TECHNICAL MEMORANDUM

Causes of Degradation and Aggradation in the Santa Ana Region

Prepared by:

RBF CONSULTING
A Baker Company

RBF Consulting
14725 Alton Parkway
Irvine, California 92618

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1 INTRODUCTION

The 2010 Santa Ana Region (SAR) MS4 Permit requires the Permittees to identify potential causes of stream degradation and aggradation. This technical memorandum is part of the larger study for the Permittees to develop the SAR Hydromodification Management Plan.

1.1 Watershed Background

Santa Ana River Watershed

The Santa Ana River Watershed is located in southern California, south and east of the city of Los Angeles. The Santa Ana River Watershed includes much of Orange County, the northwestern corner of Riverside County, the southwestern corner of San Bernardino County, and a small portion of Los Angeles County. The Santa Ana River Watershed is bound on the south by the Santa Margarita Watershed, on the east by the Whitewater Watershed and on the northwest by the San Gabriel River Watershed. The area of the Santa Ana River Watershed is approximately 2,650 square miles.

Santa Ana Region

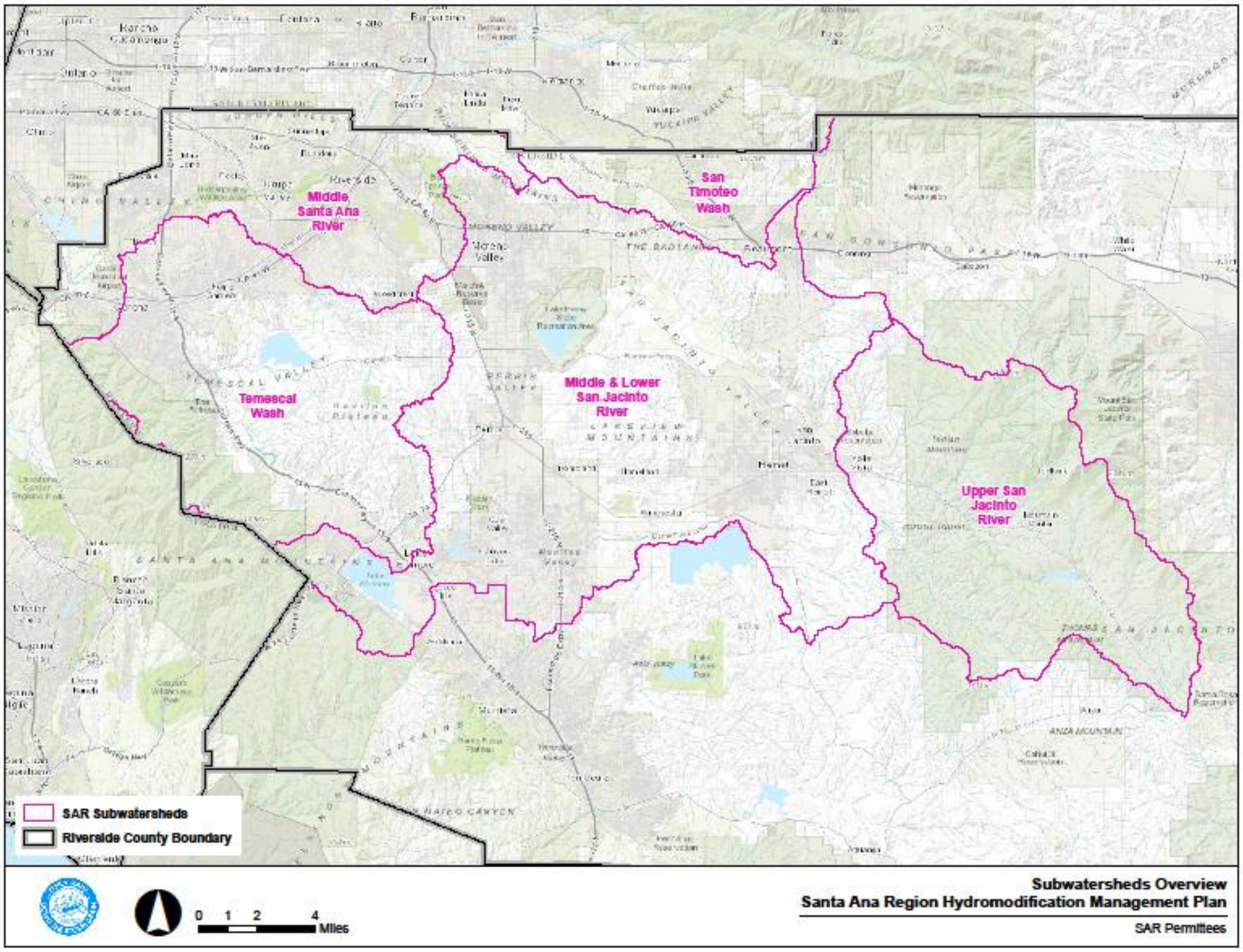
The SAR is that portion of the Santa Ana River Watershed within Riverside County and is the area addressed by this technical memorandum. The SAR extends approximately 63 miles from east to west, and more than 29 miles from north to south. The SAR lies between the Santa Ana Mountains and the San Bernardino Mountains; the topography of the SAR varies highly with altitudes ranging from 415 feet to 8,200 feet. The San Jacinto River is a tributary of the Santa Ana River. Runoff from the 768-square mile San Jacinto River Watershed is regulated by Railroad Canyon Dam and natural storage in Lake Elsinore. Only as a result of rare high intensity storm events that result in overflow from Lake Elsinore will water flow into the Santa Ana River.

The surface drainage system from the remainder of the SAR, which includes the cities of Jurupa Valley, Eastvale, and Riverside, drain through local systems to Reach 3 of the Santa Ana River.

1.2 Purpose

The purpose of this technical memorandum is to identify potential causes of stream degradation and aggradation in all major subwatersheds of the SAR, including Upper San Jacinto River, Middle and Lower San Jacinto River (see map on next page), Temescal Wash, and San Timoteo Creek. The Middle Santa Ana River (MSAR) Subwatershed is not investigated in this report. The MSAR has been identified as a large river in Section 3.2.2 of Appendix A based on drainage, tributary area, and floodplain characteristics of the river. Figure 1 identifies the geographic layout of the four subwatersheds of study.

Figure 1: Location Map



2 METHODOLOGY

The causes of channel degradation and aggradation were determined using two methods: examination of historical and current aerial photographs, and a Geographic Information System (GIS)-based desktop study. The following sub-sections summarize each method.

2.1 Aerial Photographs

Current aerial photographs were provided by Microsoft Bing. These aerials were examined to get a general idea of the existing condition of the subwatersheds. Specifically, the aerials were used to locate drainage basins, areas of significant degradation, aggradation and regions of dense urban development.

Historical aerials were obtained from the USGS Earth Explorer online database, available for download at http://earthexplorer.usgs.gov/. The aerial photographs were selected based on the engineer's best professional judgment to exhibit the channel conditions that are representative of the evolution of the subwatershed and, if any, examine the timing and the extent of degradation and aggradation of selected channels. Based on availability, aerial photographs ranged from 1948 to 2013. Historical aerials used for the study have been included as Attachment B of this Technical Memorandum.

2.2 GIS-based Desktop Study

A GIS-based methodology for identifying potential causes of degradation and aggradation was developed by the Southern California Coastal Water Research Project (SCCWRP) entitled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" dated March 2010 (Technical Report 605 - Appendix B).

According to this report, many of the same physical properties that determine the hydrologic response of a subwatershed also determine the magnitude of sediment production from those same areas. It also states that three factors were found to exert the greatest influence on the variability of sediment production rates:

1. Geology Types;
2. Land Cover; and
3. Hillslope Gradient

The SCCWRP report used the three factors to create Geomorphic Landscape Units (GLUs), which are similar to Hydrologic Response Units (HRUs). HRUs and GLUs are the grouping of like subwatershed qualities (e.g., sedimentary-developed-10% to 20% slope) and are used to reduce model complexity and data requirements. Comparing existing GLUs versus those of "prior to identified degradation and aggradation" conditions provides evidence for the causes of degradation and aggradation.

For this study a strict GLU analysis was not used. The three factors were kept separate to simplify the analysis and provide an overview of how the subwatersheds are structured.

2.2.1 Geology Types

The geology types used for this study were obtained from the California Geological Survey and State Mining & Geology Board (http://www.conservation.ca.gov/cgs/Pages/Index.aspx). Each subwatershed was divided into its respective geology types, with special consideration to areas of Sedimentary Rocks – Alluvium, especially in the downstream reaches of the subwatershed.

According to *Geomorphology: A Systematic Analysis of Late Cenzoic Landforms* by Arthur L. Bloom, alluvium is considered to be continually progressing toward the sea. Additionally, the mean grain size of bedload alluvium decreases in a downstream direction due to the loss of competence, i.e., the measure of a stream's ability to transport a certain maximum grain size of sediment. Because the velocity of flow tends to decrease in the lower reaches of a subwatershed, the energy available for transporting bedload alluvium decreases. The channelization of these natural channels may have increased the competence of the channels, notably in the lower reaches, resulting in an increased potential for the degradation of the lower reaches.

2.2.2 Land Cover

The land cover types were obtained from the National Oceanic and Atmospheric Administration (NOAA) Ocean Service, Coastal Services Center (http://csc.noaa.gov/digitalcoast/dataregistry/#/). Each subwatershed was broken up into five land cover types:

1. Agricultural/Grass
2. Developed
3. Forest
4. Scrub/Shrub
5. Other (water, bare rock, etc.)

The most important land cover type to consider is "developed". In the absence of hydrologic controls, as a subwatershed undergoes urban development, the potential for runoff may increase, and the potential sediment supply may decrease, possibly creating an imbalance within the subwatershed.

