# Chapter 4
# Land Use in the Santa Clara Basin

# Section 4.x
# Introduction:
# Effects of Land Use on Watersheds

*Prepared for the*
*Santa Clara Basin Watershed Management Initiative*
*Land Use Subgroup*
By

**Dan Cloak**
**Supervising Engineer, EOA, Inc.**

**Funded by:**
**Santa Clara Valley Urban Runoff Pollution Prevention Program**
Task SC 20.04

**December 10, 1999**

# Chapter 4
# Land Use in the Santa Clara Basin

## 4.x Introduction: Effects of Land Use on Watersheds

Table of Contents

# Chapter 4
# Land Use in the Santa Clara Basin

## 4.x Introduction: Effects of Land Use on Watersheds

This chapter was prepared by the Land Use Subgroup, with the assistance from the Santa Clara Valley Urban Runoff Pollution Prevention Program. The primary purpose of the chapter is to assist urban planners, development project reviewers, and other stakeholders to understand the effects of land uses on water bodies in the Santa Clara Basin.

This introduction reviews the literature relating land use to watershed characteristics and provides an overview of current issues relating to land use and watershed protection in the Santa Clara Basin. The introduction concludes with an idea, developed by the Land Use Subgroup, for advancing the process of land use planning for watershed protection.

The following sections discuss:

- Existing land uses and projected development.
- Distribution of imperviousness in the basin.
- Land uses within riparian corridors.

Section 6.7 (Regulation of Land Use) in Chapter 6 (Regulatory Setting) provides additional information needed to develop a land use element of a watershed management plan. In particular, Section 6.7.1 describes the state laws and enabling legislation that empower municipalities to protect watersheds, and Section 6.7.4 compares and contrasts existing municipal watershed-protection policies.

### 4.x.1. Overview: Spatial Pattern Matters

Meaningful assessment of the effects of land use on the beneficial uses of creeks, rivers or estuaries requires a watershed-level analysis. Since the era of the New Deal,[1] the effects of forestry, grazing, or agriculture on rural watersheds have been addressed by conservation districts, and more recently, through local Coordinated Resource Management and Planning (CRMP) stakeholder processes. In general, successful rural watershed management plans have considered how land uses relate spatially to watershed features (e.g., location of grazing or manure storage relative to streams, maintenance of riparian corridors). They have also explicitly integrated social and demographic considerations (i.e., who owns and takes care of the land) — in selecting and implementing appropriate “best management practices” (BMPs).

By contrast, federal mandates have required urban areas to implement BMPs to prevent (to the "maximum extent practicable") pollutants from reaching storm drains.[2] There has been little systematic analysis of the spatial relationships between land uses and streams in urban areas, nor integration of how social and economic factors affect these spatial relationships.

Nevertheless, the impacts of urbanization are closely linked to the spatial pattern of development. The pattern matters more than the proportion of the entire watershed that is urbanized, more than the relative proportions of urban land uses.

In her book *Restoring Streams in Cities,* Ann Riley concludes: "Of all the land-use changes that can impact a watershed and its hydrology, urbanization is by far the most significant."[3]

As Dr. Riley states:

> The worst physical modification of urban watersheds is the relegation of stream channels and tributaries to underground culverts. Riparian zones are eliminated or separated from the stream channels. Removal of streamside vegetation results in the loss of nutrients to the aquatic organisms, loss of shade, increased bank erosion, lateral movement of the stream channel, increased sedimentation, and decreased pool depths. Floodplains become separated from the stream channels because the channels have become incised or deepened, or the previous land-use practices have added large layers of fill to floodplains, or both these things have happened. Structural barriers such as levees and flood walls and channelization can be added causes of this separation. Floodplains can be one of the most biologically productive parts of the watershed system as well as a storage and conveyance area for floodwater, but they are often impacted by urbanization….
>
> Urbanization tends to increase the volume and peak of stream flows. The delivery of runoff to streams after the beginning of rainfall becomes flashier, reducing the lag time between the rainfall and the peak of a stream's flood stage. [4]

Non-urban land uses, such as grazing and agriculture, also affect watersheds. However, the most severe impacts to Santa Clara Basin streams are related to urbanization. Comprehensive watershed management will require maintaining and managing these uses, but the biggest challenge, by far, will be to preserve and enhance streams in urban areas.

The effects of urbanization cannot be reduced to pollutants per acre, or even to increases in acre-feet of runoff, but rather are engendered by a myriad of changes to drainage patterns, changes that accelerate the movement of runoff into streams, alter the patterns of erosion and deposition within the streambanks, and alter the flow of water, sediment and nutrients between streams and riparian areas.

Although municipalities' General Plans coordinate the spatial arrangement of land uses, they generally do not incorporate the relationship of land to drainage and to water bodies. There is a conceptual gap between the tools of urban planning – tools developed to coordinate traffic circulation, and to balance jobs with housing – and the needs of the watershed planner. Although most municipalities have adopted preservation of water resources as a goal of their comprehensive plan and have the authority to undertake a variety of initiatives, they lack a methodology for developing and implementing measures to protect and enhance watersheds at the appropriate watershed-wide scale.

To develop such a methodology, it is necessary to examine the spatial patterns of urban development, including the social causes and ecological consequences of those patterns. As the primer, *Landscape Ecology Principles in Landscape Architecture and Land Use Planning*, states:

> Spatial pattern matters. It is no longer appropriate to plan based on totals or averages of prices, jobs, wages, parkland, bicycle paths, logging area, water flows, and so forth. Rather, the arrangement of land uses and habitats is critical to planning, conservation, design, management and policy. [5]

### 4.x.2. Spatial Patterns of Urbanization

To understand the relationship between urban land uses and the streams that drain them, we must first review the characteristics and spatial relationships of the land uses themselves. As is documented in Section 4.2, the predominant characteristic of land uses in the Santa Clara Basin is the continuous swath of urban development across the valley and into the lower foothills of the Basin. Viewed in the context of land use change over the past 150 years, the pattern has been characterized as "sprawl."[6]

The report of the President's Council on Sustainable Development, Task Force on Sustainable Communities defines "sprawl" as

> …low-density development that spreads out from the edges of cities and towns. It is poorly planned, and often situated without regard to the overall design of a community or a region. It often results in types of development - such as rambling, cookie-cutter subdivisions and strip malls - that perpetuate homogeneity, make inefficient use of land, and rely almost exclusively on automobiles for transportation.[7]

In an April 12, 1999 report, the conservation organization American Rivers paints an alarming portrait of how land use change is affecting rivers across the U.S.: "…sprawl is one of the fastest growing, most ominous threats to our nation's rivers. Sprawl wreaks havoc on both the quality of water in a river and on the amount of water flowing between the banks."[8]

The Sierra Club's October 1998 report, "Dark Side of the American Dream" describes the origins of the problem this way:

> Since the end of World War II, the American Dream has been defined as a house in the suburbs. Sparked by a series of federal and state government policies, including home-buying subsidies provided by the GI Bill, massive roadbuilding projects and community planning designed around the car, Americans abandoned the cities for greener pastures in suburbia.
>
> The consequences of decades of unplanned, rapid growth and poor land-use management are evident all across America: increased traffic congestion, longer commutes, increased dependence on fossil fuels, crowded schools, worsening air and water pollution, lost open space and wetlands, increased flooding, destroyed wildlife habitat, higher taxes and dying city centers.[9]

Over the past year, despite the protests of the Heritage Foundation,[10] "sprawl" has become the focal point for an intensifying national debate on land use changes, how they affect society, and how they affect the environment — in particular, how these changes affect watersheds.

### 4.x.3. A Short History of Ideas About Cities and Nature

Economic and population growth (spurred by private investment and government defense spending) caused the Santa Clara Basin's rapid post-war urbanization. But policies—and ideas behind those policies—account for the spatial arrangement of urban land uses. Where did those ideas come from? As population and economic activity continue to grow, can different ideas about cities help bring about land use patterns that support society and nature alike?

