Chapter 3
Conditions within the Local Source Water System

Natural water quality varies from place to place, with the seasons, with climate, and with the types of soils and rocks through which water moves. When water from rain or snow moves over the land and through the ground, the water may dissolve minerals in rocks and soil, percolate through organic material such as roots and leaves, and react with algae, bacteria, and other microscopic organisms. Water may also carry plant debris and sand, silt, and clay to rivers and streams making the water appear "muddy" or turbid. When water evaporates from lakes and streams, dissolved minerals are more concentrated in the water that remains. Each of these natural processes changes the water quality and potentially the water use.

The most common dissolved substances in water are minerals or salts that, as a group, are referred to as dissolved solids. Dissolved solids include common constituents such as calcium, sodium, bicarbonate, and chloride; plant nutrients such as nitrogen and phosphorus; and trace elements such as selenium, chromium, and arsenic.

In general, the common constituents are not considered harmful to human health, although some constituents can affect the taste, smell, or clarity of water. Plant nutrients and trace elements in water can be harmful to human health and aquatic life if they exceed standards or guidelines.

Dissolved gases such as oxygen and radon are common in natural waters. Adequate oxygen levels in water are a necessity for fish and other aquatic life. Radon gas can be a threat to human health when it exceeds drinking-water standards.

3.1 Erosion

Erosion is the process of weathering and transporting of solids (sediment, soil, rock and other particles) in the natural environment from their source to deposits elsewhere. A certain amount of erosion is natural and healthy for the ecosystem. Locally, erosion occurs due to transport by down-slope creep under the force of gravity, wind, and primarily water. In general, background erosion removes soil at roughly the same rate as soil is formed.

Given similar vegetation and ecosystems (**Table 3.1**), areas with high-intensity precipitation, more frequent rainfall, more wind, or more storms are expected to have more erosion. Porosity and permeability of the sediment or rock affects the speed with which the water can percolate into the ground. If the water moves underground, less runoff is generated, reducing the amount of surface erosion.

Table 3.1 - Hydrographic Areas within Local Source Water System Boundaries
SanGIS update 2009

Watershed Name	Hydrographic Area	Hydrographic Sub-Area	Acres
San Diego River System			
San Diego	Boulder Creek	Cuyamaca	7,660
San Diego	Boulder Creek	Inaja	52,195
San Diego	Boulder Creek	Spencer	4,758
San Diego	El Capitan	Alpine	3,905
San Diego	El Capitan	Conejos Creek	51,818
San Diego	Murray	Murray	2,298
San Diego	San Vicente	Barona	10,201
San Diego	San Vicente	Fernbrook	14,077
San Diego	San Vicente	Gower	14,853
San Diego	San Vicente	Kimball	8,491
San Dieguito	Santa Ysabel	Sutherland	18,511
San Dieguito	Santa Ysabel	Witch Creek	16,041
Total			204,809
Otay-Cottonwood System			
Otay	Dulzura	Engineer Springs	1,233
Otay	Dulzura	Hollenbeck	31,727
Otay	Dulzura	Jamul	7,794
Otay	Dulzura	Lee	2,075
Otay	Dulzura	Lyon	2,076
Otay	Dulzura	Proctor	8,128
Otay	Dulzura	Savage	10,219
Tijuana	Barrett Lake	Barrett Lake	59,131
Tijuana	Cameron	Cameron	30,067
Tijuana	Cottonwood	Cottonwood	28,560
Tijuana	Monument	Mount Laguna	5,322
Tijuana	Monument	Pine	18,804
Tijuana	Morena	Morena	14,916
Tijuana	Potrero	Barrett	7,092
Total			227,144
Miramar System			
Penasquitos	Miramar Reservoir	Miramar Reservoir	640
Penasquitos	Poway	Poway	5
Total			645

Hodges System			
San Dieguito	Hodges	Bear	1,716
San Dieguito	Hodges	Del Dios	21,107
San Dieguito	Hodges	Felicita	1,820
San Dieguito	Hodges	Green	5,627
San Dieguito	San Pasqual	Guejito	12,659
San Dieguito	San Pasqual	Hidden	1,193
San Dieguito	San Pasqual	Highland	2,552
San Dieguito	San Pasqual	Las Lomas Muertas	23,954
San Dieguito	San Pasqual	Reed	1,907
San Dieguito	San Pasqual	Vineyard	1,796
San Dieguito	Santa Maria Valley	Ballena	2,494
San Dieguito	Santa Maria Valley	East Santa Teresa	882
San Dieguito	Santa Maria Valley	Lower Hatfield	2,835
San Dieguito	Santa Maria Valley	Ramona	25,850
San Dieguito	Santa Maria Valley	Upper Hatfield	1,019
San Dieguito	Santa Maria Valley	Wash Hollow	2,315
San Dieguito	Santa Maria Valley	West Santa Teresa	1,143
San Dieguito	Santa Ysabel	Boden	10,531
San Dieguito	Santa Ysabel	Pamo	36,878
Total			158,278

- **Erosion by Gravity**
  Mass wasting is the down-slope movement of rock and sediments, mainly due to the force of gravity. Mass movement is an important part of the erosion process, as it moves material from higher elevations to lower elevations where other eroding agents such as streams can then pick up and move the material. Mass-movement processes are always occurring continuously on all slopes. Some mass-movement processes act very slowly; while others occur very suddenly, often with disastrous results. Any perceptible down-slope movement of rock or sediment is often referred to in general terms as a landslide.

- **Erosion by Wind**
  The rate and magnitude of soil erosion by wind is controlled by the speed and duration of the wind, physical characteristics of the soil, soil moisture levels, and vegetative cover. Very fine particles can be suspended by the wind and then transported great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface. The continual drifting of an area gradually causes a textural change in the

soil. Loss of fine sand, silt, clay and organic particles from sandy soils serves to lower the moisture holding capacity of the soil. During periods of drought, soils with low soil moisture levels release the particles for transport by wind creating a positive feedback system.

- **Erosion by Water**

  Soil erosion by water is the result of rain detaching and transporting vulnerable soil, either directly by means of splash erosion or indirectly by runoff erosion. The rate and magnitude of soil erosion by water is controlled by rainfall intensity and runoff volume.

  The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Splash erosion is the direct detachment and airborne movement of soil particles by raindrop impact. Since soil particles are only moved a small distance, its effects are primarily on-site (at the place where the soil is detached). Although considerable quantities of soil may be moved by splash erosion, it is simply redistributed back over the surface of the soil; although on steep slopes, there will be a modest net down slope movement of detached soil.

