Contra Costa Clean Water Program

Work Plan

and

Literature Review

for the

Hydrograph Modification Management Plan

12 May 2004 (Final)

Contra Costa Clean Water Program

C.3 Technical Work Group

Mitch Avalon, *Contra Costa Flood Control District*

Mark Boucher, *Contra Costa Flood Control District*

Greg Connaughton, *Contra Costa Flood Control District*

Detlef Curtis, *City of San Ramon*

Angela El-Telbany, *City of San Pablo*

Steve Lake, *Town of Danville*

Leary Wong, *City of Pleasant Hill*

Teresa Wooten, *City of Brentwood*

Executive Summary

Regional Water Quality Control Board Order R2-2003-0022 Provision C.3.f requires the Contra Costa Clean Water Program (Program) to prepare and submit a draft Hydrograph Modification Management Plan (HMP), with implementation to begin after 15 May 2005. The Order requires submittal of this Work Plan and Literature Review as an interim work product.

The HMP will be a plan to manage increases in peak runoff flow and increased runoff volume from development projects that create one acre or more of impervious area (the threshold falls to 10,000 square feet on 15 August 2006) where the increased flow or volume is likely to accelerate erosion of creek beds or banks or otherwise impact beneficial uses of creeks.

The Program's HMP will be in the form of a manual that project applicants and municipal staff can use as an aid in designing and reviewing proposed hydrograph modification best management practices (BMPs) which must be incorporated in development projects. The Program's conceptual approach aims to streamline and simplify this process as much as possible.

Using the Program's approach, the applicant may demonstrate that the proposed project will not increase the peak flows and durations of site runoff. Failing that, the applicant may propose on-site or off-site BMPs that will mitigate the potential increases in runoff. If these BMPs are not feasible, or the applicant chooses not to include them in the project plan, the applicant has a third option of assessing stream vulnerability to erosion. The applicant may be able to determine that the downstream reaches have a low risk of erosion; if so, increases in runoff peak flows and volumes may be allowed without further mitigation. If the stream has, in fact, a high risk of erosion due to watershed hydrograph modification, then the applicant must propose additional flow-control BMPs or in-stream erosion-control BMPs as part of the project.

This Work Plan details the Program's objectives and conceptual approach to implementing the HMP and includes a scope of work to be implemented by a consultant. A schedule lists milestones (completion and review of work products) leading up to submittal of the draft HMP.

Table of Contents

1 · Introduction

1.1 Submittal Requirements and Schedule

San Francisco Bay Regional Water Quality Control Board (Water Board) Order R2-2003-0022 Provision C.3.f requires the Program to prepare and submit a Hydrograph Modification Management Plan (HMP). The Order prescribes steps and a schedule for developing the HMP. Following discussions with Water Board staff, revised dates have been proposed, as shown in the following table:

	Submittal	Date in Order	Revised Date
1	Detailed Work Plan and schedule.	15 February 2004	Submitted 29 February 2004
2	Literature review.	15 February 2004	Submitted 29 February 2004
3	Draft HMP, including an analysis that identifies the appropriate limiting storm or event range.	15 November 2004	15 March 2005
4	HMP for Regional Board approval.	15 May 2005	15 May 2005

HMP implementation is to begin upon approval by the Regional Board.

This final Work Plan incorporates Water Board staff comments on the 29 February 2004 literature review, work plan and schedule. Those comments were presented in a 7 April 2004 letter and were discussed and resolved in a 28 April 2004 meeting with Program staff.

During May 2004 the Program will solicit proposals from qualified consultants to execute the Scope of Services (Section 5 in this Work Plan) and prepare the draft HMP.

1.2 The Regional Board's HMP Vision

As a whole, the Regional Board's C.3 provisions require municipalities to revise their development review procedures so that future development and redevelopment projects are designed—to the maximum extent practicable—to prevent pollutant discharges and to protect beneficial uses of receiving waters.

Provision C.3.f requires municipalities to create and adopt a procedure for evaluating the potential impacts of new development projects on stream erosion. As stated in the Regional Board's "fact sheet" accompanying the Order:

> The HMP is an **analytical method**, with the inclusion of available relevant data, which a developer employs to demonstrate to the Permittees that the eventual design for the project will not lead to damaging flow impacts, when mitigative measures are included in the project. This often will involve some data gathering in the surrounding stream system and watershed by that development proponent, in the same way that such a developer would study the surrounding roads and traffic volumes before proposing and designing for new traffic as part of a proposed development [emphasis added].

The Regional Board also envisioned maps based on a screening-level analysis of areas based on levels of concern:

> During development of the HMP, the local flood management agency and municipalities could map potential development areas of high concern for the HMP, and also map areas in which evidence appears that the HMP is unlikely to be invoked due to existing channel hardening, or little remaining developable land and relatively stable conditions in the streams. There may be a third zone of potential development mapped in which case-by-case analysis must be done by development proponents to determine whether a more thorough HMP analysis is necessary. However, **we envision the primary resource burden for the HMP analysis borne by the development proponent,** after the stormwater program provides the analysis template [emphasis added].

Implicit in this vision is that developers and municipalities will use the HMP as a tool to do two things:

1. Analyze the potential for development to destabilize the beds and banks of the receiving stream and
2. Select and design any required management measures (BMPs) to be included in a particular project.

1.3 Provision C.3.f

Provision C.3.f. details the specific requirements for the HMP. In general, the provisions allow the Program and municipalities considerable flexibility, subject to the general requirement that the HMP be an effective means of managing increases in peak runoff flow and increased runoff volume where such increased flow or volume is likely to cause increased erosion of creek beds and banks.

Although Provision C.3.f. focuses on the need to control changes in runoff peak flows and volumes, its later sections (e.g., C.3.f.vi.5. and C.3.f.vii) also allow for equivalent protection of beneficial uses through in-stream enhancements (e.g., bank revegetation, stream buffers, and stream "restoration in advance") that would protect stream habitat from the effects of increased runoff flows.

1.4 Resources for HMP Preparation

The Regional Board added the C.3 provisions to the Contra Costa Clean Water Program's stormwater NPDES permit on 19 February 2003, with an implementation date for the C.3.f (HMP) provisions of 15 May 2005. Previously, on 17 October 2001, the Regional Board had added similar provisions to the stormwater NPDES permit administered by the Santa Clara Valley Urban Runoff Pollution Prevention Program, with an implementation date for the C.3.f. provisions of 15 October 2003 (this date was later extended). This difference in schedule has allowed the Contra Costa Clean Water Program the benefit of reviewing the Santa Clara program's work plan, literature review, and various draft HMP documents before preparing its own work plan submittal.

1.5 Local Development Review and HMP Implementation

Provision C.3.f.iv.4. requires that the HMP include a "description of how the Dischargers will incorporate… [HMP] requirements into their local approval processes…."

Ultimately, the effectiveness of the Program's HMP depends on the municipalities' ability to apply appropriate mitigation measures to the review of each applicable project. Therefore, from the Program's perspective, the principal function of HMP documentation should be to facilitate this aspect of the application/development review process.

The Program's HMP will be in the form of a manual that project applicants and municipal staff can use as an aid to designing and reviewing proposed hydrograph modification management measures. The Program's conceptual approach for the HMP (Section 3) has been developed with the aim of streamlining and simplifying this process as much as possible. As shown in the decision flow chart (Figure 1 on Page 12), the process is designed to minimize the time and effort required for data-gathering and analysis and to expedite a reasonable determination of the best management practices (BMPs) that the project will be required to implement.

This streamlining is achieved by a step-wise decision-making process that acknowledges inherent uncertainty regarding the severity of project impacts and allows most project applicants to select conservatively designed BMPs as an alternative to pursuing more detailed and protracted studies of stream and watershed conditions.

The Program's focus on implementing the HMP through the local development review process is consistent with its overall strategy for implementing the C.3 provisions. The Program recognizes that local development review is already complex and burdensome to project applicants. Applicants and municipal planners must negotiate a complex decision-making process to insure that projects are consistent with the municipal General Plan, zoning and other local ordinances, and other municipal development requirements, as well as (in most cases for projects covered by C.3) discretionary design review and compliance with the California Environmental Quality Act (CEQA).

