Chapter

7

Hydromodification Management Measures

In this Chapter

- *Explanation of hydromodification*
- *Description of hydromodification management controls*
- *Summary of requirements for reducing erosive flows from development projects*

7.1 What is Hydromodification?

Changes in the timing and volume of runoff from a site are known as “hydrograph modification” or “hydromodification”. When a site is developed, much of the rainwater can no longer infiltrate into the soils, so it flows offsite at ***faster rates and greater volumes***. As a result, erosive levels of flow occur more frequently and for longer periods of time in creeks and channels downstream of the project. Hydrograph modification is illustrated in Figure 7-1, which shows the stormwater peak discharges after rainstorms in an urban watershed (the red, or dark, line) and a less developed (the yellow, or light, line). The axes indicate the volume of water discharged, and the time over which it is discharged.

In watersheds with large amounts of impervious surface, the larger volumes, faster rates and extended durations of flows that cause erosion often cause natural creeks or earthen channels to erode, as the channel enlarges in response to the increased flows. ***Problems from this additional erosion*** often include property damage, degradation of stream habitat and loss of water quality, and have not been addressed by traditional detention designs. Figures 7-2 and 7-3 illustrate the effect of increasing urbanization on stormwater volumes.

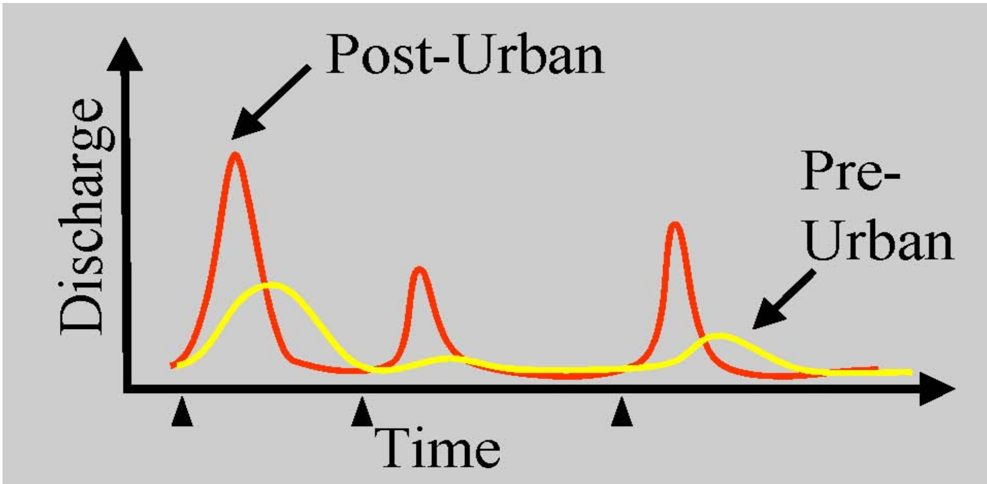


Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

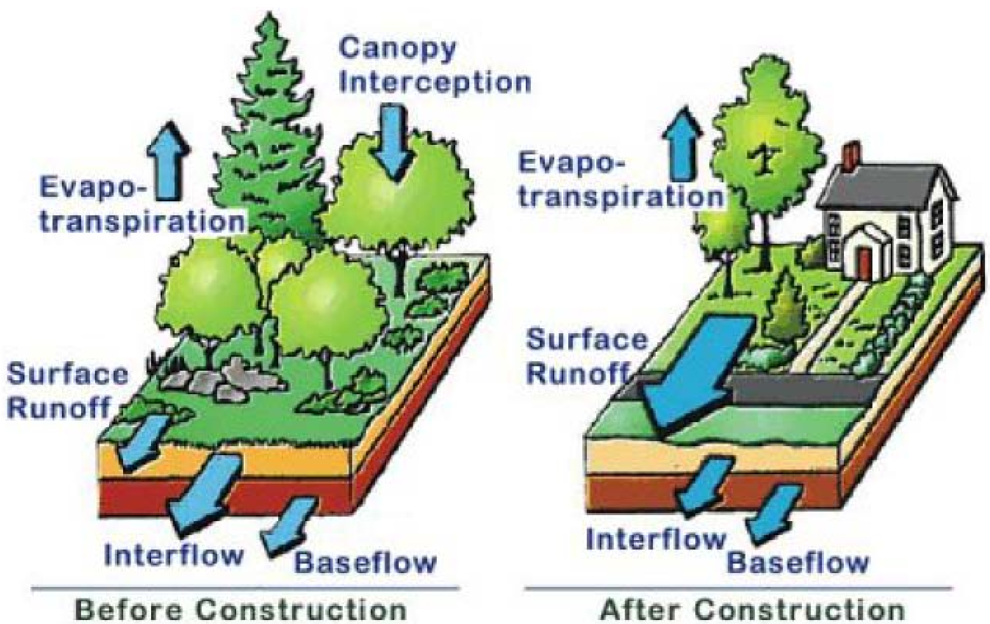


Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

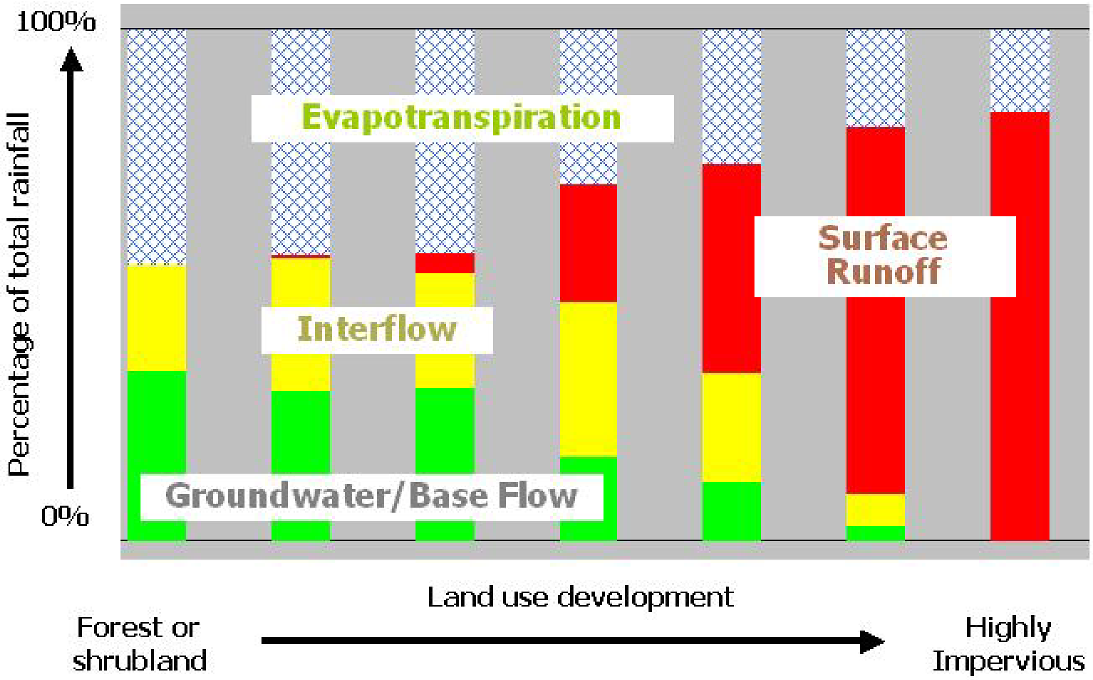


Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek

7.2 Hydromodification Management (HM) Controls

> Hydromodification management (HM) techniques focus on ***retaining, detaining or infiltrating runoff.***

Since 2007, new hydromodification management (HM) techniques have been required in areas across the San Francisco Bay Area that are susceptible to hydromodification. These techniques focus on ***retaining, detaining or infiltrating runoff*** and matching post-project flows and durations to pre-project patterns for a specified range of smaller, more frequent rain events, to prevent increases in channel erosion downstream. Within San Mateo County, a simple map-based approach is used to determine which parts of the drainage network are susceptible to hydromodification impacts. Projects that meet certain criteria, and from which runoff passes through the susceptible areas, are be required to incorporate one or more HM measures in the design in order to reduce erosive flows from a wide range of runoff conditions. HM measures can be grouped into three types:

- ***Integrated management practices***, or IMPs, which are small-scale, stormwater management techniques that are generally distributed throughout a project site. IMPs are designed to minimize directly-connected impervious areas, slow runoff, and maximize infiltration (where appropriate) as described in *Start at the Source* (BASMAA, 1999, www.flowstobay.org – click on Business, then New Development). IMPs may also include the use of bioretention areas, vegetated buffer strips, roofs that detain water, and multi-functional landscape areas.