The decrying of sprawl links general unease over rampant environmental destruction with unease over social divisions and loss of quality of life. The urban designer Peter Calthorpe conveys the sensibility that for city dwellers, community and ecology are necessarily connected:

> Communities historically were embedded in nature — it helped set both the unique identity of each place and the physical limits of the community. Local climate, plants, vistas, harbors, and ridgelands once defined the special qualities of every memorable place. Now smog, pavement, toxic soil, receding ecologies, and polluted water contribute to the destruction of neighborhood and home in the largest sense….[11]

How did sprawl get started? Calthorpe's end-of-the-20th-century reaction to the problems of suburban development was presaged, a century ago, by the reaction of planners and academics to the overcrowded living conditions, poverty and unhealthful conditions of 19th-century cities.

Indeed, the very conception of this Watershed Assessment Report might be seen as a reflection, nearly a century later, of Patrick Geddes' idea of a regional plan (for Edinburgh, Scotland), as described in Lewis Mumford's *The Story of Utopias* (1963)[12]*:*

> The aim of the Regional Survey is to take a geographic region and explore it in every aspect. It differs from the social survey with which we are acquainted in America in that it is not chiefly a survey of evils; it is, rather, a survey of the existing conditions in all their aspects; and it emphasizes to a much greater extent than the social survey the natural characteristics of the environment, as they are discovered by the geologist, the zoologist, the ecologist - in addition to the development of natural and human conditions in the historic past, as presented by the anthropologist, the archaeologist, and the historian. In short, the regional survey attempts a local synthesis of all the specialist 'knowledges.'

Geddes' purpose was to create a rational basis for planning future development that would avoid the environmental and social pitfalls of industrial-age cities.

Attempts to "design away" the problems of urban life begin with the Englishman Ebenezer Howard, who proposed, in 1898, to halt the growth of London and repopulate the countryside with a new kind of "Garden City" where the city poor might once again live close to nature. (Jane Jacobs describes this conception as a kind of "model company town, with profit-sharing." [13])

Le Corbusier expanded this modernist vision with his 1920s "Radiant City," which incorporated then-new building technology. He wrote: "Supposing we are entering the city by way of the Great Park. Our fast car takes the special elevated motor track between the majestic skyscrapers: as we approach nearer, there is seen the repetition against the sky of the 24 skyscrapers; to our left and right on the outskirts of each particular area are the municipal and administrative buildings; and enclosing the space are the museums and university buildings. The whole city is a Park."

Lewis Mumford said the "City in the Park" idea "misconceived the nature and functions of both city and park…. a suburban conception. By its very isolation of functions that should be closely connected to every other aspect of city life… it can be detached from the organic structure of the city and planted anywhere…. The City in a Park has now taken a more acceptable, commercially attractive form, and has become a City in Parking Lot."[14] Here Jane Jacobs agreed with Mumford, saying that Le Corbusier's technocratic approach attempted to "sort and sift out of the whole certain simple uses, and to arrange each of these in relative self-containment."[15]

These ideal cities (examples include Howard's Welwyn Garden City, Le Corbusier's Contemporary City, and Frank Lloyd Wright's Broadacre City) expressed not only an ideal form of urban design, but also a design for a social utopia. They were rarely built, but as Jacobs notes, they greatly influenced city planning and legislation affecting housing and housing finance.

The utopian vision of suburbia was posed as a solution to the social ills of the day, but was also rooted in intellectual city dwellers' idealization of nature. Roderick Nash notes in his 1973 book, *Wilderness and the American Mind*: "Appreciation of wilderness began in the cities. The literary gentleman wielding a pen, not the pioneer with his axe, made the first gestures of resistance against the strong currents of antipathy [toward the wilderness]."[16] Mumford notes: "This impulse to have closer contact with the rural scene was fed by the literature of the Romantic movement, from Rousseau on to Thoreau; but it did not originate there…. The rich families of Florence, Rome and Venice in the fifteenth and sixteenth centuries [built] country villas…. What marks the modern age is that both the impulse and the means of achieving it have become universal."[17]

By 1962, when Jane Jacobs wrote *The Death and Life of Great American Cities*, the unintended consequences of utopian city planning — particularly the separation of land uses and the incorporation of natural areas into the urban realm — were all too apparent. She noted: "There are dangers in sentimentalizing nature. Most sentimental ideas imply, at bottom, a deep if unacknowledged disrespect. It is no accident that we Americans, probably the world's champion sentimentalizers about nature, are at one and the same time probably the world's most voracious and disrespectful destroyers of the wild and rural countryside."

Heedless of warnings by Jacobs and others, the utopian ideology of suburbia has governed post-WW II land development throughout the Bay Area. As Calthorpe notes:

> Every piece of land in the USA is controlled by codes and planning documents that evolved after WWII. These controls have been largely founded on modernist principles — segregation of uses, circulation systems focused on the car, and a loss of public orientation for buildings and gathering places. With the exception of a few urban centers, every city, county and town has a set of zoning ordinances, planning codes, street standards and perhaps a comprehensive plan that binds the area to a future of sprawl-like development.[18]

### 4.x.4. Economy, Equity, Environment

The engineering of a modernist landscape has been implemented despite the additional public and private costs compared to more dense, integrated urban development. Tina Axelrad's 1998 synthesis of the national literature on the costs of urban sprawl notes that: “Generally, patterns of sprawl characterized by large-lot, single-family developments far from the “core” of a metropolitan area, will result in greater public capital and operating costs for local roads, schools, and utility infrastructure.”[19]

Urban Ecology, a Bay Area organization dedicated to “promoting urban environments that are ecologically, socially and economically healthy,” has noted the “hidden costs” associated with sprawl in the Bay Area. Pacific Gas and Electric’s rate structure spreads the additional costs for gas and electricity distribution in low-density areas to urban, as well as suburban, ratepayers. City dweller’s tax dollars end up subsidizing new roads and utility systems, instead of going toward transit systems and urban services they need.[20]

Another cost of sprawl is the high rate of  pedestrian injury and death. Of all Bay Area counties, Santa Clara has the second-lowest proportion of its population walking to work (2.1%). However, it had a relatively high incidence (44.7/100,000 population) of pedestrian injuries and fatalities.[21]

The tendency toward sprawl is exacerbated, in California, by the effects of Proposition 13. For example, Santa Clara County voters passed an extension of a half-cent sales tax increase (Proposition A, 1992) to provide $3.5 billion for light rail expansion. However, the measure was struck down by the California Supreme Court which rules that the sales tax extension would require a two-thirds majority.

To make up for the shift of taxing power away from municipalities and toward the state, municipalities have been pressed to approve commercial development, because it produces higher tax revenues than does housing, and demands less outlay for public services. This forces cities to vie with each other for commercial projects, undercutting their ability to negotiate mitigation measures for development.

Social attitudes and effects, including “economic polarization,” are making it difficult to control sprawl. In a May 1998 report prepared for the Urban Habitat Program (a nonprofit organization founded in 1989 to “develop multicultural urban environmental leadership for sustainable communities in the San Francisco Bay Area”) Myron Orfield warns:

> There is a dangerous social and economic polarization occurring in the San Francisco Bay Area…. First, poverty and social and economic need has concentrated and is deepening in central city neighborhoods and in older, inner suburbs…. This concentration destabilizes schools and neighborhoods, is associated with increases in crime, and results in the flight of middle-class families and businesses. As social needs accelerate in the central cities, inner suburbs, and many outlying communities, the property tax base supporting local services erodes. Second, in a related pattern, growing middle-income

> communities are beginning to experience increases in their poverty and crime rates, and could well become tomorrow's troubled suburban places…. Third, upper-income residentially exclusive suburban places are capturing the largest share of regional infrastructure spending, economic growth and jobs. As the property tax base expands in high property-wealth areas and their housing markets remain exclusive, these areas…become both socially and politically isolated from regional responsibilities.
>
> Overlaying this socioeconomic polarization is an environmental nightmare. As the wave of socioeconomic decline rolls outward from the central cities and older, inner-ring suburbs, tides of middle-class homeowners sweep into fringe communities. Growing communities, facing tremendous service and infrastructure needs offer development incentives and zone in ways that allow them to capture the most tax base. In so doing, they lock the region into low-density development patterns that are fiscally irresponsible, foster automobile dependency, contaminate groundwater, and needlessly destroy tens of thousands of acres of forest and farmland.
>
> ….At (literally) either end of regional polarization are two seemingly unrelated but actually quite interconnected negative impacts: the concentration of poverty in the region's core and environmental degradation on the region's fringe.[22]

Although Bay Area concentrations of poverty are most pronounced in Oakland and San Francisco, there is reason to be concerned about the connection between economic polarization and environmental degradation in the Santa Clara Basin. San Jose had no "extreme" poverty census tracts in 1980 or in 1990; however, the number of tracts characterized as "transitional"—where between 20 and 40% of the population lives below the federal poverty line ($1,111/month for a family of three in 1998,[23] a measure that is generally assumed to grossly underestimate actually poverty[24]) —increased from 11 to 15.