2.2.3 Hillslope Gradient

The hillslope gradients were based on a U.S. Geological Survey (USGS) 10 meter Digital Elevation Model (DEM) from http://seamless.usgs.gov/website/seamless/viewer.htm. The subwatershed was broken up into a 10 meter by 10 meter grid, where the grids were divided into three hillslope gradients:

1. 0 to 10%
2. 10 to 20%
3. Steeper than 20%

Regions of steeper slopes generally have a higher potential for erosion, degradation and aggradation.

3 SUBWATERSHEDS

This section describes the four subwatersheds examined as part of this study and explains the results of the aerial photograph review and GIS-based desktop study.

3.1 Upper San Jacinto Subwatershed

The Upper San Jacinto Subwatershed is located on the northeast portion of the SAR. The headwaters of the San Jacinto River originate in the San Jacinto Mountains of San Bernardino County. The downstream point of the Upper San Jacinto Subwatershed is at the confluence of Bautista Creek, Poppet Creek, and the San Jacinto River in the city of San Jacinto. The subwatershed drainage area to this confluence encompasses 246 square miles. The upper portion of the San Jacinto River flows through the San Bernardino National Forest and unincorporated land of Riverside County. The upper portion of the San Jacinto River is about 23 miles long and ranges from the outlet of Lake Hemet and the confluence herein specified.

Lake Hemet is the major water storage facility within this subwatershed. The dam was established in 1895 downstream of the Garner Valley Basin and operates on the principles of water supply. In addition to decreasing the downstream flow rate, the dam acts as a major debris basin.

3.1.1 Study Reach

The reach of the Upper San Jacinto River Channel that is under investigation extends for 1.7 miles from Blackburn Street to Grant Street in Valle Vista, an unincorporated community of Riverside County. No improvements within the floodplain have been made; the study reach is a natural braided channel with some vegetation observed along the long flow branch.

3.1.2 Historical Aerial Photographs

From the historical aerial photographs (Appendix A), it can be seen that this stretch of the channel has not been modified since 1972. In addition, limited development has occurred within the observed floodplain between 1972 and 2013. Agricultural activities take place south of Highway 74.

3.1.3 GIS-based Desktop Study

The following subsections summarize the results of the GIS-based desktop study for the Upper San Jacinto Subwatershed.

3.1.3.1 Geology Type

The Upper San Jacinto Subwatershed is dominated by plutonic and metavolcanic rocks (72.4%) in the upper reaches. Lower reaches, as well as the Lake Hemet plateau, are for the most part made of sedimentary rock, including alluvium, gneiss, argillite, and sandstone. Sedimentary rocks have the highest relative potential for erosion. The presence of Lake Hemet contributes to the capture of coarse grained sediments detached from reaches upstream of the Lake; the clear reservoir outflow increases the potential for erosion along the lower reaches.

3.1.3.2 Land Use

The Upper San Jacinto Subwatershed is for the most part undeveloped. Valle Vista, along with pockets of development in the upper reaches of the subwatershed, account for .82% of the entire drainage area located within Riverside County. Undeveloped areas include forest (39.2%), scrub/shrub (62.7%), grassland (6.8%), and agriculture (5.2%). The low levels of development have contributed to the maintenance of the natural hydrologic response of the subwatershed. The dynamics of the dam operations may have altered this balance for the San Jacinto River, thus impacting the frequency and intensity of flows observed in the downstream channel. Tributaries of the San Jacinto River are not impacted by development.

3.1.3.3 Hillslope Gradient

With the exception of the mouth of the Upper San Jacinto River and the Lake Hemet plateau, the majority of the upper reaches have a high potential for erosion as they exhibit gradient greater than 11%. While the majority of the developed land is located in the lower sediment production areas, the construction of Lake Hemet may have altered part of the transport of coarse grained sediments that originate from the high yield areas.