  When precipitation rates exceed soil infiltration rates, runoff occurs. Runoff may occur for two reasons: the rain arrives too quickly for it to infiltrate, or the soil has already absorbed all the water it can hold. The impact of the raindrop breaks apart the soil aggregate. Particles of clay, silt and sand fill the soil pores and reduce infiltration. Once the rate of falling rain is faster than infiltration, runoff takes place. Surface runoff turbulence often causes more erosion than the initial raindrop impact. In most situations, erosion by concentrated flow is the main cause of erosion by water. It is in such channels that water erosion also operates most effectively to detach and remove soil by its kinetic energy lowering the soils surface. Lowered areas form preferential flow paths for subsequent flow creating a positive feedback system. Eventually, this positive feedback results in well-defined linear concentrations of overland flow. The effects are both on-site and off-site (where the eroded soil ends up). The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing.

  The rate of erosion depends on many factors. Climatic factors (**Chapter Two**) include the amount and intensity of precipitation, storm frequency, wind speed, average temperature, temperature range and seasonality. Geologic factors include the sediment or rock type, porosity and permeability, slope of the land, and position of the rocks (tilted, faulted, folded, or weathered). Biological factors include the type and extent of ground cover from vegetation, and the type and density of organisms inhabiting the area including humans.

3.2 Geology

The San Diego region is underlain by three principle geologic provinces. The majority of the County is in the Peninsular Ranges province bounded by the coastal province to the west and the Salton Trough province to the east. This geomorphic division reflects a basic geologic difference between the three regions, with Mesozoic metavolcanic, metasedimentary, and plutonic rocks predominating in the Peninsular Ranges, and primarily Cenozoic sedimentary rocks predominating to the west and east of the central mountain range. The irregular contact between these geologic regions reflects the ancient topography of this area before it was buried by the thick sequence of Cretaceous and Tertiary sedimentary rocks deposited over the last 75 million years by ancient rivers and in ancient seas.

As the Peninsular Ranges province experienced uplifting and tilting, a series of large faults, such as the Elsinore and San Jacinto, developed along the edge of the province. The City of San Diego lies in the coastal plain province which extends from the western edge of the Peninsular Ranges and runs roughly parallel to the coastline. The province is composed of dissected, mesa-like terraces that graduate inland into rolling hills. The terrain is underlain by sedimentary rocks composed mainly of sandstone, shale, and conglomerate beds, reflecting the erosion of the Peninsular Ranges to the east.

- **Basement Complex**
  The basement complex consists of two principal rock units: (1) the Upper Jurassic Santiago Peak Volcanics, a succession of deformed and metamorphosed volcanic, volcaniclastic, and sedimentary rocks; and (2) mid-Cretaceous plutonic rocks of the Southern California Batholith, which intrude the Santiago Peak Volcanics.

  The Santiago Peak Volcanics:
  The Santiago Peak Volcanics comprise an elongated belt of mildly metamorphosed volcanic, volcaniclastic, and sedimentary rocks. The volcanic rocks range in composition from basalt to rhyolite but are predominantly dacite and andesite. The succession is typified by a wide variety of breccia, agglomerate, volcanic conglomerate, and fine-grained tuff-

breccia. Highly silicified rock and a variety of dark, dense, fine-grained hornfels occur locally.
The Santiago Peak Volcanics are hard and extremely resistant to erosion and form topographic highs. Most of the volcanic rocks are dark greenish gray when fresh but weather grayish red to dark reddish brown. The soil developed on the Santiago Peak Volcanics is the color of the weathered rock and supports the growth of dense chaparral.

Southern California Batholith:
Plutonic rocks of the Southern California Batholith in the area are quartz diorite and gabbro. The quartz diorite is typically coarse grained, light gray and contains large phenocrysts of plagioclase and potassium feldspar. Hornblende and biotite are present in small amounts. The gabbro varies considerably in texture and composition but is mostly medium to coarse grained and medium to dark gray. The chief minerals are calcic feldspar and pyroxene, and the accessory minerals include trace amounts of quartz and biotite. Throughout most of the area, the granitic rocks are deeply weathered.

- **Rocks known to occur in San Diego County:**
  Acmite, Albite, Allanite, Amblygonite, Andalusite, Apatite, Arsenopyrite, Azurite, Basalt, Bavenite, Bertrandite, Beryl, Biotite, Bismite, Bismuth, Bismuthinite, Bornite, Calcite (optical), Cassiterite, Celestite, Cerussite, Chalcocite, Chalcopyrite, Chrysotile, Clintonite, Cookeite, Corundum, Epidote, Erythite, Ferrimolybdite, Ferrisicklerite, Ferroaxinite, Fersmite, Fluorapatite, Francolite, Gabbro, Gahnite, Galena, Garnet, Glauconite, Gneiss, Gold, Granite, Graphite, Gypsum, Helvite, Heterosite, Heulandite, Hydromagnesite, Laumontite, Lawsonite, Leadhillite, Lepidolite, Limonite, Lithiophylite, Magnetite, Malachite, Manganite, Marcasite, Microcline, Molybdenite, Morenosite, Morinite, Muscovite, Nickel, Orthoclase, Pentlandite, Petalite, Plagioclase feldspar, Pollucite, Purpurite, Pyrite, Pyrophyllite, Pyrrhotite, Quartz, Rhodonite, Rutile, Rynersonite, Samarskite, Scheelite, Schist, Sicklerite, Silver, Sphalerite, Spinel, Spodumene, Stellerite, Stokesite, Tellurium, Tenorite, Thorogummite, Todorokite, Topaz, Tourmaline, Tremolite, Tridymite, Triphylite, Uranmicrolite, Uranophane, Violarite, Wollastonite, Zircon

Geology within the Local Source Water System

- **San Diego River System**
  Dominant:
  Pre-Cenozoic granitic and metamorphic rock, Cretaceous granitic rock of the Southern California Batholith

  Lesser emplacements:
  Jurassic metavolcanic and metasedimentary rocks of the Santiago Peak Volcanics, Mesozoic basic intrusive rocks, Pre-Cretaceous metamorphic and metasedimentary rocks, Eocene marine sedimentary and metasedimentary rocks, Pleistocene marine and metasedimentary rocks and marine terrace deposits, Quaternary lake deposits, Alluvium

