Pajaro River Watershed Study

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Technical Memorandum No. 1.2.6

Task: Land Use and Soils

To: PRWFPA Staff Working Group

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Reviewed by: L. Gutierrez

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Introduction

The purpose of this Technical Memorandum (TM) is to establish current land use and land cover (LULC) and soil conditions within the Pajaro River Watershed. Particularly relevant to the hydrologic runoff model is the percentage of the land use for each hydrologic soil group. The soil groups are based on NRCS A-D rating system.

Once the current conditions are defined, they can be used as a baseline to which other watershed conditions can be compared. This ability to compare past, future, and hypothetical conditions will allow decision makers to determine which course or courses of action to pursue to improve the level of flood protection for the residents of the Pajaro River valley.

After a brief summary of the scope, background, and setting of the Pajaro River Watershed Study, this TM will address land use and land cover as well as hydrologic soil groups found within the watershed. The source of the data will be discussed, as will the qualities and limitations of the data. Quality checks for both the soils and LULC data will be described and any necessary changes made. Current conditions will be presented and explained. At the end of the technical memorandum, a concise and direct conclusion will be drawn from the data and analysis presented within this document.

Project Scope and Background

The Pajaro River Watershed Flood Prevention Authority was formed to develop flood protection strategies in the Pajaro River Watershed. The first phase in developing the strategies is to construct a streamflow model. The model shall address a number of key issues, including the following:

- What are the causes of flooding on the Pajaro River?
- Has rainfall runoff increased downstream with increasing development upstream?
- Has the improvement and/or maintenance of streams affected flooding?
- Has erosion or sedimentation in the streams affected flooding?
- Have upstream retention basins reduced or mitigated the degree of flooding?
- How will future conditions change the degree of flooding?

Answering these and other related questions regarding Pajaro River flooding requires the development of hydrologic and sediment models for the Pajaro River and its tributaries.

Setting

The Pajaro River drains an area of approximately 1,300 square miles of the coastal plains and mountains of Central California. A tributary of Monterey Bay, the watershed drains portions of Santa Cruz, Monterey, Santa Clara and San Benito Counties. As shown in Figure 1, the watershed is somewhat elongated toward the southeast.

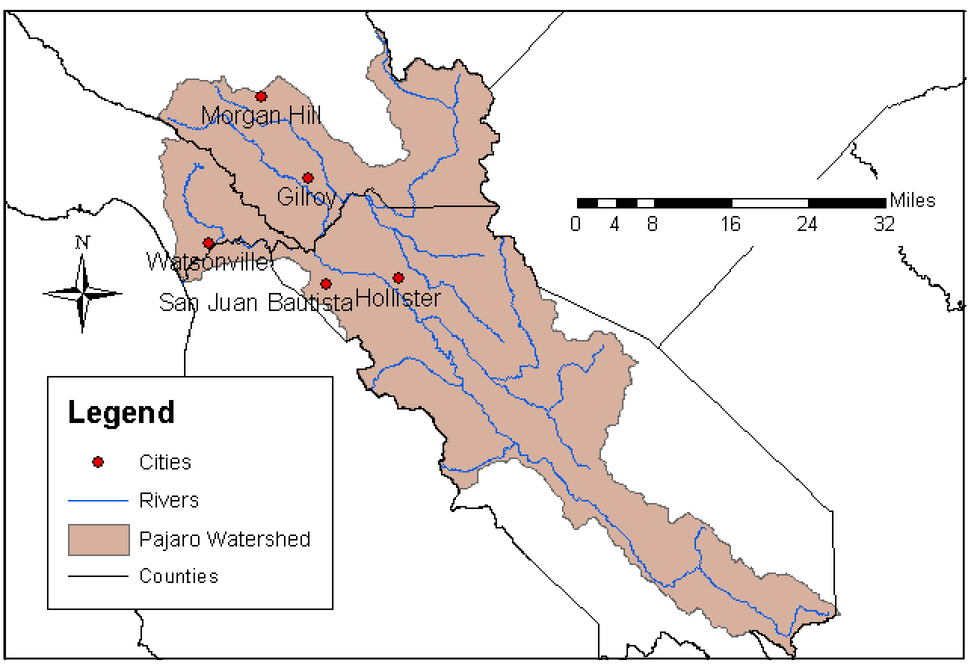

Figure 1: General map of Pajaro River Watershed.