Figure 2: Upper San Jacinto Subwatershed Land Cover Types

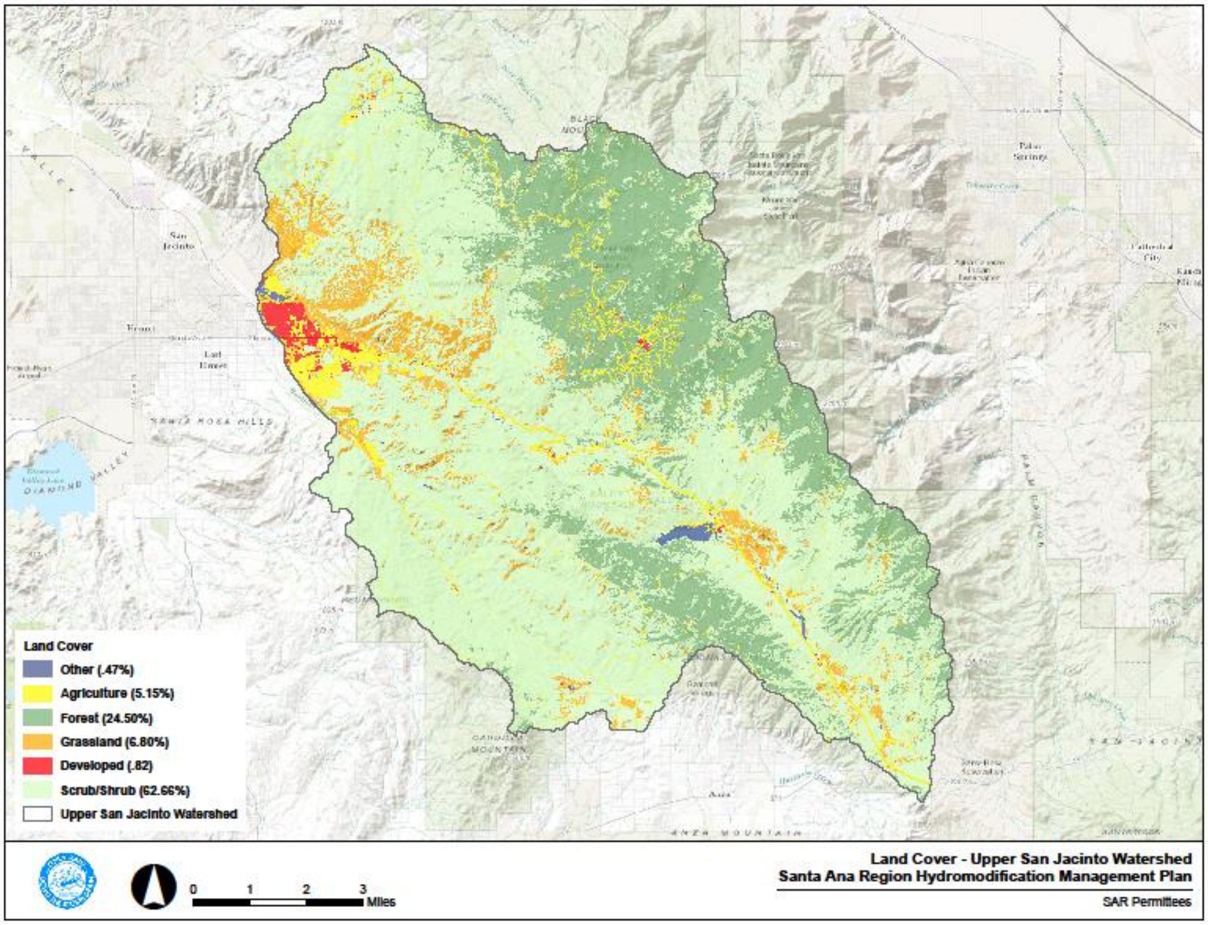


Figure 3: Upper San Jacinto Subwatershed Geology Types

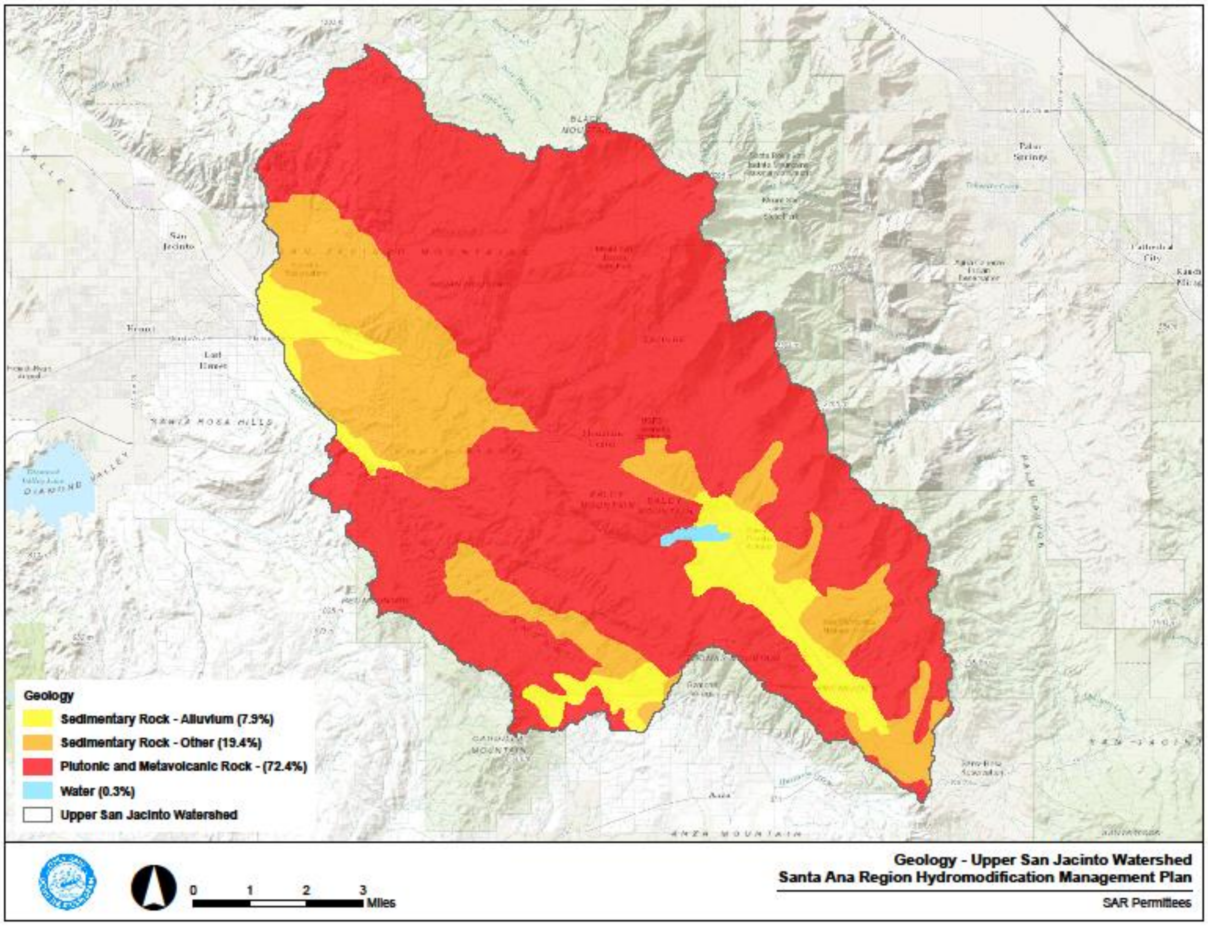
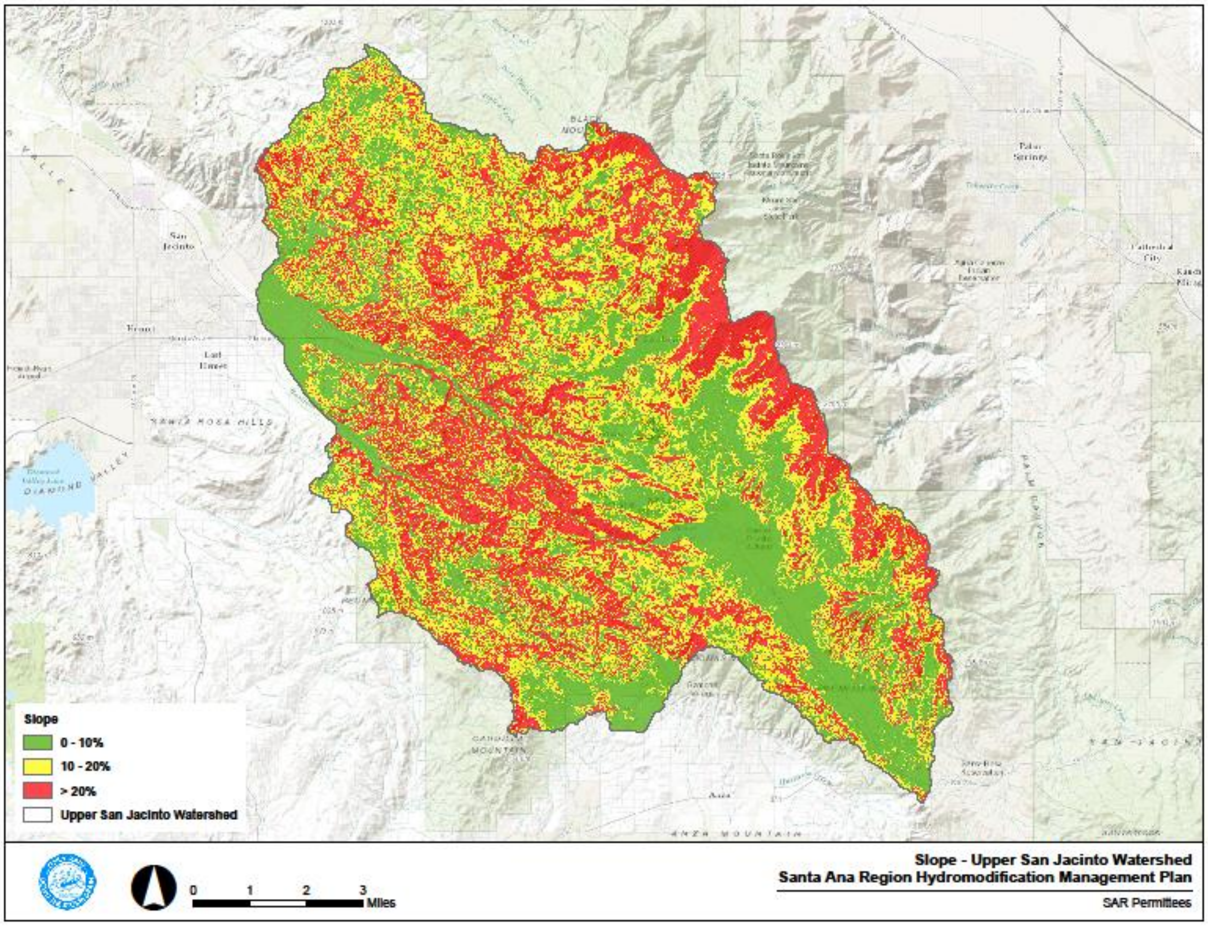


Figure 4: Upper San Jacinto Subwatershed Hillslope Gradients



3.1.4 Conclusion

Urban development within the Upper San Jacinto Subwatershed is limited (.82%) and has occurred at the mouth of the San Jacinto River, within Valle Vista, an unincorporated community of Riverside County. The majority of the upper, steeper reaches have remained in a natural condition. Generally, this would be beneficial because the steep slopes and undeveloped land would still produce significant sediment to replenish the downstream channel. The presence of Lake Hemet in the Subwatershed has partially reduced the supply of coarse grained sediment from transport to the downstream channel reaches.

Compared to "prior development" conditions, land uses have remained the same. Future urban development, if any in the upper reaches, may alter the Subwatershed dynamics and ultimately result in changes in the channel stability.

3.2 Middle and Lower San Jacinto Subwatershed

The Middle and Lower San Jacinto Subwatershed is located within the central part of the SAR. The downstream point of the Lower San Jacinto Subwatershed is the outlet of Lake Elsinore. The drainage area of the Middle and Lower San Jacinto Subwatershed encompasses 510 square miles. The combined middle and lower sections of the San Jacinto River are 35 miles long. Major tributaries to the subwatershed include Potrero Creek, Perris Valley Channel, and Salt Creek Channel. The San Jacinto River flows through the cities of San Jacinto, Perris, Menifee, Canyon Lake, and Lake Elsinore.

The San Jacinto River drains to Canyon Lake and Lake Elsinore. The Railroad Canyon Dam was built in 1928, creating the 11,600 acre-feet Canyon Lake. The Elsinore Valley Municipal Water District operates the lake based on water supply considerations and maintains a minimum lake elevation of 1,372 feet for the benefits of residents of the Lake Elsinore/Canyon Lake area. In addition, the Canyon Lake Property Owners Association leases surface rights for water recreation and regulates residential development around the edge of the lake.

Lake Elsinore is a 90,000 acre-feet natural lake located downstream of Canyon Lake. A spillway set at a relative elevation of 42 feet runoff exceeding this elevation discharges into Temescal Wash. Canyon Lake and Lake Elsinore contribute to the decrease in downstream flow rates, and represent a physical barrier to the transport of coarse grained sediments.

3.2.1 Study Reach

The study reach of the San Jacinto River starts approximately at Interstate 215 and extends for 3.1 miles to Ethanac Road within the city of Perris. Because of limited definition, available aerial photographs for the entire reach are as old as 39 years (oldest is circa 1975). Older aerials exist but their definition does not allow the engineer to distinguish the path of the San Jacinto River. In 1975, the San Jacinto River had already been channelized. Bed and banks of the channel are made of soft earthen material. Stabilization efforts have been implemented to the reach: banks are protected and consistent vegetation exists. Degradation and aggradation may still occur if hydrologic and sediment regimes are modified.

Aerial photographs indicate that there has been significant urbanization of the Subwatershed within the 1972-2013 period. The trend may be a contributing factor to the degradation and aggradation of the morphology of the channel.

3.2.2 Historical Aerial Photographs

From the historical aerial photographs (Appendix A), it can be seen that this stretch of the channel has been channelized. The engineer may also observe that stabilization work has occurred on the bed and banks of the channel. This may be related to the constant base flow received from public owned treatment works (POTWs), as well as the important urban development that has occurred over the 1972-2013 period. During this time the Subwatershed transitioned from being predominantly agricultural to predominately urban development.

3.2.3 GIS-based Desktop Study

The following subsections summarize the results of the GIS-based desktop study for the Middle and Lower San Jacinto River Subwatershed.

3.2.3.1 Geology Type

The setting of the Middle and Lower San Jacinto River Subwatershed consists of the lowlands of the overall Subwatershed, thus the geologic soils present within the valley are primarily sedimentary rocks (67.6%). Sedimentary rocks notably account for 50.7% of alluvium and have the highest relative potential for erosion. Plutonic and metavolcanic rocks account for 32.4% of soil types within the Subwatershed, notably on the Santa Rosa Hills and the Lakeview Mountains that are in proximity to the San Jacinto River. Because the debris basins capture the majority of coarse grained sediment from these mountainous areas, the clear reservoir outflows increase the potential for erosion along the lower reaches and the San Jacinto River.