- **Otay-Cottonwood System**
  Dominant:
  Jurassic metavocanic and metasedimentary rocks of the Santiago Peak Volcanics, Cretaceous granitic rock of the Southern California Batholith

  Lesser emplacements:
  Pre-Cenozoic granitic and metamorphic rock, Mesozoic basic intrusive rock, Pleistocene marine and marine terrace deposits, Plio-Pleistocene non-marine sedimentary and metasedimenntary rocks, Quaternary non-marine terrace deposits, Alluvium

- **Miramar System**
  Dominant:
  Eocene marine and non-marine sedimentary rocks

  Lesser emplacements:
  Jurassic metavocanic and metasedimentary rocks of the Santiago Peak Volcanics

- **Hodges System**
  Dominant:
  Cretaceous granitic rock of the Southern California Batholith

  Batholith *Lesser emplacements:*
  Jurassic metavolcanic and metasedimentary rock of the Santiago Peak Volcanics, Mesozoic basic intrusive rock, Alluvium

Soils and Slope

Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Loose soils can be eroded by water or wind forces, whereas soils with high clay content are generally susceptible only to water erosion. Sediment with a high sand or silt content erodes more easily than areas with highly fractured or weathered rock. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils (**Appendix 1**). Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Past erosion also has an effect on a soil's erodibility. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils due to their poorer structure and lower organic matter.

As the slope gradient of a field increases, the amount of soil lost from erosion increases. Erosion by water increases as the slope length increases due to the greater accumulation of runoff volume and velocity. Overland flow in disturbed areas is likely to flow downhill more quickly and in greater quantities (i.e. possess more flow power as a result of its kinetic energy), and so may be able to begin transporting and even detaching soil particles. USGS estimates that 70% of soil slips originate in slopes between 20° and 36° (**Table 3.2**).These soil slips have the potential to increase sedimentation in streams and reservoirs.

Table 3.2 – Slopes within Local Source Water System Boundaries
SanGIS update 2010

	San Diego River System		**Otay-Cottonwood System**		**Miramar System**		**Hodges System**	
Slope	Acres	% Area	Acres	% Area	Acres	% Area	Acres	% Area
0 < 15%	42,809	20.9	54,117	23.8	296	45.9	55,185	34.8
16% < 25%	54,394	26.6	58,504	25.8	200	31	41,529	26.2
26% < 50%	84,308	41.2	89,644	39.5	149	23.1	50,982	32.2
51% <	23,294	11.4	24,754	10.9	0	0	10,70	6.8

Slope failure is a perceptible movement of soil and rock material downhill to a lower position. Landslides are the most common naturally occurring type of slope failure in San Diego. The causes of classic landslides start with the preexisting condition inherent within the rock body itself that can lead to failure. Landslides in the San Diego region generally occur in sedimentary rocks such as sandstone, siltstone, mudstone, and claystone. The actuators of landslides can be both natural events such as earthquakes, rainfall and erosion and human activities such as grading and filling.

- Earthquakes and their aftershocks can intensify or activate an unstable slope. Loosely and weakly consolidated soils, steepened slopes which are due to either human activities or natural causes, and saturated earth materials create a fragile situation easily affected by an earthquake.
- A debris flow or mudslide is a form of shallow landslide comprised of: soils, rock, plants, and water and can be very destructive during periods of heavy rainfall. The City of San Diego is susceptible to mudslides due to abundant natural, hilly terrain.

- A slope can be made potentially unstable by human activities involving:

    1) Removing material from the bottom of the slope, thus, increasing the angle of the slope.
    2) Raising the height of the slope above the previous level.
    3) Saturating the slope with water from septic tank, gutter runoff, or diverted drainage from another part of the slope.
    4) Adding fill to the top of the slope, creating additional weight.
    5) Earth-moving activities reactivating an old slide.

Geological Hazards and Contaminants

- **Fault Zones**
  Several earthquake fault zones, as well as numerous smaller faults, exist in the City of San Diego and in Southern California. The location of the City of San Diego in close proximity to large earthquake faults increases the potential of earthquake damage to structures and potentially endangers the safety of the City's inhabitants. Damage to structures and improvements caused by a major earthquake will depend on the distance to the epicenter, the magnitude of the event, the underlying soil, and the quality of construction.

  San Andreas Fault:
  The San Andreas Fault, approximately 100 miles east of the City of San Diego, is outside the City and San Diego County limits but poses a potential hazard to the San Diego region. It extends a total of 650 miles from Baja California to the California coast north of San Francisco. The nearest inhabited sections of the San Diego region are 30 miles away.

San Jacinto Fault:

The San Jacinto Fault is the largest of the active faults (faults that have moved in the last 11,000 years) in the San Diego region. The fault extends 125 miles from the Imperial Valley to San Bernardino. The northern portion of the fault is Halocene (fault displacement within the past 11,700 years) while the southern portion has experienced displacement with the last 200 years. The maximum probable earthquake expected to occur along the San Jacinto fault would be a magnitude of 7.5 to 7.8 on the Richter scale. An earthquake of this magnitude would have the potential for moderate damage in the City of San Diego and coastal areas.

Elsinore Fault:

The Elsinore Fault represents a serious earthquake hazard for most of the populated areas of the San Diego region. This fault is approximately 135 miles long, located approximately 40 miles north and east of Downtown San Diego. The Elsinore fault is a combination of Halocene and Late Quaternary (fault displacement within the past 700,000 years), and can register earthquakes in the range of magnitude 6.9 to 7.0 on the Richter scale.

Rose Canyon Fault Zone:

The Rose Canyon Fault Zone is an active offshore/onshore fault capable of generating an earthquake of magnitude 6.2 to 7.0 on the Richter scale. The fault zone lies offshore approximately two to six miles and parallels the San Diego north county coastline before coming ashore. This portion of the fault is a combination of Halocene and Quaternary (fault displacement within the past 1.6 million years). The fault trends through coastal San Diego before travelling off shore through San Diego Bay and parallel to the south county coastline. This portion is a combination of Halocene and Late Quaternary. The fault zone is composed of a number of fault segments, including the Rose Canyon, Mount Soledad, and Country Club faults.

The La Nacion Fault Zone:

The La Nacion Fault Zone is located about five mile east of the Rose Canyon fault zone and runs parallel through central and southern San Diego County. This is a Quaternary fault experiencing displacement within the last 1.6 million years.