The Program aims to assist municipalities to integrate C.3 requirements, including the HMP requirements, into the existing review process as much as possible by combining submittals and allowing for parallel and coordinated review. This will be achieved by incorporating HMP requirements into forthcoming Program guidance for C.3 compliance.

1.6 Continuous Improvement

The Program's HMP conceptual approach (Section 3) acknowledges inherent uncertainty in any methodology to estimate and mitigate the cumulative impacts of individual development projects. The Program's approach also recognizes that it doesn't make sense to delay implementation of hydrograph modification BMPs until the uncertainties regarding potential stream impacts are resolved.

Upon approval of the Program's final HMP (scheduled for submittal to the Regional Board by 15 May 2005), the Program will implement the HMP using available analyses and reasonable, conservative assumptions. The Program will also implement a cycle of continuous improvement. This cycle will include periodic evaluations of recent developments in science and engineering related to watershed management and erosion control, re-evaluation of uncertainties related to the Program's HMP protocols, and corresponding updates to the Program's HMP analytical procedures and BMP requirements.

2 · HMP Objectives

The Program's C.3 Technical Work Group has developed the following objectives for the HMP:

- Comply with permit requirements.
- Achieve reasonable protection of beneficial uses.
- Minimize costs to taxpayers.
- Minimize costs to developers.
- Minimize staff time required for project review.
- Encourage "smart growth" and maintain economic competitiveness.
- Flexibility.
- Participation and consensus.

3 · Conceptual Approach

3.1 Rationale

Modification of urban watershed hydrographs is a cumulative effect of many development projects implemented over time. Increased imperviousness of many individual development sites, together with the paving of streets and highways that serve those sites, adds up to significant changes in rainfall/runoff relationships over the entire watershed.

A comprehensive watershed-wide strategy is required to control the extent and effects of continued watershed hydrograph modification. However, as is acknowledged in the Regional Board's permit, that "big picture" strategy must be implemented through conditions placed on the approval of individual projects.

This problem—the need to address cumulative, area-wide effects by placing conditions on individual projects—is common to many aspects of environmental review and permitting. For example, CEQA review of typical urban development projects considers a wide variety of cumulative impacts (e.g., traffic, pollution, and demands for public services).

Determining appropriate mitigation measures to be required for each individual project requires some basis for determining the proportional relationship between the individual project and the cumulative area-wide impact. Some impacts (e.g., demand for potable water or schools) can be quantified and apportioned readily; others (e.g. aesthetic impacts, cultural impacts, or effects on habitat) are much more difficult to quantify and apportion.

This difficulty arises, in large part, because some cumulative impacts are unknown, variable, and uncertain. The effects of watershed hydrograph modification exhibit all three of these characteristics. The effects are unknown in the sense that rainfall/runoff relationships, the cohesion of streambank soils, and other factors are never known precisely, but can only be estimated. The effects are variable in the sense that these same factors differ from one site to another and within the same site and also change with time. The effects are uncertain in the sense that rainfall, flow paths, soil movement, and the pace of urban development are largely unpredictable. (Although past events can be analyzed as statistical averages, projection of these averages into the future represents a guess that past patterns will continue.)

The Regional Board's Provision C.3.f requires municipalities to adopt and implement a policy for requiring individual projects to address the cumulative impacts of watershed hydrograph modification.

One approach to this requirement—although not the approach required or suggested by Provision C.3.f—would be to conduct, at public expense, a thorough assessment of the potential impacts of future hydrograph modification, to develop a comprehensive program for addressing those impacts, and then to apportion the burdens of the program (either as on-site requirements or as shared costs for common off-site mitigation measures) among future developments. This process would be performed for each watershed in the County.

A number of barriers stand in the way of implementing such an approach. First, it would require substantial up-front public investment in the initial investigation and program development. Second, because mitigation measures need to precede or be concurrent with development, construction of off-site mitigation measures would require an even greater up-front public investment and a fee structure to recoup the public outlay. Third—and most significantly—it may be impossible to distinguish, in practice, the potential effects of future hydrograph modification from currently occurring stream erosion caused by forestry, agriculture, construction of storm drains, dams, channelization, and other activities that have occurred through the region's entire history. Without such a distinction, present-day project applicants would be burdened with remedying stream erosion caused by earlier activities—a burden to which they might reasonably object.

3.2 Contra Costa Clean Water Program Approach

The Program's approach requires the applicant and municipal staff to conduct and review only that analysis specifically required to select and design hydrograph modification BMPs for the project. Selection and design of BMPs will be based on reasonable but conservative assumptions and estimates of the project's potential contribution to cumulative hydromodification of the watershed.

Using the Program's approach, the applicant may demonstrate that the proposed project will not increase peak flows and durations of site runoff. Failing that, the applicant may propose on-site or off-site BMPs that will mitigate the potential increases in runoff. If these BMPs are not feasible, the applicant has a third option of assessing stream vulnerability to erosion. The applicant may be able to determine that the downstream reaches have a low risk of erosion; if so, increases in runoff peak flows and volumes may be allowed without further mitigation. If the stream has a high risk of erosion due to watershed hydrograph modification, then the applicant must propose additional flow-control BMPs or in-stream erosion-control BMPs as part of the project.

This stepwise approach for determining required BMPs follows the decision flow chart in Figure 1 and is described in greater detail below.

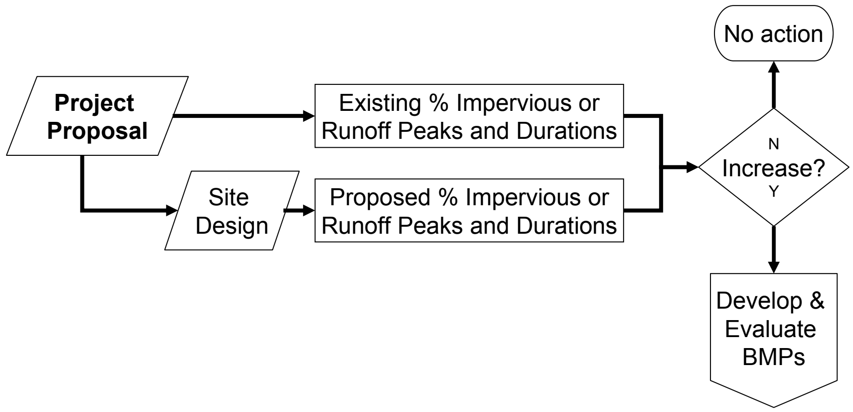
Step 1: Compare pre- and post-project runoff flows.

The first step is to compare pre- and post-project conditions to determine the extent to which the project may change the rainfall/runoff relationships for the project site. For small sites that are served by existing drainage systems, the comparison may be based on infiltration factors ("C" factors or curve numbers) appropriate for the range of storms that are typically of concern for potential stream erosion (i.e., storms of approximately a 0.5 to 10-year recurrence interval). Larger sites and developments with new drainage systems may require analysis of runoff hydrographs (peak flows and durations) using specified methods and applying the appropriate range of storms. The HMP will include criteria for determining whether runoff hydrographs must be developed in connection with a development proposal.

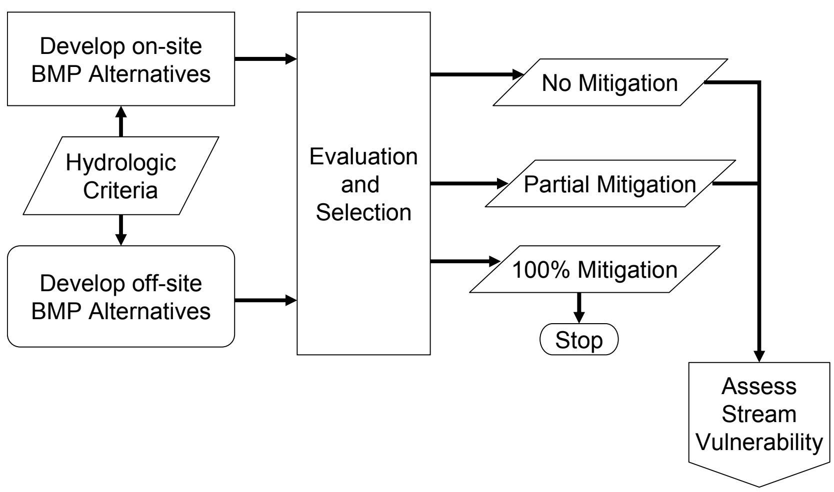
The analysis of pre-project conditions is based on site conditions at the time the project is proposed, including paving, compaction of soils, and extent of existing vegetation. The analysis of post-project conditions incorporates reductions in imperviousness that may be implemented through site design techniques (as required in Provision C. 3.b).