3.2.3.2 Land Use

Major areas of urban development (31.6% of the Subwatershed) are concentrated within Moreno Valley, the Hemet area down gradient from the Santa Rosa Hills, Menifee and Canyon Lake, as well as the northwest side of Lake Elsinore. Agriculture and grassland remain a dominant activity within the lowlands of the Subwatershed, combining for more than 49.1%. The development of several communities has resulted in a significant change in the subwatershed's imperviousness and associated increase in the frequency and flow experienced in the channel. Aerial photographs confirmed that several segments of the channel have been channelized to convey runoff from the observed urban development.

Figure 5: Lower and Middle San Jacinto Subwatershed Land Cover Types

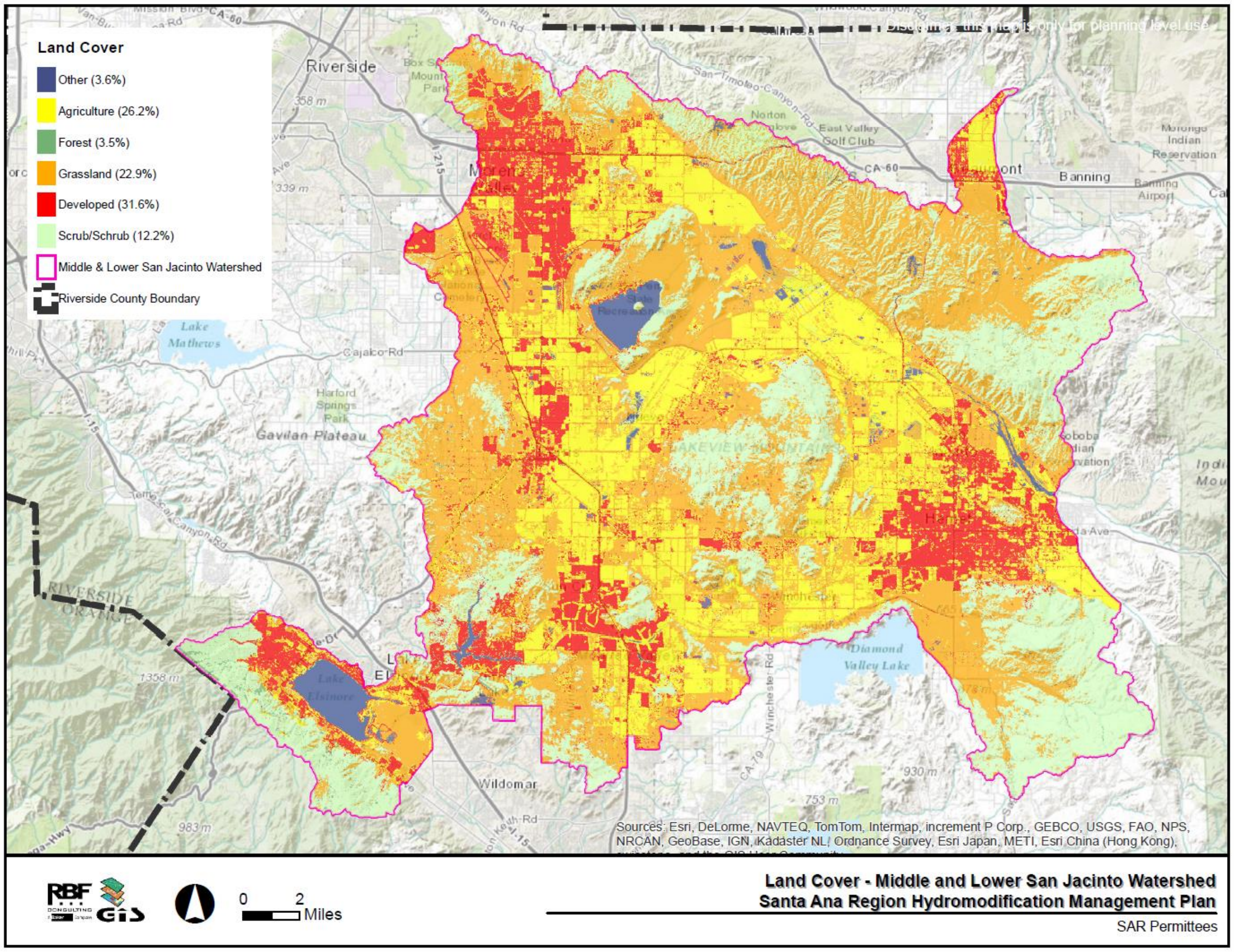


Figure 6: Lower and Middle San Jacinto Subwatershed Geology Types

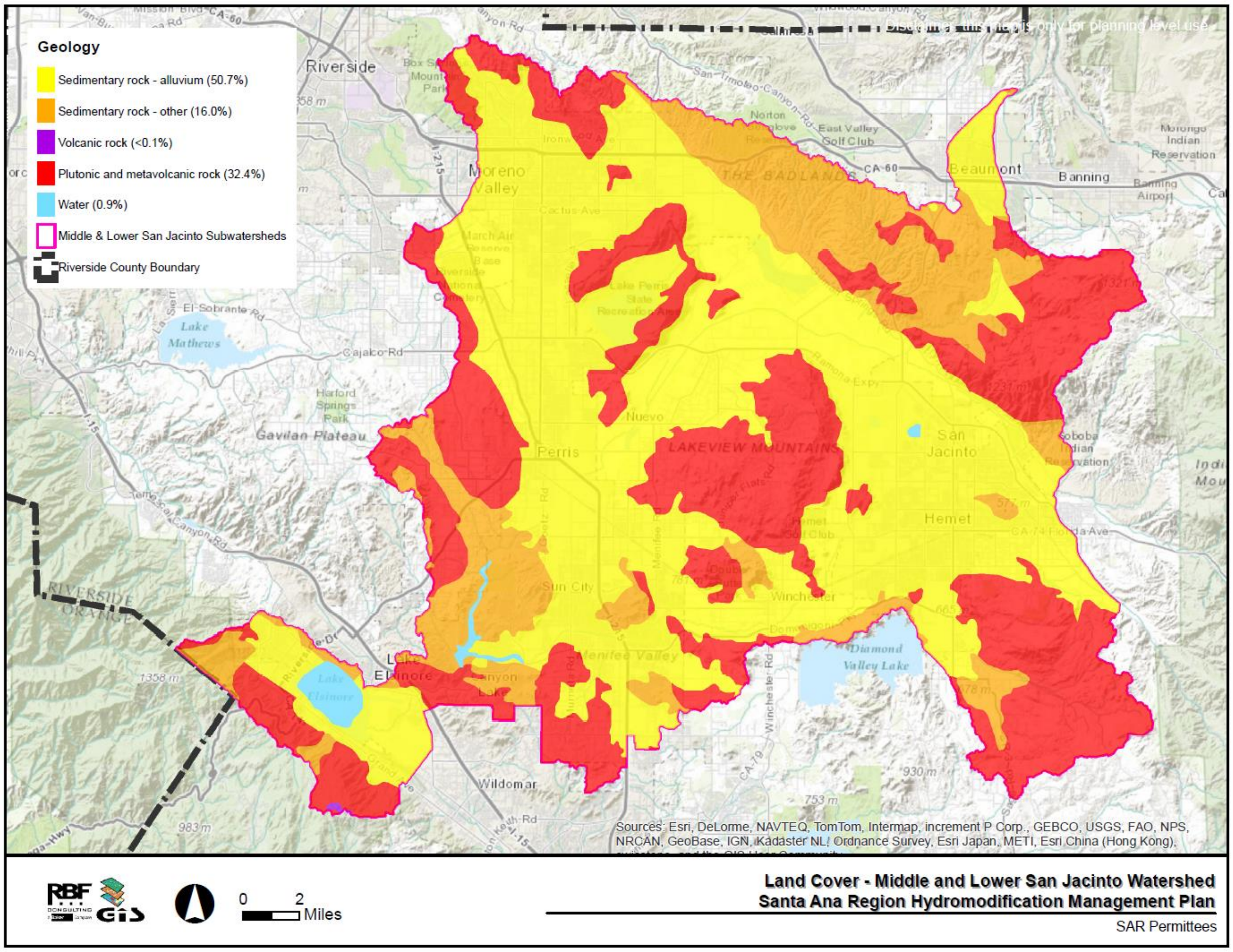
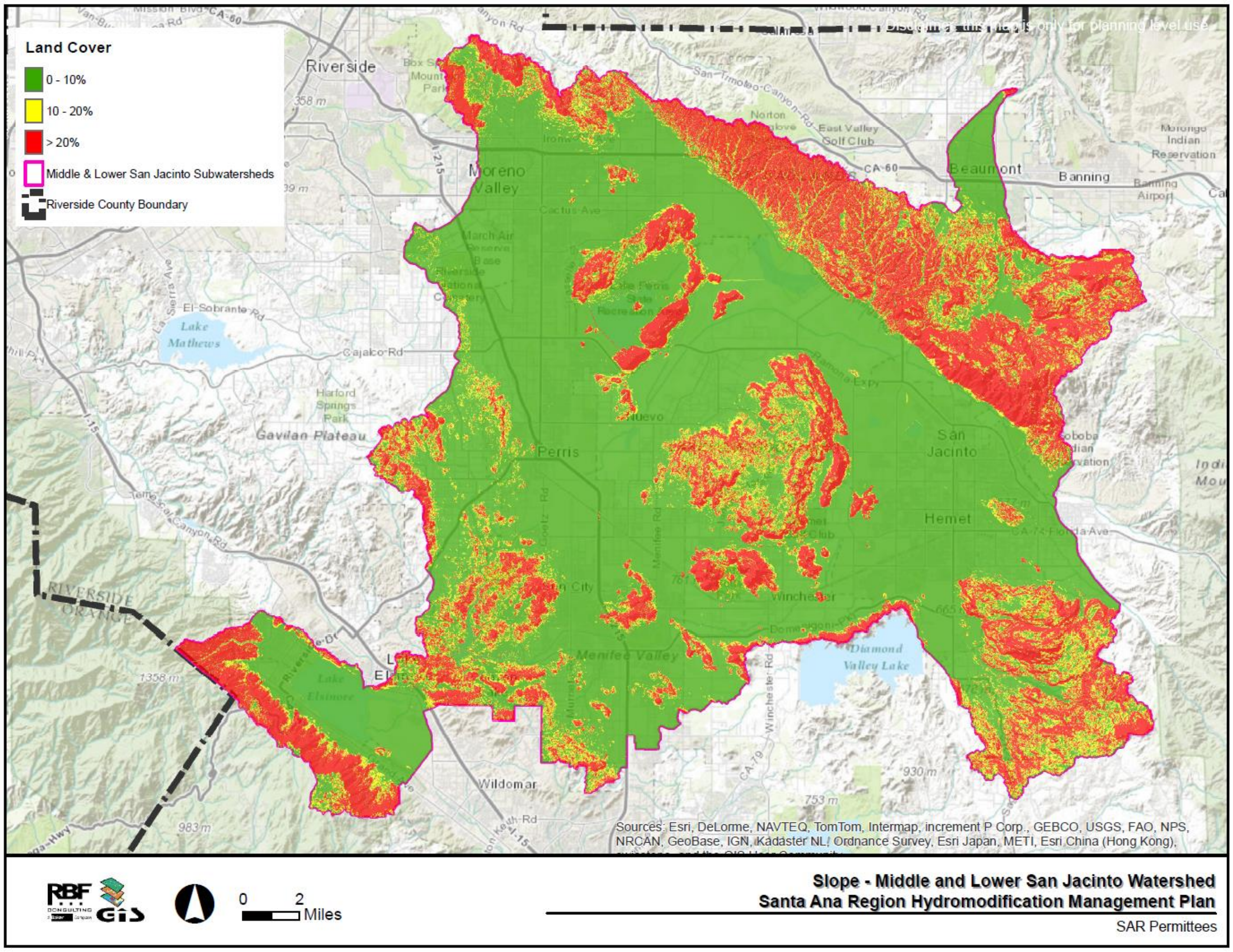