- ***Flow duration control measures*** are used to manage excess runoff from the site after IMPs are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes from stormwater collected in pipes and channels before the runoff is discharged to a natural channel that could suffer adverse effects. Examples include extended detention basins, wet ponds and constructed wetlands. Please note that there is a difference between the design approach for sizing measures to remove pollutants from stormwater and the approach for designing flow duration controls to prevent an increase in the potential for creek bank erosion. The treatment of stormwater pollutants targets capture of 80% of average runoff volume, which means that treatment measures will be bypassed every one to two years. Flow duration controls must be sized to control the statistical duration of a wide range of flow levels under simulated runoff conditions. Depending on pre-project and post project conditions, the required detention volume is ***likely to be greater*** than the capture volume required for treatment. Flow duration controls are typically used on-site, but larger facilities, such as detention basins, may be sized to control runoff from a regional drainage area.

> Flow duration control measures are sized to control the flow and duration of stormwater runoff according to a ***Flow Duration Control*** standard, which is often greater than size requirements for volume-based treatment.

- ***In-creek or restorative measures*** that modify susceptible watercourses to withstand projected increases in runoff flows and durations without increasing erosion or other impacts to beneficial uses. In-creek measures are more complicated to use than the IMPs and flow duration controls, and are best suited for creeks or channels that have ***already received impacts*** from previous development and have only localized channel instability. Examples include biostabilization techniques using roots of live vegetation roots to stabilize banks and localized structural measures such as rock weirs, boulder clusters or deflectors. These measures will not automatically provide HM protection for channel reaches farther downstream and may require longer planning timelines and cooperation among multiple jurisdictions compared to flow duration controls.

7.3 Which Projects Need to Implement HM?

Unless it is a single family home that is not part of a larger of development, your project will be required to comply with the HM requirements if it meets the following applicability criteria:

- The project ***creates and/or replaces one acre or more of impervious surface***,
- The project ***will increase impervious surface*** over pre-project conditions, AND
- The project is ***located in a susceptible area***, as shown on the HM Control Area Map.

Appendix H shows the Countywide HM Control Area Map. The boundary between areas that are subject to HM requirements and areas that are not generally follows major roadways, such as El Camino Real and Alameda de Las Pulgas. Appendix H includes a series of maps that show more detail for locations in which the boundary does not follow major roadways. Areas exempt from HM requirements tend to be ***heavily developed***

areas of the bayside, while the more open and residential hillside, and coastside areas are subject to the HM requirements. Four municipalities -- East Palo Alto, Foster City, Daly City, and Colma – are totally exempt (except for some small areas of parkland in which no development is expected to occur). All of the other municipalities have some portions of their jurisdictions where development may occur that would be subject to HM requirements.

Please note that Attachment E of the MRP allows for the ***following exceptions to the HM control area boundary*** shown on the map:

- A project located on one or more parcels in the exempt area that drain into the HM control area would be subject to HM requirements.
- A project in the HM Control Area from which runoff drains only through a hardened channel and/or enclosed pipe along its entire length before directly discharging into a waterway in the exempt area or into tidal waters would be exempt from HM requirements, if the project applicant demonstrates, in a statement signed by an engineer or qualified environmental professional, that this condition is met.