Offshore Fault Zones:
The major offshore fault zones are the San Clemente (Halocene, Late Quaternary, and Quaternary), San Diego Trough (Halocene), and Coronado Bank (Halocene, Quaternary). The San Clemente fault zone, located 40 miles off La Jolla, is the largest offshore fault. It is estimated that the maximum plausible quake along this fault would be between magnitude 6.7 and 7.7. The San Diego Trough and Coronado Bank fault zones are capable of seismic events of magnitude 6.0 to 7.7.

- **Accelerated Erosion**
  Accelerated erosion or the loss of soil at a much faster rate than it is formed can cause ecosystem damage. Excessive erosion causes serious problems including loss of soil, damaged drainage networks, lower surface water quality, and receiving water degradation. It has impacts which are both on-site and off-site.

  The main on-site impact of accelerated erosion is the reduction in soil quality which results from the loss of the nutrient-rich upper layers of the soil and reduced water-holding capacity of many eroded soils. Erosion's removal of the upper horizons of the soil results in a reduction in soil suitability for vegetation because the eroded upper horizons tend to be the most nutrient-rich. In addition, eroded soils become preferentially depleted of their finer fraction over time. The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture. Textural changes can, in turn, affect the water-holding capacity of the soil, making it more susceptible to extreme conditions such a drought. The implications of soil erosion extend beyond the removal and textural changes of the soil. Seeds and plants can be disturbed or completely removed from the eroded site.

  In addition to its on-site effects, the soil that is detached by accelerated water or wind erosion may be transported considerable distances causing off-site effects. Eroded soil deposited down slope can inhibit or delay the emergence of seeds, bury small seedlings, and necessitate replanting in the affected areas. Sediment can be deposited on down slope properties and contribute to flooding and local property damage. Sediment which reaches streams or watercourses can clog drainage ditches and stream channels, silt in reservoirs, cover fish spawning grounds, and reduce downstream water quality.

- **Asbestos**

  Asbestos is a term used for a group of magnesium silicate minerals that occur as asbestiform fibers having high tensile strength, flexibility, and heat and chemical resistance. Serpentine (chrysotile) and amphibole (tremolite) asbestos occur naturally in certain geologic settings in California, most commonly in association with ultramafic rocks (over 90 percent of whose content consists of ferromagnesian minerals) and along associated faults.

  Anthropogenic Source:
  Building materials, manufacturing, mining

  Health Effects:
  Asbestos is a known carcinogen and inhalation of asbestos may result in the development of lung cancer or mesothelioma, ingestion increases the risk of developing benign intestinal polyps.

- **Mercury**

  Mercury is present in the environment as a result of both natural processes and human activities. Natural sources of mercury include volcanoes, hot springs, and natural mercury deposits. Mercury occurs in various forms and compounds in the environment, some of which are not bioavailable. When mercury enters an aquatic environment, by erosion, atmospheric deposition or as the result of human activity, it may encounter conditions that cause its conversion to methyl mercury. Methyl mercury is readily taken up by aquatic organisms and tends to concentrate as it moves up the food chain. This process is referred to as biomagnification and can result in high mercury concentrations in predatory fish such as striped bass and sharks, and in fish eating birds and mammals.

  Anthropogenic source:
  Sources related to human activities include coal combustion, waste incineration, certain industrial activities and some mining activities. Mercury was mined historically in California and widely used for gold recovery at mines until about 1970. California environmental mercury issues relate to historical mining operations in two ways. The first is mercury mining activity that occurred between 1846 and 1981, during which time about 100 million kilograms of mercury were produced within the state. The second is historic gold mining activities that took place between 1848 and the first part of the 20th century, which depended upon gold recovery processes using mercury.

Significant quantities of mercury were lost to the environment during both of these activities.

Health Effects:
Mercury is a human neurotoxin with developing fetuses and small children being at greatest risk, kidney damage. The principal route of human exposure is through consumption of mercury contaminated fish.

- **Radon**
  Radon gas is a naturally-occurring, radioactive gas that is invisible, odorless, tasteless, and soluble in water. It forms from the radioactive decay of small amounts of uranium and thorium naturally present in rocks (Gneiss) and soils. Certain rock types, such as black shales and certain igneous rocks, can have thorium and uranium in amounts higher than is typical for the earth's crust. Increased amounts of radon will be generated in the subsurface at these locations. Because radon is a gas, it can easily move through soil. Radon-222 is the isotope of most concern to public health because it has a much longer half-life (3.8 days) than other radon isotopes (radon-219 at 4 seconds and radon 220 at 55.3 seconds). The longer half-life allows radon-222 to migrate farther through the soil. . The average concentration of radon in American homes is about 1.3 picocuries per liter and the average concentration in outdoor air is about 0.4 picocuries per liter. The geologic radon potential for San Diego County is low (<2pCi/L).

  Anthropogenic source:
  Mining, coal combustion

  Health Effects:
  Breathing air with elevated levels of radon gas results in an increased risk of developing lung cancer

- **Arsenic**
  Arsenic occurs naturally in rocks (Asenopyrite) and soil, water, air, and plants and animals. It can be further released into the environment through natural activities such as volcanic action, erosion of rocks and forest fires, or through human actions. When deposits of Arsenopyrite become exposed to the atmosphere, usually due to mining, the mineral will slowly oxidize, converting the arsenic into oxides that are more soluble in water.
  Because it occurs naturally in the environment and as a by-product of some agricultural and industrial activities, it can enter drinking water through the

ground or as runoff into surface water sources. Higher levels of arsenic tend to be found more in ground water sources than in surface water sources of drinking water. Compared to the rest of the United States, western states have more systems with arsenic levels greater than USEPA's standard of 10 parts per billion (ppb).

Anthropogenic source:
Approximately 90 percent of industrial arsenic in the U.S. is currently used as a wood preservative, but arsenic is also used in paints, dyes, metals, drugs, soaps and semi-conductors. High arsenic levels can also come from certain fertilizers and animal feeding operations. Industry practices such as copper smelting, mining and coal burning also contribute to arsenic in our environment.

Health Effects:
Increased risk of cancer, cardiovascular and dermal problems.

