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City of Avalon
RECYCLED WATER / ENERGY SUSTAINABILITY SUB-PLAN STUDY

June 2016

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CITY OF AVALON
RECYCLED WATER / ENERGY SUSTAINABILITY SUB-PLAN STUDY

JUNE 2016

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- **City of Avalon:**
  Owner of sanitary sewer collection system,
  wastewater treatment facility, and saltwater system

- **Environ Strategy Consultants (ES):**
  Operator of sanitary sewer collection system,
  wastewater treatment facility, and saltwater system

- **Southern California Edison (SCE)**
  Owner and operator of the potable water system

- **Avalon Environmental Services (a CR&R Incorporation)**
  Operator of Avalon's Pebbly Beach Landfill

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Acronyms

ASBS	Areas of Specific Biological Significance
ATW	Advanced Treatment Water
AVX	Catalina Airport
AWOS	Automated Weather Observing System
bgs	Below ground surface
BOD	Biological Oxygen Demand
CDIP	Coastal Data Information Program
CBS	Catherine Booster Station
CCC	California Coastal Commission
CCR	California Code of Regulations
CDP	Coastal Development Permit
CDPH	California Department of Public Health
CEC	California Energy Commission
CLS	Catherine Lift Station
CCT	Chlorine Contact Time
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
DDW	Division of Drinking Water
DPR	Direct Potable Reuse
DWTF	Drinking Water Treatment Facility
EPA	Environmental Protection Agency
ES	Environ Strategy Consultants
ESB	Engineered Storage Buffer
FAAST	Financial Assistance Application Submittal Tool
GFO	Grant Funding Opportunity
gpd	Gallons per day
gph	Gallons per hour
gpm	Gallons per minute
gpy	Gallons per year

GWRS	Groundwater Replenishment System
hp	Horse Power
IPR	Indirect Potable Reuse
Kts	Knots, Nautical Mile
kW	Kilowatt
L	Liter
lb	Pounds
m	meter
MCL	Maximum Contaminant Limit
MF	Micro-filtration
mg	Milligram
mgd	Million gallons per day
mg/L	Milligrams per liter
MPA	Marine Protected Areas
MPN	Most Probable Number
MSL	Mean Sea Level
MW	Megawatt
NL	Notification limit
NOAA	National Oceanic Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
PBLS	Pebbly Beach Lift Station
POTW	Publically Owned Treatment Works
ppm	Parts per million
PSI	Pounds per square inch
PV	Photovoltaic
PVC	Polyvinyl chloride
RAS	Return activated sludge
RMS	Root mean square
RPM	Rotations per minute
SCCOOS	Southern California Coastal Ocean Observing System
SCE	Southern California Edison
Scfm	Standard cubic feet per minute
SCG	Small Community Grant
SMCA	State Marine Conservation Area
SMR	State Marine Reserve
SMP	State Marine Park
SSO	Sanitary Sewer Overflow
SWRCB	State Water Resource Control Board
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
WRFP	Water Recycling Funding Program
WWTF	Wastewater Treatment Facility

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Executive Summary

The City of Avalon (Avalon) is located on Santa Catalina Island off the coast of California, approximately 22 miles southwest of Los Angeles, CA. Santa Catalina Island is 76 square miles, with the majority of that area comprising a conservancy area. Avalon is a resort community, approximately 3.2 square miles in size, surrounding Avalon Bay. Avalon has a permanent population of approximately 3,800 residents. The number of occupants within Avalon fluctuates day-to-day and seasonally as Avalon's primary industry is tourism, which affects the potable water usage, saltwater usage, sanitary sewer discharge flows into the collection system, and the waste water treatment facility operation. Due to the small number of permeant residents, it is difficult for Avalon to generate the appropriate funds to continuously maintain the public infrastructure (i.e. sewer system and saltwater system).

The main purpose of the *Recycled Water / Energy Sustainability Sub-Plan* is to provide feasibility data and assessment to provide Avalon guidance on infrastructure upgrades and replacements that would provide the most sustainable and meaningful benefit (win-win) for The City of Avalon and its residents.

Avalon currently has limited potable water resources, which is a precious resource for all Californians, but even more so for the City of Avalon. Mandatory restrictions go into effect more often for Avalon residents and retailers due to the lack of potable water. Avalon uses saltwater for flushing needs (i.e. toilets, urinals) and fire suppression to help alleviate the demand for potable water, but it comes with several issues as described in this study. This report focuses on win-win solutions that will help alleviate the issues concerning the lack of potable water, the continuous maintenance of the saltwater system, and the corrosion and degradation issues with the WWTF, associated with treating saline waste water. This study focuses on the advantages of converting the waste water treatment facility (WWTF) to a reclamation facility that produces Title 22 Disinfected Tertiary Recycled Water. The use of recycled water will help minimize the corrosion issues associated with the saltwater system (i.e. aesthetics, WWTF degradation, etc.). In addition, the surplus amount of recycled water (after toilet flushing and fire suppression), can be used for irrigation purposes (i.e. golf course, parks, etc.), and also to generate a new potable water source via indirect potable reuse (IPR), as shown in Table ES-1.

In addition, this study investigates sustainable energy opportunities for Avalon to generate its own power. Currently, Southern California Edison (SCE) is the electricity provider for Catalina Island. The SCE power plant uses diesel generators and propane-powered micro-turbines to generate electricity. The diesel and propane have to be shipped, which can cause a reliability issue if something goes wrong with the barge/ship offshore. A key focus of this *Sub-Plan* is to provide the City of Avalon with renewable (sustainable) energy alternatives that could fulfill the Cities power needs (i.e. WWTF, pump stations, City Hall, Fire Department, Cabrillo Mole, etc.) and therefore reduce if not remove electrical payments to SCE.

The following subsections describe the recommended improvements for the City of Avalon concerning recycled water, potable water, and power generation.

