5.3 Recent Studies on Criteria and Facility Size Relationships

5.3.1 CCCWP HM Facility Sizing Study

In November 2014, Dubin Environmental Consulting examined the relationship between HM criteria and facility size (Dubin, 2014). The investigation involved running the calibrated continuous-simulation model described in Section 5.2.2 above for different low-flow-thresholds of 0.1Q2, 0.2Q2, and 0.3Q2, for gravel depths of 12 inches and 30 inches, and for the current goodness-of-fit criterion and the following alternative:

> The net deviation of the post-project flow duration curve from the pre-project flow duration curve shall not be more than 10% over more than 10% of the length of the curve corresponding to the range of flows to control.

Results are shown in Table 5-1.

Table 5-1. Computed Bioretention Sizing Factors for Type D Soils				
Gravel Depth	Lower Control Threshold	Sizing Factors		
		Current Flow Duration Standard + Peak Flow Frequency Matching	Alternative Flow Duration Standard + Peak Flow Frequency Matching	Alternative Flow Duration Standard Only
12 in	0.1Q2	0.056	0.052	0.040
12 in	0.2Q2	0.050	0.044	0.040
12 in	0.3Q2	0.046	0.042	0.040
30 in	0.1Q2	0.050	0.046	0.040
30 in	0.2Q2	0.046	0.040	0.040
30 in	0.3Q2	0.042	0.040	0.040

The following conclusions were drawn from this study:

- The calibrated model yields sizing factors in the range of 0.04 to 0.06 using current MRP criteria.
- The addition of the peak flow frequency matching criterion (applicable only in Contra Costa County, see Section 5.2) interacts with the flow-duration-control criterion to produce a significant effect on minimum facility sizing.
- Using a flow duration control approach, a low-flow threshold criteria of 0.2Q2 or 0.3Q2 would substantially reduce minimum facility sizing.
- With the use of the proposed alternative curve-matching criterion, and omitting the peak flow frequency matching criterion, bioretention facilities currently sized for treatment-only (and with orifice control on the raised underdrain) would also meet HM criteria, even with the current low-flow threshold of 0.1Q2.

Note that the results apply to the Martinez gauge and to Hydrologic Soil Group (HSG) “D” (clay) soils. A small increase in facility size can be anticipated for drier climates. In the Contra Costa *Stormwater C.3 Guidebook*, sizing factors are larger in more permeable soils; however, it was recommended that development of new sizing factors for HSG “A,” “B,” and “C” soils be completed with revised estimates of infiltration rates achieved by bioretention facilities located in those soils.

5.3.2 Study of Facility Sizing Based on Maintaining Erosion Potential

In December 2014, BASMAA contracted with Geosyntec Consultants to conduct erosion potential (E_P) analyses using the flow records generated by the 2014 Dubin study and assumptions about downstream channel cross-section and longitudinal slope. The objectives of the analyses were:

1. Evaluate the erosion potential (E_P) resulting from discharge from bioretention facilities sized according to existing and alternative flow-duration-control curve-matching criteria.
2. Analyze whether an alternative flow-duration-control curve-matching criterion could substitute for the use of E_P as a criterion for determining facility size.
3. Analyze whether an E_P Control standard could be used to develop sizing factors.

<u>The analyses concluded the following:</u>

1. For the particular set of site conditions and downstream channel characteristics analyzed, the existing flow duration matching criterion results in a facility size that achieves an E_P of less than 1.0 (i.e., is slightly over-protective).
2. Preliminary results warrant further evaluation of the "Alternative Flow Duration Standard + Peak Flow Frequency Matching" standard because it produced similar sizing factors as Ep Control.
3. Further evaluation of sizing factors to achieve an Ep Control standard is warranted because Ep is a direct measure of the geomorphic processes associated with hydromodification.
4. Future studies should evaluate the sensitivity of the analyses to the following variables:
   - Channel cross-section;
   - Channel slope
   - Infiltration rate from the bioretention facility into native soil
   - Low flow threshold
   - Size of tributary area to receiving channel and percent imperviousness

The analyses are currently being documented in a memorandum to BASMAA that will be made available at a later date.

5.4 Recommendations for HM Criteria

The current Provision C.3.g containing the HM requirements (and associated attachments) represents one of the few sections of the MRP where there are different requirements for each area-wide program. Based on their experience implementing this provision, Permittees desire a consistent and more flexible set of requirements that gives project proponents options for cost-effective solutions and better integrates HM and LID approaches.