The lower portions of the Pajaro River from Murphy's Crossing to the Pacific Ocean are protected by levees constructed by the Corps of Engineers between 1949 and 1952. Four miles above this federal project is the USGS stream gage – Pajaro River at Chittenden, CA. This gage has been in continuous operation since the 1939 water year. The drainage area at this gage is 1,186 square miles.

Two miles above the Chittenden gage site, the San Benito River is confluent to the Pajaro. At this point the San Benito River drains 661 square miles - slightly more than half the drainage area at the Chittenden gage. The Pajaro River at the outlet to Soap Lake – a low-lying area of Santa Clara and San Benito Counties – has a drainage area of approximately 500 square miles.

Sources of Data

Although there are many sources of data, it is important for this study to use the most current and most accurate data available. It is also important that the data cover the entire watershed. Some sources of data examined, although otherwise excellent, pertained only to portions of the watershed. It was found to be too difficult to collect pieces of the watershed and assemble them.

LULC

Appropriate data was found for both the LULC and soil aspects of this technical memorandum. LULC data was taken from the USGS website. The 1992 National Land Cover Dataset (NLCD) is available free of charge for the entire United States. It was generated using satellite imagery supported by topography, census, agricultural statistics, soil characteristics, other land cover maps, and wetlands data. The land uses are classified into 21 different groups. A list of these groups and associated descriptions can be found at the end of the technical memorandum in Appendix A. The website also mentions an updated dataset for the year 2000, but due to the data processing requirements this data will not be available for several years. Datasets from mid-1970 are available, but would not represent the current land use as well as the more recent data.

Although the 1992 NLCD data is the best available LULC information for this project, there is a drawback to using this data. Although the data has been checked for initial quality, a final accuracy assessment from USGS or EPA is not yet available. GIS coordinators at the USGS EROS Data Center maintain that the data is generally quite good without the final assessment, but recommended an independent verification of the data. Steps taken to do this are discussed below.

Hydrologic Soil Groups

Soils data was obtained directly from the Natural Resources Conservation Service (NRCS). Digitized soil surveys, also known as SSURGO data, were not available for both Santa Clara County and San Benito County. SSURGO data is recognized as the most accurate soils data offered for public access and use. Another dataset, STATSGO, is also available but is intended for large scale planning. The NRCS State Office was able to provide STATSGO level data with the information necessary for this study.

The hydrologic soil group is the most important soil property for runoff potential. Since this property changes quickly across small distances that are not measurable at the STATSGO level, soil scientists at the NRCS office recommended that the data provided be verified to confirm adequate accuracy for the modeling needs of the study. As with LULC data, steps taken to provide this confidence are described below.

Quality Checks

Data quality checks are essential to any study, but are especially important when the data is provided with warnings. Below are checks and processes used to address any concerns regarding the accuracy of the data obtained for this aspect of the study.

LULC

Since the LULC dataset is computer generated using satellite images, it might be expected that any mistake in classifying land use and land cover would be made consistently. It is therefore necessary to check only one representative piece of the dataset for accuracy in defining land use and land cover. The land use in Santa Clara County was cross-checked using SCVWD land use parcel data from 1999. As can be seen in Figure 2a and 2b, land use patterns in the two datasets are remarkably similar. While the land use types may be different, further examination reveals that SCVWD's data can be aggregated to fit into the land types represented in the 1992 USGS dataset. For example, the public open space and scenic forest classifications of the parcel dataset might be combined to represent evergreen forest in the USGS dataset. Because the correlation between the two datasets is extremely high, it is possible to assume that the data will be as accurate throughout the entire watershed as it is in this case.