Recycled Water

Although the use of the saltwater system for flushing needs helps alleviate the demand for potable water, saltwater has several issues concerning corrosion. The saltwater corrodes the metallic isolation valves at a rapid pace and several of the existing isolation valves are no longer operational. They are costly to replace (approximately $15,000 each) and most times do not get replaced due to budget constraints.

Therefore when a saltwater pipe breaks, it is difficult to isolate the problem without shutting down large areas within the distribution system. This can be a big nuisance to retailers (i.e. restaurants, etc.) who rely on the saltwater system. In addition, saltwater use for toilet flushing creates an aesthetic issue for residents and retailers due to staining of toilet fixtures and increased corrosion. The resulting high total dissolved solids (TDS) in the wastewater causes problems for the WWTF, consisting of increased corrosion of metals and concrete, reduced oxygen transfer capability, and unique sludge dewatering characteristics.

Given the above issues due to the corrosion, aesthetics, and treatment issues associated with the saltwater system, it is beneficial for Avalon to develop a new water source for flushing toilets / urinals and fire suppression. Using potable water is an option, but the main purpose of the saltwater system is to alleviate the demand of potable water. Therefore, the preferred alternative is to convert the existing WWTF into a water reclamation facility capable of producing Title 22 Disinfected Tertiary Recycled Water, which is discussed in Section 5.0 and Section 6.0.

The benefits of replacing saltwater with recycled water include significant reduction in Total Dissolved Solids (TDS) of the generated wastewater, which assists in reduction of metals corrosion, increase in oxygen transfer efficiency of the wastewater treatment process, and increase in efficiency of the sludge dewatering process. In addition, it will increase the useful life of the distribution system.

The proposed Title 22 Disinfected Tertiary Recycled Water reclamation facility will have a capacity of 1.2 mgd. Although the WWTF is designed to produce 1.2 mgd of treated wastewater, the current average wastewater flow is approximately 0.41 mgd with a peak of approximately 0.68 mgd as shown in Table 3-1, which is due to highly encouraged water conservation since the City of Avalon, in addition to the entire State of California, is experiencing an extreme 5-year drought. Therefore, under existing conditions, the recycled water produced would only be capable of fulfilling the saltwater system demand of approximately 0.39 mgd for urinal flushing and fire suppression, as shown in the Table below. If the reclamation facility were able to produce 1.2 mgd, the surplus of approximately 0.81 mgd of recycled water could be available for additional uses, which include, but are not limited to, irrigation (i.e. golf course, parks, etc.) and indirect potable reuse (i.e. Avalon Canyon). Refer to Section 5.0 and Section 7.0 for further discussion on recycled water and potential IPR projects.

Table ES-1 Potential Recycled Water Demand Uses

Potential Use	Demand, mgd
Toilet/Urinal Flushing / Fire Suppression	0.39
Irrigation	0.07
IPR/DPR	0.74
Total	**1.20**

Figure ES-1 illustrates the proposed improvements concerning the treatment process flow schematic at the WWTF, to produce disinfected tertiary recycled water. Figure ES-2 presents the conceptual site plan for the proposed tertiary recycled water treatment system. The secondary effluent is diverted to a new below ground pump station and conveyed to the new gravity multi-media filtration system. The filtered water then flows by gravity to the reconstructed chlorine contact basin for disinfection. It then flows to a new below ground pump station, which conveys the disinfected tertiary recycled water to the existing

Catherine Booster Station (CBS) to connect to the existing distribution system for non-potable water use. The existing ocean outfall will be maintained as a by-pass during low recycled water demand or any off-spec water quality events. The new conveyance pipeline consists of approximately 7,500 lineal feet of 8-inch diameter PVC pipeline. Figure ES-3 illustrates the conceptual pipeline alignment from the WWTF to CBS. Refer to Section 6.0 and 7.0 for further discussion on recycled water.

The capital cost estimate for the proposed recycled water project is approximately $11.6 million. Refer to Table 6-6 for a detailed breakdown of costs. The estimates are based on professional experience and judgement, and have an accuracy of -30% to +50% per American Association of Cost Engineers guideline for conceptual level cost estimates. In addition, refer to Section 6.5, which provides a 5-year implementation plan to finance and construct the recommended recycled water project.

Potable Water

The potable water system for Santa Catalina Island is owned and operated by SCE. Avalon relies on both groundwater and seawater desalination to meet peak demands of the summer months when thousands of tourists visit daily. Groundwater supply is replenished from rain that either fills the reservoirs on the island, or infiltrates into the shallow alluvium deposits that create the aquifer on Catalina Island. The Middle Ranch Reservoir is used to recharge the aquifer then groundwater is pumped through several shallow wells from the aquifer to the Wrigley Reservoir for distribution. Several older wells exist in Avalon Canyon that are being explored by the Santa Catalina Island Company as additional groundwater supply, due to the current extreme drought as described in further detail in Section 7.0.

If Avalon or the Island Company pursue Avalon Canyon as a new potable water source, rather than treating the brackish water pumped from the canyon, the proposed water reclamation facility could be upgraded to produce recycled water suitable for indirect potable reuse (IPR). Refer to Section 5.2.3 for a discussion on IPR. Advanced treated water could be introduced into Avalon Canyon on the upstream end of the basin using injection wells and then recovered from the aquifer through wells in either alluvial aquifer or the bedrock aquifer at the downstream end. The low TDS advanced treated recycled water would “clean up” the basin, reducing the TDS concentration overtime. Detailed studies, incorporating additional extensive subsurface hydrogeological analysis, would be required to determine the feasibility of an IPR project in Avalon Canyon as a new potable water source.

