



HMP Applicability Mapping Methodology

Prepared for:
Contra Costa Clean Water Program

September 11, 2017

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TITLE PAGE

Document Name: *HMP Applicability Mapping Methodology*
 Publication Date: September 11, 2017
 Contract Number: 7519-2310-6x7665
 Project Number: Psomas Project No. 4CON030100
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PREFACE

PROJECT BACKGROUND

The Contra Costa Clean Water Program (CCCWP) is responsible for assisting Contra Costa County, its 19 incorporated cities and towns, and the Contra Costa Flood Control and Water Conservation District with compliance with their Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) Permit.

The United States Environmental Protection Agency published final rules implementing the 1987 CWA amendments in November 1990. The rules mandate that the Permittees obtain and implement stormwater permits designed to reduce and eliminate the discharge of pollutants into and from Municipal Separate Storm Sewer Systems (MS4s) they own or operate. Permit provision C.3.g requires stormwater permittees to develop a Hydromodification Management Plan (HMP).

Hydromodification is generally defined as changes in channel form associated with alterations in flow and sediment due to past or proposed future land-use alteration. Hydromodification management has emerged as a prominent issue because degradation of the physical structure of a channel is often indicative of and associated with broader impacts to many beneficial uses, including water supply, water quality, habitat, and public safety. Conversely, reducing hydromodification and its effects has the potential to protect and restore those same beneficial uses.

CCCWP has developed an HMP that establishes flow control requirements for new development projects within Contra Costa County intended to minimize increased stormwater runoff and protect receiving stream channels from accelerated erosion. HMP implementation guidelines for land developers have also been created. One of the significant remaining challenges is determining where, geographically, the HMP regulations apply and what areas of the County are exempt. Those primary exemptions are:

- Projects that drain to tidally-influenced areas or the Bay
- Project that drain through continuous hardened stormwater infrastructure (e.g. pipes and concrete channels) to tidally-influenced areas or the Bay
- In-fill projects in hydrographical areas that are already 70% or more impervious

Working with Psomas, the technical approach decided upon to meet this challenge was to use Geographical Information System (GIS) technology to assist in determining geographical areas that are exempt from HMP, with the remaining geographical extent becoming areas of HMP applicability.

PURPOSE & SCOPE OF THE DOCUMENT

This document describes the methodology used to determine HMP applicability and the deliverable outputs of the project.

INTENDED AUDIENCE

This document is intended for use by permittees, as well as authorized key technical staff from other organizations that CCCWP wishes to engage for management of the project.

DOCUMENT VERSION CONTROL

It is the reader's responsibility to ensure they have the latest version of this document. Questions should be directed to the owner of this document, or the project manager.

REVISION SHEET

Release Name	Date	Revision	Description
First Draft	7/5/2017	1.0	Initial release for CCCWP review
Second Draft	9/11/2017	2.0	Updated and re-formatted

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1 METHODOLOGY OVERVIEW

To determine HMP applicability requires a significant amount of knowledge about the current stormwater drainage infrastructure within Contra Costa County. The ideal solution would be a computer system and accompanying datasets that could model (figuratively) each drop of rain water, simulating its flow over land, through creeks, gutters, catch basins, pipelines, outfalls, ditches, and channels, until it ultimately reaches the Bay. Unfortunately, that system and datasets do not exist in any holistic fashion. What does exist, however, are various GIS datasets of municipal stormwater systems, hydrology, terrain, as well as imagery and datasets generated from satellites. Therefore, the primary challenge of this project was to develop a suitable methodology for objectively determining HMP applicability of hydro-geographical areas using the available GIS data.

The first task became an assessment of the available GIS and other datasets that could be used to establish drainage areas, stormwater flow directions, tidally-influenced areas, land cover imperviousness, and the configuration of channels as either hardened or vulnerable to hydro-modification (documented in Section 2). Then followed the development and implementation of a methodology that could use this available information to determine HMP applicability (documented in Section 3).