3.3 Biology

Vegetation

Vegetation anchors the soil, protects the soil from splash erosion, slows down the movement of surface runoff, allows excess surface water to infiltrate, and provides a wind break effect. The lack of windbreaks (*e.g.*, trees, shrubs, and residue) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. The effectiveness of vegetative covers depends on the type, extent and quantity of cover; vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface are the most effective (*e.g*. forests, shrubs, and permanent grasses). Partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil. Typically, only the most severe rainfall and large hailstorm events will lead to overland flow in a forest.

In addition to providing soil stability, vegetation cover provides other ecological services pertinent to water quality. Wetlands and other riparian plant communities act as natural filters removing suspended sediments and contaminants. Sediments are trapped by densely growing wetland plants, and many contaminants are absorbed or chemically altered by the vegetation (**Table 3.3**).

Table 3.3 - Vegetation Categories within Local Source Water System Boundaries
SanGIS updates 2010 & 2005

Vegetation Category	2010 Acres	2010 % Area	2005 Acres	2005 % Area
San Diego River System				
Blank	0	0	0	0
Wetlands	574	0.3	1,132	0.6
Forest	20,041	9.8	20,380	10
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	15,045	7.3	13,902	6.8
Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	16,532	8.1	15,983	7.8
Riparian	5,136	2.5	5,067	2.5
Scrub and Chaparral	116,762	57	117,202	57.2
Woodland	30,720	15	31,139	15.2
Total	204,810	100	204,804	100
Otay-Cottonwood System				
Blank	0	0	6,435	2.8
Wetlands	315	0.1	257	0.1
Forest	15,496	6.8	15,380	6.8
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	9,076	4	8,274	3.6
Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	12,711	5.6	11,884	5.2
Riparian	3,341	1.5	3,321	1.5
Scrub and Chaparral	175,330	77.2	170,706	75.2
Woodland	10,751	4.7	10,761	4.7
Total	227,018	100	227,018	100
Miramar System				
Blank	0	0	0	0
Wetlands	0	0	0	0
Forest	0	0	0	0
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	10	1.5	10	1.5
Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	405	62.8	405	62.8
Riparian	0	0	0	0
Scrub and Chaparral	230	35.7	230	35.7
Woodland	0	0	0	0
Total	645	100	645	100

Hodges System				
Blank	0	0	0	0
Wetlands	269	0.2	268	0.2
Forest	120	0.1	120	0.1
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	14,806	9.4	14,733	9.3
Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	45,580	28.8	43,976	27.8
Riparian	4,070	2.6	4,086	2.6
Scrub and Chaparral	72,054	45.5	73,880	46.7
Woodland	21,374	13.5	21,209	13.4
Total	158,272	100	158,272	100

The description of the different plant communities found in the watershed (Sawer and Keeler-Wolf classification, 1995) and their respective response to fire is from the 2003 Southern California Fires Burned Area Emergency Stabilization and Rehabilitation Plan prepared by: Interagency Burned Area Emergency Response Team in November, 2003. For an in depth list of vegetation potentially found within the local source water system see **Appendix 2**.

- **Oak Woodlands**
  Vegetation Types:
  Oak woodlands typically occur in the foothills and transition into mixed conifer/oak woodlands at higher elevations. Each community type can vary from open savannas in broad valleys and rolling hills, to dense woodlands in canyons and along streams. Oak woodlands are dominated by live oak trees species that include Black Oak, Coast Live Oak, Engelmann Oak, and Canyon Live Oak.

  Response to Fire:
  Oak woodlands have evolved with fire. Dense woodlands typically experience infrequent stand destroying fires. Oak trees that experience some canopy fire often survive unless the ground fire temperature is extreme enough to kill the root system. The complex of species associated with dense oak woodlands will either re-sprout or germinate from seed. Frequent or hot fires can affect the seed bank and the root system of Oak Woodland species, resulting in degraded habitat that is susceptible to habitat conversion.

- **Eucalyptus Woodland**
  Vegetation Types:
  Eucalyptus Woodland is a non-native closed canopy community. This community is typically a monotypic stand of Eucalyptus trees with a thick mulch of Eucalyptus tree leaves.

Response to Fire:
Eucalyptus stands can be fire retardant to low intensity fires. Low intensity fires will consume the leaf litter and can be carried into the canopy where leaves are singed or tops are burned. High intensity fires are typically stand destroying.

- **Forests**

  Vegetation Types:
  Coniferous forests occur in the lower to upper montane zone in the Peninsula Ranges. The lower montane forests typically include the Southern Interior Cypress Forest, which is intermixed with oak woodlands and chaparral. Upper montane forests include Coulter Pine Forest, Jeffery Pine Forest, and mixed Sierran Forest. They range from pure stands of a single species, to mixed conifer forests intermixed with oak woodlands and chaparral.

  Response to Fire:
  Montane forests are typically surrounded by chaparral or adjacent to forests subject to fire, and are therefore susceptible to fire. When fires occur more frequently than twenty-five years, Coulter pine habitat may convert to chaparral. Jeffery Pine Forests and Mixed Coniferous Forests historically experience periodic low-to-moderate intensity fires in the understory. Fuel buildup due to fire suppression can increase the risk of stand replacing crown fires.

- **Chaparral**

  Vegetation Types:
  Chaparral occurs throughout the coastal lowlands, foothills, and montane region. This community typically forms a dense, almost impenetrable shrub community with no herbaceous layer. Chaparral is a highly variable plant community that includes Chamise Chaparral, Coastal Sage-Chaparral Scrub, Mixed Chaparral, Montane Chaparral, Semi-desert Chaparral, and Scrub Oak Chaparral.

  Response to Fire:
  Chaparral is a fire adapted community, that stump sprouts or germinates from seed after a low-to-moderate intensity burn. Large fires often result in homogenous stands of chaparral. Frequent fires and hot fires can burn the root system and surface seed bank, resulting in a loss of diversity and low-density vegetative communities. For a few years after a fire, annual forbes germinate and establish on site, until the woody shrubs mature.

- **Coastal Sage Scrub**

  Vegetation Types:

  Locally, Coastal Sage Scrub consists of low, woody soft-shrubs and is classified as Diegan Coastal Sage Scrub (DCSS). DCSS is dominated by California sagebrush and/or flat-topped buckwheat and often intergrades with Chaparral communities.

  Response to Fire:

  DCSS species are fire adapted and quickly regenerate from seed after a fire. However, frequent fires in an area can reduce the seed bank for native shrub species and increase the presence of non-native grasses and forbs resulting in degraded habitat. Once this habitat conversion occurs, DCSS species typically do not re-colonize the area due to competition from dense populations of invasive grasses that increase the fire frequency.

