

## Lesson 2: Water in San Diego

**Focus Question:** What affect does water have on the economy of San Diego?

### Activity # 1 “Why is Water an Important Natural Resource?”

Review from Lesson 1 the meaning of *natural resources* (something from nature that people can use, such as trees, land, water, animals, and minerals). Explain to students that in this lesson, we will learn about **water**. Water is a vital natural resource. In extreme amounts, it can flood and destroy. Without it, nothing survives.

**Why is water an important natural resource?** Students will respond with many uses for water. Mainly, water needs to be available for people (human consumption), businesses, and agricultural purposes. In San Diego, water has played and continues to play a key role in the growth and development of the economy.

**How does the water get into the faucet?** Water is piped to homes, businesses and farms through pipes that are buried underground. Generally, water is provided by a city-owned water department, a water district, a private company, or a mutual company.

**What are the main sources of San Diego’s water?** The City of San Diego currently buys (imports) most of its water (75-90 percent) from the **San Diego County Water Authority** which supplies the water through two aqueducts consisting of five pipelines. While the City imports a majority of its water, it also uses two local supply sources: **local surface water** and **reclaimed or recycled water**. Suggest students ask their parents to show them their water bill.

### Activity # 2 Where Does San Diego Get its Water?

Materials needed: For each group of students, a map of the *San Diego Region* (AAA map works well) and a map of California (*See Reflections: Communities*, page R13). **Refer to pages 14-17 for Teacher Background on San Diego’s ater sources and supply.**

Post the following chart on the board or chart paper. Discuss the three sources of water for San Diego

### Three Main Sources of Water for San Diego

1. Local rainfall and run-off stored in reservoirs (up to 20%)	2. Imported water purchased from San Diego Water Authority and stored in reservoirs (75-90%)	3. Reclaimed Water used for irrigation, manufacturing and other non-drinking purposes.
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1. Using maps of San Diego County, have students locate the reservoirs: Barrett, El Capitan, Hodges, Miramar, Morena, Murray, Otay, San Vicente, and Sutherland,

**Up to 20 percent of the City of San Diego’s water comes from local rain water and runoff that is stored in reservoirs.** The average rainfall is around 10 inches annually. Most of the rainfall is from November thru March with January, on average, receiving the most rainfall. The local rainwater and runoff is stored in nine reservoirs: Barrett, El Capitan, Hodges, Miramar, Morena, Murray, Otay, San Vicente, and Sutherland, eight of which are directly connected to water treatment operations. This is not enough water to supply all the needs of the people, businesses and farmers in San Diego.

2. Using a map of California (*Reflections: Communities page R13*), have students locate the Colorado River, Lake Havasu, the Sacramento River, the San Joaquin River, and the Imperial Valley.

**The City of San Diego purchases (buys) 75 to 90 percent of its water from the San Diego County Water Authority (Water Authority).** The Water Authority purchases most of its water from the Metropolitan Water District (MWD) who imports the water from Northern California and from the Colorado River and brings it to San Diego along aqueducts (canals) and pipes where it is stored in local reservoirs.

The A 242 mile-long **San Diego Aqueduct**, completed in 1947 brings Colorado River water from **Lake Havasu** to the Southland. This became San Diego's first link to MWD. In the 1940's it became apparent that MWD's Colorado River system was not enough to serve the enormous growth of population in Southern California.

The State of California created the **State Water Project (SWP)**. This water is captured in reservoirs north of Sacramento and released through natural rivers and streams into the Sacramento-San Joaquin Delta. The water is delivered to southern California through a 444 mile-long aqueduct. MWD purchases water from the SWP and blends Colorado River and SWP water at a facility in Riverside County, and then transfers it to San Diego water treatment plants.

Recently, the Water Authority negotiated the landmark water transfer agreement with the Imperial Irrigation District (IID) for up to 200,000 acre-feet of water. This water travels from Hoover Dam 200 miles downstream along the Colorado River to the Imperial Dam near Yuma, Arizona where the water is diverted from the Colorado River into the All-American Canal and the Imperial Irrigation District.

3. Discuss with students the concept of reclaimed, or recycled, water.

**The City of San Diego reclaims, or recycles water that is used for irrigation, manufacturing and other non-drinking purposes.** Large amounts of water used by San Diego customers do not have to be drinking water quality. Examples are golf courses, some agriculture and industrial uses. Reclamation plants take the water discharged from sewage plants (effluent) and treat it. The City of San Diego has built the North City Water Reclamation Plant (NCWRP) and the South Bay Water Reclamation Plant (SBWRP) to meet future water demands. Recycled water is a local source of water not affected by droughts or other water shortages.