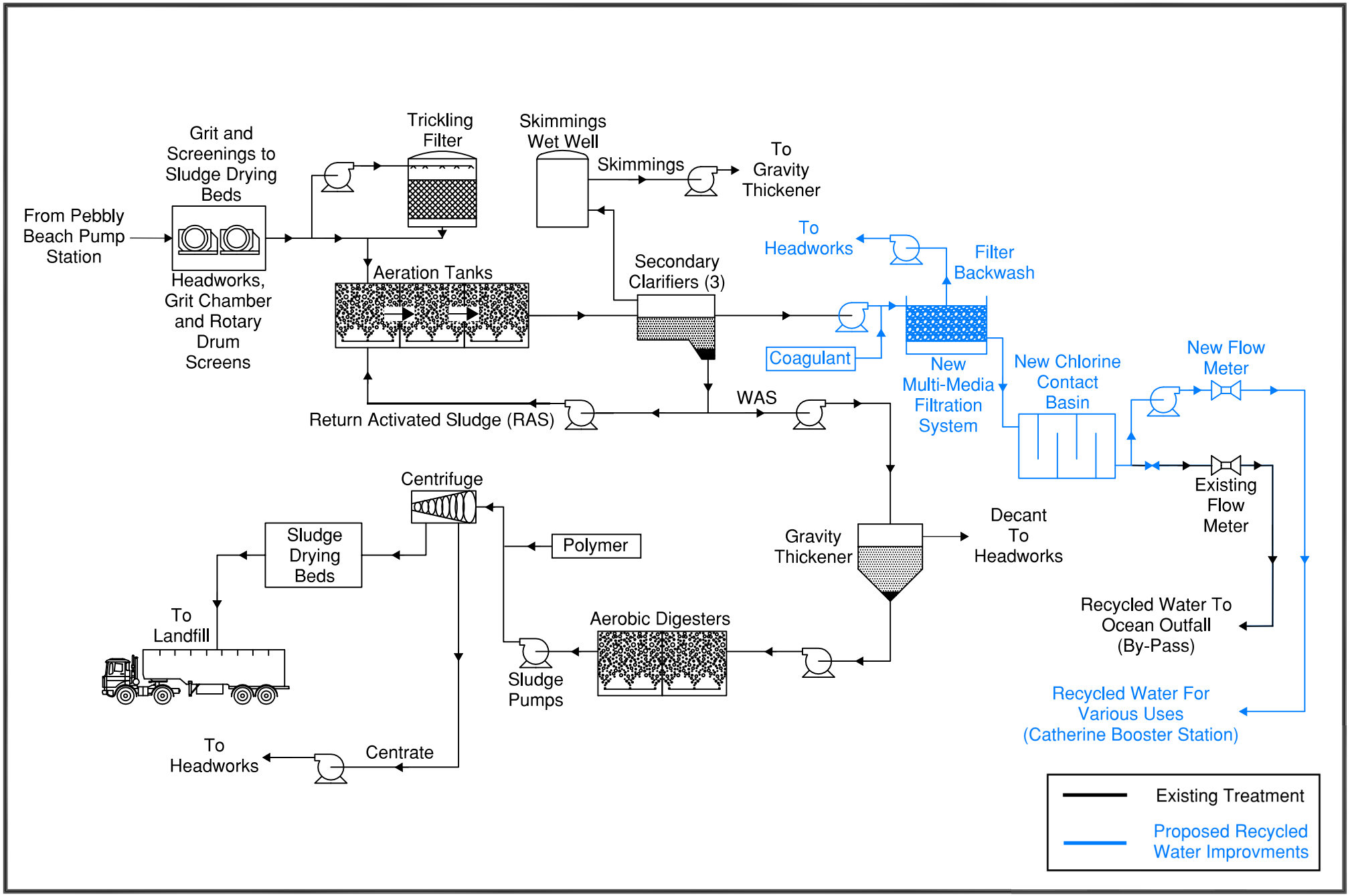
Energy Sustainability

Currently, Southern California Edison (SCE) is the electricity provider for Catalina Island. The SCE power plant uses diesel generators and propane-powered micro-turbines to generate electricity. Diesel and propane are shipped, which can cause a reliability issue if something goes wrong with the barge/ship offshore. A key focus of this *Sub-Plan* is to provide the City of Avalon with renewable (sustainable) energy alternatives that could fulfill the Cities power needs and minimize costs associated with paying SCE for power. The renewable energy alternatives that were investigated, consisted of wave, tidal, wind, and solar power. This study does not look at providing power for the entire City of Avalon, but looking at the power production needs of the City to offset the power costs associated with, but not limited to, the waste water treatment facility, pump stations, City Hall, the Fire Department, Cabrillo Mole, etc. Based on Table 8-1, the peak power usage for the WWTF and booster stations is approximately 2,800 kWh per day.

Section 8.0 provides the renewable alternative energy options for Avalon, that have no carbon footprint because they are based on recovery of solar energy or kinetic energy associated with wind, ocean wave and current motion, or potential energy associated with tidal variations in sea surface elevation.

Several renewable energy alternatives were considered but determined to be infeasible for Avalon due to being a navigational hazard or environmental impact (i.e. Areas of Special Biological Significance, Marine Protected Areas (MPA), bird strikes, etc.). The Catalina Island Conservancy protects the natural and cultural heritage of Santa Catalina Island, stewarding approximately 42,000 acres of land (88% of the island) and at least 50 miles of shoreline (50% of island coastline). Due to this, only two (2) are considered feasible, which are offshore wind turbines and solar power. An offshore wind turbine could provide enough power to fulfill the City of Avalon's direct power demands at a cost of approximately $3 million, which includes one (1) offshore wind turbine and power transmission cable. The other feasible renewable energy alternative is a land based solar array located in the hills above the City. If a feasible area cannot be obtained, City owned rooftops (i.e. City Hall, Fire Department, Schools, Mole, etc.) could be fitted with solar panels to offset Avalon's power needs. The average cost of photovoltaic solar panels is approximately $7 - $10 per watt of rated power. Therefore a solar array would cost approximately $1 million for the City of Avalon's needs.