- **Big Sagebrush Scrub**

  Vegetation Types:

  Locally, big sagebrush is dominated by flat-topped buckwheat, broom snakeweed, deerweed, saw-toothed golden brush, and a variety of DCSS species.

  Response to Fire:

  The fire ecology of Big Sagebrush Scrub in eastern San Diego County is not well documented. Many of the species in this community occur in DCSS and are fire adapted. Frequent fires in the vegetative community will result in habitat conversion to non-native grasslands.

- **Grasslands**

  Vegetation Types:

  Perennial Grasslands vary among Valley Needlegrass and Valley Sacaton grasslands. Valley Needle Grassland is dominated by the tussock forming purple needlegrass with a variety of native forbs including colar lupin, rancher's fireweed, and adobe popcorn-flower; and the native bunchgrasses, foothill needle grass, and coast range melic. The species composition can vary as it transitions into the foothills and montane zone. Valley Sacaton Grassland is dominated by sacton or salt grass. This community typically occurs in the areas with a high seasonal water table and is often associated with Alkali Seeps and Alkali Meadows. Non-native grasslands are dominated by Red brome, Ripgut brome, and Softchess brome. Non native grasslands often intergrade with open oak woodlands and disturbed DCSS communities.

Response to Fire:
Grassland communities in San Diego County have evolved with, and are typically maintained by fire. Fire in non-native grasslands results in a continued dominance by invasive grasses, and prevents reestablishment by native shrub species.

- **Meadows**

  Vegetation Types:
  Montane Meadows occur in the montane zone and are dense growths of sedges and perennial herbs that experience wet cold winters. Montane Meadows are typically interspersed with montane forests. Wildflower Field is an amorphous community of herbaceous plant species where dominance varies from site to site and year to year, depending on climatic factors. Wildflower Field is typically associated with grasslands and oak woodlands in the valleys and foothills.

  Response to Fire:
  Wet meadows typically do not burn since the moisture content in the plants and soils retards fire advance. During drought times and in dry meadows fire will quickly burn through these communities. Fall fires typically have little impact on local meadows since most plants are dry and have dispersed their seed.

- **Riparian**

  Vegetation Types:
  Riparian communities vary depending on the aquatic system they are associated with and can have seral stages of community succession. Mulefat Scrub and Southern Willow Scrub are typically early seral stages for Southern Cottonwood-Willow Riparian Forest, which develops into Southern Coast Live Oak Riparian Forest. In steep drainages, Mulefat Scrub and Southern Willow Scrub may be early stages for Southern Sycamore-Alder Riparian Forest or White Alder Riparian Forest.

  Response to Fire:
  Riparian communities often resist fire since riparian species do not experience drought. During drought, riparian species become more susceptible to fire. Stand destroying fires can assimilate flooding events in that they set communities back to early seral stages. Stump sprouting species can reestablish in the early successional communities. Most mature trees that experience high intensity fires will die.

- **Wetlands**

  Vegetation Types:

  Wetland communities are highly variable. Riparian and Wet Meadows are communities that can establish in areas with sufficient hydrology to be considered wetlands. In addition, emergent wetlands occur along seeps and as emergent wetlands in shallow water. These wetlands include Alkali Seep, Freshwater Seep, and Freshwater Marsh.

  Response to fire:

  Historically, fire impacts to wetlands in San Diego County are not documented. Wetlands typically do not experience fire. Many wetland species are rhizomous and will likely survive fires. Woody species in scrub and forested wetlands may recover from fire by epicormic sprouting from stems or basal sprouting from roots.

Wildlife

A diverse assemblage of wildlife species including; reptiles, birds, and mammals are commonly found within the boundaries of the local source water system. Many species are common to both upland and lowland areas occurring form sea level to the mountains where suitable habitat is available. Few of the terrestrial mammals of southern California are dependent on wetland habitats; however, some are more common along streams than in upland areas. Many birds are adapted to life on open water, and in or adjacent to wetland habitats. These include numerous species of waterfowl and wading birds. Most amphibians are also associated with temporary or permanent sources of water. The fishes associated with southern California streams and reservoirs are primarily warm-water fishes. For an in depth list of wildlife potentially found within the local source water system see **Appendix 3**.

Land Ownership and Population

Land ownership (**Table 3.4**) and population (**Table 3.5**) are indicators of current and future potential levels of human disturbance within an area. These effects accumulate from a variety of outdoor human activities arising from too many people using a finite land resource and are generally in the form of development and the overuse of open spaces. Land areas with small population densities are usually rural areas with natural landscapes that trap rainwater and allow it to filter slowly into the ground. In contrast, large population densities are associated with urbanized areas. Development can result in vegetation modification and increased impervious surface area with a resulting modification to runoff amounts, velocities, and patterns. Urbanization also increases the variety and amount of pollutants carried into streams, rivers, and lakes. The overuse of open spaces by increased recreational use causes erosion from vegetation removal, foot traffic, and off road vehicle activity.

Table 3.4 - Land Ownership within Local Source Water System Boundaries
SanGIS Updates 2009 & 2005

	2010		2005	
Ownership Category	Acres	% Area	Acres	% Area
San Diego River System				
City of San Diego	9,912	4.8	9,817	4.7
Local	22,480	11	22,072	10.5
State	12,696	6.2	12,372	5.9
Federal (Including Indian Reservations)	84,261	41.1	80,240	38.2
Total Public	119,437	58.3	114,684	54.6
Private	85,371	41.7	95,178	45.4
Otay-Cottonwood System				
City of San Diego	10,780	5.3	10,780	4.8
Local	12,172	5.9	12,049	5.4
State	15,836	7	13,561	6
Federal (Including Indian Reservations)	140,752	62	140,740	62.7
Total Public	168,760	74.3	166,350	74.2
Private	58,384	25.7	57,981	25.8
Miramar System				
City of San Diego	462	71.8	457	70.9
Local	459	71.3	458	71
State	0	0	0	0
Federal (Including Indian Reservations)	0	0	0	0
Total Public	459	71.3	458	71
Private	185	28.7	187	29
Hodges System				
City of San Diego	18,638	11.8	18,719	11.8
Local	24,372	15.4	27,453	17.3
State	2,326	1.5	2,336	1.5
Federal (Including Indian Reservations)	26,209	16.6	26,203	16.5
Total Public	52,907	33.4	55,992	35.3
Private	105,371	66.6	102,425	64.7