Figure 7: Lower and Middle San Jacinto Subwatershed Hillslope Gradients



3.2.3.3 Hillslope Gradient

The majority of reaches with the highest potential for erosion with a hillslope gradient greater than 21%, are concentrated on the upper reaches near the San Jacinto Mountains, the Santa Rosa Hills, the Lakeview Mountains, and the Sana Ana Mountains surrounding Lake Elsinore. The central (developed and agricultural) portion of the subwatershed has a hillslope gradient of 0-10% with a lower potential for sediment production. While the majority of the developed land is located in the lower sediment production areas, the construction of the debris basins have effectively obstructed a majority of the coarse sediment produced in high yield areas from reaching the downstream watercourse.

3.2.4 Conclusion

The majority of the urban development within the Lower and Middle San Jacinto Subwatershed is located in the lower reaches, while the upper, steeper reaches have remained in a natural condition. Generally, this would be beneficial because the steep slopes and undeveloped land would still produce significant sediment to replenish the downstream channel. The issue is that the debris basins have been constructed just downstream of the upper reaches. The debris basins have reduced the supply of coarse grained sediment from making it to the downstream channel reaches. In addition, the significant change in impervious area due to subwatershed development has increased the frequency and rate of flow in the channel.

Compared to "prior to development" conditions, the Lower and Middle San Jacinto Subwatershed has been heavily developed. But with a decrease in sediment production from the upstream reaches of the Subwatershed due to the debris basins, the hydrologic and sediment transport dynamics of the San Jacinto Subwatershed has been significantly altered. The sediment supply has been reduced, and the stream flow has been increased which has resulted in an imbalance in the sediment supply and transport capacity. This imbalance would be anticipated to result in changes in the channel stability. This can be seen in the two unprotected channel segments located respectively upstream of Canyon Lake and upstream of Interstate 215 where significant degradation and aggradation has occurred.

3.3 Temescal Wash

The Temescal Wash Subwatershed is located within the western part of the SAR. The 29-mile long Temescal Wash connects Lake Elsinore with the Santa Ana River. The tributary drainage area to Temescal Wash before the confluence with the Santa Ana River in Corona is 250 square miles large. Along its watercourse, several tributaries, including Wasson Canyon Wash, Arroyo Del Toro, Stovepipe Canyon Wash, Rice Canyon Wash, and Lee Lake discharge into Temescal Wash. Temescal Wash flows through an arid rain shadow zone of the Santa Ana Mountains and is ephemeral for most of its length.

3.3.1 Study Reach

The study reach of Temescal Wash starts approximately at Riverside Drive (Highway 74) and extends for 1.3 miles to Nichols Road within the city of Lake Elsinore. Available aerial photographs for the entire reach span from 1952 to 2013. The natural alignment of Temescal Wash has not been modified for the reach of study and urban development has occurred on adjacent land, bringing commercial and transportation infrastructures to the area. The bed and banks of Temescal Wash are vegetated but are not stabilized by adequate engineering methods, and two ephemeral pools have been conserved.

3.3.2 Historical Aerial Photographs

From the historical aerials (Appendix A), it can be seen that the Temescal Wash Subwatershed has observed a significant urban development within the 1952-2013 period. Historical agricultural land uses have progressively been modified for residential, commercial, and transportation purposes. The trend may be a contributing factor to the modification of the geomorphology of the wash. In addition, the implementation of a shallow dam on Lake Elsinore may have over the long run, significantly reduced the discharge from the lake. The historical aerials show the establishment of riparian vegetation over the banks of the evaluated segment between 1980 and 2013. The vegetation on the channel banks may have enhanced their ability to resist both changes in hydrologic and sediment regimes.

3.3.3 GIS-based Desktop Study

The following subsections summarize the results of the GIS-based desktop study for the Temescal Wash Subwatershed.

3.3.3.1 Geology Type

Geologic soils within the Temescal Wash Subwatershed are dominated by plutonic and metavolcanic rocks (52.8%) that are located on the northern slopes of Temescal Canyon (Gavilan Plateau) and southern slopes of Temescal Canyon (Santa Ana Mountains). Sedimentary rocks combine for 45.9%, and are for the most part located within the floodplain of Temescal Wash where urban development has been occurring. Urban development has reduced the potential for delivery of alluvium to the receiving waters, which may impact the morphology of Temescal Wash. Because several debris basins capture the majority of coarse grained sediment from the upper reaches, the clear reservoir outflows increase the potential for erosion along the lower reaches and Temescal Wash.

3.3.3.2 Land Use

The majority of the areas under urban development are located along the floodplain of Temescal Wash, as well as the lowlands within the city of Corona. Urban development accounts for 32.3% of all land uses within the Temescal Creek Subwatershed. The remainder of the Subwatershed is mostly undeveloped, including forest, scrub, and grassland. Agriculture and grassland remain a dominant activity within the lowlands of the subwatershed, combining for more than 49.1%. Development along Temescal Wash and within the city of Corona has resulted in a significant change in the Subwatershed imperviousness and associated increase in the frequency and flow experienced in Temescal Wash. Aerial photographs confirmed that the natural hydrologic response of the Subwatershed has been significantly altered by urban development.

3.3.3.3 Hillslope Gradient

The majority of reaches, which have the highest potential for erosion with a hillslope gradient greater than 21%, are concentrated to the northern and southern sides of Temescal Canyon, where the Gavilan Plateau and the range of Santa Ana Mountains are located, respectively. The remainder of the Subwatershed exhibit slopes lower than 10%, where the potential for erosion is much lower. The majority of development has occurred within areas of low gradient.

3.3.4 Conclusion

The majority of the urban development within the Temescal Wash Subwatershed is located in the lower reaches or within the floodplain of Temescal Wash, while the upper, steeper reaches have remained in a natural condition. Generally, this would be beneficial because the steep slopes and undeveloped land would still produce significant sediment to replenish the downstream channel. The issue is that several debris basins have been constructed just downstream of the upper reaches. The debris basins have cut off part of the supply of coarse grained sediment from making it to the downstream channel reaches. In addition, the significant change in impervious area due to subwatershed development has increased the frequency and rate of flow in the channel.

The subwatershed dynamics have been significantly altered. The sediment supply from the northern slopes of Temescal Canyon (Gavilan Plateau) and southern slopes of Temescal Canyon (Santa Ana Mountains) to Temescal Wash has been reduced. In addition, urbanization has resulted in increased channel flow, thus creating an imbalance in the sediment supply and transport capacity. This imbalance would be anticipated to result in changes in the channel stability. Several unimproved segments of Temescal Wash exhibit significant degradation and aggradation. Because of dry-weather runoff from agricultural and publicly-owned treatment works, the segment near Highway 74 and Corona Lake has observed a development of riparian vegetation on the channel banks. This presence of riparian vegetation may improve the channel resistance to the changes in flow and sediment regimes.