The California Energy Commission (CEC) offers different grant funding opportunities, low interest financing, as well as other incentives in order to promote innovation and implementation of renewable energy projects throughout California.



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Recycled Water Sub-Plan

Proposed Disinfected Tertiary Treatment Process Flow Schematic Concept

Figure ES-1

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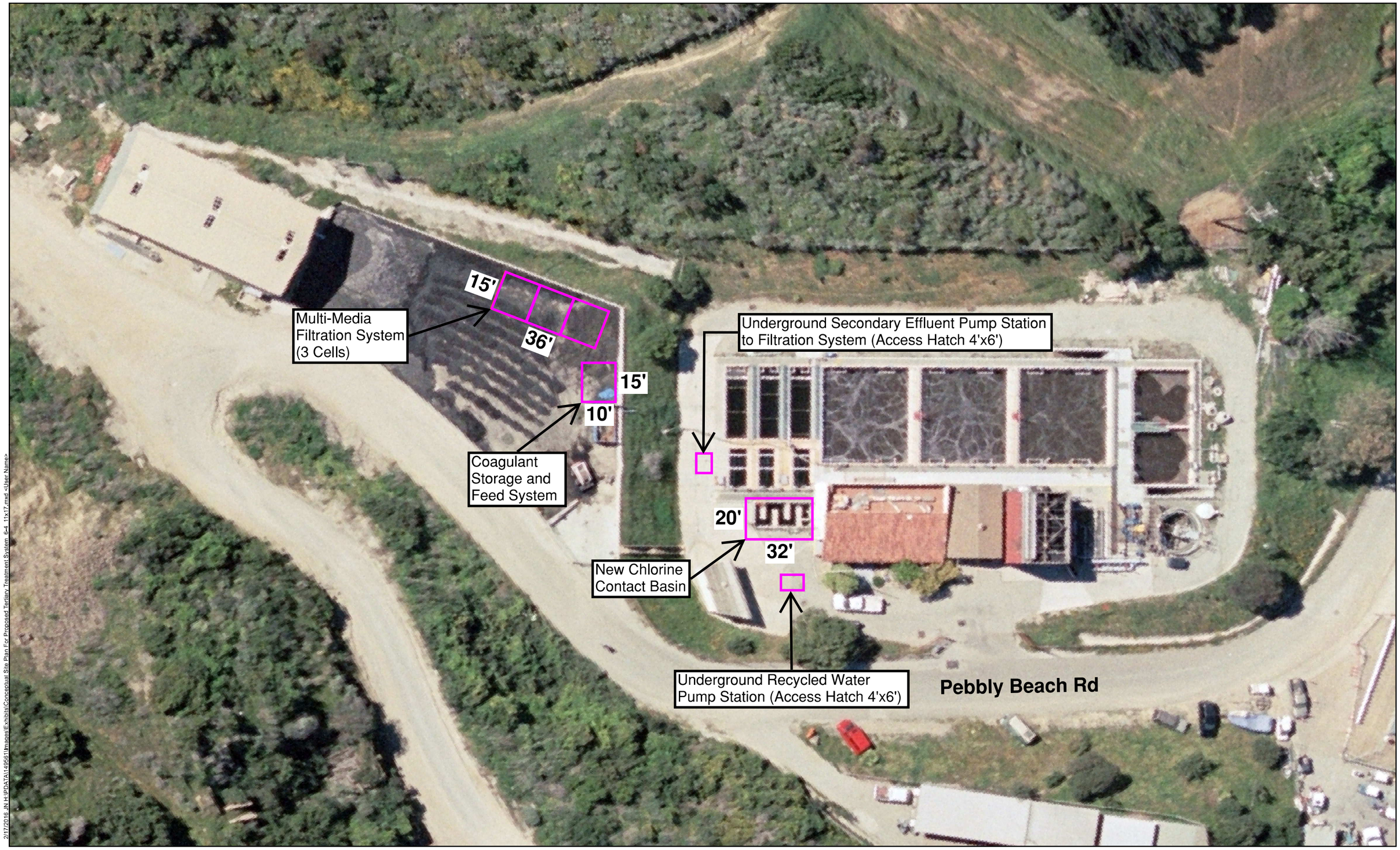

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Conceptual Site Plan For Proposed Tertiary Treatment System

Figure ES-2

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Conceptual Recycled Water Pipeline Alignment

Figure ES-3

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1.0 Introduction

The City of Avalon (Avalon) is located on Santa Catalina Island off the coast of California, approximately 22 miles southwest of Los Angeles, CA. Santa Catalina Island is 76 square miles, with the majority of that area comprising a conservancy area. Avalon is a resort community, approximately 3.2 square miles in size, surrounding Avalon Bay. Avalon has a permanent population of approximately 3,800 residents. The number of occupants within Avalon fluctuates day-to-day and seasonally as Avalon's primary industry is tourism, which affects the potable water usage, saltwater usage, sanitary sewer discharge flows into the collection system, and the waste water treatment facility operation.

Avalon is making extensive efforts to actively maintain and improve Avalon's water resources, sewer collection system, waste water treatment facility (WWTF), and provide a level of service indicative of Avalon's high standards. Avalon has contracted with Environ Strategy (ES) Consultants for the operation and maintenance of their publicly owned WWTF, sanitary sewer collection system, and saltwater system (used for toilets, urinals, and fire suppression). Southern California Edison (SCE) operates Avalon's electrical grid and potable water system, which relies on aquifer recharge from rain and seawater desalination.

Avalon currently has limited resources, when considering potable water and electricity. The purpose of the *Recycled Water / Energy Sustainability Sub-Plan* is to provide feasibility data and assessment to provide Avalon guidance on infrastructure updates and replacements that would provide the most sustainable and meaningful benefit (win-win) for the community.