Table 3.5 - Population within Local Source Water System Boundaries

SanGIS updates 2009 & 2005

Name	Total Population	% Population	Acres	% Area	Density
San Diego River System					
County of San Diego	10,251	19	178,016	87	0.06
Alpine	10,991	20	10,290	5	1.07
El Cajon	720	1	84	0	8.59
Harbison Canyon	156	0	8	0	20.09
Julian	570	1	2,012	1	0.28
La Mesa	3,915	7	96	0	40.73
Poway	0	0	587	0	0
Ramona	432	1	884	0	0.49
San Diego	17,396	32	2,118	1	8.21
San Diego Country Estates	9,262	17	10,710	5	0.86
Total 2010	53,693	100	204,804	100	0.26
Total 2005	53,693	100	204,804	100	0.26
Otay-Cottonwood System					
County of San Diego	7,166	62	214,476	94	0.03
Chula Vista	171	1	1,839	1	0.09
Jamul	2,727	24	6,028	3	0.45
Pine Valley	1,501	13	4,675	2	0.32
Total 2010	11,565	100	227,018	100	0.05
Total 2005	NA	NA	NA	NA	NA
Miramar System					
San Diego	6,077	100	645	100	9.4
Total 2010	6,077	100	645	100	9.4
Total 2005	6,077	100	645	100	9.4
Hodges System					
County of San Diego	21,169	19	119,033	75	0.2
Escondido	22,022	20	5,626	4	3.9
Poway	12,178	11	9,017	6	1.4
Ramona	15,691	14	8,721	6	1.8
San Diego	35,769	33	15,849	10	2.3
San Diego Country Estates	2,142	2	26	0	81.2
Total 2010	108,971	100	158,272	100	0.7
Total 2005	109,825	100	158,272	100	0.7

Aquatic Invasive Species

In California, the spread of invasive species has threatened the biodiversity of native plant and wildlife and the quality and quantity of water supplies. The term "invasive species" refers to non-native (i.e., exotic) pests and diseases that are likely to cause agricultural, environmental or economic harm or be harmful to food safety and human health. They also raise maintenance costs for roads, public lands, and waterways.

The duration, rate of spread and extent of invasion determine the feasible response. Nevertheless, pest control measures are not without controversy, whether they be mechanical removal, depopulation, application of chemical pesticides, introduction of predatory or disease causing "biocontrol" organisms, genetic engineering for pest resistance, or regulatory imposition of quarantines and the requirement of pest-free certification and permits for export, import or local transport. However, a policy of preemptive surveillance and exclusion rather than reactive adaptation would likely minimize the long-run costs associated with invasive species.

California's waterways are vulnerable to the introduction of invasive species from multiple sources and damage to the water transfer system could impact irrigation and urban water supplies. Aquatic Invasive Species (AIS) includes both aquatic plant and aquatic animal species. Invasive aquatic plants are introduced plants that have adapted to living in, on, or next to water, and that can grow either submerged or partially submerged in water. Invasive aquatic animals require a watery habitat, but do not necessarily have to live entirely in water.

In January 2007, the AIS Quagga mussel, *Dreissena bugensis,* was discovered at a marina in the Nevada portion of Lake Mead, and two other lakes on the Colorado River, Lake Mohave and Lake Havasu.

Zebra mussels, the first Dreissenid mussel introduced in North America, rapidly spread throughout many major river systems and the Great Lakes causing substantial ecological and environmental impacts. The Quagga mussel was first observed in North America in September 1989 when it was discovered in Lake Erie near Port Colborne, Ontario. It was not identified as a distinct species until 1991.

The introduction of both Dreissenid species into the Great Lakes appears to be the result of ballast water discharge from transoceanic ships that were carrying veligers, juveniles, or adult mussels. The genus Dreissena is highly polymorphic and prolific with high potential for rapid adaptation attributing to its rapid expansion and colonization.

Dreissenid’s are prodigious water filterers, removing substantial amounts of phytoplankton and suspended particulate from the water. By removing the phytoplankton, Quaggas, in turn, decrease the food source for zooplankton, therefore altering the food web. Impacts associated with the filtration of water include increases in water transparency, decreases in mean chlorophyll concentrations, and accumulation of pseudofeces. Water clarity increases light penetration causing a proliferation of aquatic plants that can change species dominance and alter the entire ecosystems. The pseudofeces that is produced from filtering the water accumulates and impacts the environment. As the waste particles decompose, oxygen is used up, water acidity increases (decreased pH) and toxic byproducts are produced. In addition, Quagga mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment and these pollutants are found in their pseudofeces, which can be passed up the food chain, therefore increasing wildlife exposure to organic pollutants.

Dreissena's ability to rapidly colonize hard surfaces causes serious economic problems. These major biofouling organisms can clog water intake structures, such as pipes and screens, therefore reducing pumping capabilities for power and water treatment plants, causing increased costs to industries, companies, and communities. Recreation-based industries and activities have also been impacted; docks, break walls, buoys, boats, and beaches have all been heavily colonized. Many of the potential impacts of *Dreissena* are unclear due to the limited time scale of North American colonization.

In response to the detection of Quagga mussels in Lake Mead and the Colorado Aqueduct, the CSD Public Utilities Department initiated a *Dreissena* veliger (planktonic life stage) monitoring program and updated its settled adult monitoring program. This Response and Control Plan was prepared to satisfy the CSD’s obligation under Fish and Game Code 2301 and 2302.

To date, all CSD owned reservoirs that receive water from the Colorado River Aqueduct have been confirmed to contain veligers and adult *Dreissena* mussels. These reservoirs are El Capitan, Miramar, Murray, Otay and San Vicente (**Figure 2.1**). The CSD also owns four reservoirs that are not connected to the Colorado River Aqueduct: Barrett, Hodges, Morena and Sutherland Reservoirs. Veliger and adult population monitoring is being conducted on these reservoirs with the exception of Barrett. Since no private water crafts are permitted at Barrett and the reservoir does not receive Colorado River Aqueduct water, Barrett Reservoir is at minimum risk of being colonized by Dreissenid mussels.

In accordance with Fish and Game Code Section 2301, the Draft CSD Public Utilities Department *Dreissena* Mussel Response and Control Plan was submitted for review and is currently under revision. In fulfillment of the request of DFG to supply them with all activities related to *Dreissena* mussels, the CSD is required to submit an annual report. **Appendix 4** contains the CSD's 2009 annual report to DFG.