Figure 8: Temescal Wash Subwatershed Land Cover Types

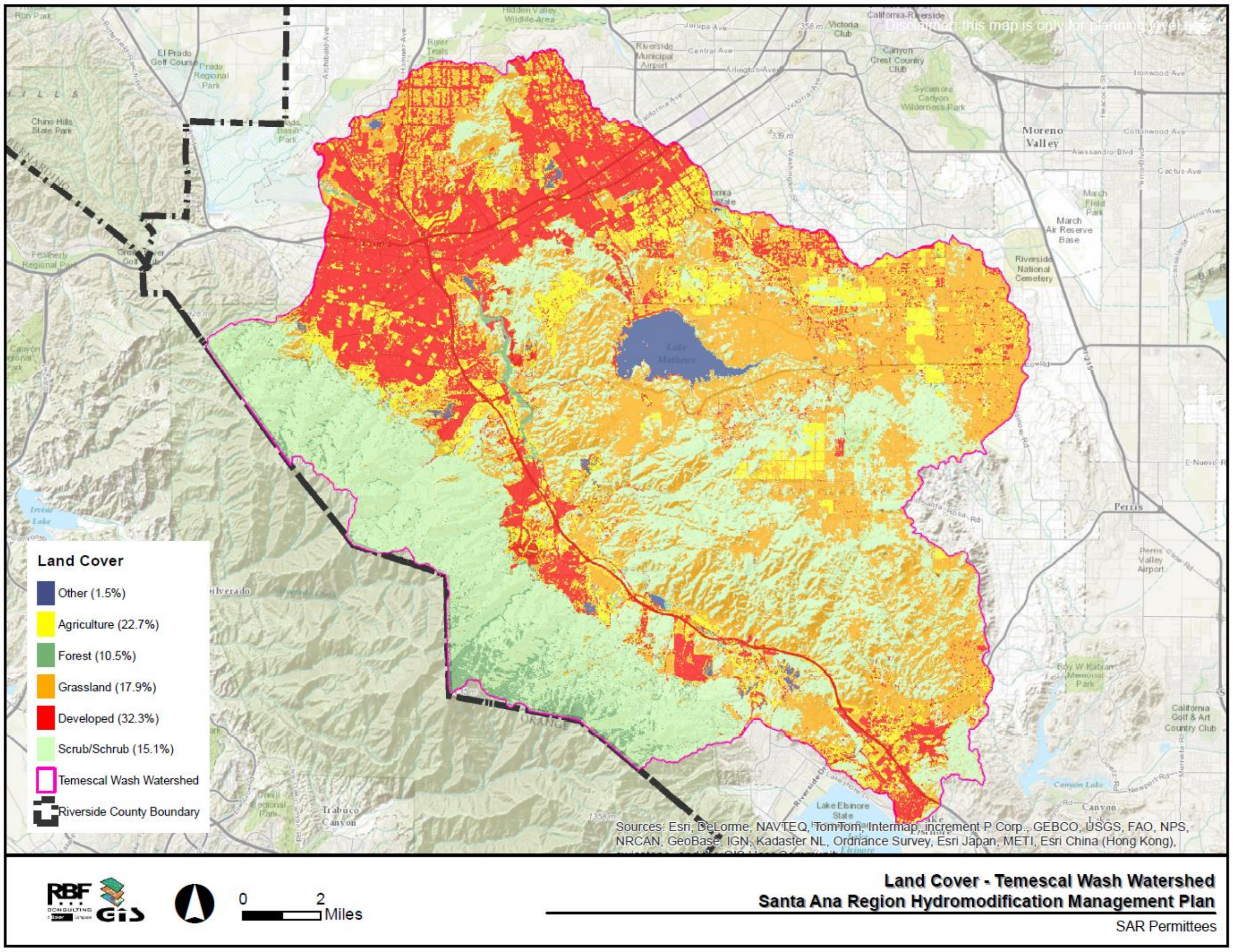


Figure 9: Temescal Wash Subwatershed Geology Types

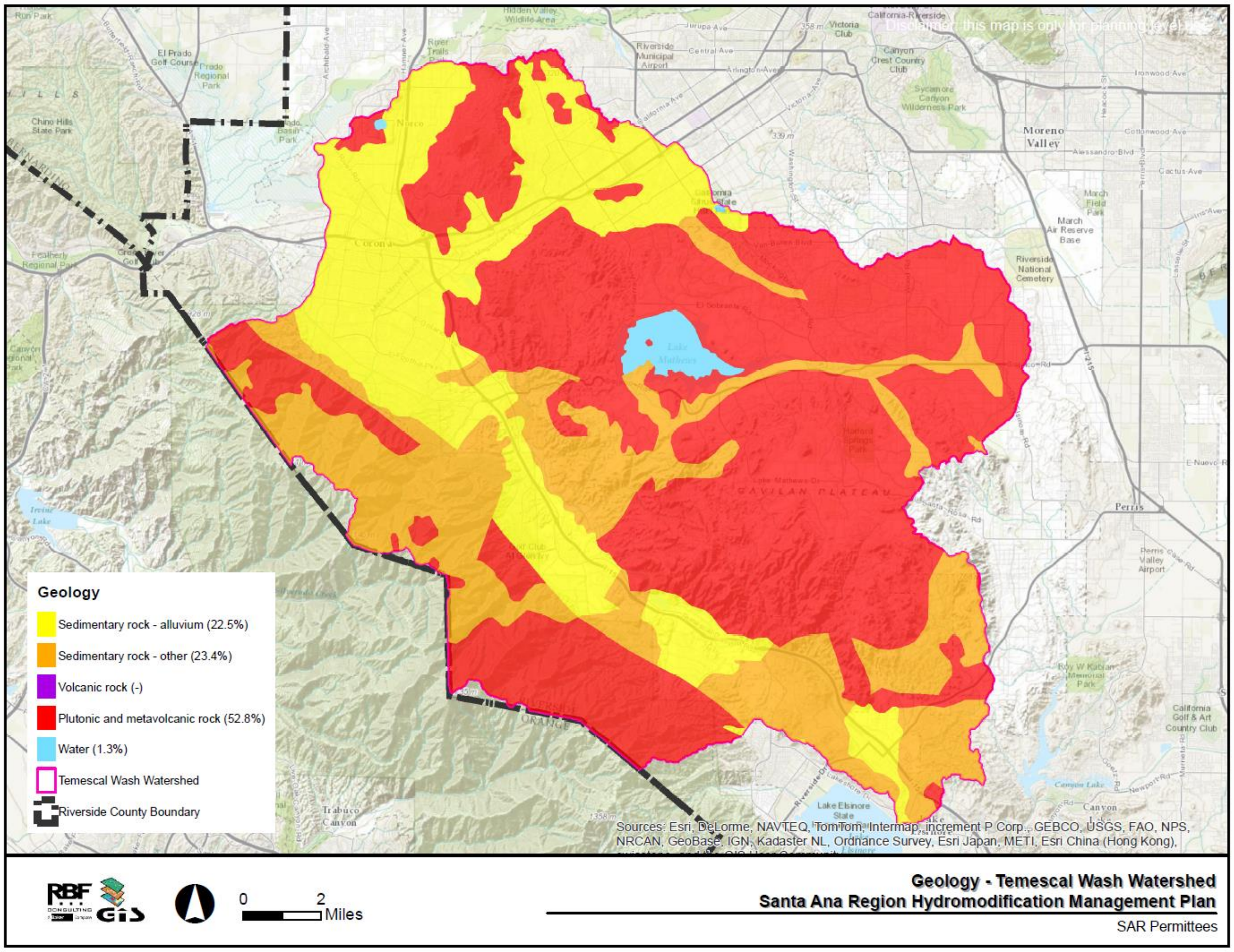
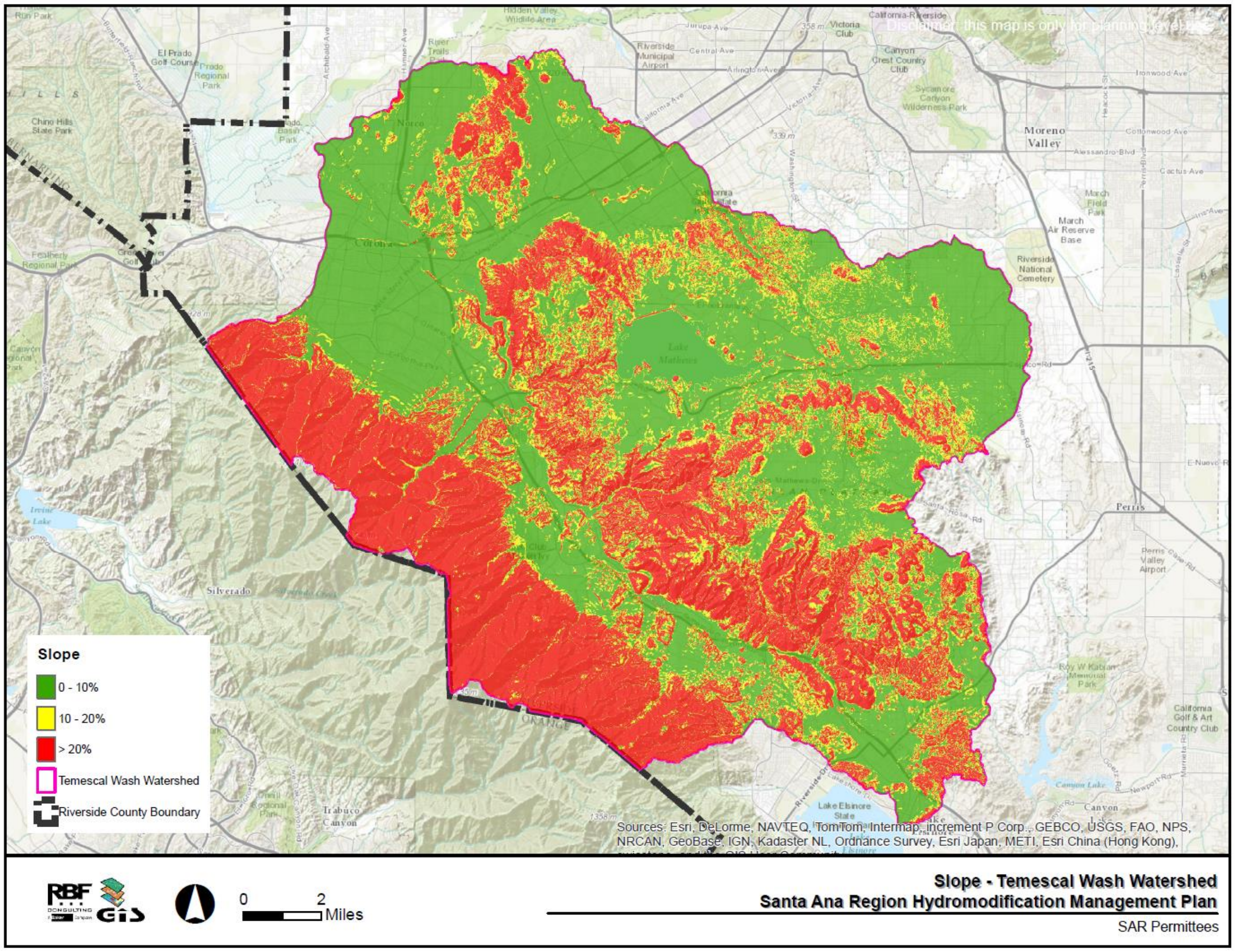