To achieve this goal, we recommend the following:

- Eliminate the attachments with separate HM requirements and create one consistent set of requirements for all Permittees, including consistent exemptions, while allowing some variation in low flow thresholds based on stream-specific studies if available.
- Allow Permittees to utilize any of the available tools, including the BAHM, IMP sizing factors, and sizing curves, as applicable and calibrated to the particular hydrologic and geologic conditions of the project site.
- Allow flexibility in the numerical control standard for hydromodification management in order to meet an overarching erosion potential management objective. The sizing methodology should be allowed to be based on either a flow duration control standard, an Ep Control standard, or a flow duration curve matching criterion that more closely approximates an Ep Control standard (to be explored in future studies).

6 ▪ Operation and Maintenance

In this section, we review the current MRP requirement to operate a program to verify the operation and maintenance (O&M) of stormwater treatment and HM facilities, describe our experience with implementation of the requirements for different types of facilities, and provide recommendations for changes in the next permit.

6.1 Current Requirements

MRP Provision C.3.h requires Permittees to:

- Have a means to make owners of facilities responsible for O&M.
- Have the authority to inspect privately-owned facilities.
- Conduct inspections of privately-owned facilities at a prescribed frequency.
- Conduct O&M and inspections of the facilities they own.
- Maintain records and submit annual reports.

The requirements in Provision C.3.h. are very similar to O&M verification requirements in other California municipal stormwater permits (including the predecessor permits to the MRP). The requirements were written in an era when the common stormwater treatment technologies included continuous-deflector separation (CDS) units, in-vault proprietary media filters, extended detention basins, and (less commonly) sand filters and infiltration basins.

All of these technologies require frequent maintenance to be effective. Also, many of the technologies are "out of sight, out of mind" by either being located in below-ground manholes or vaults (in the case of CDS units and in-vault media filters), or are typically located in inaccessible or fenced-off locations (in the case of extended detention basins). The earlier permits' emphasis on establishing effective operation and maintenance verification programs—and in particular, ensuring that municipalities had means and mechanisms to compel facility owners to conduct regular maintenance—made sense in this context.

Nationally, the impetus to shift from these systems to LID came, in large part, because of the need to develop a different strategy for operation and maintenance. Despite best efforts, staff in Prince Georges County, MD, had found that detention basins were often neglected and became both an aesthetic and maintenance liability. LID facilities, and rain gardens in particular, were seen as a means to make stormwater treatment facilities visible and attractive, and to thereby foster community engagement in their inspection and upkeep.

While LID facilities also require periodic maintenance to continue to function effectively, the LID approach also focuses on outreach to and education of the community in which the facilities are located. People become involved in the facilities' upkeep because of direct ownership, or they may have indirect "ownership" in the sense that they benefit from the aesthetic or other ancillary purposes of the facilities.

6.2 Experience with Implementation

6.2.1 Administration

These requirements are simple in concept. However, developing legal and other mechanisms to compel property owners to maintain facilities in perpetuity is complicated in some cases—especially if the ownership or responsibility is divided among owners, as frequently happens when land is subdivided.

Further, when organizing municipal staff stormwater responsibilities, there has been difficulty coordinating the O&M verification program. (This is in contrast to planning, design, and construction of facilities, which generally goes along with parallel responsibilities for other aspects of a development project.) Finally, tracking ownership, status, and inspection history of each facility, and recovering costs of the O&M verification inspections, creates a substantial administrative challenge.

After a decade of C.3 implementation, some municipalities' O&M verification programs are organized on a small scale. For these agencies, there aren't yet enough facilities to justify developing a database to track them, or a fee to recover costs, so local stormwater coordinators conduct the inspections as part of their normal varied duties. Other municipalities have large numbers of facilities, both LID and non-LID, that have been installed over the years, and have developed detailed tracking systems and databases as well as permitting and fee recovery programs.

As the number of facilities that have been built and are subject to O&M verification requirements continues to increase each year, all municipalities will need to shift additional resources toward the oversight of thousands of facilities distributed across the urban landscape. It is essential that MRP 2.0 anticipate this shift, by allowing flexibility in the frequency of O&M verification inspections, eliminating unnecessary and nonproductive requirements from within Provision C.3, and promoting the planning, design, and construction of robust and easily inspected facilities.

6.2.2 Bioretention Facilities

If built correctly, bioretention facilities can perform for many decades with minimal maintenance. Typical annual maintenance requirements are to prune vegetation once in winter and to clean up any accumulated trash or debris. Depending on conditions, and typically less frequently than annually, it may be necessary to add mulch, remove invasive weeds, and remove accumulated sediments near inlets.

Problems may occur as the vegetation grows in during the first one to two years following installation. Typical problems include the choking of inlets with excessively dense vegetation, covering of the soil surface with woody roots, or failure of vegetation to thrive. These are remediated by removing and replacing the vegetation as necessary.