Creating drainage areas (sub-basins) and flow directions from County terrain data was relatively straightforward to accomplish. What was critically missing was information on gutter flow through subdivisions, stormwater pipeline flow directions, and detailed information on channel configurations (concrete or rip-rap sides, concrete or earth bottom, etc.). The methodology that was developed used flow directions based upon terrain and visual interpretation of satellite imagery to develop a first-pass map product that would then be systematically reviewed and validated by individual permittee staff with expert knowledge of their local drainage systems.

2 ASSESSMENT OF AVAILABLE GIS DATASETS

To determine HMP applicability, the following city and county-wide GIS datasets were requested from permittees and evaluated by the Psomas team:

- Stormwater infrastructure (e.g. pipelines and channels)—to determine where infrastructure has been hardened.
- Streams, wetlands, and other water bodies—to determine natural streams and earthen channels that need to be protected, as well as bay lands and tidally-influenced areas that would be directly exempt.
- Hydrologic basins / sub-basins (if available)—to determine hydrographic areas and natural stream flow directions.
- Digital elevation model (DEM)—terrain data, in the event that hydrographic sub-basins were not available for the entire county and needed to be derived from land topology.
- Datasets from which percent impervious is an attribute or could be derived—in order to help determine areas exempt for being 70% or more impervious.

The following GIS datasets were received and assessed.

STORM INFRASTRUCTURE DATA FROM PERMITTEES

The storm drainage infrastructure GIS data received was deemed mostly adequate for determination of where hardened stormwater conveyances exist, but complete and detailed information was not available. Completeness of infrastructure representation was validated through permittee review of final maps.

Observations:

- Various levels of unknown quality and completeness of storm drainage infrastructure data received from 19 different agencies.
- No datasets included curb flow that would have been very useful to understand the full drainage system.
- Not able to determine flow direction from datasets (largely derived from CAD systems).
- Focused on pipe infrastructure, with non-pipes listed as “channels”, “ditches”, and “creeks” that was not consistent across multiple organizations.

Knowing that stormwater drainage systems generally follow land topography, Psomas decided to use hydrographic sub-basins as the secondary means of determining drainage areas and flow direction. Sub-basins were not available for the entire county, but a high-resolution county-wide DEM was available. Therefore, Psomas generated hydrologic sub-basins using standard GIS-based hydro-analysis techniques.

CARI AND BAARI STREAMS AND WETLANDS

The California Aquatic Resource Inventory (CARI) and Bay Area Aquatic Resource Inventory (BAARI) stream data was determined to be adequate for determination of tidally influenced channels and to provide a visual reference for non-hardened stormwater conveyances.

Observations:

- Identify streams as either “fluvial” or “tidal” and “natural” or “unnatural”

- “Fluvial Natural” are vulnerable streams to be protected by HMP
- “Tidal” is very helpful in identifying tidally-influenced stream / channels
- “Unnatural” could include any number of hardening improvements
- BAARI data includes wetlands category “bay lands”

Stream / channel data completeness appeared to be good from CAARI/BAARI and other sources. However, no data source provided quality information of whether a channel was earthen, concrete (riprap), or some combination thereof. It was concluded that hardness of a channel would need to be assessed by visually assessing the available ortho-photography (more about this in the next section).

STORM WATER UTILITY FEE—EQUIVALENT RUNOFF UNIT DATA

The Storm Water Utility Fee (SWUF) Equivalent Runoff Unit (ERU) data provided by the County was not useful for determining percent impervious for a geographic area, due to the structuring of the data and large holes in coverage.

Observations:

- Parcel-based dataset
- Equivalent Runoff Unit (ERU) can be converted to percent impervious for the parcel using the formula $\%Impervious = ERU * 3,300 / Parcel SqFt.$, however:
 - Forced ERUs can result in percent impervious > 100%
 - Standardized ERUs assigned to very small parcels result in percent impervious > 100%
- Data does not cover entire county
- ERU values not calculated for exempt properties (e.g. local, state, or federal government owned parcels)
- ERU not represented accurately geographically:
 - ERUs assigned to individual building parcels—see Figure 1
 - Total ERU for single-owner multi-parcels assigned to the parcel that includes the primary office, examples: trailer parks, DOW Chemical

NATIONAL LAND COVER DATASET (NLCD)

The NLCD impervious data was determined adequate for identifying hydrological areas that are 70% or greater imperviousness.