## 4.x.5. Effects of Urbanization on Santa Clara Basin Watersheds

A number of studies have investigated, or are investigating, physical and biological parameters of Santa Clara Basin streams, but the overall condition of aquatic ecosystems has not been systematically assessed. A detailed assessment of conditions in three Santa Clara Basin watersheds will be reported in Volume II of this Watershed Assessment Report. However, it is possible — based on a knowledge of watershed structure and function, and examination of land use patterns — to identify generalized effects of land use on Santa Clara Basin streams.

San Francisco Bay area landscapes have been progressively altered, over 150 years, by mining, forestry, ranching, agriculture, and urbanization. Chapter 7.1 includes descriptions of the Santa Clara Basin's pre-settlement flora and fauna and changes due to development.

Because we are accustomed to the current conditions of creeks, we are most likely to notice when "normal" conditions change. Visible trash and pollutants, bank washouts, increased turbidity, and fish kills are immediate and obvious effects of land use. However, these visible changes are usually symptomatic of larger, more serious changes affecting hydrology, flow regime and riparian vegetation.

The Santa Clara Basin's land uses are described in Section 4.1: Urbanized areas extend over the valley floor to an elevation of 600-800 feet. Above this level, moderately sloped areas are mostly rangeland, and steep-sloped areas are forested. (Figure 4-3). Within the urbanized area, small patches of natural area and park dot an otherwise continuous swath of residential, industrial and commercial development. Continuous bands of riparian vegetation along creeks, which typify less disturbed areas in the region, exist in some urbanized watersheds; in others, they have been reduced to a few disconnected lengths or eliminated entirely (see Sections 7.1 and 7.2).

From a watershed perspective, the primary effects of sprawl development are the segregation of land uses, low density, and dependency on automobiles for transportation. The vast, uniform swath of houses and workplaces disrupts watershed function principally by altering the characteristics of its drainage. The principles of landscape ecology tell us that the disturbance from the natural landscape pattern — most notably the narrowing and linear discontinuity of streamside corridors — will have specific effects on the functioning of watersheds.

Land uses change the characteristics of a watershed when, individually or in combination, they alter its structure or impair key ecological functions. These changes are best understood by how they affect ecosystem structure, processes and functions.[25] Wesche describes the chain of events as follows: changes in land use lead to changes in geomorphology and hydrology, to changes in stream hydraulics, sediment transport and storage, and on to changes in the functions of stream habitat.[26]

The following discussion is organized under these topics:

- Urbanization and Imperviousness
- Geomorphic Changes and Disconnection of Streams from Floodplains
- Riparian Areas
- Pollutants

### 4.x.5.1. Urbanization and Imperviousness

Various studies have simply correlated biological changes with urbanization or other land use change, without elucidating causal mechanisms.

Karr (1997)[27] uses simple graphs to illustrate that biological metrics (benthic index of biological integrity, taxa richness) decline with increasing "human influence." The latter quantity is characterized by percent impervious area or (even more simply) by subjective characterizations of intensity of use (after Patterson, 1996).[28] Pitt and Bozeman were unable to conclude that urban runoff pollutants impair beneficial uses of Coyote Creek, but did find significant differences in fish and benthic macroinvertebrate assemblages (decreased diversity and biomass) in urban locations.[29]

May et. al. (1997)[30] use percent total impervious area to represent "urbanization" of streams in the Puget Sound (WA) region, and correlate other quantifiable measures related to habitat quality (road density, 2-year storm/baseflow discharge ratio, riparian buffer width, and quantity of large woody debris). The authors show that road density is strongly correlated to percent total impervious area, and could even be used as a substitute measure for imperviousness.

Schueler (1994)[31] demonstrates the relationship between increased impervious cover and increases in peak flow and total volume of runoff. Schueler concludes that the hydrologic changes cause degradation of habitat structure, water quality and biodiversity of aquatic systems at relatively low levels of imperviousness (10-20% of total drainage area).

Tom Richman (1999), in his design guidance manual prepared for the Bay Area Stormwater Management Agencies Association, summarizes the environmental consequences of impervious land coverage:

1. Rainwater is prevented from infiltrating the soil and recharging groundwater. This reduces base stream flows.
2. More rainwater runs off, and runs off more quickly, increasing flow volumes, accelerating erosion in natural channels, and reducing habitat. Flooding and channel destabilization may lead to channelization of the stream, with further loss of beneficial uses.
3. As runoff moves over large impervious areas, it collects and concentrates pollutants.
4. Impervious surfaces retain and reflect heat, causing increases in ambient air and water temperatures.[32]

Increased imperviousness has little effect on flows during "extreme" events (such as the extensive flooding in the Santa Clara Valley 1952-53). During these events, rainfall saturates even natural soils, rendering them effectively impervious. Hollis (1975)[33] shows that urbanization can increase smaller frequent floods by up to 10 times, while extreme events barely increase at all. Mineart and Ha (1999)[34] showed that flooding in Coyote Creek has not increased with urbanization, largely due to management of flows at Anderson Dam. However, there may have been an increase in the tendency to flood in specific urban catchments within the watershed.

Related to imperviousness is the increase in drainage density, which is defined as the length of drainage conduit (pipe, ditch, or stream) divided by the drainage area.[35] Drainage density encourages rapid runoff, exacerbating the effects of imperviousness, but also represents physical alteration of smaller tributary streams.

The studies by Schueler, May et. al. and others show that imperviousness is correlated to an increase in peak and volume of flow (particularly during smaller storms and in smaller streams) and that imperviousness is also correllated to reduced habitat quality, as measured by biological indices. However, to understand the causal relationships, it is necessary to examine the relationship between imperviousness and stream geomorphology.

### 4.x.5.2. Changes to Geomorphology and Disconnection from Floodplains

The most significant and characteristic impacts of land use to Santa Clara Valley streams are (1) the destabilization of streambeds and banks, which is caused by imperviousness, increased drainage density and changes to sediment inputs, and (2) the disconnection of streams from floodplains, caused by incising, channelization and levees.

Imperviousness associated with urban development magnifies the peak flow and total runoff during the 1.5- to 2-year flood event – the size of flood that most strongly influences stream characteristics. The major "work" by a perennial stream in moving sediment, and thereby determining its form, is accomplished by floods which occur, on average at 1- to 2-year intervals.[36] Consistently, this frequency corresponds to the flood of near bankfull depth, i.e., the discharge when water just begins to leave the channel and spread onto the floodplain.

Ann Riley summarizes the scientific consensus on the geomorphic parameters of streams in equilibrium with their channel:

- Depth of flow is proportional to discharge. Depths increase with increasing discharges, but not as much as width.

- Channel width is proportional to both water discharge and sediment discharge.

- Channel shape (width/depth) is directly related to sediment discharge.

- Channel gradient flattens with an increase in discharge and increases with a decrease in discharge.

- Channel slope is proportional to both sediment discharge and sediment grain size.

- Sinuosity (or degree of meandering) is proportional to valley slope.