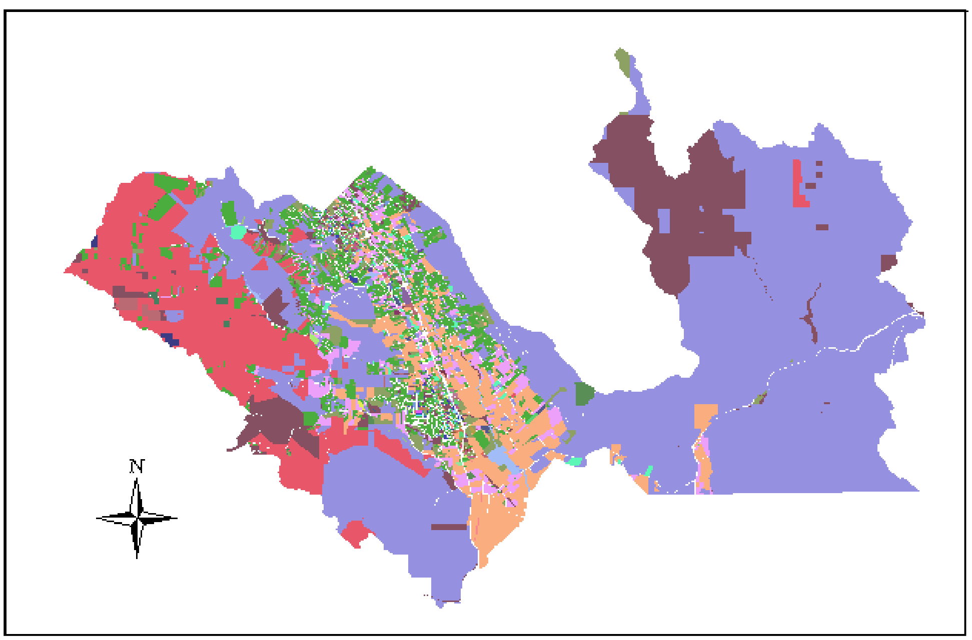

Figure 2a: SCVWD 1999 land use parcel data.

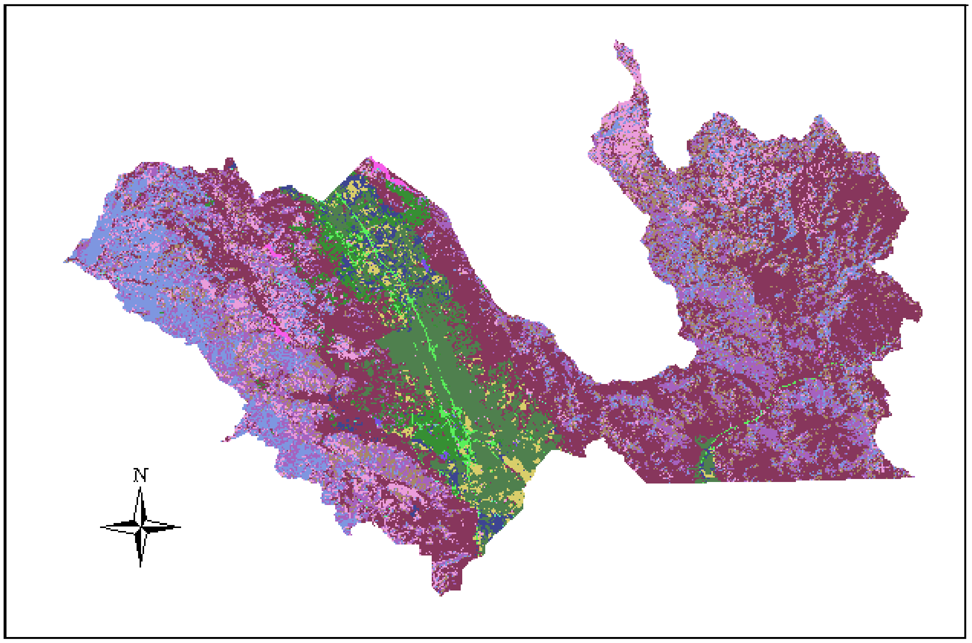

Figure 2b: 1992 USGS NLCD land use data.