Figure 1. Flowchart illustrating BMP selection process.

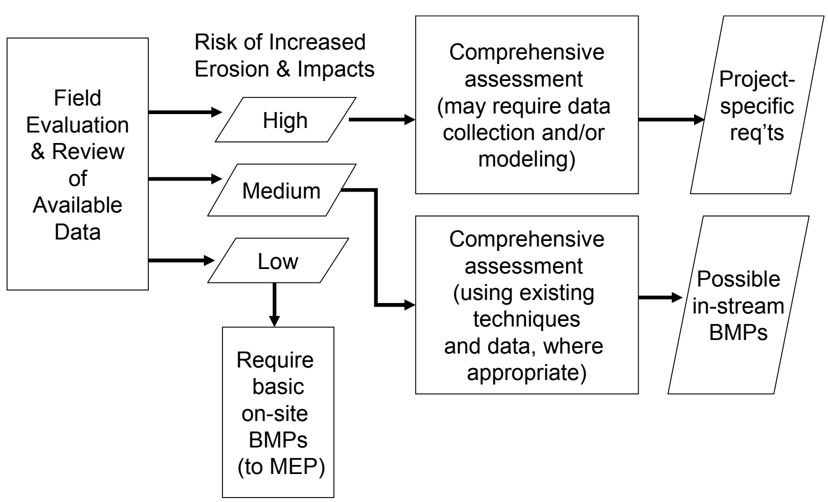
Step 1: Compare pre- and post-project site imperviousness.



Step 2: Develop and Evaluate BMP alternatives.



Step 3: Assess Stream Vulnerability to Stream Erosion.



The need for further analysis is contingent on the results of this comparison. If the comparison shows that there will be no increase in the peak flows and durations of site runoff, it is assumed that there the project does not have potential cumulative impacts on the watershed hydrograph. No additional hydrograph modification BMPs are required, and the project is effectively exempt from HMP requirements.

If the comparison shows that there will be a significant increase in peak flow or volume of runoff from the site, the analysis continues to the next step.

As described in Section 5 of this work plan, the HMP will include methods and criteria for analyzing pre- and post-project runoff and peak volumes.

Step 2: Develop BMP Alternatives

Rainfall/runoff relationships developed in Step 1 may be used to develop on-site and off-site BMP alternatives to mitigate increases in site runoff.

Hydrograph modification BMPs must include some combination of infiltration/retention and detention of site runoff. A number of BMP designs have been developed by various agencies around the U.S. In some cases, it may be possible to simply adjust the sizing of stormwater treatment BMPs (such as swales or bioretention areas) so that these BMPs can also provide sufficient retention or detention for effective hydrograph modification control.

As described in Section 5 of this work plan, preparation of the HMP will include compilation of resources for selecting and designing hydrograph modification BMPs and will also include identification of a set of design storms to be used as a basis for sizing hydrograph modification BMPs.

To demonstrate the effectiveness of BMPs in mitigating hydrograph modification, the applicant will prepare charts showing key runoff parameters (e.g., peak flow, volume, and duration) as a function of storm size or recurrence interval for the pre-development and post-project site conditions. By a similar approach, the applicant may show that “regional” BMPs serving more than one development are effective in mitigating hydrograph modification for the area served by the BMPs.

If this analysis shows that the BMPs are effective—i.e. fully mitigate any increase in peak flow or duration—the applicant has met HMP requirements and no further investigation is needed.

If the analysis shows that the proposed BMPs do not fully mitigate site hydrograph modification, or if the applicant prefers to assess stream vulnerability rather than fully mitigating the site hydrograph, then the analysis continues to the next step.

Step 3: Assess Stream Vulnerability to Accelerated Erosion

Assessment of the vulnerability of a stream to accelerated erosion due to watershed hydrograph modification would only be required in the event that the project applicant is unable to, or chooses not to, incorporate BMPs that fully mitigate the effects of development on the site hydrograph.

The Program's approach provides for different levels of analysis, depending on the complexity of the watershed and the size and location of the project. The analytical approach is based on two observations: First, creation of maps denoting "exempt" and "non-exempt" areas, while simple in concept, would in fact require a substantial expenditure of time and money. Instead, the Program will identify procedures and criteria for determining the relative risk of stream erosion posed by development on a particular site. Second, it should be possible to use these procedures and criteria to classify some developments as "low risk." "Low risk" projects include those located where creeks are significantly hardened down to their outfall to the Bay, infill projects in highly developed watersheds, and other situations where the potential for impacts—whether project-specific or cumulative—is minimal (as described in Provision C.3.f).

The Program's philosophy is to identify these projects as "low risk" rather than "exempt" and to require all projects to implement site design measures to reduce imperviousness to the maximum extent practicable (as stated in Provision C.3.b). The "low risk" designation may also apply to projects where, although some portion of the downstream drainage system is not hardened, potential impacts of hydrograph modification are minimal and remaining uncertainties may be reasonably addressed through implementation of the already-required "maximum extent practicable" site design measures.

At the other end of the "risk" spectrum, the Program's HMP will identify those conditions which, individually or together, create a presumption that a project's location and characteristics create a "high risk" that the project will, alone or cumulatively with other projects, contribute to accelerated stream erosion. Conditions contributing to "high risk" may include steep topography, erodible soils, evidence of existing or incipient stream bed and bank erosion, overall increase in impervious area, and/or location in areas of planned urban expansion (as shown in general plans).

The outcome of a "high risk" determination would be to require the project applicant to either return to Step 2 and develop detention/retention BMPs that address site hydrograph modification, or to propose in-stream BMPs to allow the stream to convey increased runoff without accelerated erosion of the stream bed and banks, or to propose some combination of the two types of BMPs. Proposals to use in-stream BMPs would require a comprehensive assessment of stream and watershed conditions and would likely involve collection of additional data.

Some projects will not meet the criteria for "low risk," but also cannot be reasonably identified as "high risk." A project may be designated as "medium risk" because, for example, it's contribution to overall watershed imperviousness is small and it is not in an area subject to urban expansion, because it discharges to already urbanized (but unhardened) streams, or because stream reaches downstream of the project generally accumulate, rather than produce, sediments.

In such situations, the impacts of additional imperviousness are probably low, but considerable uncertainty exists. In these cases, some additional mitigation is appropriate. The outcome of a "medium risk" determination would be to require the project applicant to implement on-site BMPs to the maximum extent practicable and to also provide some additional compensatory mitigation that is closely related to the project's potential effects on streams. This might take the form of contributing to projects to repair or maintain the stability of downstream stream beds and banks in a way that preserves or enhances stream habitat.

As described in Section 5 of this Work Plan, the Program's HMP will include procedures and criteria for evaluating and classifying projects as presenting a "low risk," "medium risk," or "high risk" of contributing to accelerated stream erosion.

The HMP will also include characterizations of three Contra Costa County streams, one in each category, as a guide to evaluating and classifying projects. The HMP will include a comprehensive assessment of one "high-risk" watershed and guidance to be used in future comprehensive assessments of "high risk" watersheds.

4 · Literature Review

4.1 Introduction

Provision C.3.f.(iv)(i) requires that the Program submit a review of literature pertinent to the HMP. Provision C.3.f.(viii) provides that this review be submitted at the same time as the Work Plan.