- Meander wavelengths tend to maintain a constant relationship with channel width. Increased discharges tend to increase meander wavelength and channel width.[37]

To understand the geomorphological relationship between watershed disturbance and stream health, Dave Rosgen advocates a stepwise analysis of stream geomorphology (channel slope, shape and patterns), followed by a detailed morphological description (width/depth, sinuousity, channel slope, channel materials). According to Rosgen, these steps are required before proceeding to develop a description of stream condition as it relates to "stream potential," defined as the best condition achievable for a stream's morphological characteristics. The degree of departure from potential is then assessed by comparing the subject stream to criteria based on streams of similar geomorphic type.[38]

The geomorphology of the Santa Clara Valley—a gently sloping plain underlain by alluvial gravels interspersed with clays — was created by the "work" of streams carrying sediment down from the hillsides. The relatively flat alluvial plain was created (and in geologic time, is being recreated) by streams moving back and forth over the valley floor.

In addition to reconstructing and maintaining the characteristic channel morphology and substrate, periodic flooding is essential to some riparian plants (e.g., willows and cottonwoods) and replenishes floodplains with sediments and nutrients. The flooding yields a "pulsed" increase in habitat, which is essential for invertebrate communities, amphibians, reptiles, and fish spawning. Flooding also replenishes shallow groundwater, extending stream flows longer into the summer.[39]

### 4.x.5.3. Riparian Areas

Ann Riley summarizes the functions of riparian vegetation in supporting fish habitat:

Tree roots and other growth bind the stream bank soil and resist erosion. This produces deeper channels with banks that are undercut but held together with exposed root systems. These undercut banks, with overhanging vegetation, provide important escape cover for fish.

- Riparian vegetation moderates water temperatures.

- Most of a stream's biological energy comes from plant detritus.

- Woody debris that falls in the stream creates habitat in backwater pools and provides storage for sediment that would otherwise be released into spawning areas.

- Riparian vegetation slows flood velocities and helps deposit and store sediment on the floodplains, rather than in the stream channel.

- A well-vegetated channel helps store water during the rainy season; subsequent release in the dry season helps maintain base flows.[40]

In addition, riparian vegetation helps to moderate stream temperatures, which in turn moderates fluctuations in dissolved oxygen concentrations and the toxicity of pollutants.

As is noted in the City of San Jose's Riparian Corridor Policy Study (1994)[41]:

> … land uses, coupled with the accompanying need for flood protection have, over time, altered the natural features of the City's landscape, including the amount and condition of its riparian resources. Creeks and rivers that historically supported relatively wide corridors of natural vegetation over their flood plains now support narrow bands of vegetation within their banks or have been modified for flood protection and water supply purposes.

Similar conditions exist throughout the urbanized areas within the Santa Clara Basin.

#### 4.x.5.4. Pollutants

Santa Clara Basin streams receive no "point source" discharges from industries or municipal sewage. Industrial discharges are routed to municipal sanitary sewers and then to one of three regional municipal sewage treatment plants. These plants discharge to tidal sloughs or to the Bay. "Non-point" sources, including urban runoff, contribute pollutants to Santa Clara Basin streams. Many toxicants are associated with the particulate matter in urban runoff; this particulate matter is deposited in stream sediments.[42,43,44]

From 1989 to 1996, Bay Area stormwater agencies regularly sampled urban runoff flows during storm events. The samples were analyzed to determine the concentrations of potentially toxic chemical constituents. A 1996 summary of this monitoring, prepared for the Bay Area Stormwater Management Agencies Association (BASMAA), concluded that concentrations of metals in runoff from urban areas are generally lower than USEPA's dissolved water quality criteria for the protection of freshwater aquatic life.

Concentrations of total cadmium, copper, lead, nickel and zinc were sometimes higher than Regional Water Quality Control Board (RWQCB) freshwater objectives. The stormwater agencies conducted additional studies to determine whether the presence of these metals caused the runoff to be toxic to stream organisms. Toxicity, when found, was generally attributable to nonpolar organics, rather than particulates or dissolved metal ions. However, sampling and laboratory bioassays conducted in 1988-92 indicated that dissolved metals caused runoff from the Walsh Avenue catchment, an industrial area in the City of Santa Clara, to be acutely toxic to the water flea *(Ceriodaphnia dubia)* under laboratory conditions. Runoff from the catchment had elevated concentrations of zinc, copper and lead.

The results of chemical monitoring of runoff suggest that metals in urban runoff can potentially cause toxicity to stream organisms. However, actual toxic effects are probably rare because of instream dilution, sorption and speciation.[45] In addition, there is evidence that organophosphate pesticides (e.g., Diazinon) occur at concentrations toxic to *Ceriodaphnia dubia*. However, laboratory toxicity results have not been correlated to instream impacts.[46]

Although urban land uses as a whole result in increased pollutant concentrations in runoff, the distinction among residential, commercial and industrial land uses is relatively insignificant. In general, average pollutant concentrations in runoff do not vary significantly from one place to another within an urbanized watershed.[47,48] Pollutant concentrations do increase when impervious cover is greater than 40% to 50% of the drainage area.[49] However, runoff volume is the single most important variable for predicting pollutant loads.[50] A recent study in the Santa Clara Basin found that localized sources (e.g., fugitive emissions from electroplating operations) may elevate concentrations of copper and nickel in runoff from specific industrial sites. But the study confirmed that, as a whole, different types of urban land uses do not produce significantly different concentrations of copper and nickel in runoff.[51]

This suggests that control of imperviousness and total quantity of runoff may be the most meaningful strategy for reducing urban runoff pollutant loads to San Francisco Bay.

Efforts to reduce pollutant concentrations in San Francisco Bay have focused on the total load of pollutants coming from the watershed and their long-term effects on biota. By contrast, the most significant pollutant effects on aquatic life in streams may be acute response to transitory phenomena. Anecdotal evidence links first-of-season rainstorms with low dissolved oxygen and fish kills in the Santa Clara Basin's urban creeks.[52] Throughout the year, illegal dumping incidents can cause severe, localized effects in creeks.

### 4.x.5.5. Summary: Effects of Urbanization

In summary, the beneficial uses of creeks, including those in the Santa Clara Basin, are sustained by:

- A characteristic surface-water hydrology, including a bankfull discharge caused by the 1.5 to 2-year flood, with less-frequent floods causing periodic overbanking and extension on to the floodplain.

- The sinuousity of the creeks, and movement within their floodplain, which creates and sustains a characteristic stream channel structure and variety of habitat types.

- Groundwater inflows to some creek reaches, which determine the extent and annual duration of flow within the channels.

- Characteristic extent and types of streamside vegetation.

Alterations to creek hydrology, the disconnection of creeks from floodplains, and the loss of riparian vegetation have affected the ability of Santa Clara Basin streams to support healthy aquatic ecosystems. The evidence is mixed on whether pollutants from urban runoff have chronic effects on aquatic life. The long-term fate and effects of urban runoff pollutants in creeks depend on the transport of water and sediment between creek and floodplain and movement of water and sediment down the stream corridor. Pulses of organic litter and illegally dumped materials can have localized, acute effects.

In the Santa Clara Basin, the spatial pattern of urbanization– a continuous swath of urbanized area across the valley floor – is key to the overall effects of land use on the watershed. That is, the degradation of Santa Clara Basin water bodies is not so much due to the intensity of land use as it is that land uses are arranged without regard to the natural structure and functions of stream corridors.

## 4.x.6. Opportunities to Change Land Use and Development Patterns

### 4.x.6.1. "Smart Growth"

"Smart Growth" has been prescribed as the solution to sprawl. The Urban Land Institute defines smart growth this way:

> "Growth is inevitable, growth is necessary, but how growth is accommodated can be good or bad. In setting the framework for land development and redevelopment, we must focus on practices that are environmentally sound, economically vital, and that encourage livable communities—in other words, smart growth." [53]

The concept of smart growth is considered new and distinctive (i.e., distinguished from earlier concepts such as "Green Development"[54]) in that it seeks to identify a common ground where developers, environmentalists, public officials, citizens, and financiers all can find ways to accommodate growth that is acceptable to each entity. Many public officials, citizens, and environmental groups have figured out that the way to get good projects built in the places that make fiscal and environmental sense is to do everything possible to make them economically successful. Projects that are the most sensitive to the environment and to community values should be given the best opportunity to succeed and should not be subject to costly delays and conditions.