Also note that projects located in susceptible areas are encouraged to include hydrologic source control measures for HM if they are likely to cause hydrograph changes, ***even if they create and/or replace less than one acre of impervious surface.***

7.4 Hydromodification Management HM) Requirements

The HM objective is to control stormwater discharges from non-exempt development projects so that these discharges do ***not increase the erosion potential*** of the receiving creek over the pre-project (existing) condition. This is accomplished by implementing four performance criteria:

- Projects shall ***provide hydromodification management (HM) controls*** as needed to maintain the pre-project creek erosion potential. These controls may include a combination of on-site or off-site (regional drainage area and/or in-creek) control measures. An erosion potential (Ep) of up to 1.0 shall be maintained for creek segments downstream of the discharge point. Ep can be expressed as the ratio of post-project to pre-project erosive "work" done on the creek.
- On-site stormwater controls that are designed to provide ***flow duration control*** to the pre-project condition shall comply with the HM requirements. Flow duration controls shall be designed so that the post-project stormwater discharge rates and durations match those of the pre-project condition, from 10 percent of the pre-project two-year peak flow up to the pre-project 10-year peak flow.
- Projects may use ***off-site control measures*** in lieu of or in combination with on-site controls, where an approved plan – including an appropriate funding

Flow Duration Control looks at the full range of flows in a simulated long-term history, and is ***not directly comparable*** to approaches based on one or a few synthetic "design storms".

mechanism – is in place and accounts for the creek changes expected to result from changes in project runoff conditions. The off-site control measures or combination of controls shall be designed to achieve the management objective of keeping the erosion potential (Ep) at 1.0 or less, from the point of discharge to the creek as far down stream as potential impacts will occur.

7.5 How to Implement HM Requirements

Projects subject to HM requirements need to consider HM at every stage of project development, following the step-by-step instructions for C.3 submittals in Chapter 3. The most effective use of land and resources may require a combination of IMPs, flow duration control facilities and in-creek measures, which are described in Section 7.2. In general, the strategy for designing HM measures should:

- ***Start with site design*** to minimize the amount of runoff to be managed (see Chapter 4).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration is limited by site constraints such as slope stability concerns, low-permeability soils or groundwater protection constraints.
- Use ***flow duration controls*** to detain the remaining calculated runoff from the site enough to ***control its release*** in a way that meets the remaining runoff design requirements. This may be accomplished with a measure that also provides volume-based treatment, such as an extended detention basin. For some project locations, off-site options may be available to reduce or eliminate the need for onsite detention.

> The duration of channel flows below the ***"critical flow"*** may be increased indefinitely without significant contribution to hydromodification impacts.

7.5.1 Flow Duration Control

Flow Duration Control (FDC) differs from traditional "design storm" approaches used to design detention facilities for flood control or water quality treatment. Instead of specifying static holding times for one or a few discrete events, the Flow Duration standard manages runoff discharge over the full range of runoff flow levels predicted through continuous hydrologic simulation modeling, based on a long-term precipitation record. Flow Duration Control requires that the increase in surface runoff resulting from new impervious surfaces be ***retained on-site with gradual discharge*** either to groundwater through infiltration, losses by evapotranspiration, and/or discharge to the downstream watercourse at a level below the critical flow that causes creek channel erosion. ***Critical flow,*** or Qc, is the lower threshold of in-stream flows that contribute to sediment erosion and sediment transport or effective work. The duration of channel flows below Qc may be increased indefinitely without significant contribution to hydromodification impacts.