Observations:

- Percent impervious calculated from satellite



Figure 1. ERUs Assigned to Individual Buildings



Figure 2. National Land Cover Dataset—Impervious

imagery

- 2011 raster dataset with 30m pixel resolution
- Percent imperviousness represented geographically
- Good spatial alignment with county datasets.

CONTRA COSTA COUNTY GIS DATASETS

Various GIS datasets supplied by the County were used as basemap information and instrumental supporting the HMP applicability analysis.

Observations:

- Parcels—complete and up-to-date
- Watersheds—useful for administrative / jurisdictional purposes, but not precisely-aligned with topography
- Sub-basins—not available for entire county
- Digital Elevation Model—county-wide coverage with apparent high resolution and quality

3 METHODOLOGY FOR DETERMINATION OF HMP APPLICABILITY

The following methodology was used to determine the HMP applicability of stormwater drainage areas, represented by sub-basins, to create a HMP Applicability GIS layer for further mapping and analysis purposes.

STEP #1—CREATE SUB-BASINS

Psomas created hydrologic sub-basins based upon topography using the Contra Costa DEM—see Figure 3.

The process used hydro-analysis software tools provided with the Esri ArcGIS Desktop—Spatial Analyst software extension. The sub-steps were:

- Fill sinks
- Set flow direction
- Calculate flow accumulation
- Generate streams (simulated streams based upon flow accumulation threshold)
- Determine stream links (stream segments defined by stream confluences)
- Create sub-basins (hydrographic areas) for each stream link
- Convert raster sub-basins to vector sub-basin polygons

The end result was a sub-basin polygon and generated streams polyline vector GIS layers—see Figure 4.