On April 26, 1999, the California Senate adopted Senate Resolution 12 (Solis) relative to the use of "Smart Growth" approaches to land use and development.

The resolution indicates that more than 300 California organizations have called upon California officials to follow "Smart Growth" principles in addressing California's future growth and development, including all of the following:

1. Planning for the future, by making government more responsive, effective, and accountable through reforming the system of land use planning and public finance.

2. Promoting prosperous and livable communities, by making existing communities vital and healthy places for all residents to live, work, obtain an education, and raise a family.

3. Providing better housing and transportation opportunities, by developing efficient transportation alternatives and a range of housing choices affordable to all residents without jeopardizing farmland, open space, and wildlife habitat.

4. Conserving green space and the natural environment, by focusing new development in areas planned for growth while protecting air and water quality and providing green space for recreation, water recharge, and wildlife.

5. Protecting California's agricultural and forest lands, by shielding California's farm, range, and forest lands from sprawl and the pressure to convert farmland to development.

This resolution encourages the development of "Smart Growth" approaches to land use and development as an effective way to ensure California's economic prosperity, social equity, and environmental quality.[55]

In the San Francisco Bay Region, the Bay Area Alliance for Sustainable Development — which includes economic development interests, environmental groups, advocates for social equity, and elected officials — envisions

> …a Bay Area where the natural environment is vibrant, healthy and safe, where the economy is robust and globally competitive, and where all citizens have equitable opportunities to share in the benefits of a quality environment and a prosperous economy.…
>
> The Bay Area Alliance will work with others to identify and protect high-priority lands. We will seek resources to develop a region-wide plan and map showing which lands should be considered for preservation and which should be considered for development, consistent with sustainability criteria. These criteria should include compact, efficient development patterns that use land efficiently, match jobs with housing, link homes, jobs and services, and reduce dependence on motor vehicles. We will work to obtain funds for land protection and management, through acquisition and other means, to protect watersheds and preserve open space, agriculture, and natural resources. We will work with local and regional park and open space agencies, environmental organizations, and local governments to identify priority areas."[56]

"Smart Growth" incorporates the protection of open space and natural resources, more efficient use of land, and acceptance of more dense development (through an agenda of urban livability and equity). Design of dense, livable multi-use urban spaces ("new urbanism") is a key component of "Smart Growth," as is recognition that the most efficient way to get these projects built in the places that make fiscal and environmental sense is to do everything possible to make them economically successful.

"Smart Growth" is consistent with many of the growth-management policies already adopted in Palo Alto, San Jose and other Santa Clara Basin municipalities. These policies are described in Chapter 6.4. Two current projects within the Santa Clara Basin exemplify the "new urbanism" approach to design and the "Smart Growth" approach to land-use policy:

The City of San Jose is currently implementing the "Jackson-Taylor Revitalization Strategy" in a previously industrial area. The project's designer, Peter Calthorpe, describes this vision:

> This project represents an ubiquitous urban opportunity — to transform old rail-oriented industrial zones into mixed-use neighborhoods with excellent transit service…. Decaying industrial sites would redevelop adding density and diversity to a semi-suburban section of town. Much of San Jose is marked by an odd combination of an urban street system and a low-rise, low-density building fabric.… San Jose has done much to urbanize its downtown through intelligent planning, redevelopment, and a new light rail system. This project would extend this largely successful effort by beginning to create a series of urban nodes radiating from the central city.

> The plan provides for a gradual transition of a 75-acre area directly north of downtown from low-intensity industrial and residential uses to a mix of retail, office, and medium and high-density housing. [57]

The Crossings Transit-Oriented neighborhood project, in Mountain View, is transforming a 1960s auto-oriented strip mall into a vibrant pedestrian-oriented community. Located adjacent to a new CalTrain commuter station, The Crossings provides a range of housing and retail opportunities, with single-family homes, townhouses, rowhouses, and apartments all located within a short walk of shopping and transit. An interconnected network of tree-lined streets and pedestrian paths knit this new mixed-use neighborhood together. Streets connect to an existing grocery store, allowing residents to walk directly to the store without crossing arterial streets. Community parks and open spaces are distributed throughout the 18-acre site.[58] Construction on the first phase of the project is nearly complete; 97 single-family homes and 30 townhouses have been completed or are under construction. For Phase II, TPG Development has proposed 240 more units consisting of 5 single-family homes, 132 apartments and 103 row houses. The City of Mountain View is currently reviewing the Phase II proposal.[59]

### 4.x.6.2. Changing Land Use Patterns to Preserve and Enhance the Watershed

The Federal Interagency Stream Restoration Working Group (1998) (after Schueler 1996)[60] recommends the following "key tools" for restoring urban streams:

1. Partially restore the predevelopment hydrological regime (e.g., by constructing upstream storm water detention ponds).
2. Reduce urban pollutant pulses.
3. Stabilize channel morphology (e.g., bank stabilization using bio-engineering methods).
4. Restore instream habitat structure that has been "blown out" by erosive floods (e.g., with log checkdams, wing deflectors, or boulder clusters along the stream channel).
5. Re-establish riparian cover.
6. Protect critical stream substrates and reduce clogging by fine sediment deposits (often, the energy of storm water inflows can be used to create "cleaner" substrates).
7. Allow for recolonization of the stream community (e.g., by removing downstream fish barriers).

As the Working Group notes, "The best results are usually obtained when the following tools are applied together." [61]

Some of these tools (#4, #7) require no changes in land use pattern. Some reduction of urban pollutants (#2) is being implemented by municipal urban runoff pollution prevention programs (e.g., elimination of illicit discharges, inspection of industries, cleaning of storm drains). However, most of the "tools" —most significantly, restoration of the hydrologic regime — would require restoring the landscape pattern that links creeks to floodplains in more-or-less continuous streamside corridors. Storm water detention ponds, where appropriate and effective, would need to be located within or adjacent to these corridors.

Therefore, preserving and enhancing the watershed will require changes to the spatial structure of land use in the Basin, from one continuous swath of urbanized land to a more fine-grained mosaic characterized by more intensely urbanized areas that are interstitial to broad, continuous stream corridors. Floodplains should be reconnected to streams, where feasible, and development within the floodplain should be designed to accommodate flooding.

Changes to land-use patterns may take many decades to significantly improve watershed function. However, advocates of watershed preservation and enhancement should be encouraged by current efforts, already underway, to radically alter the urban fabric to enhance economic sustainability and improve the quality of life. In most cases, the land-use pattern changes required to meet these objectives dovetail, rather than conflict, with the changes needed to enhance the watershed. There should be opportunities to apply the methods of landscape ecology to integrate "Smart Growth"- inspired development and redevelopment initiatives with restoration of crucial links between creeks and floodplains.

Richard Register (1987) uses a series of seven maps to illustrate his vision of a Bay area city transformed, over 40 to 125 years, from a continuous urban swath to patches of intensely developed centers surrounded by agricultural and natural areas. Register's vision is that, even with a 50% increase in population, urbanized area would decrease 35%.[62]

However, implementation of changes in the Santa Clara Basin's land-use patterns should not be tied to a utopian vision. Consistent with the "Smart Growth" idea, change must be implemented through consensus and practical extension of existing land use policies and initiatives.

#### 4.x.6.3. Linking Development/Redevelopment to Watershed Enhancement

The WMI's Land Use Subgroup (LUS) developed a generalized approach to implementing land use changes that favor watershed enhancement.[63] As illustrated in Figure 4.1, land use planners must find ways to translate the "grand objectives" (e.g., goals and mission statements adopted by the WMI, the Bay Area Alliance for Sustainable Development, the California legislature, and others) to specific municipal actions (i.e., public capital improvements and conditions of approval for private projects).

As is also illustrated in Figure 4.1, the LUS' approach is different than earlier efforts to mitigate the effects of new development on watersheds. In general, those early efforts focussed on implementing design features or devices at specific sites without due regard the characteristics of the surrounding watershed or the placement of the site within the watershed.