Mangarella and Palhegyi (2002) prepared a literature review for the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) in compliance with these same requirements and in preparation for the development of SCVURPPP's HMP.

Those authors reviewed about 50 articles representing the current scientific understanding of hydrologic and geomorphic processes. They also reviewed some of the tools used to assess the stability of streams and some of the management measures employed to control the effects of increased runoff flows and durations.

In subsequent work for SCVURPPP, Geosyntec Consultants et al. (2003) prepared an assessment of the Lower Silver – Thompson Creek subwatershed in the Santa Clara Valley. The interim report describes a detailed methodology, including theoretical and technical background, for assessing potential stream erosion and for identifying runoff thresholds needed to control future erosion.

The two SCVURPPP documents, and the works they reference, detail current scientific and engineering principles and methods available for understanding watershed hydrograph modification and how this modification may contribute to stream erosion. The two documents also describe some of the control measures (BMPs) that may be used to mitigate hydrograph modification, the resulting stream erosion, or both.

What remains—as a permit requirement and as a practical requirement—is to devise a protocol (analytical method or procedure) for setting conditions of approval for specific developments. This protocol should provide the project applicant with clear directions for preparing their submittal and for selecting and designing any BMPs that may be needed to mitigate their project's impacts on the watershed hydrograph.

That is the focus of this review.

4.2 "Essential Nexus" and "Rough Proportionality"

The problem presented by Provision C.3.f is to determine, for each proposed project, the degree of runoff control to be attained and the specific runoff parameters that may apply to the specific site.

Local governments have limited powers to require mitigations for project impacts. Legal tests of the extent of these powers have focused on the Fifth Amendment clause prohibiting the taking of private property without just cause. In general, the clause protects against regulatory schemes that impermissibly concentrate the cost of providing a public benefit on the shoulders of a few. Current tests for interpreting this clause, particularly with respect to mitigations for land-use development, rest on two Supreme Court decisions.

In the 1987 decision *Nollan vs. California Coastal Commission*,[*] the court found that a development exaction must have an "essential nexus" to the perceived harm that the proposed development would otherwise create and which would justify denial of the permit. In the 1994 decision *Dolan vs. City of Tigard*,[†] the Court majority used the phrase "rough proportionality" to describe the required relationship between the perceived harm and the exaction, and clarified that while a "precise mathematical calculation" was not mandatory, the municipality must "make some sort of individualized determination that the required [exaction] is related both in nature and extent to the impact of the proposed development."

To make such an individualized determination for hydrograph modification, one could begin with a calculation of the allowable increase in runoff, on a watershed basis, that would insure that cumulative watershed impacts remained insignificant. Each proposed development might then be allowed to increase runoff by a specified amount over and above the existing condition, with the amount of increase being equitably apportioned among the various developments planned within the watershed. Geosyntec Consultants et al. (2003) attempted to determine the allowable increases in

---

[*] 483 U.S. 825 (1987).

[†] 512 U.S. 687 (1984)

runoff that might be shared among future developments planned for the Lower Silver – Thompson Creek subwatershed.

If, due to previous urbanization or other land-use change, excessive runoff is already causing accelerated bed and bank erosion, then there is no allowable increase to apportion. Developments would need to retain pre-project durations and flows by infiltrating or evaporating any extra volume of runoff. This is apparently the actual condition in the Lower Silver – Thompson Creek subwatershed (Geosyntec Consultants, et al., 2003, page 77).

As Geosyntec et al. suggest, it might be possible, and beneficial, to address the problem of stream erosion by re-designing stream channels or by stabilizing stream beds and banks. Some methods and experience for doing so are described by Rosgen (1996), Riley (1998), FISRWG (1999), and Watson and Annable (2003).

However, as discussed in more detail below, the causes of stream instability are myriad, and may include natural conditions (e.g. climate change or channel evolution), past land uses such as logging, farming, or grazing, and the current level of urbanization (FISRWG, 1999). The restoration of streams so impacted is certainly a public benefit, but generally cannot be fairly financed through conditions on new development. Exceptions may occur when one or a few very large developments are planned within a single subwatershed and stream restoration is integrated into the plan to mitigate multiple impacts. In such cases, requirements for individual developments should be made consistent with the needs of the restoration plan.

4.3 Methods for Demonstrating “No Significant Impact”

In Contra Costa County, many of the projects to be reviewed for C.3 compliance will be redevelopment or infill projects that convert land from one urban (or semi-urban) use to another. In addition, some project applicants may choose, by applying various techniques to reduce site imperviousness (BASMAA, 1999, Prince Georges County, 1999a) to match (or improve) the pre-project hydrological characteristics.

To facilitate review of these projects for compliance with Provision C.3.f, the Program may develop, as part of the HMP, simple methods to compare the pre- and post-project effects on downstream hydrographs.

4.3.1 Modelling rainfall excess.

A number of equations and procedures have been developed for estimating the proportion of rainfall that is retained on the earth's surface (i.e., abstraction) and does not contribute to surface flow (ASCE 1996, Chapter 3). Detailed models of abstraction consider an initial depth of rainfall that produces no runoff (due to initial absorption and ponding on uneven surfaces), followed by a consistent or slowly declining rate of loss (due to infiltration), which gradually approaches zero as soils become saturated.

To estimate peak flows and volumes of runoff, rainfall abstraction is usually lumped into a single parameter that describes a steady-state ratio between rainfall and runoff (ASCE 1996, Chapter 6).

One such commonly used parameter is the runoff coefficient or "C" factor used in the rational formula

$$Q = CiA$$

where Q is flow rate, i is rainfall intensity, and A is area.

The curve number, or CN, is used in algorithms and computer models developed by the Soil Conservation Service (SCS) and is also a lumped parameter representing the volume of runoff produced by a given rainfall depth, considering initial abstraction (USDA, 1986). The curve number may be adjusted to account for antecedent moisture conditions (ASCE 1996, Table 6.1).

One or the other of these parameters—"C" or CN—is used in practically any calculation of runoff volumes, regardless of the simplicity or complexity of the specific algorithm or model used.

Put another way, "C" or CN may be used as an indicator of a site's ability to generate runoff volume. Comparison of pre- and post-project "C" or CN values provides a ready and reliable way of determining whether a development proposal could potentially contribute to a cumulative impact due to increased runoff volume.

4.3.2 Time of concentration

Even if it does not create an increase in runoff volume, a project could potentially modify the watershed hydrograph and result in stream impacts if the timing of that runoff changes. Paving, channeling of surface flows, and piped drainage all reduce the time for runoff to be concentrated at the discharge from the site.

In addition to promoting reduced imperviousness, the site design approaches described in BASMAA (1999) and (particularly) the literature for “Low Impact Development” (Prince Georges County, 1999a, Prince Georges County, 1999b, USEPA, 2000) emphasize increasing the length and duration of overland flow (i.e., “microdetention”), and the extension of the time of concentration. Implementation of stormwater treatment controls, such as detention basins or biofilters, as required in Provision C.3.d, will also tend to increase the time of concentration, or T_c.

Various manuals, including ASCE (1996) and USDA (1986) provide detailed guidance and tables of factors that may be used to calculate T_c. “No significant impact” with regard to increases in peak flow could be demonstrated by comparing pre- and post-project T_c; alternatively, it may be possible to create a checklist of factors that would demonstrate that the project could not significantly reduce site T_c (e.g., all new impervious area is routed through treatment BMPs). This will be examined further during development of the HMP.

4.4 Comparison of Pre- and Post-Project Hydrographs

A number of computer models have been developed to facilitate and standardize preparation of hydrographs. The models differ in the methods for calculating the proportion of rainfall that runs off (“precipitation excess”), the method of adding up individual sub-basin hydrographs to create one basin-wide hydrograph, and in the method for calculating the routing of flows through pipes, channels, and detention basins (ASCE 1996, Table 9.28).

Through the 1980s or so, flood control engineers used urban hydrology models mainly to calculate the required capacity of pipes, channels, and detention basins to avoid flooding during large storms. As dictated by Federal insurance requirements and standard practice, this typically involved modeling watershed response to storms with recurrence intervals of between five and 500 years.