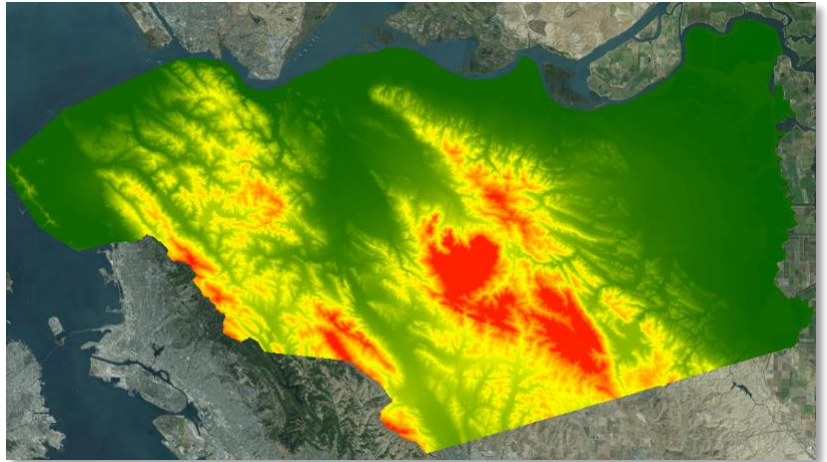


Figure 3. Contra Costa County DEM

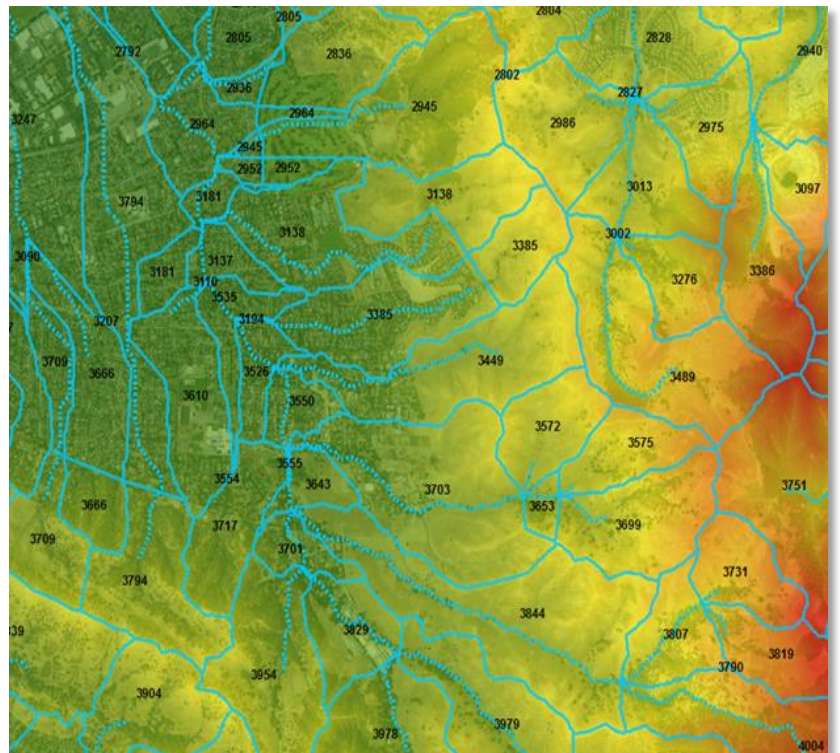


Figure 4. Sub-basins and Generated Streams Derived from County DEM

STEP #2—PERFORM OVERLAY GIS ANALYSIS ON IMPERVIOUS DATA

A GIS overlay zonal analysis was performed to determine the average percent impervious for each sub-basin using the NLCD impervious raster layers as data source. A clip of the results for the Richmond area is shown in Figure 5. The areas in red were 70% or greater impervious and areas in deep yellow were 65% to 70% impervious, i.e. just missing the cutoff.

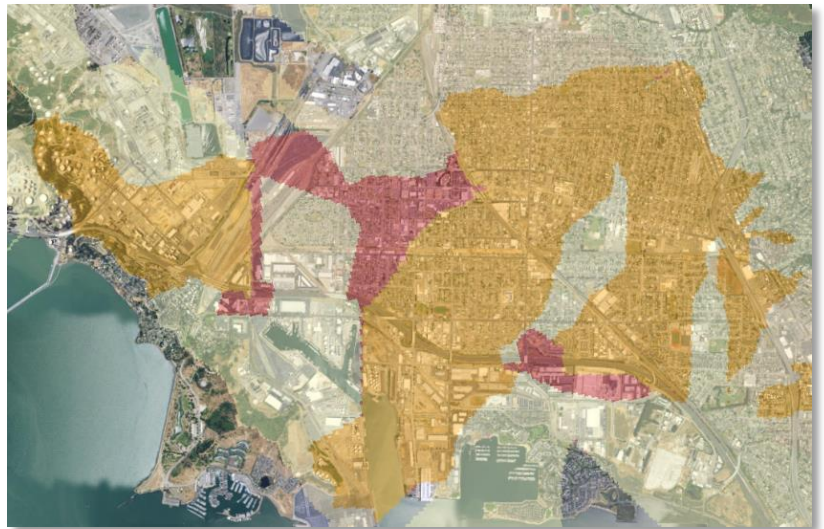


Figure 5. Impervious Zonal Analysis Results using NLCD Data

STEP #3—DETERMINE TIDAL-INFLUENCED AREAS

The BAARI / CARI datasets were used as the primary data source reference to determine tidally-influenced areas. The extent inland that streams and channels were attributed as “tidal” established the boundary limit. Any flat, low-lying, land area between two tidally-influenced stream segments were also determined to be tidally-influenced, since that area shares the same hydrological characteristics. Areas marked “bay lands” were presumed to also be tidally-influenced.