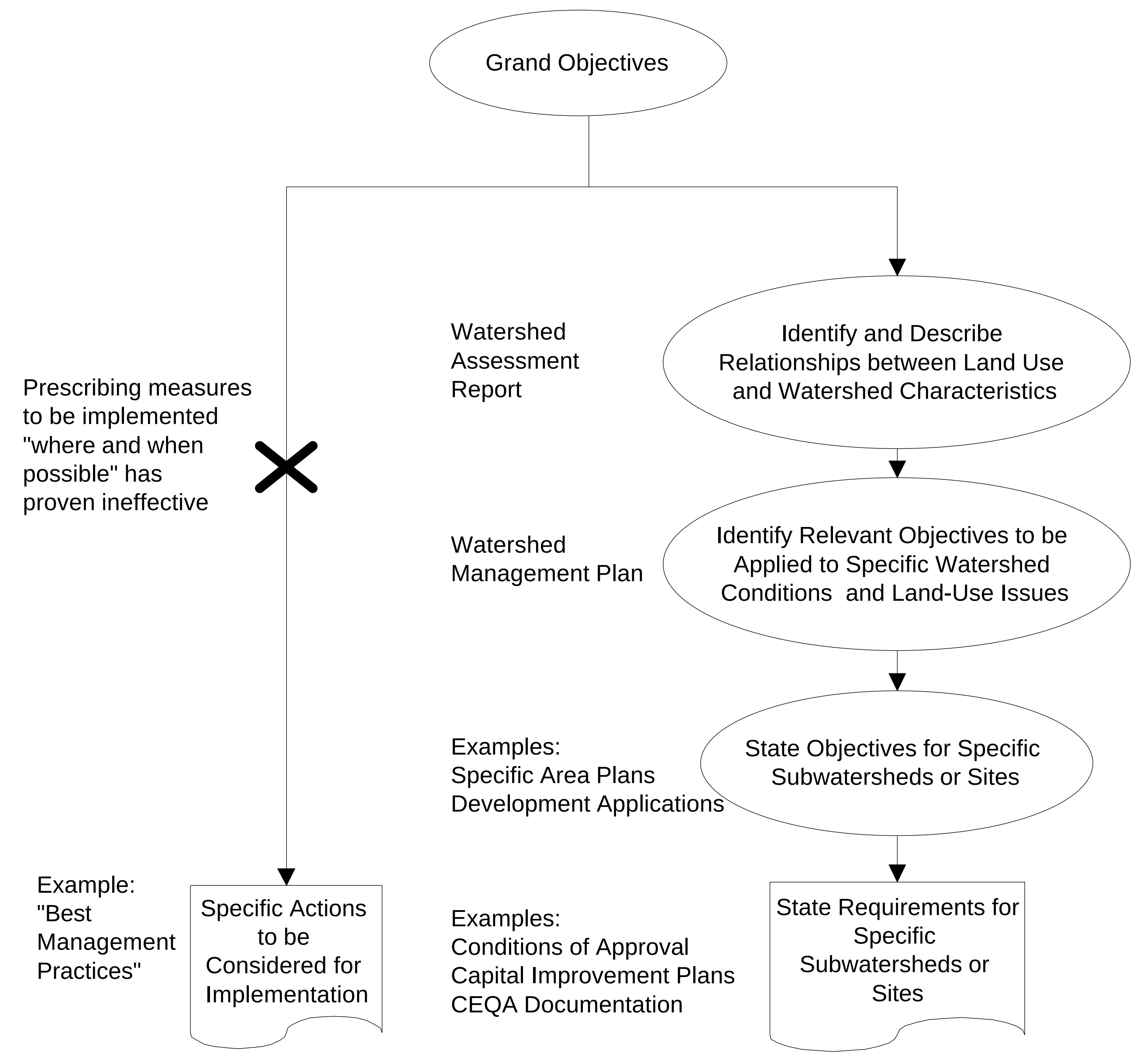
The key to changing the effects of land use on watersheds is to express watershed objectives spatially. A future land use pattern — one that protects and enhances the watershed — must be mapped.

The mapping would need to be at a geographic scale that is appropriate to the planning level. The Basin scale — i.e., the WMI's Watershed Management Plan — could map the general spatial objectives for land use change within the major stream and river corridors. Municipalities could consider these objectives for incorporation into their General Plans. The Basin-scale Watershed Management Plan could become the framework for local plans that map, in more detail, the spatial objectives appropriate to protect and enhance subwatersheds. These local plans could be incorporated into Specific Area Plans that would integrate the watershed objectives with social and economic considerations at the neighborhood level. Subwatershed-level Specific Area Plans could then be the basis for reviewing the watershed impacts of specific development projects — and for defining appropriate mitigations for those projects. This would enable municipal planners to address watershed impacts proactively.

The mapping should also incorporate a time-scale that is appropriate to the changes envisioned (probably measured in decades).

Figure 4.x - 1

Process for Integrating Watershed Management Into Land Use Decision-Making



## 4.x.7. Methods for Reducing Impacts from Developed Sites

### 4.x.7.1. Site Design Considerations

Control and treatment of runoff requires considerable land area to store water long enough to settle or to infiltrate into the soil. The Metropolitan Washington Council of Governments (1987)[64] provided a comprehensive manual for designing "structural" best management practices. The Council updated the manual in 1992.[65] Many of the same structural techniques were incorporated into the California Storm Water Quality Task Force's (1993) Best Management Practices Handbooks.[66] In 1994, staff from the San Francisco Bay Regional Water Quality Control Board provided guidance for implementing these techniques.[67]

Because runoff cannot be effectively controlled or treated in a small space, emphasis has shifted to site design elements that limit imperviousness and that disperse and infiltrate runoff, rather than collecting and treating it.

Imperviousness has been proposed as an indicator for the extent of urbanization.[68] Proposed methods for controlling imperviousness tend to mix urban planning and design objectives (e.g., control of sprawl and a more pedestrian-oriented urban environment) with site planning and design methods. The City of Olympia's Impervious Surface Reduction Study (1995) listed 19 recommendations, including policies to limit sprawl, cluster development and provide public transit. Methods for reducing imperviousness of developed sites include narrower streets and alleys and the use of pervious paving.[69]

*Start at the Source*, a design guidance manual prepared by the Bay Area Stormwater Management Agencies Association, promotes "new urbanist" or "neo-traditional" neighborhood design as a means of reducing imperviousness.[70] This includes detailed designs for narrower streets and driveways and methods for reducing parking demand. The manual advocates "using drainage as a design element" by integrating open drainage into landscapes, rather than piping runoff off-site. However, most of the manual is devoted to site designs and landscape details, with "case studies" showing how these can be applied to typical sites where residential and commercial development is planned. Some design details for street and parking lots are provided, as are details for the use of porous paving materials and for some infiltration devices, such as swales and detention basins.

The *Low Impact Development Design Manual*, prepared by Prince George's County, Maryland (1997)[71], emphasizes the use of hydrologic analysis, and setting of hydrologic objectives, as a precursor to site planning. The *Consensus Agreement On Model Development Principles To Protect Our Streams, Lakes and Wetlands* codifies many of these principles and represents consensus reached by a group of planners, architects, engineers and environmental advocates convened by the Center for Watershed Protection.[72] Steps to implementing the principles are described in a handbook.[73] Wendy Edde, in a study for the San Mateo Stormwater Pollution Prevention Program,[74] describes methods and incentives used in Santa Monica, CA, San Rafael, CA, Olympia, WA, Menlo Park, CA, and Charlotte, NC, to reduce impervious surfaces for new developed and redeveloped sites.

Effective urban watershed management will require that site design standards mature beyond "do what you can, where you can" toward explicit consideration of site location and drainage to streams. Imperviousness may be of little account in one watershed location (e.g., in a low-lying district where drainage is pumped over a levee to a tidal slough), but critically important in another (e.g., in a medium-density area with moderate slopes and an intact riparian corridor).