### **Activity # 3 Construct a Lock Book titled The Sources of San Diego's Water**

Materials needed: For each student, 2 sheets of 8 ½" by 11" paper and scissors

#### Directions to Make a Lock Book

1. Distribute to each student 2 sheets of 8 ½" by 11" paper and scissors.
2. Fold each sheet of paper in half vertically (hamburger fold).
3. Open each sheet of paper. Measure along the crease and make two small pencil marks 1 ½ inches and 7 inches from the top.
4. On piece of paper #1, cut along the crease from the 1 ½ inch mark to the 7 inch mark. (*It may be helpful to fold the paper in half lengthwise, but be careful not to crease it.*)
5. On the second piece of paper, cut along the crease from the top of the page to the 1 ½ inch mark. Then cut along the crease from the bottom of the page to the 7 inch mark.

6. Take the second piece of paper that has been cut at the top and the bottom of the crease, fold one side of the paper, and feed the paper through the hole in paper #1. (*Be careful not to crease the page.*) **Unfold the page so it locks into place.**
7. Fold the pages into a book shape.
8. Hold the book horizontally. Write *Sources of San Diego's Water* on the cover of the lock book and the student's name.
9. On page 1, students write about the reservoirs and the local sources and water; on page 2 write about the sources of imported water, and on page 3 write about reclaimed or recycled water.
10. Add designs and illustrations to each page..

### **Alternative: three-tab book The sources of San Diego's Water.**

- Fold a sheet of paper in half like a hot dog.
- With the paper horizontal, and the fold of the *hot dog* up, fold the right side toward the center, trying to cover one-third of the paper.
- Fold the left side over the right side to make a book with three folds.
- Open the folded book. Place your hands between the two thicknesses of paper and cut up the two *valleys* (folds) on the top layer only along both folds. This will make three tabs.
- Across the top of the book near the horizontal fold, write *The Sources of San Diego's Water*.
- Label each tab with one of the sources of water write information you have learned about San Diego's three sources of water.

### **Activity # 4 Water for San Diego's Future**

Due to the water supply crisis in the first half of the 2000's, and the threat of further limitations on city water supplies, the City of San Diego has declared a water emergency: Level 1 Drought Watch Condition. To promote water savings, the City is calling for increased conservation by all of its water customers. Discuss with students what we can do to save water both indoor and outdoors.

From the Teacher Background (San Diego's Water Supply Crisis, pages 14-17), share information about new projects under development (the satellite project and the ocean and ground water desalination projects). For a guest speaker, contact the **City of San Diego Water Department** at (619) 515-3500.

### **Conclusion for the Lesson**

Return to the questions about water in San Diego posed at the beginning of the lesson. Discuss these again and any other questions that surfaced during the lesson:

- Why is water an important natural resource?
- How does the water get into the faucet?
- What are the main sources of San Diego's water?
- Where does the water bill come from?
- What affects and effects did the completion of the San Diego Aqueduct (242-mile long aqueduct brings water from the Colorado River) and the State Water Project (444-mile long aqueduct from Northern California) have on San Diego?
- What is reclaimed water? For what is it used?
- How can we conserve water?

### **Assessment:**

- Construct a lock book and write information learned about the three sources of San Diego's water.

## San Diego's Water Supply Crisis

The San Diego region is experiencing an unprecedented water supply crisis. Environmental stresses, including the ongoing drought in the Colorado River basin and reduced snow pack and runoff in Northern California are reducing water flows leading to San Diego. In addition to these environmental stresses, court-ordered pumping restrictions on the State Water Project have continued to reduce the amount of water that can be delivered to our region. Since San Diego imports 85-90 percent of its water, these conditions have put considerable stress on the City's water system.



### Climate Data

The City of San Diego's climatic conditions are characterized as Mediterranean, with warm, mild winters and cool, dry summers. The service area is semi-arid with little rain occurring throughout the year. The average rainfall is around 10 inches annually. More than 80 percent of the region's rainfall occurs in the period of November thru March with January, on average, receiving the most rainfall. Approximately 10 percent of the total seasonal rainfall normally occurs from May to October and only roughly 2 percent occurs during the three-month period from June through August.

### History of the City of San Diego Water Department

The history of the City of San Diego's water supply indicates that water surpluses are rare. Therefore, constant attention to water conservation and management programs is required. San Diego was founded as a Spanish community by Father Junipero Serra and the Franciscan Friars in 1769. Established as the first mission site in the state, Father Serra and the Friars built the region's first drainage ditches, wells, and a dam situated on the San Diego River which created a reservoir.

The City of San Diego was incorporated in 1850, and became a charter city in 1889. Municipal ownership of the City's water supply and distribution system began in 1901 with the purchase for \$40 million of the privately owned San Diego Water Company.

The expansion of the City's water supply system occurred in four phases over a period of 30 years.