This study provides a description of each existing utility on the island and the issues associated with them and recommended improvements to increase sustainability within Avalon. Listed below is a brief summary of the utility systems and their issues:

- **Saltwater system:** The saltwater system (described in Section 2.0) is used for flushing toilets, urinals, and fire suppression. Although the use of the saltwater system helps alleviate the demand for potable water, saltwater has several issues concerning corrosion. The metallic isolation valves corrode rapidly due to the saltwater and become inoperable. Therefore, when a saltwater pipe breaks, it is difficult to isolate the problem without shutting down large areas within the distribution system, which leads to higher maintenance, repair, and replacement costs. In addition, saltwater use for toilet flushing creates an aesthetic issue for residents (consumers) due to staining of toilet fixtures and increased corrosion.

- **Sanitary sewer collection system:** The resulting high total dissolved solids (TDS) in the wastewater due to using saltwater to flush toilets and urinals, causes several problems for the WWTF, consisting of increased corrosion of metals and concrete, reduced oxygen transfer capability, and unique sludge dewatering characteristics. Section 3.0 describes in detail the sanitary sewer system and WWTF. This study will look at converting the WWTF to a water reclamation facility, producing tertiary treated water to replace the saltwater system. This in return will reduce the corrosion and unique treatment issues associated with the saltwater system.

- **Potable water system:** The potable water system is owned and operated by SCE. The potable water resources on the island are limited to reservoir storage (rainfall), groundwater recharge (rainfall), and seawater desalination. Refer to Section 4.0 for detailed information concerning the potable water system. If recycled water is implemented, the additional treated water, after replacing the saltwater system demand and potential irrigation demand, could be used for an indirect potable reuse (IPR) project, using recycled water to recharge groundwater aquifers (i.e. Avalon Canyon) as described in Section 7.0. Currently, based on the wastewater flows treated at the WWTF, there would not be additional recycled water supply for either irrigation uses or potable water uses (i.e. IPR/DPR).

- **Electricity:** Electrical service is provided by SCE. SCE currently generates electricity for Catalina Island using diesel generators and propane-powered micro-turbines. Due to being on an island, both diesel and propane need to be shipped to the island, which creates a reliability concern and increase in cost. Therefore, a key focus of this *Sub-Plan* is to provide Avalon with renewable (sustainable) energy alternatives, consisting of wave, tidal, wind, and solar power that could fulfill the City's power demands (i.e. WWTF, City Hall, Fire Dept., etc.), as described in Section 8.0.

The key focus of the *Sub-Plan* is to determine improvement projects that create win-win synergistic opportunities for the City of Avalon and its residents. This study will focus on whether upgrading the WWTF to a wastewater reclamation facility, capable of producing recycled water to replace the existing saltwater system, is feasible and more beneficial than continually maintaining the unconventional and corrosive saltwater system and dealing with its negative implications on the WWTF and residents / business toilet fixtures and piping.

2.0 Saltwater System

Saltwater is used to extend Avalon's limited potable water resources. The saltwater supply and distribution system provides saltwater throughout Avalon's residential and commercial buildings for toilet and urinal flushing and fire suppression. The saltwater system consists of a screened ocean intake and pump station (Catherine Booster Station), distribution pipeline network, two (2) storage reservoirs, and two (2) additional booster pump stations.

2.1 Saltwater Demands

The current average daily saltwater demand is approximately 385,000 gallons as shown in Table 2-1. Saltwater use is primarily based on demand per person and is also used for fire suppression. Fire flow requirement are established by the City Fire Chief, but typically, for adequate fire suppression, a hydrant needs to deliver 1,500 gallons per minute (gpm) for a two-hour period or 180,000 gallons. Additional saltwater demand from potential future development and resulting population increases are estimated at approximately 60,000 gallons per day (gpd).

Table 2-1 City of Avalon Saltwater Demands

Usage	Dwellings or Rooms	Daily Population	Saltwater Allocation Factor (gpd per capita)	Peak Daily Saltwater Demand (gpd)
Permanent	2,289	3,780	15	56,700
Seasonal	600	1,300	15	19,500
Total Dwellings	**2,889**	**5,080**	**15**	**76,200**
Transient Rental	287	861	15	12,915
Hotels	806	2,015	15	30,225
Moorings	346	1,038	10	10,380
Campground	62	124	15	1,860
Total Visitor Housing	**1,501**	**4,038**	**13.75**	**55,600**
Cruise Ship		3,680	5	18,400
Passenger Ship		3,500	15	52,500
Total Day-Visitors		**7,180**	**10**	**72,000**
Fire Suppression				**180,000**
Combined Totals	**4,390**	**16,298**		**383,800**

Dwelling values based on 2030 Avalon Master Plan (CA Dept. of Finance, 2012 Housing Data)

2.2 Saltwater Intake and Distribution

The seawater intake consists of an 18-inch diameter pipeline approximately 350 feet long with an open ocean intake, located in Avalon Bay. Water from the intake is conveyed to the Catherine Booster Station (CBS), located near the intersection of Crescent Avenue and Pebbly Beach Road. CBS contains two (2) constant speed, 100 hp pumps with an approximate capacity of 1,800 gpm and 200 feet of total dynamic head (TDH). Figure 2-1 provides an image of the CBS. CBS pressurizes the saltwater distribution system throughout Avalon, while also filling both Mount Ada and Falls Canyon saltwater reservoirs. The Avalon

saltwater distribution system consists of approximately 24,000 feet of pipelines, ranging in diameter from 4-inch to 12-inch. The distribution pipelines are made of asbestos concrete (AC), but are replaced with PVC on an as needed basis. Refer to Figure 2-4 for an illustration of the saltwater distribution system.

The saltwater distribution system also includes two small booster stations to provide saltwater to the higher elevations within Avalon. These two booster stations known as Hill Street Booster Station and Whittley Booster Station each have 7.5 hp centrifugal pumps that pressurize a 260 gallon hydro-pneumatic (bladder) tank to provide saltwater to the residential units and for fire suppression above Hill Street and along Camino del Monte (elevations above 120 feet). The Hill Street Booster Station is located on Hill Street, east of Vieudelou Avenue. The Whittley Booster Station is located on the corner of East Whittley and Country Club Drive. Figure 2-2 provides an image of each booster station, respectively, while Figure 2-4 illustrates their location.