Chapter 6.7.4 compares and contrasts some of the Santa Clara Basin municipalities' existing watershed protection policies. For the Santa Clara Valley Urban Runoff Pollution Prevention Program, Pacific Municipal Consultants (1998)[75] prepared a catalog of Santa Clara Basin muncipalities' General Plan and Development-related policies, including riparian protection, open space preservation, imperviousness, and policies regarding automobile dependence and transporation use.

### 4.x.7.2. Reducing Impacts from Existing Land Uses

As described in its Urban Runoff Management Plan (1997)[76], the Santa Clara Valley Urban Runoff Pollution Prevention Program assists municipalities within the portion of Santa Clara County that drains to South San Francisco Bay, and the Santa Clara Valley Water District, to implement measures to prevent urban runoff pollutants from entering the storm drain system.

Each municipality implements a comprehensive program to eliminate illegal discharges to storm drains and to control pollutants in runoff from urban activities. The municipalities' efforts include response to spills and illegal dumping incidents, cleaning and maintenance of storm drains, inspections of commercial and industrial facilities, inspections of construction sites, and public education and outreach. The municipalities also take steps to eliminate sources of pollutants related to their own capital improvements and to ongoing maintenance of streets and public areas.

The Santa Clara Valley Urban Runoff Pollution Prevention Program's and municipalities' extensive participation in the Land Use Subgroup is part of a joint effort to develop planning policies and development approval procedures that will protect and enhance the beneficial uses of streams, wetlands and South San Francisco Bay most effectively. The Program and municipalities also participate in other aspects of the Watershed Management Initiative.

### 4.x.8. Summary

The national angst over sprawl is often expressed as loss of community and sense of place and immersion in an ugly, environmentally degraded landscape. Sprawl is not a consequence of market preferences; rather, its origins lie in utopian attempts to segregate land uses and develop ideal forms for the city based on romanticized views of nature and society. Despite the warnings of iconoclasts like Jane Jacobs, post-WWII land use and economic policies encouraged and subsidized suburban development. Economic polarization became reflected in urban geography, resulting in disempowered, high-poverty central cities and expansion of low-density, high-cost, environmentally unsound development into ecologically sensitive areas. According to Orfield's analysis, this tendency threatens to accelerate unless actions are taken to reverse the trend.

Land uses in the Santa Clara Basin are characterized by a continuous swath of urban development. The primary watershed effects of this development are an increase in imperviousness, destabilized stream geomorphology, disconnection of streams from floodplains, and loss of riparian corridors. Pollutants and toxicity are a secondary concern. In general, pollutant loading is not a function of specific urban land use, but is related to imperviousness and total volume of runoff.

The California Senate and the Bay Area Alliance for Sustainable Development have adopted a policy of "Smart Growth," which endorses compact, efficient development patterns and protection of watersheds and natural areas. Projects typifying "Smart Growth" and "New Urbanism" designs are being built in the Santa Clara Basin.

Enhancement of streams within the urbanized portion of the Basin will require partial restoration of the predevelopment hydrologic regime, including reconnection of streams with floodplains (where feasible) and restoration of riparian cover. This would require changes to the spatial structure of land use in the Basin, from one continuous swath of urbanized land to a more fine-grained mosaic characterized by more intensely urbanized areas that are interstitial to broad, continuous stream corridors.

The Watershed Management Plan should incorporate maps showing spatial objectives for land use changes. In this way, continuing development and redevelopment, as it occurs in the "Smart Growth" context, can contribute toward new spatial patterns that help protect and enhance the watershed.

Implementation of spatial objectives for land use change can best be accomplished through consensus and practical extension of existing land use policies and initiatives. Within newly developed and redeveloped areas, "low-impact" site design techniques, where appropriate, can best be implemented in the context of hydrologic objectives determined for the specific location within a subwatershed. Similarly, the municipalities' comprehensive urban runoff pollution prevention programs will be most effective when they are targeted to subwatershed-scale objectives.

## 4.x.9. References

[1] Riley, Ann L. (1998) *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens.* Island Press, Washington, D.C. (p. 200)

[2] Clean Water Act Section 402(p) and EPA Stormwater Regulations

[3] Riley, Ann L. (1998) *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens.* Island Press, Washington, D.C.

[4] ibid.

[5] Dramstad, Wenche E., James D. Olson, and Richard T.T. Forman (1996). *Landscape Ecology Principles in Landscape Architecture and Land Use Planning.* Island Press, Washington D.C.

[6] A pictorial and video representation of urbanization sprawling across the Bay area can be viewed at http://geo.arc.nasa.gov/sge/william/urban.html

[7] President's Council on Sustainable Development (1997). Sustainable Communities Task Force Report. http://www.whitehouse.gov/PCSD/Publications/suscomm/ind_suscom.html

[8] American Rivers Press Release, April 12, 1999. http://www.amrivers.org/99national.html

[9] Sierra Club (1999). *The Dark Side Of The American Dream: The Costs and Consequences of Suburban Sprawl.* San Francisco. http://www.sierraclub.org/transportation/sprawl/sprawl_report/

**[10]** Wendell Cox (1999*). The President's New Sprawl Initiative: A Program In Search Of A Problem.* Heritage Foundation, Washington, D.C. http://www.heritage.org/library/backgrounder/bg1263es.html

[11] Calthorpe, Peter(1993). *The Next American Metropolis.* 168 pp. Princeton Architectural Press, New York.

[12] Mumford, Lewis (1963): The Story of Utopias. Peter Smith Publishers, ISBN: 0844613193

[13] Jacobs, Jane. *The Death and Life of Great American Cities.* 448 pp. Vintage Books, New York (1961).

[14] Mumford, Lewis. "The Future of the City—Part II: Yesterday's City of Tomorrow," *Architectural Record* 132, no. 5 (Nov. 1962) 139:44, excerpted in Donald Miller, ed., *The Lewis Mumford Reader* (Pantheon Books, 1986).

[15] Jacobs, Jane. *The Death and Life of Great American Cities.* 448 pp. Vintage Books, New York (1961).

[16] Nash, Roderick (1982). *Wilderness and the American Mind*. Yale University Press, New Haven.

[17] Mumford, Lewis (). *Yesterday's City of Tomorrow.* In: Donald Miller, ed., *The Lewis Mumford Reader* (Pantheon Books, 1986).

[18] Calthorpe, Peter(1993). *The Next American Metropolis.* 168 pp. Princeton Architectural Press, New York

[19] Axelrad, Tina (1998) "Measuring & Coping With The Costs Of Sprawl: A Summary Of The National Literature On Costs Of Sprawl." Prepared by Clarion Associates for 10,000 Friends of Pennsylvania. http://ls.wustl.edu/~mandelke/Land_Use/axelrad.html

[20] Urban Ecology (1996). *Blueprint for a Sustainable Bay Area.*Berkeley, CA.

[21] Bay Area Transportation and Land Use Coalition (1999). *Warning Signs: The Bay Area's Collision Course with Sprawl and How Smart Growth Can Help.* www.priven.sf.ca.us/coalition

[22] Orfield, Myron (1998). *San Francisco Bay Area Metropolitics: A Regional Agenda for Community and Stability*. Urban Habitat Program (a project of the Tides Foundation), San Francisco.

[23] U.S. Department of Agriculture, Food Stamp Program Net Monthly Income Eligibility Standards (100 Percent of Poverty Level) FY 1998, http://fns1.usda.gov:80/fsp/menu/admin/certification/support/incomstd.htm

[24] Schwarz, John, "The Hidden Side of the Clinton Economy, *Atlantic Monthly*, October 1998. http://www.theatlantic.com/issues/98oct/clintec.htm

[25] Federal Interagency Stream Restoration Working Group (1998). *Stream Corridor Restoration: Principles, Processes, and Practices.* U.S. Department of Agriculture. http://www.usda.gov/stream_restoration/newgra.html

[26] Wesche, T.A. (1985). Stream Channel Modifications and Reclamation Structures to Enhance Fish Habitat. Chapter 5 in J.A. Gore, ed., *The Restoration of Rivers and Streams.* Butterworth, Boston (cited in Federal Interagency Stream Restoration Working Group).