4.4.1 Estimation of geomorphically significant flows.

To apply the same models to the problem of controlling stream erosion, it is necessary to identify the storm size, or range of sizes, thought to be geomorphically significant or “channel forming” flows.

Based on a concept of “effective work,” Leopold et al. (1964) noted that most sediment transport occurred as a result of relatively frequent events. The flows that most significantly affect channel features and geometry are those that correspond to “bankfull stage.” The trained observer can identify the height of bankfull stage in the field, even in incised channels, although armored or cobble-bottomed channels can confound the definition (Rosgen, 1996). This “channel-forming” flow corresponds to a recurrence interval of between one and two years (Leopold et al., 1964) and has been more narrowly defined as between 1.5 and 1.7 years for typical North American streams (Rosgen, 1996).

Initial attempts to control excessive stream erosion due to hydrograph modification focused on maintaining the peak discharge resulting from the 2-year-recurrence-interval storm. This approach has proven to be ineffective (Mangarella and Palhegyi, 2002, citing MacRae (1992) and MacRae et al. (1993)).

Urbanization changes watershed response to small storms, resulting in a dramatic increase in the peaks and duration of frequency of runoff (Scheuler, 1994). The increase in the frequency of these “sub-bankfull” events seems to be the cause of the relatively sudden and radical expansion of stream channels in response to urban development (Ontario, 2003).

Following MacRae’s (1996) demonstration of the inadequacy of the 2-year-peak-flow criterion, various agencies and investigators have proposed alternative methods and criteria for designing hydrograph modification controls.

GeoSyntec et al’s (2003) analysis of the Lower Silver – Thompson Creek subwatershed involved development and calibraton of a detailed hydrologic model of 50 drainage areas within the watershed and continuous simulation of runoff using hourly rainfall data collected over a 50-year period. Continuous modeling allowed consideration of watershed responses to a full range of storm sizes and antecedent soil moisture conditions, both for the pre- and post-development conditions.

Geosyntec et al (2003) characterized bed and bank materials throughout the watershed by visual observation, and determined critical shear stresses and velocities for these materials using standard references.

Stability was assessed using an effective work index, *W*, which integrates the time steps during which channel velocities cause critical shear stresses to be exceeded.

Bed and bank erosion is a natural process and is required for maintenance and renewal of characteristic stream channel forms. Therefore it is necessary to determine the extent to which runoff flows may cause “excessive” erosion, i.e., erosion beyond that of a “stable” stream.

Geosyntec et al (2003) adapted MacRae’s (1996) Erosion Potential (E_p) ratio, which compares the effective work index for stream sections found to be unstable to the effective work index for stream sections determined to be stable. The erosion potential for future development projects is characterized as:

$$E_{\mathrm{p}} = W_{\mathrm{post}} / W_{\mathrm{pre}}$$

This calculation is meaningful only when the pre-project condition represents a stable stream. The authors provide evidence (topographic maps and historic photographs) that these reaches of Lower Silver Creek and Thompson Creek were stable prior to urban development, but it should be kept in mind that many Bay Area creeks, including those with rural watersheds, are not typically characterized as stable. Buckhorn Creek is a Contra Costa example.

4.4.2 Practical application of hydrograph comparisons.

Although there are strong arguments for development of comprehensive watershed plans (see Section 4.7, below), in practice public agencies have defined allowable changes from pre- to post-project hydrographs based on individual site characteristics rather than the requirements of an overarching watershed plan. Some examples follow.

- Although Ontario (2003) states that “urban development without watershed/subwatershed planning is discouraged,” the ministry’s draft guidance recommends a methodology for designing BMPs based on a water balance for the individual site (Ontario, 2003, Chapter 3). A “simplified design approach” provides a methodology and nomograph for detention basin sizing based on tributary impervious area and hydrologic soil group (Ontario, 2003, Appendix C).

- The Prince George's County, Maryland, *Stormwater Manual* (Prince George's County, 2001) requires 24-hour extended detention of the one-year 24-hour storm event for stream erosion control, in addition to requirements to implement Low Impact Development, which aims to maintain post-development composite CN and the site T_c below pre-project values.
- The *Stormwater Manual for Western Washington* requires that "stormwater discharges to streams shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. In addition, the developed peak discharge rates should not exceed the predeveloped peak discharge rates for 2-, 10-, and 50-year return periods. In general, matching discharge durations between 50% of the 2-year and 50-year will result in matching the peak discharge rates in this range" (Washington, 2001).
- Clackamas, Oregon, requires that on-site detention be designed to reduce the 2-year, 24-hour post-developed runoff rate to ½ of the 2 year, 24-hour pre-developed discharge rate. (Clackamas, 2002).
- Portland, Oregon provides a streamlined, simplified method for designing combined treatment/hydrograph control BMPs using sizing factors. The applicant simply multiplies the area served by the sizing factor to determine the required BMP surface area. All of the "simplified method" BMPs use infiltration through contained and underdrained soil, rather than detention and release through an outlet orifice. The sizing factors vary from 0.06 to 0.10, depending on the type of BMP, and are based on detaining a 25-year, 24 hour storm (Portland, 2002).
- After conducting a detailed analysis and modeling of the Lower Silver – Thompson Creek subwatershed, Geosyntec et al. (2003) suggested that detention requirements for individual sites could be based on matching post-project to pre-project volumes or durations for a specified range of storms, rather than basing site requirements directly on the needs determined by the watershed analysis and modeling. The authors also suggested the use of erosion potential (E_p) as an alternative criterion.

Regulation of allowable flows for new development based on the specific needs and capacities (e.g., erosion potential) of stream reaches is a technically valid concept. However, the most practical application seems to be as a guide for determining generalized requirements for applicants to match pre-project flow volumes or durations for specified design storms. Knowledge of stream stability (based on modeling of E_p or on other knowledge or analyses) can be used to adjust these generalized requirements. As shown in the examples above, this can be accomplished by applying a factor, typically between 0.5 and 1.2, to the pre-project flows or durations.

4.5 Hydrograph modification and impacted streams

Hydrograph modification is just one of many factors affecting the stability of Contra Costa streams, and hydrograph modification management is neither always necessary nor always sufficient; rather, it should be regarded as just one of many “tools in the toolbox” for restoring stream stability.

Scheuler (1994) proposes imperviousness as an indicator of urbanization and a corollary for the physical and biological degradation of streams and the loss of their beneficial uses. However, as when applying other indicators, there is a need to consciously avoid confusing correlation with causation.

Contra Costa streams are subject to a myriad of influences, and it is typically difficult, if not impossible, to generalize regarding causes and effects across the entire County. Further, it is often difficult to attribute any particular observed condition in a specific stream to only one proximate cause. In general, it is necessary to consider many potential causes and to consider their relative significance. For example, Riley (2002) attributes the incision of stream channels in the Bay Area over the past 100 years primarily to climate changes and earth movement, while noting that incision may be induced accelerated by land use change as well.

As an illustration of the interaction of these influences, consider the stream equilibrium equation identified by Lane (1955).

$$(\text{Sediment load x sediment size}) \; \alpha \; (\text{slope x discharge})$$

A change in any one of these four factors may contribute to disequilibrium (net erosion or deposition stream sediments) and consequent changes in channel width and depth.

- Sediment load may increased by earth movement (e.g., geologic uplift and mass wasting), land disturbance (e.g., agriculture, road construction), or loss of vegetation, or may be decreased by land development (e.g., paving, terracing), by dams, or by dredging.

- Sediment size may be affected by changed balance among different sediment loads (and the erosion of different geologic strata), by dams, or by in-stream mining.
- Stream slopes are often increased by straightening (removal of meanders), or may be increased or decreased by the placement of downstream culverts or grade controls.
- Finally, stream discharge, and particularly rainfall/runoff relationships, may be increased by deforestation, agriculture, and other land use changes, prior to and including urbanization, or may be decreased by dams and diversions.