Figure 10: Temescal Wash Subwatershed Hillslope Gradients



3.4 San Timoteo Creek Subwatershed

The San Timoteo Creek Subwatershed encompasses an area of 60 square miles. Upper reaches that account for 59.9 square miles are located within the County of Riverside, whereas lower reaches are located within the County of San Bernardino. Headwaters of San Timoteo Creek within Riverside County are located in the San Bernardino Mountains, which drain to Cherry Valley. Other headwaters located within the County of San Bernardino include Yucaipa Creek and Live Oak Canyon. Upon leaving the San Timoteo Canyon, the Creek discharges into the Santa Ana River near the Interstate 10 and Interstate 215 interchange. Agricultural activities and POTW discharges to the Creek occur year-around, creating a perennial flow condition.

3.4.1 Study Reach

The reach of San Timoteo Creek that is evaluated extends for approximately 3.0 miles along Oak Valley Parkway, known also as San Timoteo Canyon Road. The Creek naturally meanders in the canyon upstream of Palmer Avenue, upon which the reach is conveyed along the railroad and Oak Valley Parkway. Available aerial photographs for the entire reach span from 1952 to 2013. Based on the 2013 aerial photograph, the channel bed and banks are densely vegetated, which may significantly contribute to channel stability.

3.4.2 Historical Aerial Photographs

From the historical aerial photographs (Appendix A), it can be seen that the Subwatershed has experienced some degree of urban development with the establishment of a residential community (Fairway Canyon) and the Tukwet Canyon Golf Course between 1980 and 2013. Historical agricultural and natural land uses have progressively been modified for residential, commercial, and transportation purposes. Based on the available aerial photography, the geomorphology and the alignment of San Timoteo Creek have not drastically changed since 1952. This may be related to the perennial flow condition caused by agricultural and POTW activities, which promotes establishment of vegetation that may protect the channel bed and banks from degradation.

3.4.3 GIS-based Desktop Study

The following subsections summarize the results of the GIS-based desktop study for the San Timoteo Subwatershed.

3.4.3.1 Geology Type

Sedimentary rocks account for the majority of soils (92.2%) within the San Timoteo Subwatershed; alluvium, which have the highest potential for erosion, account for 67.9% of the soils within the Subwatershed. Plutonic and metavolcanic rocks are only present in the northwestern portion of the Subwatershed that is located in Riverside County (Box Springs Mountains Range). Urban development has reduced the potential for delivery of alluvium to the receiving waters, which may impact the morphology of San Timoteo Creek in the future. The presence of debris basins is limited to the alluvial fans located downstream of Little San Gorgonio Peak area to protect the community of Cherry Valley. The future implementation of debris basins, if any, should consider the impacts that these may have on the geomorphology of the lower reaches.

3.4.3.2 Land Use

The upper reaches of the Subwatershed are primarily in agriculture land (19.0%) and grassland (24.8%). The subwatershed has observed a significant degree of urban development over the past 30 years, notably in the cities of Beaumont and Calimesa. Portions of the subwatershed that are located within the mountain ranges are still undeveloped with native vegetation, such as scrub and shrub. Urban development in the subwatershed has resulted in a change in the Subwatershed imperviousness and associated increase in the frequency and flow experienced in San Timoteo Creek. Aerial photographs show that the dense vegetation has helped stabilize the Creek under altered hydrologic and sediment regimes.

3.4.3.3 Hillslope Gradient

The majority of reaches, which have the highest potential for erosion with a hillslope gradient greater than 21%, are concentrated along San Timoteo Canyon and Wildwood Canyon. Other parts of the San Timoteo Creek Subwatershed are fairly flat, notably in the vicinity of Cherry Valley plateau; these areas exhibit a low potential for erosion.

3.4.4 Conclusion

The majority of the urban development within the San Timoteo Creek Subwatershed is located in the upper reaches, specifically in the vicinity of the Cherry Valley plateau. The majority of soils within the subwastershed are composed of alluvium or other sedimentary rocks, which are highly prone to erosion. Upper, steeper reaches along San Timoteo Canyon and Wildwood Canyon have remained in a natural condition. Generally this would be beneficial because the steep slopes and undeveloped land would still produce significant sediment to replenish the downstream channel. The issue is that several debris basins have been constructed just downstream of the upper reaches. The debris basins have reduced part of the supply of coarse grained sediment from making it to the downstream channel reaches. In addition, the significant change in impervious area due to urban development in the Subwatershed has increased the frequency and rate of flow in the channel.