Since the land use parcel dataset is much more current than the 1992 dataset, it is possible to compare how the land use has changed over those seven years. The similarity between the two suggests that the LULC changed little in this time span, with the exception of some residential and urban areas. These are likely to spring up as the population grows and cannot be expected to appear in the 1992 USGS data. The likeness of the two is strong evidence to support the use of the 1992 data as representative of current conditions.

To address the population growth and urban development, as well as further check the accuracy of the USGS dataset, visits to and around the urban centers were made. While this fieldwork verified the accuracy of most of the dataset, urban development was noted in several areas not indicated on a map generated using the USGS data. These were mostly in the vicinity of Gilroy, Morgan Hill, Watsonville, Hollister, and San Juan Bautista, all of which can be seen in Figure 1. The locations of the unmarked urban areas were noted. How this problem is addressed is discussed in a future section.

Another check of the 1992 USGS data, the general plans of the four counties and five cities included in the study were examined. No indication was found within those general plans that the suggested dataset would be unacceptable for this watershed study.

In 1999, AMBAG published a report of which a section was dedicated to land use. Through simplifying the Pajaro River Watershed Study land use definitions to match those used by AMBAG, the land use statistics became similar. For example, the AMBAG report states that about 76% of the watershed is used for agriculture and grazing. A summation of agriculture and grazing land uses in this study gives a total of about 72%. This difference is well within the acceptable standards of error.

Soils

Taking the recommendation of the NRCS soil scientist, the precision of the STATSGO hydrologic grouping was checked to determine whether it was adequate for a runoff model. A comparison was made between the provided data and the soil surveys for the four counties. Although there were small-scale differences between the surveys and soil data, based on the size of the watershed and qualitative nature of the ranking system it was decided that the digital STATSGO data would be sufficient for the modeling needs.

Data Updates

The quality checks described above demonstrated that the 1992 USGS LULC and the STATSGO soils data are reliable. The STATSGO data can be imported into the runoff model without any alterations. The LULC data has been shown to be more than adequate for most of the watershed. The only areas that are lacking are those that have been developed since 1992. In these areas, land uses marked as rural have become urban and are therefore more impervious to any rainfall or waterflow.

Rather than alter the LULC data file, the change in land use will be accounted for directly in the runoff model. Subwatersheds will have an artificially increased runoff coefficient if they have recently urbanized areas within the boundaries. Not only is this more time efficient but also might be more accurate and allow for better calibration. Since the exact extent of the urbanized area is unknown, additional calibration would be necessary anyway. Leaving the LULC data intact in its original form reduces errors that could be generated while changing the data attributes and provides a reference point for future modeling efforts.

Current Conditions

Population Growth

With a growing population come changes in land use. Perhaps the most important and obvious difference is the development of rural and agricultural areas. The additional population, housing, and community expansion such as parking lots and roads affect the percentage of pervious soil over an area. This is reflected in the runoff coefficient. For further explanation and description, please refer to TM 1.2.3.

Assuming that there is sufficient space and resources, existing urban areas tend to expand more rapidly than undeveloped areas. Based on field observations, this appears to be the case within the Pajaro River Watershed. There has been significant development associated with the sudden increase with population in the five major cities of the watershed, those being Gilroy, Hollister, Watsonville, Morgan Hill, and San Juan Bautista. While the raw land use data has not be altered to reflect these changes, the runoff coefficient within the runoff model is changed to reflect the population increase shown in Figure 3.