The above considerations address only system-wide instabilities, those that are in effect over a long reach or series of reaches. Bank erosion at specific sites may be related to the presence or absence of vegetation and to localized channel conditions (e.g., placement or removal of woody debris or riprap upstream or downstream).

Evaluation of existing conditions and development of a stream restoration plan for an urban stream may require consideration of many or all of these factors (FISRWG, 1999, Chapter 3).

4.6 Methods for Characterizing Geomorphic Stability of Streams

Techniques have been developed for streamlined or rapid geomorphic assessment of streams.

- Appendix C in Ontario (2003) provides such a method associated with a “simplified design approach.” Forms are provided for recording field data and calculating a stability score based on the presence or absence of specific geormorphic features.
- FISRWG (1999) provides a general overview of qualitative and quantitative methods for assessing both systemwide and local stream instability of stream beds and banks (FISRWG, 1999 pp. 7-51-7-62.)
- Rosgen (1996) provides useful guidance for field reconnaissance and determination of key parameters and a detailed methodology for assessment of stream condition and departure from an equilibrium state. Of particular

interest are a method and criteria for assessing stream bank erosion potential (Rosgen, 1996, page 6-41).

- Vermont (2003) has created a set of *Stream Geomorphic Assessment Protocol Handbooks*, along with assessment aids and database forms. The 3-stage methodology provides for remote sensing, rapid field assessment, and survey-level field assessments of stream stability.
- Riley (2002) provides an excellent guide to qualitative assessment of stream problems, including diagrams and pictures that illustrate the processes at work.

Rosgen's (1996) emphasis on organizing diverse stream data into systems for categorizing and rating streams (in part building on criteria originally developed by Pfankuch (1975)) will facilitate development of local criteria that can be used to classify Contra Costa streams as at high, medium, or low risk of accelerated stream erosion.

4.7 Watershed-scale Analysis and Planning

Restoration of streams destabilized by land-use change and channelization generally requires analysis and planning at a watershed scale (Riley, 1998, FISRWG, 1999). A similarly comprehensive approach may be optimal for planning the development of urban watersheds. Ontario (2003) calls for the integration of watershed planning with municipal land use planning (Ontario, 2003, Chapter 2).

A fully adequate plan for an urbanized or soon-to-be urbanized watershed should be preceded by a detailed analysis of the existing stream condition (including the past and present causes of channel instability and ecological degradation) and should also identify opportunities to integrate management of runoff with creation of riparian buffers, open space, trails and recreation facilities, and transportation, so as to create "a network of natural features and complementary and compatible land uses which will be the spine or centerpiece of the community" (Ontario, 2003, p. 2-16). In the Bay area, this type of integrated urban watershed planning has been advocated by SCBWMI (2003) and is consistent with the increasing emphasis on "multi-objective" flood control projects, such as those on the Guadalupe and Napa Rivers.

Successful implementation of this watershed management approach is dependent on establishing a process whereby watershed stakeholders employ sound scientific data, tools, and techniques in an iterative decision making process (USEPA, 1996).

4.8 References

ASCE. American Society of Civil Engineers. *Hydrology Handbook.* 2nd Edition. ASCE Manuals and Reports on Engineering Practice No. 28. New York, New York: ASCE. 1996. 784 pp.

BASMAA. Bay Area Stormwater Management Agencies Association. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection,* 1999 Edition. Prepared by Tom Richman and Associates for BASMAA. 154 pp. + appendices.

Clackamas. Clackamas County, Oregon, Service District No. 1. "Surface Water Management Rules and Regulations" August 1, 2002.

FISRWG. Federal Interagency Stream Restoration Work Group. Stream Corridor Restoration: Principles, Processes, and Practices. United States Department of Agriculture, 1998. www.usda.gov/stream_restoration/

GeoSyntec Consultants, Inc., Balance Hydrologics, Inc., Philip Williams and Associates, and Raines, Melton, and Carella, Inc. 2003. *Hydromodification Management Plan Draft Interim Report: Assessment of the Lower Silver – Thompson Creek Subwatershed.* Prepared for the Santa Clara Valley Urban Runoff Pollution Prevention Program. Chapters 1 -6. July 2003. www.scvurppp.org

Lane, E.W. "The Importance of Fluvial Morphology in Hydraulic Engineering." *Proceedings of the American Society of Civil Engineers,* Volume 81, No. 745 (1955).

Leopold, Luna B., M. Gordon Wolman, and John P. Miller. 1964. Fluvial Processes in Geomorphology. Mineola, NY: Dover Press (republished 1995).

MacRae, C.R. 1992. The Role of Moderate Flow Events and Bank Structure in the Determination of Channel Response to Urbanization. Resolving conflicts and uncertainty in water management: Proceedings of the 45th Annual Conference of the Canadian Water Resources Association. Shrubsole, Dan, Ed. 1992, pp. 12.1-12.21 (cited in Mangarella and Palhegyi, 2002).

MacRae, C.R. 1993. An Alternate Design Approach for the Control of Instream Erosion Poential in Urbanizing

Watersheds. Proceedings of the Sixth International Conference on Urban Storm Drainage, Sept. 12-17, 1993. Torno, Harry C., vol. 2, pp. 1086-1098 (cited in Mangarella and Palhegyi, 2002).

MacRae, C. R. 1996. Experience from Morphological Research on Canadian Streams: Is Control of the Two-Year Frequency Runoff Event the Best Basis for Stream Cahnnel Protection? Effects of Watershed Development and Management on Aquatic Ecosystems, ASCE Engineering Foundation Conference, Snowbird, Utah, pp. 144-162 (cited in Mangarella and Palhegyi, 2002).

Mangarella, Peter and G. Palhegyi. 2002. *Hydromodification Management Plan Literature Review.* Prepared by GeoSyntec Consultants for the Santa Clara Valley Urban Runoff Pollution Prevention Program. 13 September 2002. 59 pp. + figures + appendices. www.scvurppp.org

Ontario. Ministry of the Environment. *Stormwater Management Planning and Design Manual.* 2003. http://www.ene.gov.on.ca/envision/gp/4329eindex.htm

Pfankuch, D.J. "Stream reach inventory and channel stability evaluation." USDA Forest Service R1-75-002. USGPO #696-260/200, Washington D.C., 1975. 26 pp. (cited in Rosgen, 1996).

Portland. City of Portland Environmental Services. *Stormwater Management Manual, Revision #2.* September 2002. http://www.cleanrivers-pdx.org/tech_resources/2002_swmm.htm

Prince George's County, Maryland. *Stormwater Management Design Manual.* 2001. http://www.co.pg.md.us/government/agencyindex/der/prd/SWMfinal.pdf

Prince George's County, Maryland. *Low-Impact Development Design Strategies: An Integrated Design Approach.* Department of Environmental Resources, Programs and Planning Division. June 1999. 150 pp.

Prince George's County, Maryland. *Low Impact Development Hydrologic Analysis.* Department of Environmental Resources, Prgorams and Planning Division. July 1999. 39 pp. + app.

Riley, Ann L. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. Washington, D.C.: Island Press, 1998.

Riley, Ann L. "A primer on stream and river protection for the regulator and program manager." Technical Reference Circular, W.D. 02-#1. California Regional Water Quality Control Board for the San Francisco Bay Region. October 2002. http://www.swrcb.ca.gov/rwqcb2/Agenda/04-16-03/Stream%20Protection%20Circular.pdf

Rosgen, Dave L. *Applied River Morphology.* Pagosa Springs, CO: Wildland Hydrology, 1996.

SCBWMI. Santa Clara Basin Watershed Management Initiative. August 2003. Watershed Action Plan. Watershed Management Plan, Volume 3. Compiled by Dan Cloak Environmental Consulting. www.scbwmi.org.

Scheuler, Tom. *The Importance of Imperviousness.* In Scheuler, ed., *Site Planning for Urban Stream Protection.* Environmental Land Planning Series. Metropolitan Washington Council of Governments, 1994.. 232 pp.

USDA. United States Department of Agriculture. *Technical Release 55: Urban Hydrology for Small Watersheds.* USDA Natural Resources Conservation Service, Conservation Engineering Division. June 1986.