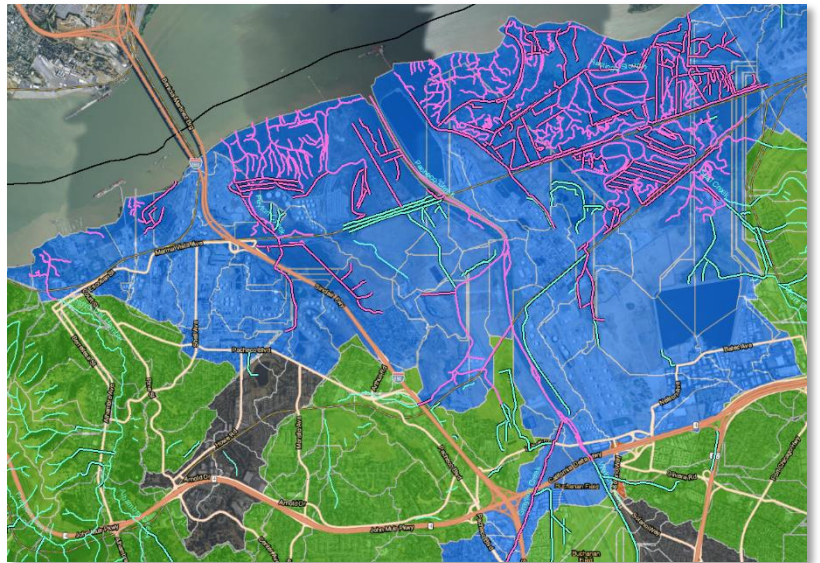


Figure 6. Tidally-influenced Area Defined by BAARI / CARI Data

STEP #4—DETERMINE CHANNEL HARDENING

As described in the previous section, there appeared to be no suitable county-wide data source that adequately defined the degree to which a channel was constructed of hardened materials (e.g. concrete, rip-rap).

Psomas established channel hardened / non hardened status through visual interpretation of the available ortho-imagery. The following were used as guidelines.

- Curvy streams / channels tend to be natural
- Straight-line and engineered curve channels tend to be man-made
- Narrow channels with vertical concrete sides are assumed to have hardened bottom
- Lack of heavy vegetation (trees, brush) indicate a hardened channel

Hardened channels were validated through permittee review of final maps.

STEP #5—MANUALLY CODE SUB-BASINS FOR HMP APPLICABILITY

An “HMP Category” attribute was added to the Sub-basins GIS layer with the following possible coded values:

- Bay Lands—not subject to HMP due to tidal influence.
- Tidal Influenced—not subject to HMP as channels / streams are tidally influenced.
- Exempt > 70% Impervious—not subject to HMP as sub-basin has average imperviousness > 70%.
- Hardened—not subject to HMP as the area drains to the Bay or tidal-influenced areas through continuous hardened storm infrastructure.
- HMP Applicable—contains or drains to an unhardened stream or channel.
- Undetermined—applicability is to be determined.

Each sub-basin was evaluated manually and assigned to the appropriate HMP Category using the GIS datasets described previously as visual input. An example of the process is depicted in Figure 7.

In this example, the stormwater flows from a hill ridgeline bordering the right (East) side of the area and then flows to the left (westwardly) towards the main channel, then North and exiting the area through the main channel in the top left corner. Through interpretation of the ortho-imagery it was determined that this main channel transitions from natural to hardened where the background color changes (you can also see the transition from curvy natural to engineered man-made in the layout of the channel). It was also determined that this main channel stays hardened continuously through to a tidally-influenced area.