7.5.2 Application of Flow Duration Control to Project Areas

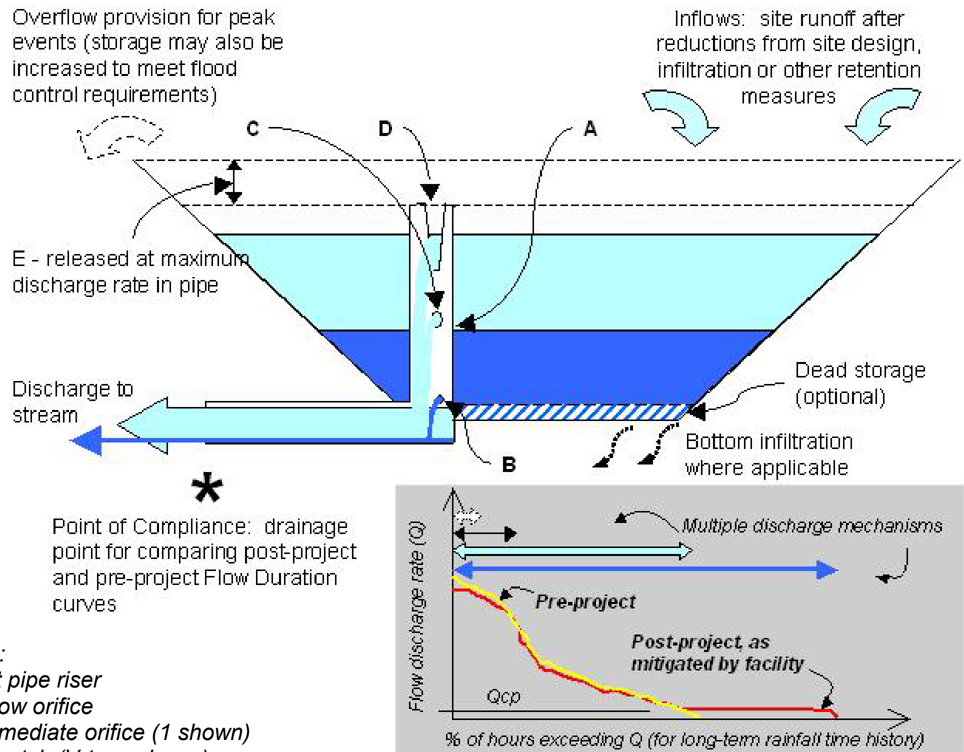
The Flow Duration approach involves a continuous model that applies a time series of at least 20 years of rainfall records to a watershed area or project site to generate a simulated stormwater runoff record based on two sets of inputs, one representing future development and the other representing pre-project conditions. The 20-year precipitation record is the minimum length necessary to capture the range of runoff conditions that are cumulatively responsible for most of the erosion and sediment transport in the watershed, primarily flow levels that would recur at average intervals of 10 years or less in the pre-project condition. The design objective is to ***preserve the pre-project cumulative frequency*** distribution of flow durations and sizes under post-project flows. This is done with a combination of site design, infiltration and detention. Typically the post-project increase in surface runoff volume is routed through a ***flow duration control basin*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4).

The flow duration basin, tank or vault is designed conceptually to incorporate multiple pools that are filled with different frequencies and discharge at different rates. The low-flow pool is the bottom level designed to capture and retain small to moderate size storms, the initial portions of larger storms, and dry weather flows. These flows are discharged through the lowest orifice which allows continuous ***discharge below the critical flow rate*** for a project (Qcp). Successively higher-flow pools store and release higher but less frequent flows through other orifices or graded weir notches to approximate the pre-project runoff durations. In practice the multiple pools are usually integrated into a single detention basin, tank or vault that works as a unit with the specialized outlet structure. Matching the pre-project flow durations is achieved through fine-tuning of the number, heights and dimensions of orifices or weir notches, as well as depth and volume of the basin, tank or vault.

As shown in the example chart of Figure 7-4, the post-project flow duration curve (red, or dark line) is reduced by the facility to remain ***at or below the pre-project curve*** (yellow, or light line), except for flows less than Qcp. Minor exceedances are permissible at a limited number of higher flows since at other flow levels the post-project duration is actually less than the pre-project condition.

> Flow Duration facilities are subject to ***Operations and Maintenance*** reporting and verification requirements similar to those for numerically sized treatment measures.

If feasible, ***combining flow duration and water quality treatment*** into a single facility reduces the overall land requirements for stormwater management. Adequate maintenance of the low-flow orifice or notch is critical to proper performance. The outlet may be in a protective enclosure to reduce risk of clogging. Please note that Flow Duration facilities are subject to Operations and Maintenance verification requirements similar to those for numerically sized treatment measures.



Legend:
A-outlet pipe riser
B-low flow orifice
C- intermediate orifice (1 shown)
D-weir notch (V-type shown)
E-freeboard above riser (typically 1 foot)

Figure 7-4: Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume. (Source: ACCWP, 2006)

7.5.3 Bay Area Hydrology Model (BAHM)

To facilitate the simulation modeling aspect of FDC for project applicants and their engineers, the Countywide Program collaborated with the Santa Clara and Alameda counties' stormwater programs to develop a Bay Area Hydrology Model ***software package*** that is adapted from Version 3 of the Western Washington Hydrology Model (WWHM) developed by Clear Creek Solutions for the State of Washington Department of Ecology (WDOE). The WWHM was specifically developed to help engineers design facilities to meet a Flow Duration Control standard for development projects.