USEPA. United States Environmental Protection Agency. "Watershed Framework Guiding Principles." 1996. http://www.epa.gov/owow/watershed/framework/ch3.html

USEPA. United States Environmental Protection Agency. *Low Impact Development (LID): A Literature Review.* EPA-841-B-00-05. Washington, DC: USEPA Office of Water, October 2000.

Vermont. Agency of Natural Resources. *Stream Geomorphic Assessment Protocol Handbooks. Remote Sensing and Field Surveys Techniques for Conducting Watershed and Reach Level Assessments.* April, 2003. http://www.anr.state.vt.us/dec/waterq/rv_geoassesspro.htm

Washington. State Department of Ecology Water Quality Program. *Stormwater Management in Western Washington, Volume III: Hydrologic Analysis and Flow Control Design/BMPs.* August 2001. Publication 99-13.

Watson, Chester C., and William Annable. Channel Rehabilitation: Processes, Design, and Implementation. Notes for Applied Fluvial Geomorphology and River Restoration Short Course, sponsored by the Guadalupe-Coyote Resource Conservation District. Held at the Santa Clara Valley Water District, San Jose, CA, July 14-18, 2003.

5 · Scope of Work

The following scope of work has been compiled and formatted to facilitate timely issuance of an RFP following Regional Board approval of this Work Plan.

General

Consultant shall prepare a Hydromodification Management Plan (HMP). The HMP shall be in the form of a manual to be used by applicants for development approvals and by municipal staff. The manual will assist and guide applicants and staff in selecting appropriate hydromodification management measures to be incorporated into development projects.

The Program will solicit, receive and compile comments on this work plan and on Consultant's interim or draft work products and will forward the compiled comments to Consultant. These may include comments from Program staff, consultants, municipal staff, Regional Board staff, or other interested parties. The Consultant will respond to the comments and/or incorporate the comments into subsequent work products. The Program will direct Consultant as to the format of responses to each set of comments; this format may be informal or may require a matrix showing each comment and the corresponding response.

5.1 Task One: Refine decision flow chart.

Consultant shall review the procedure delineated in Section 3.2, above, and shall also review comments on the procedure by the Regional Board and interested parties.

Based on these comments and on the Consultant's professional expertise, the consultant shall revise and refine the procedure and shall prepare revised or new flow charts and corresponding text.

Deliverables:

- Flow charts and corresponding text, suitable for incorporation into the HMP (draft).
- Technical memorandum describing the background and rationale for the refined flow chart (1 draft and final).

5.2 Task Two: Guidance for characterizing pre- and post-project site hydrology.

Combining standard, documented engineering practice with knowledge and investigation of typical soils and site conditions in Contra Costa County, Consultant shall prepare detailed guidance for estimating the imperviousness and comparing peak flows and runoff volumes of building sites in their existing state and following development. The guidance shall include the following:

- Criteria for when a simple comparison of composite “C” factors is appropriate and when a more complex analysis of peak flows and volumes should be used.
- Methods for evaluating and analyzing the characteristics and conditions of existing soils, slopes, and surfaces and developing appropriate runoff (“C”) factors. “C” factors shall be appropriate for the range of rainfall intensity and duration that is relevant to stream erosion.
- Methods for evaluating the influence of existing vegetation on rainfall/runoff relationships.
- Methods for accounting for the influence of planned grading, landscaping, structures, and vegetation on “C” factors.
- Example calculations.

Deliverables:

- Text, tables, and example calculations to be incorporated into the HMP (draft).
- Technical memorandum describing the background and rationale for the determination and application of “C” factors and criteria for determining when the generation of site hydrographs should be required, including references (1 draft and final).

5.3 Task Three: Methods & criteria for predicting BMP effectiveness.

Consultant shall prepare a methodology, develop design criteria, and prepare design guidance and examples that will assist project applicants and municipal staff in designing and reviewing hydromodification BMPs.

5.3.1 Using standard practice, results of current research, and knowledge of local rainfall patterns, Consultant shall select and characterize a range of storms that may be most relevant to controlling hydromodification and stream erosion.

5.3.2 Consultant shall identify a set of design storms, defined by rainfall depths, intensities, and/or recurrence intervals, to be used in designing hydromodification best management practices (BMPs).

5.3.3 Consultant shall describe and detail a step-by-step methodology that project applicants may follow for preparing charts or other means of comparing pre- and post- project site hydrographs. The methodology shall include criteria for evaluating the differences in pre- and post-project hydrographs as a measure of the predicted effectiveness of BMPs in controlling hydromodification, considering both site-specific and cumulative impacts. The methodology shall be designed for ease of implementation by project applicants and ease of review by municipal staff.

5.3.4 Consultant shall compile descriptions, design criteria, sketches, drawings, and other information regarding BMPs that have been implemented or are required by public agencies. Based on engineering practice, best professional judgment, and input from Program staff and others, Consultant shall select and prepare a "design gallery" or similar presentation of BMP options and design information, including examples of their application. Options should include BMPs that serve single sites and BMPs that serve large-scale developments or are included in Specific Plans for newly developing areas (i.e. "regional" BMPs).

Deliverables:

- Text, tables, and design drawings to be incorporated into the HMP (draft).
- Technical memorandum, including data, analyses and references used to select design storms; supporting information and rationale for the hydrograph-comparison methodology, and backup and references for BMP design guidance and criteria (1 draft and final).

5.4 Task Four: Criteria for classifying streams

Consultant shall evaluate the feasibility of, and develop protocols and criteria for, the classification of projects as presenting a "high risk," "medium risk," or "low-risk" of contributing, individually or cumulatively, to accelerated bed and bank erosion due to future hydromodification of the upstream watershed. The purpose of this task is to develop, if feasible, a relatively simple and low-cost method of assessing and categorizing relative levels of risk that the proposed development poses to downstream stream reaches, including immediately downstream reaches and reaches further downstream between the project location and the Bay. The method will be applied in the context of the review of individual proposed developments.

As a starting point for the characterizing developments that present a "low risk" of accelerating downstream erosion, the Consultant should consider projects where the discharge is to "creeks that are concrete-lined or significantly hardened (e.g. with rip-rap, sackcrete, etc.) downstream to their outfall in San Francisco Bay, underground storm drains discharging to the Bay, and construction of infill projects in highly developed watersheds, where the potential for single-project and/or cumulative impacts is minimal." (Provision C.3.f.ii.)

As a starting point for characterizing developments that present a "medium risk" of accelerating downstream erosion, the Consultant may consider projects where the contribution to overall watershed imperviousness is small and that are not in an area subject to urban expansion, projects that discharge to already urbanized (but unhardened) streams, and projects in locations where downstream reaches generally accumulate, rather than produce, sediments. Water Board staff has noted that the categories of "low risk" and "medium risk" should be developed conservatively and with care.

Consultant's evaluations of relative risk and estimates of uncertainty shall be based on expert opinion and best professional judgment.

5.4.1 Consultant shall review and evaluate existing methods for predicting the vulnerability of streams to erosion due to watershed hydromodification. Consultant's review shall include the methods reviewed and developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program and others, including those referenced in Section 4.6.

5.4.2 Consultant shall review the availability and completeness of relevant data for Contra Costa County streams. This data may include rainfall records, stream gage records, topographic maps, geological information, soil types, stream maintenance records, reports of field investigations, and other information relevant to stream characteristics and past or potential stream erosion. The Program will assist by compiling available information in the possession of the cities, County and the Flood Control District.

5.4.3 Consultant shall evaluate the applicability and usefulness of methods for predicting increased vulnerability to stream erosion. This initial evaluation shall assume that vulnerability to accelerated stream erosion will be evaluated using available existing information for Contra Costa County streams and watersheds, with incorporation of estimated factors where relevant watershed-specific information is not available.

5.4.4 Consultant shall evaluate the relative uncertainty resulting from such a procedure in terms of the risks that the procedure will qualitatively underestimate or overestimate the likelihood that erosion in a particular stream would significantly accelerate in response to foreseeable changes in watershed imperviousness. This evaluation of uncertainty shall focus on typical scenarios that may be encountered in the course of HMP implementation.