As a result of the above interpretation, the sub-basins that contained stormwater lines (red) that drained to the natural sections of the channel were coded as “HMP Applicable” (green background). Sub-basins that contained stormwater lines that drained to the hardened section of the channel were coded as “Hardened” (dark grey background). The

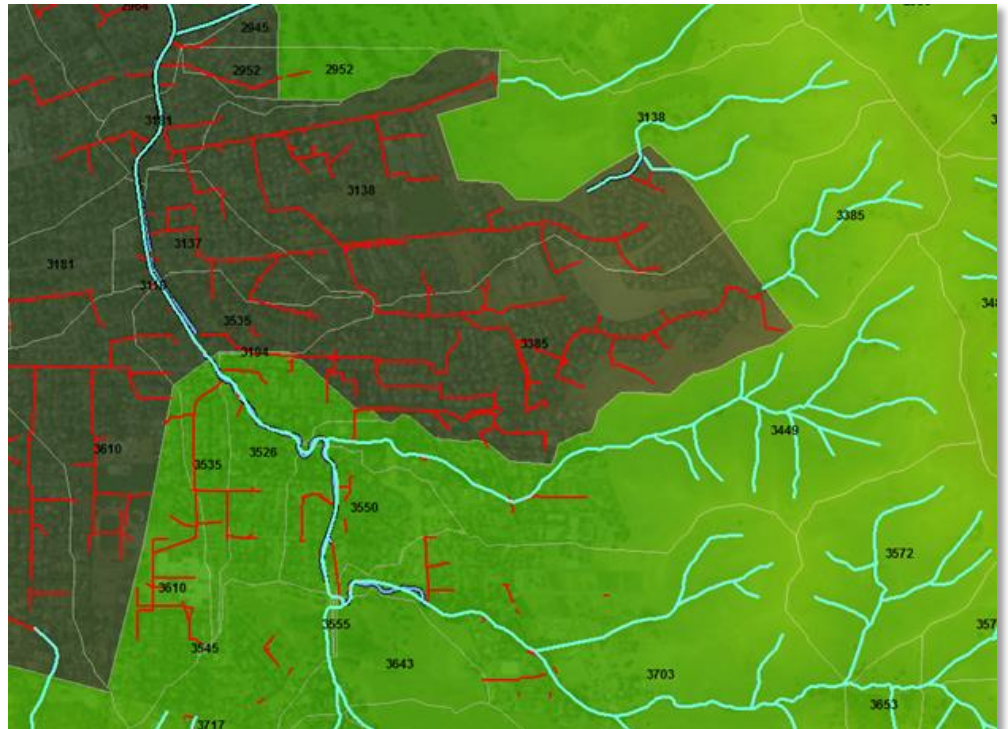


Figure 7. Sub-basins Assigned HMP Applicability

exception were the sub-basins that extend to the right that start out as urban area and end in undeveloped areas. In those cases, the sub-basin was manually split at the natural-urban boundary and the upper portions were coded as “HMP Applicable.” In this manner, any new development that expands to the west will fall under HMP requirements and any infill projects within the “Hardened” areas will not.

HMP applicability coding was validated through permittee review of final maps.

STEP #6—PERMITTEE REVIEW

A draft set of HMP Applicability maps were created, one for each permittee, and distributed to permittee members for quality review and red-line markup. The review was to be performed by permittee agency personnel that had expert knowledge of the local storm drainage infrastructure. The purpose was to validate the interpretations made by the development team with first-hand knowledge of the characteristics of local channels and other stormwater infrastructure.

REVIEW PROCESS

It was anticipated that mapping errors would be revealed by systematically manually inspecting the maps for the following two conditions:

1. Streams and Channels Vulnerable to Hydro-modification versus Hardened

An initial determination of where channels are hardened was attempted by visually interpreting available ortho-imagery (satellite photos). Permittee staff reviewed the hardness of streams and channels, as shown on the draft maps, based on their knowledge of the local drainage system and by field-checking where necessary to identify and redline any issues.

2. Stormwater Pipeline Flow Directions

Permittees reviewed the flow directions of all stormwater pipelines, paying particular attention to any that cross sub-basin boundaries. Based on local knowledge of pipe and gutter flow directions, and on field-checking where necessary, portions of sub-basins or entire sub-basins were re-classified as to HMP applicability.