Figure 11: San Timoteo Creek Subwatershed Land Cover Types

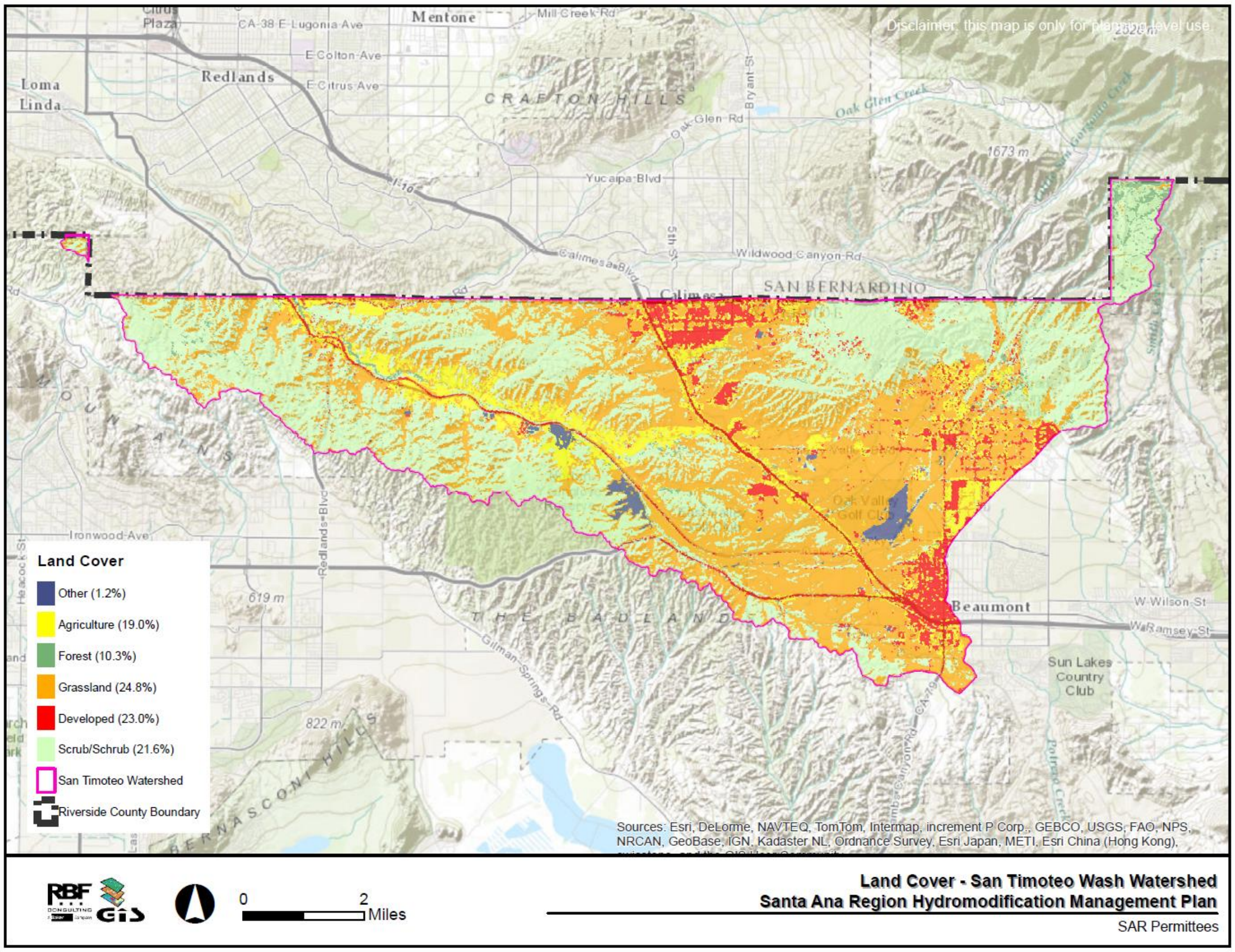


Figure 12: San Timoteo Creek Subwatershed Geology Types

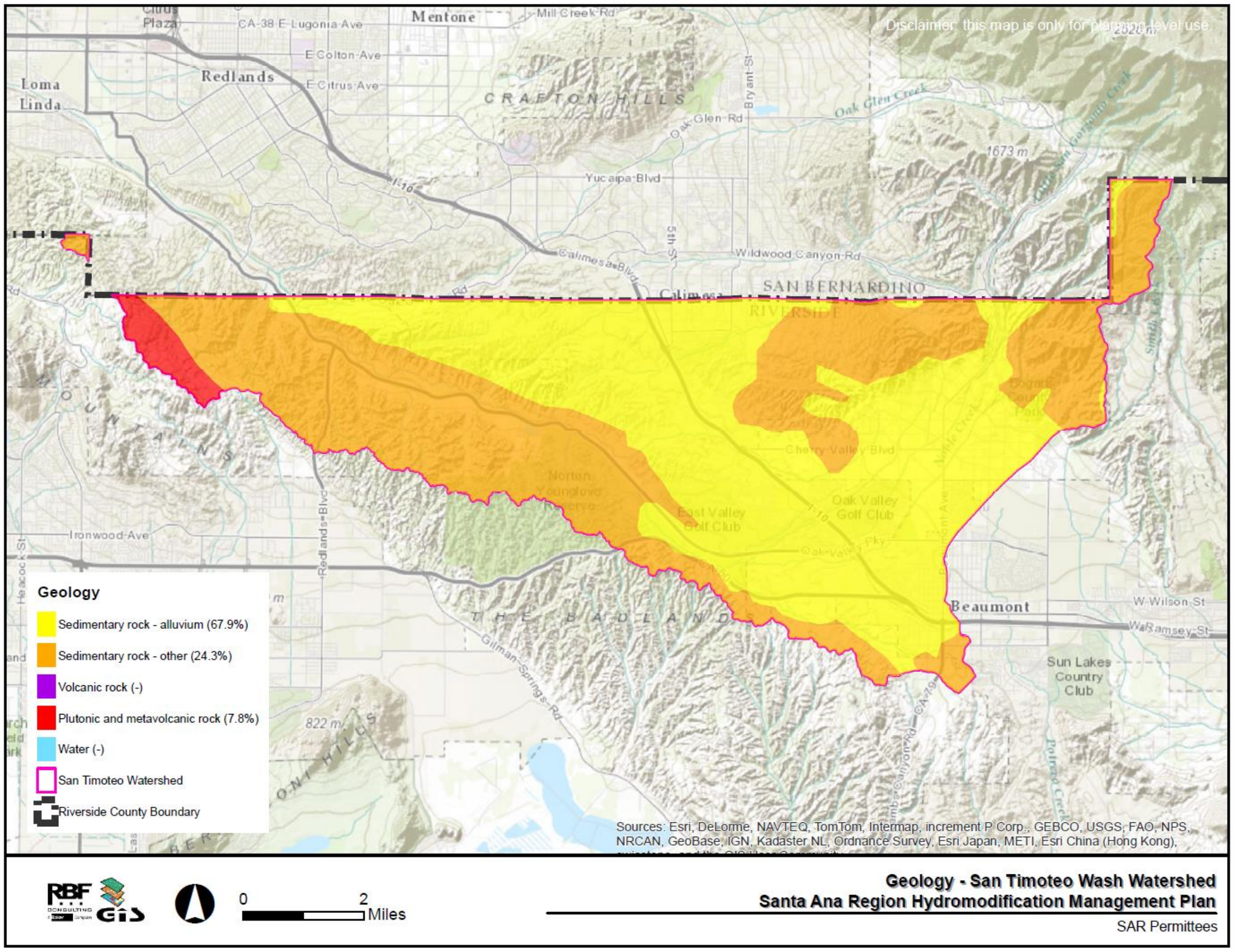
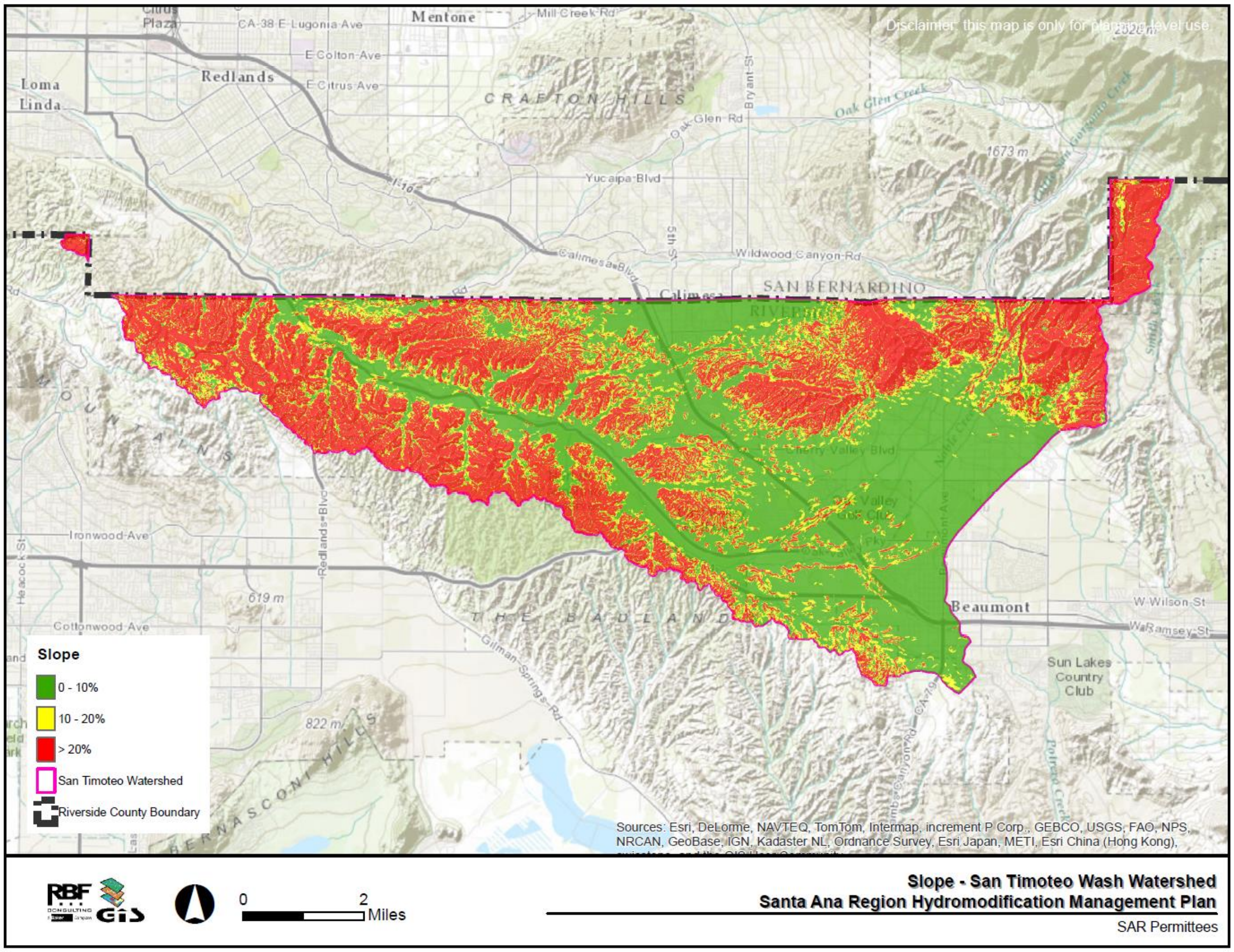


Figure 13: San Timoteo Creek Subwatershed Hillslope Gradients



4 CONCLUSION

There are three main reasons for the current level of degradation and aggradation in the four subwatersheds under investigation: the geology is vulnerable to erosion, urban development has occurred resulting in less sediment yield, and detention basins have been constructed that reduce upstream sediment supply.

The presence of sedimentary rocks, especially alluvium, is confirmed at different degrees within the four subwatersheds. This geology type is a significant factor in channel degradation and aggradation. This is especially evident in the most downstream portions of the subwatersheds where the mean grain size of the sediment will be at its smallest, and thus more likely to degrade.

The development of the land, especially in the Middle and Lower San Jacinto River Subwatershed, as well as the Temescal Wash Subwatershed, has increased the potential runoff while at the same time decreasing the sediment produced. This change caused an imbalance and increased the degradation and aggradation in the downstream reaches of the Subwatersheds.

The last major cause of degradation and aggradation, the construction of water storage/debris basins, was not part of the original GIS-based analysis, but its effect on the subwatersheds was very evident. The downstream portions of the subwatersheds rely on the coarse sediment from the upper reaches to replenish the channel bottoms. With reduced upstream sediment supply, the channels have a much higher potential for degradation. Even with the decrease in peak flow rates, an imbalance within the subwatersheds was created, resulting in downstream erosion. Additionally, the attenuation of the storm flows has caused an increased amount of time that the channels could experience degradation and aggradation.

Some additional factors that have not been assessed in this technical memorandum are the variability of storm events, the arid region, and the impacts that a significant high intensity storm may have on a dry watercourse. A historic timeline of significant events has not been performed. Other notable factors, also not included in this technical memorandum, are sediment removal operations typically located within debris basins and river systems. The sediment removal operations may be for public health and safety or commercial mining operations.

REFERENCES

1. Bloom, Arthur L., Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, 3rd Ed., 1998.

2. U.S. Army Corps of Engineers, San Antonio and Chino Creeks Channel: Feasibility Study, August 1998.

3. Southern California Coastal Water Research Project, Hydromodification Screening Tools: GIS-based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge, Technical Report 605, March 2010.

APPENDIX A

Historical Aerials

APPENDIX B

Hydromodification Screening Tools:

GIS-based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge

By SCCWRP

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