- Phase One: the acquisition of existing dams which created reservoirs, including Lower and Upper Otay in 1913, and Morena Dam in 1914
- Phases Two and Three: purchasing Lake Hodges and the San Dieguito Dam in 1925, and the construction of El Capitan Dam in 1935
- Phase Four: As a result of a wartime population (WWII) growth of more than 400,000 people, the demand for water became well above the system's safe yield. As a result of this supply deficiency, the Navy requested that the City connect to the Colorado River Aqueduct (CRA), which was completed by the Metropolitan Water District (MWD) in 1941 to serve the Los Angeles area but later expanded to include San Diego County. Thus began the City's reliance upon imported water, which now constitutes up to 90 percent of its supply.

### Components of a Water System

As a short roadmap to understanding terms used in the water industry, it is helpful to summarize components of a water system. A basic local water system consists of:

- Local water supply(wells or rainwater runoff, mostly from rivers) and, more recently, reclaimed sewer water and desalinated ocean and ground water
- Imported water that us purchased a long way from the city so that an aqueduct is used to transport the water to the city system
- Long term storage (dams/reservoirs)
- Treatment facilities, both to make it safe and/or better quality
- Pumps and short term storage (tanks or ponds)
- Distribution pipes to provide customers with potable water (quality sufficient for drinking), and customer water meters (some systems don't use these). Recently, duplicate pipelines have been installed to deliver non-potable water for agricultural and industrial customers.

### **Local Water Supply System**

San Diego is semi-arid with the average rainfall around 10 inches annually. Local water supplies which come from precipitation run-off are stored in nine **reservoirs** (raw water storage facilities): Barrett, El Capitan, Hodges, Miramar, Morena, Murray, Otay, San Vicente, and Sutherland, eight of which are directly connected to water treatment operations. These reservoirs capture local rainwater and runoff to supply up to 20 percent of the City's water if rainfall is normal and less if there is a drought. The City's reservoir system also operates in combination with the imported water system.

### **Purchased (Imported) Water Supply System**

The City of San Diego purchases 75-90% of its water from the San Diego County Water Authority (Water Authority), a wholesale agency that was formed by San Diego and neighboring communities in 1944 to provide imported water by purchasing water from **Metropolitan Water District (MWD)** which supplies the water (raw and treated) through two aqueducts consisting of five pipelines. The imported water is then stored in local reservoirs. The Water Authority connected to MWD in 1946 in order to economically **import Colorado River water** to the San Diego region. The A 242 mile-long San Diego Aqueduct, completed in 1947 brings Colorado River water from Lake Havasu to the Southland. This became the region's first link to MWD.

In the 1940's it became apparent that MWD's Colorado River system was not sufficient to serve the enormous growth of population in Southern California. The State of California created the **State Water Project (SWP)**. This water is captured in reservoirs north of Sacramento and released through natural rivers and streams into the Sacramento-San Joaquin Delta. The water is delivered to southern California through a 444 mile-long aqueduct. MWD purchases water from the SWP and blends Colorado River and SWP water at a facility in Riverside County, and then transfers it to San Diego water treatment plants.

The Water Authority has been working to identify and secure additional sources of water and improve water supply reliability in the region. The Water Authority negotiated the landmark water transfer agreement with the Imperial Irrigation District (IID) for up to 200,000 acre-feet of water.

### **Non Potable (Non-drinkable) Sources of Water Supply**

Large amounts of water used by San Diego customers do not have to be drinking water quality. Examples are golf courses, some agriculture and industrial uses. This opened up the use of treating the effluent (discharged water) from sewer plants. Reclamation plants take this effluent and treat it sufficiently for irrigation, manufacturing and other non-drinking, or non-potable purposes.

The City of San Diego has built the North City Water Reclamation Plant (NCWRP) and the South Bay Water Reclamation Plant (SBWRP) to meet future water demands. These plants treat wastewater to a level that is approved for irrigation, manufacturing and other non-potable purposes. The Water Department maintains and operates the recycled water distribution system. It consists of 66 miles of recycled water pipeline, a 9 MG reservoir and two pump stations. The pipeline sizes vary from 4-inches to 36-inches in diameter. Currently, over 350 meters are signed up for recycled water use; customers include the Torrey Pines Golf Course, Miramar Landfill, University of California at San Diego, CALTRANS, as well as City parks and landscape maintenance districts. Since 1997, the City has successfully marketed and used more than 7.5 billion gallons of recycled water. By implementing water conservation measures and maximizing the use of recycled water, industrial customers can benefit from a program that exempts them from drought related mandatory cutbacks in potable water use. Moreover, recycled water is a local source of water not affected by droughts or water shortages.