GUIDELINES

The following were the general definitions and guidelines to follow when reviewing the draft HMP Applicability maps:

- The overall objective is to protect vulnerable sections of streams and channels from hydro-modification by incorporating HM controls into new development projects in all drainage basins upstream of those stream and channel sections.
- A sub-basin is a hydro-geographic area that drains to a single downstream point. Sub-basins were generated by hydrographic computer analysis of the terrain. The sub-basins are being used as representative geographical base unit areas of the drainage system, which are then coded as to their HMP applicability.
- A stream or channel is hardened if it is not susceptible to scouring or reshaping as the result of stormwater drainage, which generally means it is either fully concrete, on the bottom and banks, or has a concrete bottom with rip-rap banks. Generally, only engineered channels are considered “hardened.” A linear accumulation of rip-rap or other measures placed to control localized erosion does not qualify a reach as “hardened.”
- All areas upstream of any non-hardened stream reach are HMP applicable. Therefore, it is not critical to determine the status of a reach that is upstream of a reach known to be unhardened. To put it another way, for parcels within a sub-basin to be considered exempt from HM requirements, there must be no points of susceptibility at any point of the entire downstream drainage from that sub-basin to either a tidal-influenced area, designated Bay land, or to the Bay/Delta.
- Changes to the sub-basin boundaries are appropriate when local knowledge or field investigation shows that portions of a sub-basin drain to pipes or hardened channels (all the way downstream)

and not to a natural stream. In these cases, the sub-basin should be divided and the subdivided portions assigned HMP applicability as appropriate.

- Stormwater pipelines, as well as concrete curb and gutters, are hardened infrastructure. If a gutter and pipeline system drains to a vulnerable stream or channel, then the entire sub-basin, including the areas served by hardened infrastructure, will be coded as “HMP Applicable.” Conversely, if all the gutter and pipeline systems within a sub-basin drain to hardened channels all the way downstream, then the entire sub-basin will be coded as “Hardened.”
- If a sub-basin is partially-developed and the drainage through the developed portion is hardened (using the above definitions) and the drainage through the upstream portion is unhardened (natural), then the sub-basin can be divided at the urban/natural boundary. The upstream portion will be coded as “HMP Applicable” and downstream portion will be coded as “Hardened.”
- If there are both susceptible streams and hardened channels in a sub-basin, and it is not known if all drainage systems drain to the hardened channel, then the sub-basin will be coded as “HMP Applicable.”

REDLINE SUBMITTALS AND MAP UPDATES

The paper and electronic (PDF) red-line markups have been preserved and changes made by permittees recorded in notes as attributes within an “HMP_Review” GIS layer. From this set of markups, the Psomas team created a final version of the HMP Applicability maps and submitted those to individual permittees for final review and approval. Permittee approvals were also documented and archived for historical reference and accountability.

STEP #7—MERGE SUB-BASIN POLYGONS

The HMP sub-basin layer with HMP Category attribute and HMP_Review layer with notes will remain the master record. An optimized version of the HMP applicability GIS layer has been created to enhance fast display and analysis within the GIS by merging contiguous areas of HMP applicability.

4 PROJECT OUTPUTS

The primary deliverable outputs of the project are: 1) county-wide HMP Applicability GIS layers that can be used for mapping, analysis, and the foundation for 2) a web application to assist in determining HMP applicability for development projects.

HMP APPLICABILITY GIS LAYERS

Three GIS layers were developed for the project:

1. HMP_Subbasins—a GIS layer of hydrographic generated sub-basins each coded as to their HMP applicability.
2. HMP_Applicability—a simplified version of the HMP_Subbasins GIS layer that dissolves out the sub-basin boundaries, used for quick display and user analysis.
3. HMP_Review—a GIS layer documenting the HMP Applicability map review input that was received from permittees and the changes to the HMP applicability mapping that were made as a result.