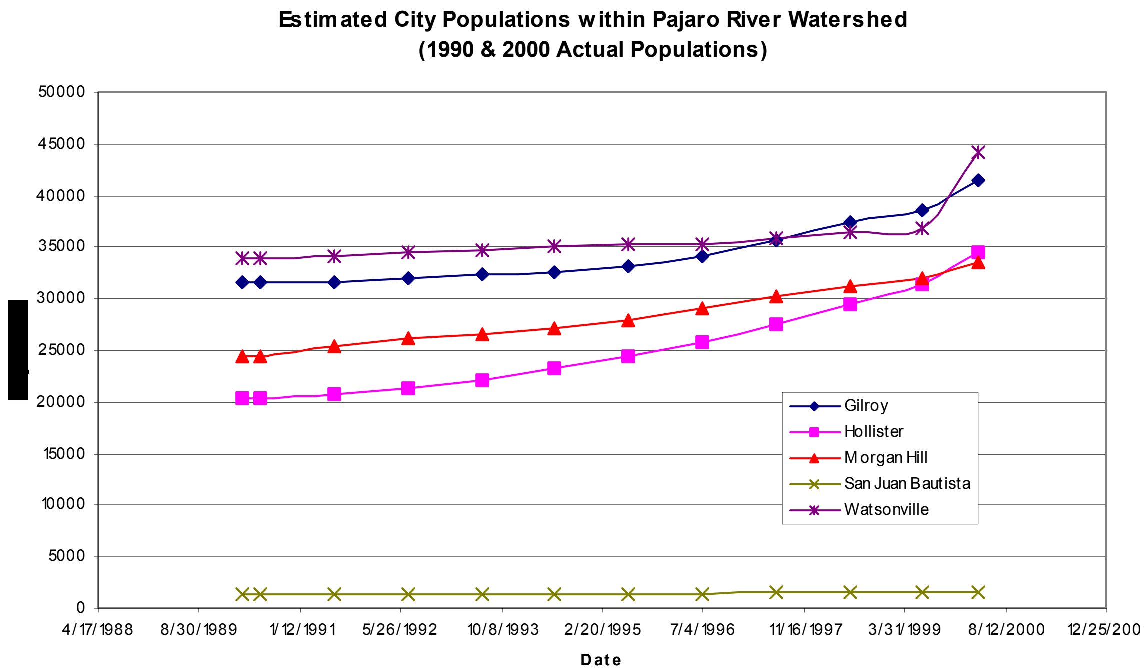

Figure 3: Population growth curves for five cities within the Pajaro River Watershed.

Land Use, Land Cover, and Hydrologic Soil Groups

As described in previous sections of this technical memorandum, the 1992 land use and land cover data obtained from the USGS adequately represents current conditions. Figure 4 shows land use and land cover trends across the entire watershed. It is apparent that a grassy land cover is the most prevalent classification. With further analysis it can be shown that about 40% of the watershed is grass or other herbaceous species. The next most common land covers are shrubland at 16% and evergreen forest at 13%. As can be seen in the Figure 4, high and low intensity residential land uses are not very influential as they combine for less than 2% of the total watershed land use. A percentage breakdown of all of the land uses found in Figure 4 can be found at the end of this technical memorandum in Appendix B.

Figure 5 represents the hydrologic soil groupings based on NRCS data. Soil type D is the most widespread classification across the watershed. Type B is fairly common in the urbanized areas in the northwest as well. The balance between all four types, A through D, within the subwatersheds can be found below. For a more thorough description of the effects of this balance please refer to TM 1.2.3. A qualitative description of the differences between the soil types can be found at the end of this technical memorandum in Appendix C.