Figure 2-1. Catherine Booster Station (Saltwater) and Pumps

Figure 2-2. Hill Street and Whittley Booster Stations (Saltwater)

Hill Street **Whittley**

2.3 Saltwater Reservoirs

In addition to the saltwater pipeline distribution system, the system includes two (2) storage reservoirs. The Mount Ada Reservoir is located north of Wrigley road, near the Wrigley Mansion. The Falls Canyon

Reservoir is located north of Cemetery Road, west of Cabrillo Drive. The storage capacity of each reservoir is approximately 300,000 gallons and 420,000 gallons, respectively. Both reservoirs are approximately 220 feet above sea level giving the system sufficient pressure to provide service to most areas within central Avalon up to 170 feet above sea level. Pressure is approximately 80 pounds per square inch (psi) in the Avalon flats area, and the CBS can provide increased pressure. Figure 2-3 provides an image of each reservoir, while Figure 2-4 illustrates their location

Figure 2-3. Falls Canyon and Mount Ada Saltwater Reservoirs

Falls Canyon **Mount Ada**

2.4 Saltwater Issues

Although the use of the saltwater system helps alleviate the demand for potable water, saltwater has several issues concerning corrosion. Metallic isolation valves corrode at a rapid pace and therefore if a saltwater pipeline breaks, it can be difficult to isolate the problem without shutting down large areas within the distribution system. This leads to higher maintenance, repair, and replacement requirements and costs associated with these issues. In addition, saltwater use for toilet flushing creates an aesthetic issue for residents (consumers) due to staining of toilet fixtures and increased corrosion. Furthermore, the resulting high total dissolved solids (TDS) in the wastewater causes several problems for the WWTF, consisting of increased corrosion of metals and concrete, reduced oxygen transfer capability, and unique sludge dewatering characteristics.

Given the above issues due to the corrosion, aesthetics, and treatment issues associated with a saltwater system, it would be beneficial for Avalon to develop a new water source for flushing toilets and fire suppression. Using potable water is an option, but the main purpose of the saltwater system was to alleviate the demand for potable water. Therefore, the preferred alternative is to convert the saltwater system into a recycled water system, which is discussed in Section 5.0 and Section 6.0.

The benefits of replacing saltwater with recycled water would be a significant reduction in TDS of the generated wastewater, which assists in reduction of metals corrosion, increase oxygen transfer efficiency of the wastewater treatment process, and increase in efficiency of the sludge dewatering process at the WWTF.

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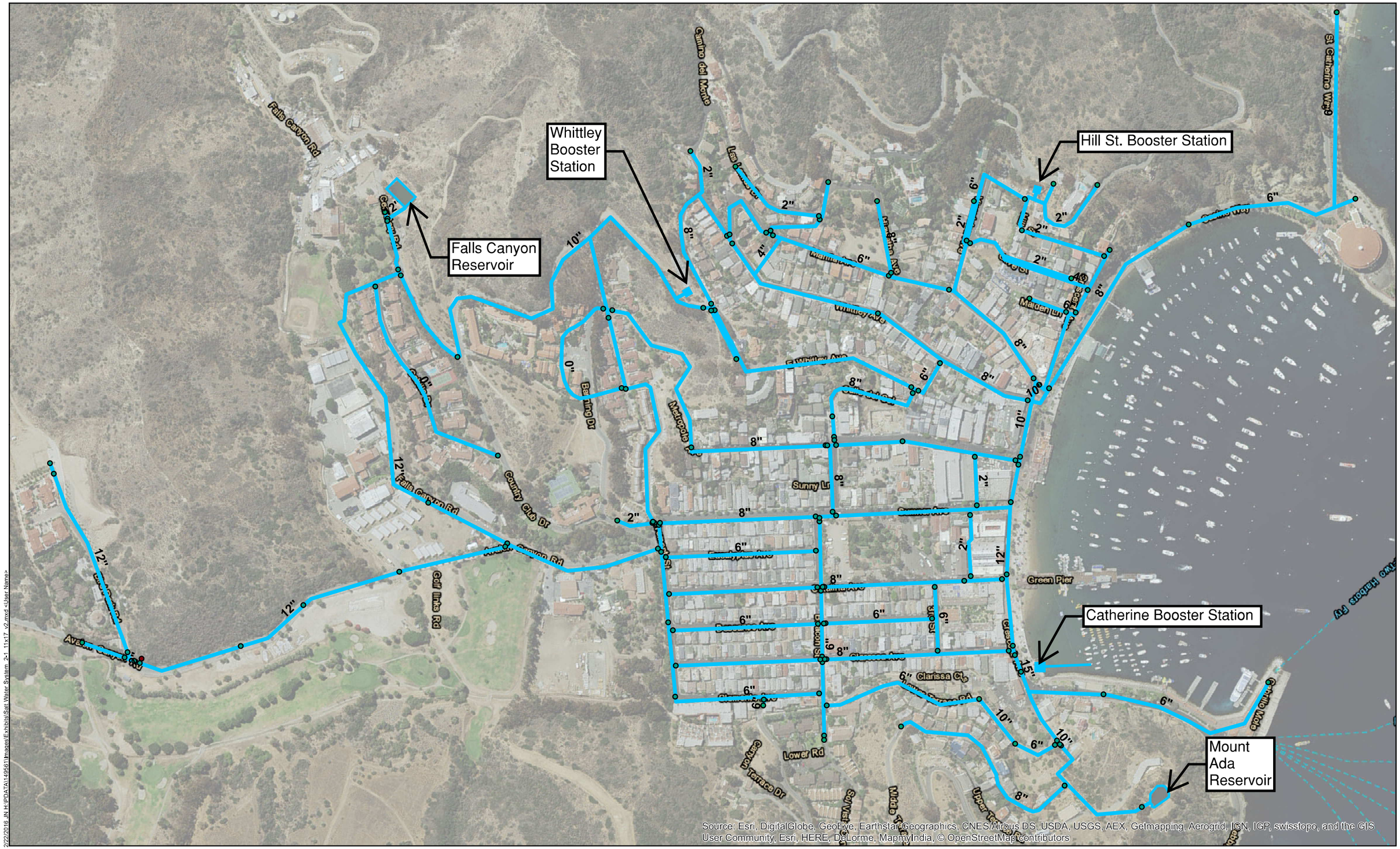