- **Other Aquatic invasive species found in the CSD reservoirs:**

  Corbicula fluminea:
  Asian clam, *Corbicula fluminea,* is a freshwater clam that has caused millions of dollars worth of damage to intake pipes used by power, water, and other industries. In addition, the introduction of C. fluminea has caused many populations of native clams to decline due to competition for food and space. C. fluminea requires well-oxygenated waters and prefers fine, clean sand, clay, and coarse sand substrates. Introduction and spread of this species is caused when it is attached to boats or carried in ballast water, used as bait, sold through the aquarium trade, and carried with water currents.

  Pomacea canaliculata;
  Channeled apple snail, *Pomacea canaliculata*, is a freshwater snail with a voracious appetite for water plants including lotus, water chestnut, taro and rice. Introduced widely from its native South America by the aquarium trade and as a source of human food, it is a major crop pest in south-east Asia (primarily in rice) and Hawaii (taro) and poses a serious threat to many wetlands around the world through potential habitat modification and competition with native species.
  Myriophyllum spicatum:
  Eurasian water-milfoil, *Myriophyllum spicatum*, is a submerged aquatic plant that can rapidly colonize a pond, lake or area of slow-moving water. It creates dense mats of vegetation that shades out other native aquatic plants, diminishes habitat and food resource value for fish and birds, and decreases oxygen levels in the water when the plant decays.

The City has no plans to monitor these species development.

Biological Hazards and Contaminants

- **Ecosystem Degradation**
  Ecosystems perform services pertinent to water quality, flood protection, water storage, and decomposition of organic wastes. The health and biodiversity of ecosystems depends on the maintenance of high-quality habitat. Habitat provides essential food, cover, migratory corridors, and breeding/nursery areas for a broad array of organisms. Ecosystems can be damaged through change or degradation in structure, function, composition, or a loss of habitat. Degradation can encourage the establishment of invasive species; alter the natural flow regimes of tributaries; increase runoff of sediments, nutrients, pathogens, and toxins causing significant effects upon the water quality; and distribution of living resources in the receiving waters.

  Anthropogenic source:
  Ecosystem degradation is usually caused by overuse of a resource caused by overpopulation, pollution or over-exploitation related to development, agriculture, industry, and recreation.

- **Habitat Loss**
  Habitat destruction involves outright loss of areas used by wild species due to removal of vegetation and erosion. Plants and other sessile organisms in these areas are usually directly destroyed. Mobile animals (especially birds and mammals) retreat into undisturbed areas of habitat.

  Habitat fragmentation invariably involves some amount of habitat destruction. Fragmentation occurs when native species are squeezed onto small patches of undisturbed land surrounded by disturbed areas. Habitat fragments are rarely representative samples of the initial landscape. The remaining habitat fragments are smaller than the original habitat; therefore, this can lead to crowding effects and increased competition. Species that can move between fragments may use more than one fragment. Species which cannot move between fragments must survive utilizing resources available in the single fragment.

  Anthropogenic source:
  The conversion of open land to commercial development and agriculture.

- **Nutrients**
  Nutrients such as nitrogen and phosphorus are necessary for growth of plants and animals and support a healthy aquatic ecosystem. In excess, however,

nutrients can contribute to algae blooms, subsequent low dissolved oxygen levels and fish kills. Excessive nutrients stimulate the growth of algae. As the algae die, they decay which consumes the dissolved oxygen in the water. The condition where dissolved oxygen is less than 2 parts per million is referred to as *hypoxia*. Many species are likely to die below that dissolved oxygen level as the dissolved oxygen level of healthy waters is 5 or 6 parts per million. The algae also prevent sunlight from penetrating the water killing submerged aquatic vegetation. Increased algae may also cause foul smells and decreased aesthetic value.

Anthropogenic sources:
Sewage discharges, stormwater runoff from urban and agricultural lands, erosion, pet and livestock wastes, atmospheric deposition originating from power plants or vehicles, and groundwater discharges.

Health Effects:
Acute exposure through ingestion increases the risk of developing methemoglobinemia. Chronic exposure through ingestion may potentially increase the risk of developing certain cancers and birth defects.

Pathogens

Pathogens are disease-causing organisms. Wildlife species may act as potential sources of contaminants by spreading protozoa such as *Giardia* cysts and *Cryptosporidium* oocysts. To contaminate surface waters, these species must be infected and actively shedding cysts or oocytes in or near the water. In addition to protozoan's, waterborne pathogenic bacteria and viruses many be carried by wildlife and are typically found in animal waste. Numerous species of waterfowl and wading birds may be considered a source of pathogenic bacteria contamination as they introduce fecal material to the surface waters.

Anthropogenic source:
Sewage discharges, urban and agricultural stormwater runoff, erosion, pet and livestock wastes.

Health effects:
The diseases range in severity from mild gastroenteritis and viral infections to potentially life-threatening ailments such as giardaiasis, cryptosporidiosis cholera, dysentery, infectious hepatitis, and severe gastroenteritis.

- **Toxins**
  Pollutants such as herbicides, pesticides, and other wastes pose a threat to living resources by contaminating the water, food chain, and eliminating food sources. Toxic substances such as metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, and pesticides can alter aquatic habitat, harm animal health, reduce reproductive potential, render many fish unsuitable for human consumption, and make recreational areas unsafe and unpleasant. Other threats include bioaccumulation of toxins, outbreaks of contagious and infectious diseases, and algae blooms.

  Anthropogenic sources:
  Sewage discharges, urban and agricultural stormwater runoff, industrial discharges, atmospheric deposition originating from power plants or vehicles.

  Health effects:
  Toxins increase the risk of cancer, acute and chronic illnesses, and organ damage.

- **Introduced Species**
  Intentional or accidental introduction of invasive species may often result in unexpected ecological and economic impacts to the environment. Through predation and competition, introduced species have contributed to the eradication of some native populations and drastically reduced others, fundamentally altering the food web. Overpopulation of some introduced herbivorous species has resulted in overgrazing of wetland vegetation and the resultant degradation and loss of marsh. Other impacts include altered water tables, modified nutrient cycles or soil fertility, increased erosion, and possibly caused introducing pathogens.

  Anthropogenic sources:
  Land development, agriculture, and recreation.