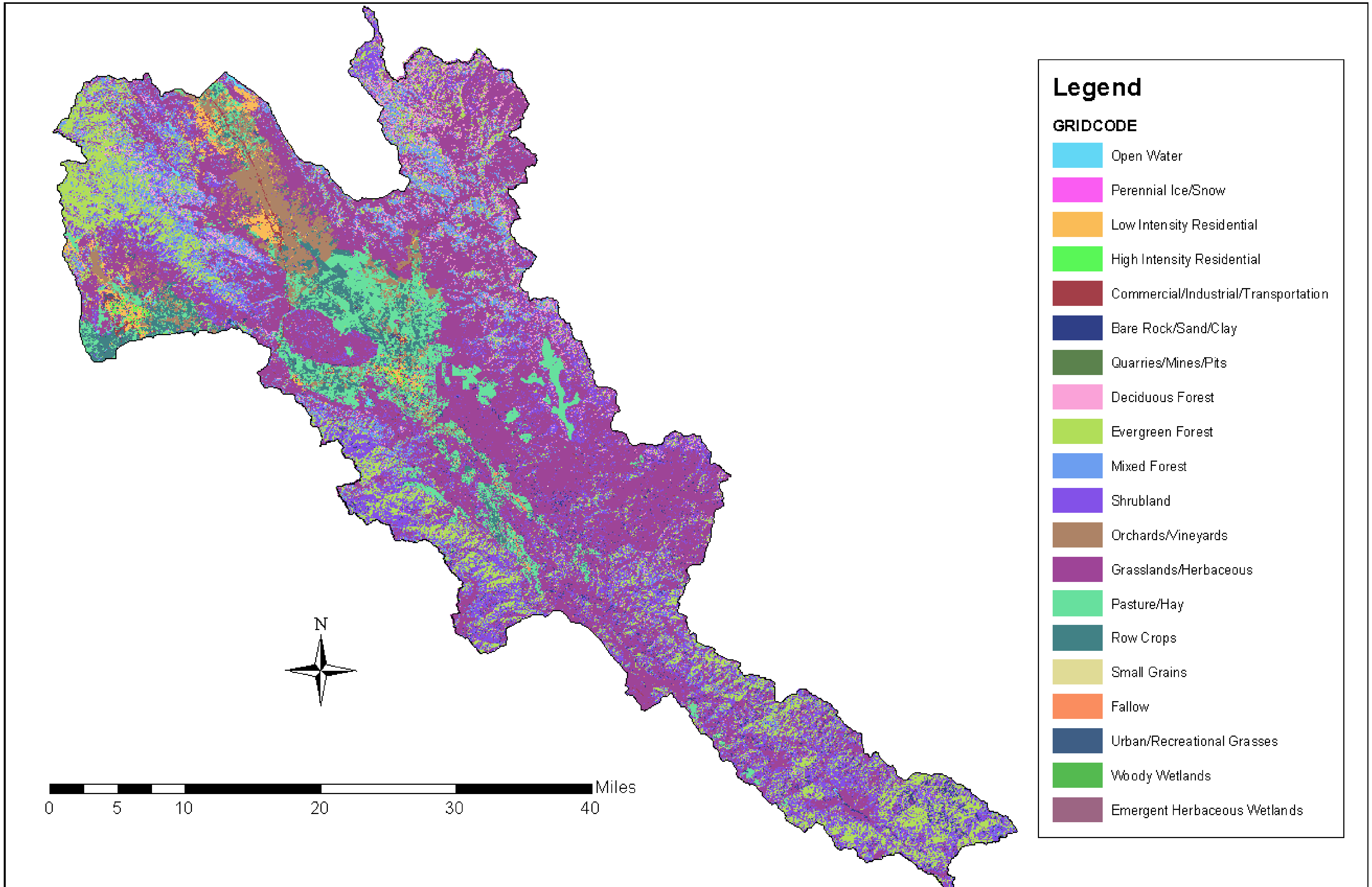

Figure 4: USGS land use and land cover for the Pajaro River Watershed.