The BAHM, which may be downloaded from the Program's website together with county-specific data, includes:

- Databases to automatically assign default ***rainfall conditions*** for a project location selected within the County boundary.
- A user interface for developing a ***schematic drainage model*** of the project site, with forms for entering areas of land use or impervious surface for multiple sub-basins.

- Continuous simulation modeling of ***pre-project and post-project runoff*** from the site using actual long-term rainfall records appropriately scaled for the project location.
- A design module for sizing a ***FDC detention facility*** and designing the discharge structure to meet the Flow Duration standard for matching post-project and pre-project duration-frequency curves. Pre-project and post-project runoff are compared at a "point of compliance" selected by the designer, usually near the point where runoff leaves the project area.
- Options to check facility sizing for ***volume-based treatment***, and incorporate runoff reductions attributable to some common hydrologic source control measures.
- Standardized output ***report files*** that can be saved in Word format, and include all information about data inputs, model runs, facility design, and summary of the hydrological statistics showing the compliance of post-project flow duration curves with the Flow Duration standard. Project input and output data can also be saved in Excel and other formats for other uses.

7.6 Area-Specific HM Provisions

Individual municipalities may have special policies or ordinances for creek protection applicable in all or part of their jurisdictions. ***Contact municipal staff*** from your jurisdiction to identify any special local provisions that may encourage or affect specific forms of HM implementation. Examples of area-specific HM provisions can include:

> Some municipalities may have special policies or ordinances for ***creek protection.***

- Watershed-based land-use planning measures, such as creek buffers, which may be incorporated in local General Plans, zoning codes or watercourse ordinances.
- Special permitting provisions for project design and review of projects on streamside properties.
- Specific plans for regional HM measures or in-stream restoration projects.
- Any Equivalent Limitation Protocols that may be proposed, in accordance with Provision C.3.f.vii of the municipal stormwater permit, as alternatives to the default HM requirements in specific jurisdictions or watersheds.

7.7 When On-site HM is Impracticable

Under specific conditions, the MRP allows projects to meet HM requirements by providing for or contributing financially to an off-site alternative HM project.

7.7.1 Determining Impracticability

In order to use an off-site alternative HM project, you would need to demonstrate the following:

- Due to onsite conditions (such as extreme space limitations) the ***total cost to comply with both HM and stormwater treatment requirements*** exceeds two percent of the project construction cost, excluding land costs. (When calculating costs of HM and stormwater treatment measures, do NOT include land costs, soil disposal fees, hauling, contaminated soil testing, mitigation, disposal, or other normal site enhancement costs such as landscaping or grading that are required for other development purposes.)
- There is ***no available regional HM measure*** to which runoff from your project can be directed. A regional HM measure is considered available if there is a planned location from the regional HM measure AND if an appropriate funding mechanism for the regional HM measure is in place by the time of your project's construction.
- Meeting the HM requirements by constructing ***an in-stream measure is not practicable***. An in-stream measure is considered practicable if an in-stream measure for your project's watershed is planned, and an appropriate funding mechanism for the in-stream measure is in place by the time of project construction.

7.7.2 Requirements for Using an Alternative HM Project

If you have demonstrated that on-site HM is impracticable for your project, you will need to implement the following requirements to use an alternative HM project.

- Include site designs in your project that ***provide hydrologic source control***. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention.
- Include in your project stormwater treatment measures that collectively ***minimize, slow and detain runoff*** to the maximum extent practicable. (This generally includes bioretention areas, flow-through planters, and other stormwater treatment measures that filter runoff through soil or other media.)
- ***Contribute financially*** to an alternative HM project, such as a stormwater treatment retrofit, HM retrofit, regional HM control, or in-stream measure that is not otherwise required by the Water Board or other regulatory agency. The contribution shall consist of the difference between two percent of the project construction costs and the cost of the treatment measures at the site (based on calculations described in Section 7.6.1).