During their life, bioretention facilities are susceptible to alteration, which can happen when maintenance personnel are unaware of the facilities' operating parameters and requirements. The most common problematic alteration occurs when soil, plants, or excessive mulch are added to the planting soil, raising the top of soil elevation. This can cause some areas of the facility surface to remain dry even when the surface reservoir is full and spilling into the overflow.

Another, related, concern is that maintenance personnel who are unaware of the facility's purpose could apply fertilizer or pesticides during landscape maintenance.

6.2.3 Pervious Pavements

Bay Area municipalities have had limited experience with long-term maintenance of pervious pavements. Earlier guidance emphasized the need for regular vacuum cleaning of porous concrete and porous asphalt; however, industry representatives note these materials are so permeable that the normal pace of clogging is unlikely to substantially affect the facilities during their useful life.

A more realistic maintenance concern is the potential for unintentional alteration, caused by:

- Storage of dirt or like materials on the pavement surface,

- Sealing of surface materials to address raveling or surface deterioration, particularly “slurry sealing” of pervious asphalt, or
- Utility trenching and pavement patching

In the MRP and stormwater program guidance documents, pervious pavements are considered a site design measure and not a treatment measure. As a result, pervious pavements are not always included in maintenance agreements and in municipalities’ inventories for O&M verification inspections. Some municipalities have begun regular inspections of pervious pavement that are coordinated with inspections of other treatment measures on the same site. However, in cases where the use of pervious pavement reduces the impervious surface created or replaced on a project below the C.3 regulated project threshold, that project is no longer tracked by the municipality for stormwater compliance.

6.3 Recommendations

The Permittees’ O&M verification programs have become institutionalized over the past decade and have been relatively successful. There are no compelling reasons to make major changes to the current O&M verification requirements. However, based on our experience with implementation of the current requirements, we make the following recommendations for improvement:

- Eliminate the requirement to annually inspect 20% of the total number of installed stormwater treatment systems and HM controls, but maintain the requirement to inspect facilities at least once every five years.
- Allow Permittees options and flexibility to make O&M verification programs more efficient, such as utilizing third party inspectors and allowing responsible property owners to self-certify by submitting self-inspection reports and proof of maintenance.
- Pervious pavements should not be required to be tracked and inspected, but permittees should include them in maintenance agreements and provide educational information on proper maintenance of pervious pavement to the property owner.
- Reduce annual reporting requirements for O&M verification programs, but require Permittees to continue to track ownership, status, and inspection history of each facility and maintain detailed records.

- Eliminate unnecessary and nonproductive requirements from other sections of Provision C.3 and promote the planning, design, and construction of robust and easily inspected facilities.

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APPENDIX A

Special Projects Categories, Criteria, and LID Treatment Reduction Credit

Category	Impervious Area	Project Characteristics	Criteria (Acreage refers to total site acreage)	LID Credit	Comments
A Lot Line to Lot Line	X ≤ ½ Ac	Urban/Pedestrian design[1] in Business/ Downtown Districts[2]	No density criterion	100%	Zero surface parking[3] ≥ 85% Site Coverage[4]
B High Density	½ Ac ≤ X ≤ 2 Ac	Urban/Pedestrian design* in Business/ Downtown Districts	Floor Area Ratio (FAR) ≥ 2:1; OR for Residential (Res) projects, ≥ 50 Dwelling Units (DU)/Acre	50%	Zero surface parking[3]
			FAR ≥ 3:1; OR Res ≥ 75 DU/Acre	75%	
			FAR ≥ 4:1; OR Res ≥ 100 DU/Acre	100%	
C Transit Oriented	No limit	TOD characteristics Non-auto-use project FAR ≥ 2:1 OR Res ≥ 25 DU/Ac	*Location Credits (count only one)*		
			within ¼ mi of transit hub[5]	50%	50%+ of site w/in distance
			within ½ mi of transit hub	25%	
			within a Priority Development Area	25%	100% of site w/in PDA
			Density/FAR Credits		
			FAR ≥ 2:1; OR Res ≥ 30 DU/Acre	10%	
			FAR ≥ 4:1; OR Res ≥ 60 DU/Acre	20%	
			FAR ≥ 6:1; OR Res ≥ 100 DU/Acre	30%	
			Minimized Parking Credits		
			≤ 10% at-grade surface parking	10%	Surface parking uses LID
			Zero surface parking[3]	20%	

[1] Built as part of- a municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design.

[2] Located in a municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian-oriented commercial district, or historic preservation site and/or district.

[3] Incidental parking allowed: surface parking required for emergency vehicle access, ADA accessibility, and passenger and freight loading zones.

[4] Remaining portion to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections and public uses.

[5] Transit hub as defined in MRP Provision C.3.e.