## **Water Conservation**

Due to the water supply crisis in the first half of the 2000's, and the threat of further limitations on city water supplies, the City of San Diego has declared a water emergency: Level 1 Drought Watch Condition. The City, in close cooperation with its water wholesalers, continues to evaluate current-year water demand and supply requirements and is calling for increased conservation by all customers.

The City's Water Conservation Program has been and continues to be effective in promoting permanent water savings. To help meet future water demand, the City is planning to continue the popular water conservation programs and introduce new programs aimed at achieving significant water savings in both indoor and outdoor water uses. Pilot programs are also being developed to investigate new technology and systems that become available to San Diegans.

## **Water Treatment System**

San Diego's Water Department maintains and operates three water treatment plants, including

- Miramar Water Treatment Plant, originally constructed in 1962
- Alvarado Water Treatment Plant, operational since 1951
- Otay Water Treatment Plant was originally constructed in 1940

The Department maintains and operates 32 treated water storage facilities, including steel tanks, standpipes, concrete tanks and rectangular concrete reservoirs, with capacities varying from less than 1 million gallons (MG) to 35 MG.

## **Water Supply Delivery System**

The water system consists of approximately 3,460 miles of pipeline, including transmission lines up to 84 inches in diameter and distribution lines as small as 4 inches in diameter.

Underway is the Emergency Storage Project (ESP), scheduled to be completed in 2011 by the Water Authority. This will connect existing sources of water, allowing water to flow throughout the system even in the event a disaster disrupts the region's imported water supply.

## **Emergency Storage**

San Diego City policy mandates that the City store sufficient water (emergency storage) in active, available storage to meet the City normal water demands for at least 7 months. Emergency storage is stored at Lake Skinner (a Metropolitan reservoir) and several City of San Diego reservoirs (San Vicente, El Capitan, Lower Otay, Murray, and Miramar). In addition, the City has made substantial investments in the San Diego Water Authority's Diamond Valley Reservoir.

## New Programs Under Development

### *Satellite Project*

Satellite technology will soon play an integral part of water conservation efforts in San Diego. An innovative new project is underway that will use satellite imagery to create a citywide map designed to determine accurate water budgets for all landscaped areas. In addition to being more cost-effective, the use of satellite images, versus aerial photographs, will provide the city with more expansive land use data. The project is a joint partnership between the U.S. Bureau of Reclamation (USBR), who is funding the project, and the Water Department. AgriCast, Inc., the technical consultant for the project, will turn satellite imagery provided by USBR and the Earth Satellite Corporation from multi-spectral color images into a functioning Geographical Information System (GIS) map. The satellite image map will consist of various color pixels, each representing a 2.5-meter by 2.5-meter (8ft. x 8ft.) area of land. The color pixels in the image are matched to what is on land to show all irrigated landscape plants, such as trees, shrubs or groundcover, by assigning each individual landscape type to a specific pixel color. Accurate areas designated for each landscape type can then be calculated. Once all irrigated landscape areas are accurately accounted for, the Water Department can easily create water budgets based on the needs for each individual plant type per square meter. Comparisons can then be made between data from past water meter readings for irrigation purposes and how much water is actually needed to maintain healthy landscapes. The differing amount between what is needed and what is being used becomes the water that is available for conservation. On average, water budgets show a potential water savings of 20 percent or more.

### Ocean Desalination

Ocean Desalination is a process where salt and other impurities are removed from seawater. Desalinated seawater is used as a potable water supply in many areas of the world where fresh water is deficient and sometimes described as a solution to the San Diego region's over reliance on the Colorado River and Northern California. Although the City of San Diego is not including an ocean desalinated water supply in the 2005 Plan to meet demands in the 2005-2010 timeframe, the City supports the Water Authority in its hard efforts to promote ocean desalination as a viable technology in San Diego County. The City plans to include the further investigation of ocean desalination in the southern area of the City for the time period of 2010-2030 in the Water Resources Implementation Plan that is presently in draft form. In the southern portion of the San Diego Bay there is a potential site at a seawater cooled power generation facility which might provide some suitability for a co-located seawater desalination project. For the purposes of this Plan from 2005 to 2010, seawater desalination is not included as a resource to meet demands.

### Groundwater Desalination

Over the past several years, the Water Department has studied numerous potential groundwater supply options and has a CIP project to continue the quest to develop potential groundwater resources including groundwater desalination. The City is preparing a Water Resources Implementation Plan that will evaluate and recommend groundwater storage and desalination projects for implementation from 2010 to 2020.

**Given these regional efforts to secure more water and storage, and the City's efforts to conserve potable (drinkable) water, maximize the use of recycled water, and consider new alternative sources of water, the City's projected water supply through 2030 looks reasonable in meeting San Diego's future water demand.**

**City of San Diego Water Department Phone: (619) 515-3500**