[27] Karr, James R., and Ellen W. Chu (1997). *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively.* University of Washington, Seattle. EPA 235-R97-001.

[28] Patterson, A.J. (1996). The effect of recreation on biotic integrity of small streams in Grand Teton National Park. MS thesis, University of Washington, Seattle.

[29] Pitt, Robert and Martin Bozeman (1982). *Sources of Urban Pollution and its Effects on an Urban Creek.* EPA-600/S2-82-090.

[30] May, Christopher W., R. Horner, J.R. Karr, B. Mar, E.B. Welch (1997). Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion. *Watershed Protection Techniques* 2:4, p. 483-493

[31] Scheuler, Tom (1994). *The Importance of Imperviousness.* Watershed Protection Techniques 1:3

[32] Bay Area Stormwater Management Agencies Association (1999). *Start at the Source: Guidance Manual for Stormwater Quality Protection.* Tom Richman and Associates, Consultants.

[33] Hollis, G.E. (1975). The Effect of Urbanization on Floods of Different Recurrence Interval. *Water Resources Research* 66: 84-88.

[34] Mineart, Phillip and Trang Ha (1999). Stormwater Environmental Indicators Pilot Demonstration Project Technical Memorandum: Indicator Profile #10, Increased Flooding Frequency. URS/Greiner/Woodward Clyde for the Santa Clara Valley Urban Runoff Pollution Prevention Program.

[35] Graf, W.L. (1977). Network Characteristics of Suburbanizing Streams. *Water Resources Research* 13:2 459-463

[36] Leopold, Luna B., M. Gordon Wolman, John P. Miller. *Fluvial Processes in Geomorphology.* Dover Publications, New York. P. 82.

[37] Riley, Ann L. (1998) *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens.* Island Press, Washington, D.C. (p. 128)

[38] Rosgen, Dave (1996). *Applied River Morphology.* Wildland Hydrology, Pagosa Springs, CO.

[39] Federal Interagency Stream Restoration Working Group (1998). *Stream Corridor Restoration: Principles, Processes, and Practices.* U.S. Department of Agriculture. http://www.usda.gov/stream_restoration/newgra.html

[40] Riley, Ann L. (1998) *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens.* Island Press, Washington, D.C.

[41] City of San Jose (1994). *Riparian Corridor Policy Study.* The Habitat Restoration Group and Jones and Stokes, Consultants.

[42] Pitt, R., R. Field, M. Lalor and M. Brown (1995). *Urban Stormwater Toxic Pollutants: Assessment, Sources and Treatability.* Water Environment Research 67:3.

[43] Schueler, T.R. (1987). *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, D.C.

[44] Pitt, Robert and Martin Bozeman (1982). *Sources of Urban Pollution and its Effects on an Urban Creek.* EPA-600/S2-82-090.

[45] Bay Area Stormwater Management Agencies Association (1996). *Compilation of BASMAA Monitoring Studies.* Prepared by Woodward-Clyde Consultants.

[46] Katznelson, Revital and Thomas Mumley (1997). *Diazinon in Surface Waters in the San Francisco Bay Area: Occurrence and Potential Impact.* Prepared for the California State Water Resources Control Board, the Alameda County Flood Control and Water Conservation District, and the Alameda Countywide Clean Water Program.

[47] Schueler, T.R. (1987). *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, D.C.

[48] Chandler, Robert (1994). Estimating Annual Urban Nonpoint Pollutant Loads. *Journal of Management in Engineering* Nov./Dec. 50-59.

[49] Konnan, Jon (1999). *Literature Search on the Relationship Between Watershed Impervious Cover and Creek Water Quality.* EOA, Inc. for the San Mateo Countywide Stormwater Pollution Prevention Program.

[50] Charbeneau, Randall and Michael E. Barrett (1998). Evaluation of Methods for Estimating Stormwater Pollutant Loads. *Water Environment Research* 70:7 1295-1302.

[51] Soller, Jeff and Robert Gallo (1998). *City of Sunnyvale Industrial Stormwater Monitoring Pilot Project.* Santa Clara Valley Urban Runoff Pollution Prevention Program.

[52] Marty Stevenson, Kinnetic Laboratories, Santa Cruz, CA. Personal communication regarding data collected for the Santa Clara Valley Urban Runoff Pollution Prevention Program's Stormwater Environmental Indicators Demonstration Project.

[53] Pawlukiewicz, Michael. "What is Smart Growth?" Urban Land Institute, Washington D.C. http://www.uli.org/smartgrowth.htm

[54] U.S. Environmental Protection Agency, Office of Water (1996). *Green Development: Literature Summary and Benefits Associated Alternative Development Approaches.* EPA 841-B-97-001. Tetra Tech, Consultant.

[55] Legislative Analyst's Summary for SR 12. www.sen.ca.gov

[56] Bay Area Alliance for Sustainable Development (1999). *Draft Compact for a Sustainable Bay Area*. http://www.abag.ca.gov/planning/baasd/

[57] Calthorpe, Peter (1993): *The Next American Metropolis.*

[58] Calthorpe Associates. The Crossings Transit-Oriented Neighborhood Project. www.calthorpe.com/Project%20Sheets/crossings.htm

[59] City of Mountain View (1999). Economic Development Highlights. VI: Residential Development Activity. www.ci.mtnview.ca.us/mvecon/mvecon9601/residential.html

[60] Schueler, Thomas (1996). Controlling cumulative impacts with sub-watershed plans. In *Assessing the cumulative impacts of watershed development on aquatic ecosystems and water quality,* proceedings of a 1996 symposium.

[61] Federal Interagency Stream Restoration Working Group (1998). *Stream Corridor Restoration: Principles, Processes, and Practices.* U.S. Department of Agriculture. http://www.usda.gov/stream_restoration/newgra.html

[62] Register, Richard (1987). *Ecocity Berkeley: Building Cities for a Healthy Future.* North Atlantic Books, Berkeley, CA

[63] Santa Clara Basin Watershed Management Initiative, Land Use Subgroup. Summary of the April 14, 1999 meeting.

[64] Schueler, T.R. (1987). *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, D.C.

[65] Schueler, Thomas R., Peter A. Kumble, and Maureen A. Heraty (1992). *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone.* Metropolitan Washington Council of Governments, Washington, D.C.

[66] California Storm Water Quality Task Force (1993). *California Storm Water Best Management Practice Handbooks.* Prepared by Camp Dresser & McKee, Larry Walker Assocaites, Uribe Assocaites, Resources Planning Associates.

[67] California Regional Water Quality Control Board, San Francisco Bay Region (1994). *Staff Recommendations for New and Redevelopment Controls for Storm Water Programs.*

[68] Schueler, Tom (1994). *The Importance of Imperviousness.* Watershed Protection Techniques 1:3

[69] City of Olympia Public Works Department, Water Resources Program (1995). *Impervious Surface Reduction Study, Final Report.*Funded by the Washington Department of Ecology.

[70] Bay Area Stormwater Management Agencies Association (1999). *Start at the Source: Guidance Manual for Stormwater Quality Protection.* Tom Richman and Associates, Consultants.

[71] Prince George's County Department of Environmental Resources (1997). *Low-Impact Development Design Manual.*

[72] Center for Watershed Protection (1998). Consensus Agreement On Model Development Principles To Protect Our Streams, Lakes and Wetlands. http://www.pipeline.com/~mrrunoff/

[73] Center for Watershed Protection (1998). *Better Site Design: A Handbook for Changing Development Rules in Your Community.* Ellicott City, Maryland.

[74] San Mateo Stormwater Pollution Prevention Program (1999). *Technical Memorandum: Methods and Incentives to Reduce Impervious Surface Areas at New and Redevelopment Sites.* Wendy Edde for EOA, Inc., Consultant.

[75] Pacific Municipal Consultants (1998). Catalog of General Plan and Development Related Policies (Phase 2). Prepared for the Santa Clara Valley Urban Runoff Pollution Prevention Program.

[76] Santa Clara Valley Urban Runoff Pollution Prevention Program (1997). *Urban Runoff Management Plan.* EOA, Inc., Consultants.