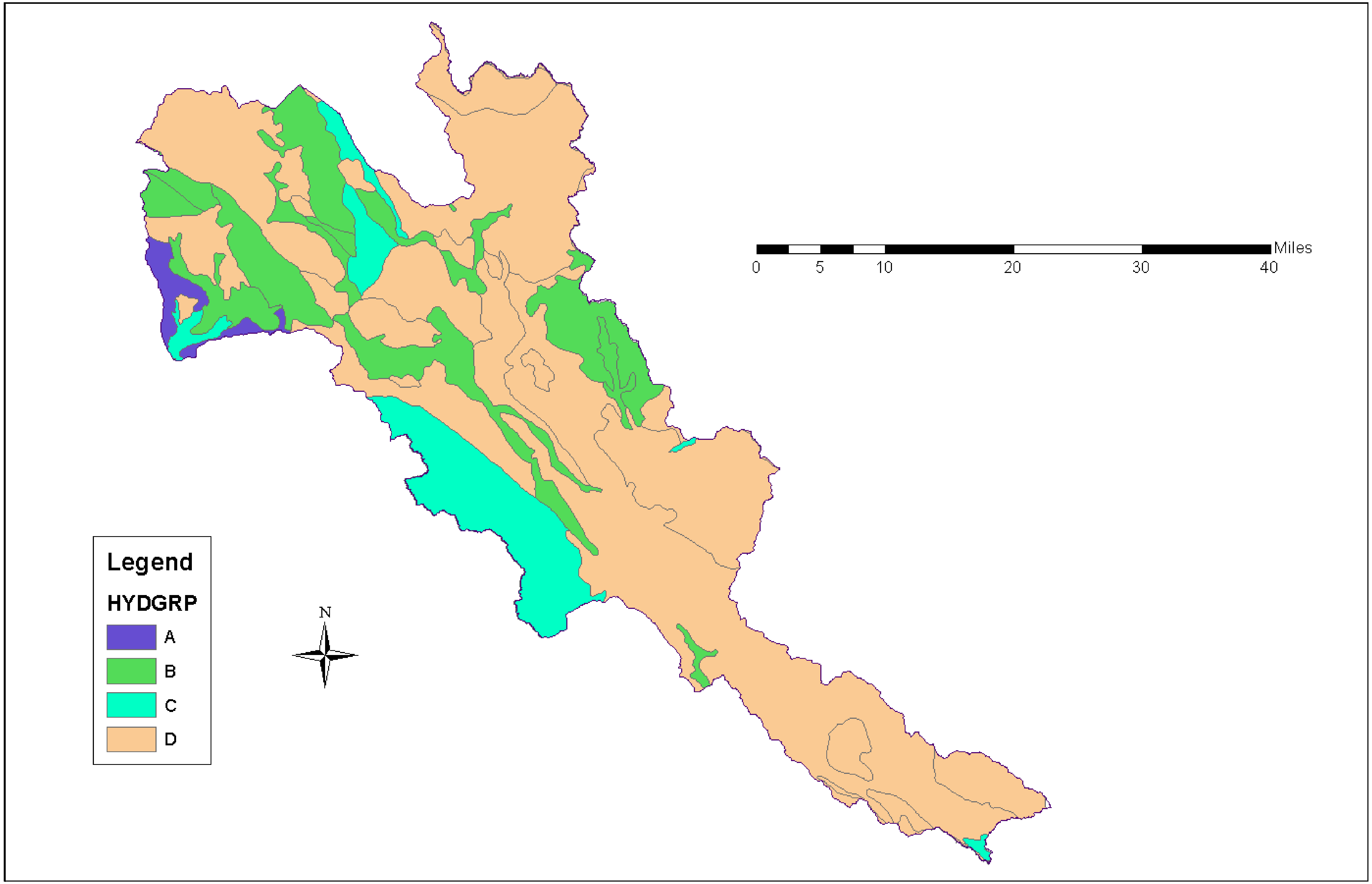

Figure 5: NRCS hydrologic groups of the Pajaro River Watershed.

Curve Numbers

Using GIS tools, the USGS land use and the NRCS soils data wered merge together. This data was then spatially partitioned to each subwatershed. The percent of the various land use types was computed for each hydrologic soil group in individual subwatersheds. Runoff curve numbers (CN), derived from the soil-land use percentages, can be applied to the runoff model to determine the effects of soil infiltration potential and land use on flood events.

Conclusion

This technical memorandum has shown that the land use and soils data presented here adequately represents the current conditions of the watershed. This data can be used within the hydrologic runoff model for baseline conditions and be adjusted to represent past, future, and hypothetical watershed conditions.