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Michael Baker INTERNATIONAL

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Source:

RECYCLED WATER SUB-PLAN

Saltwater Distribution System

Figure 2-4

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3.0 Sanitary Sewer Collection System

Avalon is making extensive efforts to actively maintain and improve Avalon's sewer collection system, reduce sanitary sewer overflows (SSOs), and provide a level of sewer service indicative of Avalon's high standards. Avalon has taken action by completing a comprehensive inspection of the entire sewer collection system to assess the condition of each pipeline within the system. Avalon has also contracted with ES for the operation and maintenance of their WWTF, sewer collection system, and saltwater system.

The sanitary sewer collection system runs through city streets, alleys, and easements, and consists of approximately 7.1 miles of gravity pipes ranging in size from 6-inch to 18-inch as well as 1.2 miles of 16-inch and 12-inch force mains, as shown in Figure 3-6 and Figure 3-7. The system dates back to the 1920s and has recently undergone significant rehabilitation and replacement. The force main consists of pressurized and gravity pipeline segments, varying in size and material. Low flow diverters are installed at the Crescent Avenue storm drain inlets that divert nuisance dry weather surface water and the initial storm water flow for a storm to the sewer system. The saltwater (seawater) used to flush toilets and urinals makes Avalon's wastewater highly corrosive due to the salinity.

3.1 Wastewater Flows

The WWTF has an average dry weather design capacity of 1.2 million gallons per day (mgd). However, due to the extreme conservation measures that have been implemented over the past few years because of a historic drought affecting all of California, the wastewater flows to the WWTF have decreased significantly. Table 3-1 below provides the average daily flows treated at the WWTF for each month from July 2014 to December 2015. Since July 2014, the average daily flow is approximately 0.41 mgd. The peak flow since July 2014 is approximately 0.70 mgd. A report prepared by Malcom Pirnie in November 1997 (*Benchmark Engineering Report for the City of Avalon Wastewater Treatment Plant Improvements*), provided peak monthly flowrates as high as 1.3 mgd, proving the drastic reduction in wastewater flow over the past two decades.

Table 3-1 City of Avalon Wastewater Flows (2014-15)

Year 2014	Average Flow	Year 2015 (con't)	Average Flow
Jul	0.53	Apr	0.36
Aug	0.47	May	0.38
Sep	0.38	Jun	0.42
Oct	0.36	Jul	0.55
Nov	0.34	Aug	0.51
Dec	0.36	Sep	0.46
Year 2015	**Average Flow**	Oct	0.43
Jan	0.32	Nov	0.39
Feb	0.32	Dec	0.36
Mar	0.36		
Avg. Day	**0.41**	**Avg. Month**	**0.41**
Min. Day	**0.22**	**Min. Month**	**0.32**
Max. Day	**0.68**	**Max. Month**	**0.53**

NOTE: All flows shown in table are in million gallons per day (mgd)

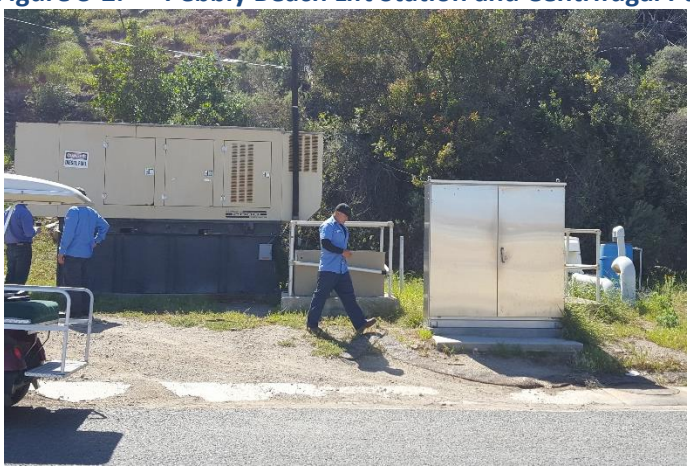
3.2 Wastewater Lift Stations

The Catherine Lift Station (CLS) is located in the heart of Avalon near the intersection of Crescent Avenue and Pebbly Beach Road. The CLS serves as the initial lift to convey wastewater collected from Avalon to the WWTF. Figure 3-1 provides an image of the CLS, while Figure 3-4 illustrates the location of the CLS. The CLS was reconstructed in early 2000, and consists of a dry well/wet well configuration. The wet well collects the raw wastewater from Avalon's gravity sewer collector system and the dry well houses the pumps and controls. The CLS has two (2) Flygt centrifugal pumps, model 3153 (see Figure 3-1).

Figure 3-1. Catherine Lift Station and Centrifugal Pump

Pebbly Beach Lift Station (PBLS), is located along Pebbly Beach Road near the SCE power generating facility. The PBLS serves as the final lift to the WWTF. Figure 3-2 provides an image of the lift station, while Figure 3-4 illustrates its location. The PBLS collects raw wastewater from the industrial complex in Pebbly Beach, in addition to wastewater pumped from the CLS. Based on As-built drawings, the PBLS was constructed in 1981. Based on the site reconnaissance, the pump configuration was changed at some point after initial construction. The PBLS has three (3) Flygt centrifugal pumps, model 3171.