5.4.5 Consultant shall identify additional data that, if available, could substantially reduce the relative uncertainty in estimates of the risk of accelerated stream erosion. The Consultant shall provide an opinion whether uncertainty in estimates of risk can be substantially reduced through limited field work.

Deliverables:

- Text, tables, drawings, and illustrations, to be incorporated into the HMP, describing the data and methods for classifying streams as at “low risk,” “medium risk,” or “high risk” of accelerated erosion due to watershed hydromodification (draft).
- Technical memorandum evaluating the applicability and robustness of the classification method, including an evaluation of the benefits of limited field work (1 draft and final).

5.5 Task Five. Prepare example characterizations of streams.

In coordination with the development of methods and criteria described in Task 4, Consultant shall evaluate and characterize three Contra Costa County stream reaches. The three reaches shall be selected to typify the categories “low-risk," "medium-risk," and "high-risk" of accelerated erosion due to watershed hydromodification. The example characterizations are intended to be used by project applicants and municipal staff as examples to help illustrate application of the methods and criteria for categorizing streams.

5.5.1 In consultation with the Program, Consultant shall identify candidate streams in each risk category and shall select one stream in each category.

5.5.2 Consultant shall evaluate available information for each of the three streams and shall document step-by-step the application of the methods and criteria developed in Task 4 to each stream, illustrating the justification for the categorization.

5.5.3 As a separately budgeted task, to be expended on separate written authorization from the Program, the Consultant shall conduct field work necessary to appropriately characterize the three selected reaches where this is necessary to illustrate the methods used and to provide an example of a well-justified categorization of "low-risk," "medium-risk," or "high-risk" of accelerated stream erosion due to watershed hydromodification.

5.5.4 Based on the results of Task 5.5.3, Consultant shall develop a list of data to be collected through field work and shall develop guidelines for conducting and reporting the results of field work. The guidelines shall reference appropriate methods or manuals for field data collection and reporting, such as those discussed in Section 4.6.

Deliverables:

- Report characterizing and justifying categorization of a "low-risk" stream reach (1 draft and final).
- Report characterizing and justifying categorization of a "medium-risk" stream reach (1 draft and final).
- Report characterizing and justifying categorization of a "high-risk" stream reach (1 draft and final).

5.6 Task Six: Comprehensive Assessment in One Contra Costa Watershed

Consultant shall prepare a comprehensive assessment of one Contra Costa watershed that would be characterized as at "high risk" of accelerated bed and bank erosion due to watershed hydromodification. Consultant shall document the protocols and references used, including recommended changes, and shall prepare guidance to be used in future comprehensive assessments of "high-risk" watersheds.

5.6.1 In consultation with the Program, Consultant shall identify a list of candidate "high-risk" watersheds and shall select one watershed to be the subject of a comprehensive assessment.

5.6.2 Consultant shall convene a panel of experts, with an appropriate mix of scientific disciplines, to review the assessment.

5.6.3 Consultant shall prepare a plan for the assessment, to include a description of the analytical methods to be used, compilation and review of existing data, collection and analysis of field data, participation of agency staff and interested parties, independent expert review, dissemination of results, and recommendations for adaptive management. The plan shall include a schedule for completion.

5.6.4 Consultant shall assess the watershed and shall evaluate and present options for mitigating the effects of watershed hydromodification, based on general plan build-out and including options for stormwater retention or detention (on individual sites or at a watershed scale) and in-stream measures that may reduce the potential for accelerated bed and bank erosion.

5.6.5 Consultant shall compile and summarize the results of the assessment in a report detailing project objectives and organization, methods applied to analyze the potential for accelerated erosion, results, mitigation measures considered, costs and cost-effectiveness of mitigation measures, and expert panel comments.

5.6.6 Consultant shall review the "lessons learned" from preparation of the comprehensive assessment and shall make recommendations for future comprehensive assessments of "high-risk" watersheds, including methodologies, resources and references, and project organization and management.

Deliverables:

- List of review panel members and qualifications.
- Assessment plan (1 draft).

- Assessment report (1 draft and final).
- Recommended protocols and references for comprehensive assessments of “high-risk” watersheds (1 draft).

5.7 Task Seven: Continuous Improvement Process

In consultation with the Program, the Consultant shall prepare a continuous improvement process for the HMP. The continuous improvement process shall apply the general concepts of the plan-do-check-adapt cycle, and other concepts common to environmental quality management, to the specific decision-making steps described in the HMP. The continuous improvement process shall provide for periodic evaluations of ways to reduce the uncertainties related to the HMP’s decision-making and analytical protocols and updates to the list and descriptions of hydromodification BMPs.

5.8 Task Eight: Final Products

Consultant shall compile selected products prepared in Tasks 1-7, including comments compiled and provided by the Program, into a manual and appendices for use by project applicants and municipal staff.

5.8.1 Consultant shall prepare a manual to be used by project applicants and municipal staff to prepare and review submittals in compliance with Provision C.3.f. The manual shall incorporate the refined flow chart and accompanying explanatory text and shall include step-by-step instructions for preparing and presenting calculations of pre- and post-project imperviousness, for demonstrating the effectiveness of BMPs in mitigating modification of the site hydrograph, and for identifying watersheds as “low risk,” “medium risk,” or “high risk” of accelerated bed and bank erosion due to watershed hydromodification.

5.8.2 As an appendix to the manual or a separate document, the Consultant shall prepare, suitable for distribution, the results of the comprehensive assessment (Task Six) and the recommendations for future assessments.

5.8.3 As an appendix to the manual, the Consultant shall prepare documentation of the continuous improvement process.

Deliverables:

- Manual (2 drafts)

- Revised Manual (in response to Regional Board comments)
- Results of comprehensive assessment (final)
- Documentation of continuous improvement process

5.9 Task Nine: Meetings and Public Participation

The Program will coordinate input and review by agency staff, interested parties, and the public, including preparation of notices, meeting summaries, and outreach materials. Consultant shall present updates and interim results and participate in meetings as requested, subject to an overall budget allocated to this task.

It is estimated that Consultant participation will be required at the following meetings:

Program Work Groups	12 meetings
Management & Oversight Committees	6 meetings
Public Forums	2 meetings

Meetings of Program Work Groups and Management and Oversight Committees may include participation of interested parties, including Regional Board staff.

6 · Products and Schedule

Milestone	Date
Issue Request for Proposals	28 May 2004
Proposals Due	30 June 2004
Award Contract for Services	1 Aug. 2004
Refined flow chart, text, and technical memorandum (Task One)	1 Sep. 2004
Select three stream reaches for example categorization of streams (Task Four)	1 Sep. 2004
Plan for comprehensive assessment of one watershed (Task Six)	1 Sep. 2004
Technical Work Group and Water Board staff informal review and comment	15 Sep. 2004
Text, tables, example calculations, and technical memorandum on characterization of pre- and post-project site hydrology (Task Two)	15 Nov. 2004
Text, tables, drawings, and technical memorandum on selection and design of hydromodification BMPs (Task Three)	15 Nov. 2004
Text, tables, drawings, illustrations, and technical memorandum describing and evaluating methods for categorizing streams (Task Four)	15 Nov. 2004
Reports characterizing and justifying categorization of 3 stream reaches (Task Five)	15 Nov. 2004
Draft Manual for Program Review (Task Seven)	15 Nov. 2004
Technical Work Group and Water Board staff informal review and comment	30 Nov. 2004

Milestone	**Date**
Workshops with the development community, community leaders, advocates, and other interested parties	Nov. 2004
Additional public outreach and preparation for municipal implementation	Dec. 2004 – April 2005
Submittal of Draft Manual (HMP) to Water Board	15 Mar. 2005
Water Board comments on Draft Manual	15 Apr. 2004
Final HMP to Water Board for approval	15 May 2005
Begin HMP Implementation	On Water Board Approval
Complete comprehensive assessment of one watershed—Assessment Report and recommended protocols and references for future assessments of “high-risk” watersheds (Task Six)	1 Sep. 2005