Bibliography

1990 – 1999 Census Data. url: http://www.census.gov/population/estimates/metro-city/placebyst/SC99T7_CA.txt. 11/29/01.

2000 Census Data. url: http://factfinder.census.gov/servlet/BasicFactsTable?_lang=en&_vt_name=DEC_2000_PL_U_GCTPL_ST7&_geo_id=04000US06. 11/29/01.

"City of Morgan Hill General Plan." July 2001.

Communication with EROS Data Center Staff, USGS. 11/15/01.

Communication with Kit Parris and Terryl Kocsis, NRCS. 10/23/01.

"County of San Benito Environmental Resources and Constraints Inventory." July 26, 1994.

"Design Standards and Standard Details for Construction." City of Morgan Hill Department of Public Works. August 2000.

"Gilroy General Plan 1999-2020 (Draft)." Community Development Department. June 1999.

"Hollister General Plan 1995-2010." City Council Resolution No. 95-156. November 6, 1995.

"Land Cover Characterization Program." url: http://landcover.usgs.gov. 10/26/01.

"Monterey County 21st Century General Plan Update." Monterey County. October 1999.

"Pacific Southwest Major Land Resource Area Soil Survey Office, Region #2." url: http://www.ca.nrcs.usda.gov/mlra/index.html. Various dates from 10/15/01 through 12/11/01.

"Pajaro River Watershed Management Draft Plan." AMBAG. March 1999.

"San Benito County General Plan Revision." August 1984.

"San Benito County Open Space and Conservation Element Update of the San Benito County General Plan." February 7, 1995.

"San Juan Bautista General Plan." City of San Juan Bautista. 9/29/1998.

"Santa Clara County General Plan." Planning Office. 12/10/94

Santa Clara Valley Water District 1999 Land Use Parcel Data. 11/19/2001.

"Santa Cruz County 1994 General Plan." Santa Cruz County Planning Department. 12/19/94.

"Soil Survey for Eastern Santa Clara Area." USDA. September 1974.

"Soil Survey for Monterey County." USDA. April 1978.

"Soil Survey for San Benito County." USDA. November 1969.

"Soil Survey for Santa Cruz County." USDA. August 1980.

"State Soil Geographic Data Base." USDA and NRCS. Publication Number 1492. December 1994.

"Watsonville 2005: General Plan." City of Watsonville Planning Department. May 24, 1994.

Appendix A

Land Cover Class Definitions

from http://landcover.usgs.gov/classes.html

Water - All areas of open water or permanent ice/snow cover.

Open Water - all areas of open water, generally with less than 25% cover of vegetation/land cover.
Perennial Ice/Snow - all areas characterized by year-long surface cover of ice and/or snow.

Developed - Areas characterized by a high percentage (30 percent or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential - Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to100 percent of the cover.
Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.
Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.
Transitional - Areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover.

Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest - Areas dominated by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species

represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-Natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.
Fallow - Areas used for the production of crops that do not exhibit visable vegetation as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.
Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Appendix B

Pajaro Watershed LULC Breakdown

LULC Classification	Percentage of Watershed Area
Open Water	0.11%
Perennial Ice/Snow	0.0%
Low Intensity Residential	1.5%
High Intensity Residential	0.14%
Commercial/Industrial/Transportation	0.58%
Bare Rock/Sand/Clay	1.5%
Quarries/Strip Mines/Gravel Pits	0.04%
Transitional	0.0%
Deciduous Forest	3.6%
Evergreen Forest	13.0%
Mixed Forest	7.7%
Shrubland	16.4%
Orchards/Vineyards/Other	3.9%
Grasslands/Herbaceous	40.4%
Pasture/Hay	7.4%
Row Crops	3.4%
Small Grains	0.05%
Fallow	0.13%
Urban/Recreational Grasses	0.19%
Woody Wetlands	0.0%
Emergent Herbaceous Wetlands	0.0%

Appendix C

NRCS Hydrologic Soil Groups

from the State Soil Geographic Database

Hydrology Class	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils with moderately coarse textures.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.