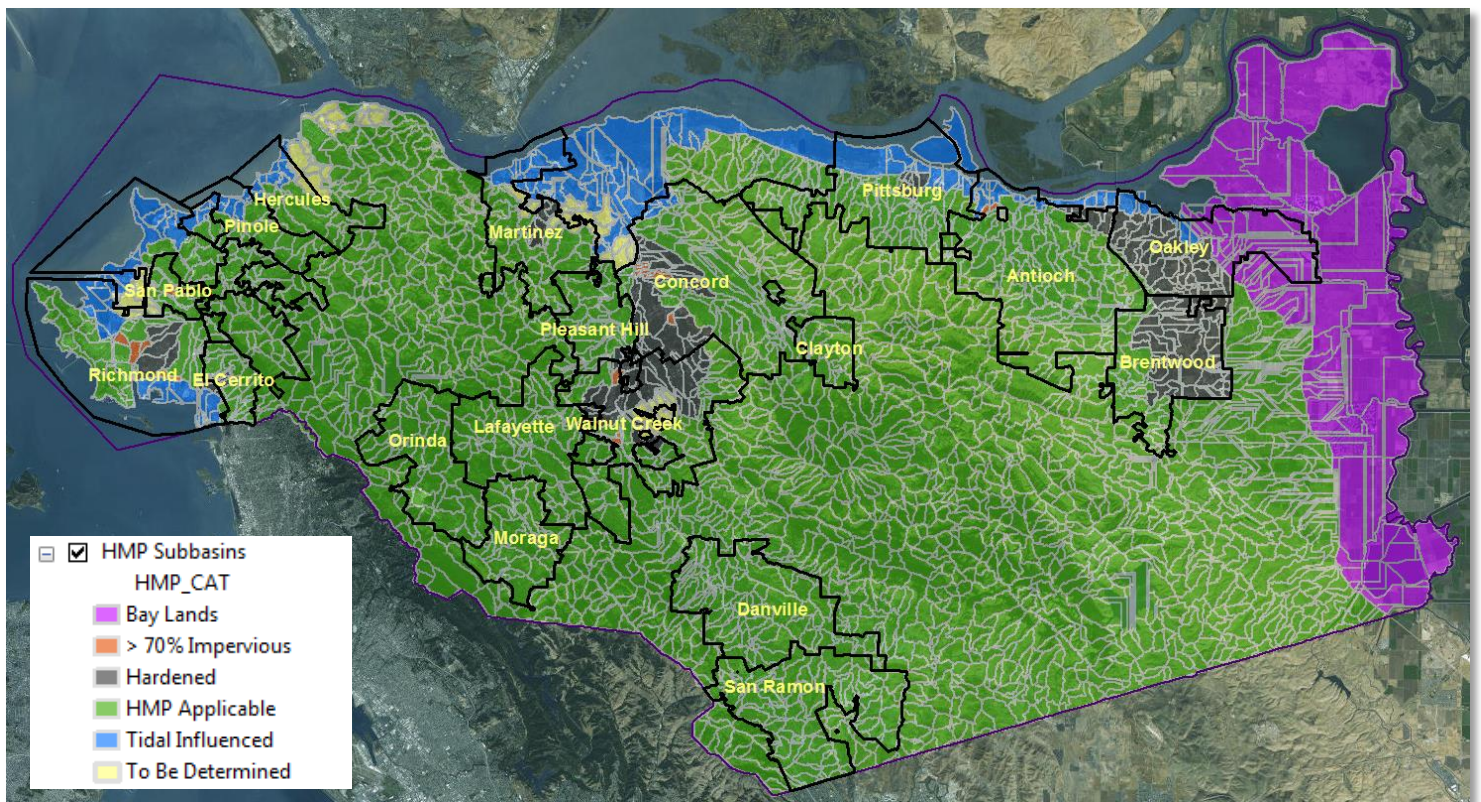


Figure 8. HMP Applicability GIS Map

HMP APPLICABILITY GIS APPLICATION

An Esri ArcGIS Online application has been developed that displays the HMP_Applicability layer in association with ortho-imagery, city boundaries, and county parcels. The application is currently only available through the CCCWP internal GIS portal, but the intention is to make the application available to the public in the near future.