Figure 3-2. Pebbly Beach Lift Station and Centrifugal Pumps



A pump test was performed in August 2011 on both the CLS and the PBLS pumps, which noted, the cast iron impellers were extensively deteriorated due to the highly saline wastewater. Since that time, Environ Strategy has rebuilt the pumps (new seals, lubricant, etc.) and replaced the impellers with new chrome blades that are better suited for the high TDS wastewater. This proactive O&M program has increased pump longevity, reliability, and efficiency. One of the several advantages of converting the saltwater system into a recycled water system is the increased useful life of the sewer lift stations.

3.3 Wastewater Treatment Facility

The WWTF, as shown in Figure 3-3, was originally constructed in 1973 with major improvements in 1987. From 1988 to 2011, United Water Services operated and maintained the WWTF and sewer collection system. Since February 2011, ES has taken over O&M duties. A unique characteristic of Avalon's wastewater is the salinity or high level of TDS due to the use of saltwater for Avalon's toilet flushing system. The high TDS in the wastewater causes several problems for the WWTF, which consists of increased corrosion of metals and concrete, reduced oxygen transfer capability, and unique sludge dewatering characteristics.

The WWTF has an average dry weather design capacity of 1.2 million gallons per day (mgd). Under emergency circumstances, it can treat up to a rate of 2.0 mgd for a short period of time. The treated wastewater is discharged to the Pacific Ocean through an ocean outfall approximately 400 feet off Pebbly Beach at a depth of approximately 130 feet below the surface. The WWTF consists of the following unit processes: rotary drum screens, grit chamber, trickling filter, extended aeration, secondary clarifiers, and chlorination. Figure 3-4 illustrates the existing WWTF's process flow schematic and Figure 3-4 illustrates a plan view of the WWTF. Further details related to design of each unit process are described in the following subsections.

Figure 3-3. Avalon Wastewater Treatment Facility

Source: Catalina Island Blog Website

3.3.1 Headworks

The existing headworks consists of two (2) rotary drum screens (1 duty + 1 standby) to remove large solids. Each screen has a hydraulic capacity of 1,750 gpm and is operated by a two speed motor. The screened wastewater flows into an aerated grit chamber, which consists of three chambers. The grit is removed from each chamber with an air lift and placed in a grit settling channel located at grade. When the channel becomes full with grit, the grit is vacated and placed on the sludge drying beds for further dewatering. The grit chamber pump is a 3-inch diameter air lift with a capacity of 100 gpm and 2 feet of lift. The air flow rate per lift is 8 scfm. The maximum daily flow rate capacity of the three hoppers is 55 ft^3.

3.3.2 Trickling Filter

The trickling filter is used to provide biological wastewater treatment utilizing a non-submerged fixed-film biological reactor using plastic packing over which wastewater is distributed continuously. Biological treatment occurs as the liquid flows over the attached biofilm. The existing trickling filter is 29 feet by 19 feet with a media depth of 18 feet. Three (3) feed pumps (2 duty + 1 standby) supply wastewater from the grit chamber effluent to the filter. Each pump has a capacity of 210 gpm with 30 feet of head. The filter is operating as a super high rate filter with a typical five day biological oxygen demand (BOD5) removal efficiency of 65-80%.

3.3.3 Aeration Basins and Secondary Clarifiers

Aeration basins are used to provide biological wastewater treatment in which microorganisms are responsible for the conversion of the organic matter or other constituents in the wastewater to gases and cell tissues are maintained in suspension within the liquid. Air is introduced to the process via blowers to provide dissolved oxygen for the microorganisms' growth. Secondary clarifier is a settling tank built with mechanical means for continuous separation and removal of solids/biomass produced in the biological process in the aeration basins. There are three (3) aeration basins, 40 feet by 40 feet with a 13 feet side water depth, which are operated in series. The basins operate as a conventional aeration system with nitrification in the summer and as an extended aeration system with nitrification in the winter. The design criteria for aeration basins during peak season include the applied BOD5 loading rate of 22-27 lb/day per 1,000 ft^3 and hydraulic detention time of 10-12 hours. The three (3) secondary clarifiers are rectangular (50 feet by 12 feet) and have a water depth of 8 feet. The design criteria for the secondary clarifiers during peak season include the overflow rate of 500-600 gpd/ft^2 and solids loading rate of 0.64-0.68 lb./hr.ft^2.

3.3.4 Chlorine Contact Basin

Chlorine contact basin is used to ensure proper contact time for disinfection of secondary treated effluent using calcium hypochlorite solution in order to maintain approximately 1.0 to 2.0 mg/L of free residual chlorine in the system. The existing chlorine contact basin consists of a rectangular serpentine concrete structure with total volume of approximately 21,000 gallons (dimensions: 25' L x 10' W x 11' D). Chlorine is injected in the chlorine contact basin influent in form of calcium hypochlorite solution, which is prepared onsite for the disinfection of the treated wastewater. The chemical feed system includes one (1) metering pump with the capacity of 3.2 gph and a polyethylene storage tank.

3.3.5 Gravity Thickener

Gravity thickening is accomplished in a tank for removal of water from sludge (Waste Activated Sludge) to achieve reduction in the volume of sludge for greater efficiency in subsequent processes. The dilute

sludge is fed to the gravity thickener tank to settle and compact, and the thickened sludge is withdrawn from the bottom of the tank. The thickened sludge would be pumped to the aerobic digesters for further treatment prior to the final solids dewatering process. The existing gravity thickener is 16.7 feet in diameter and has a sidewall depth of 5.5 feet to thicken the waste activated sludge (WAS) prior to aerobic digestion process. The gravity thickener was designed for the unthickened sludge concentration of approximately 0.5-0.6% and thickened sludge concentration of approximately 2% during the peak season.

3.3.6 Aerobic Digesters

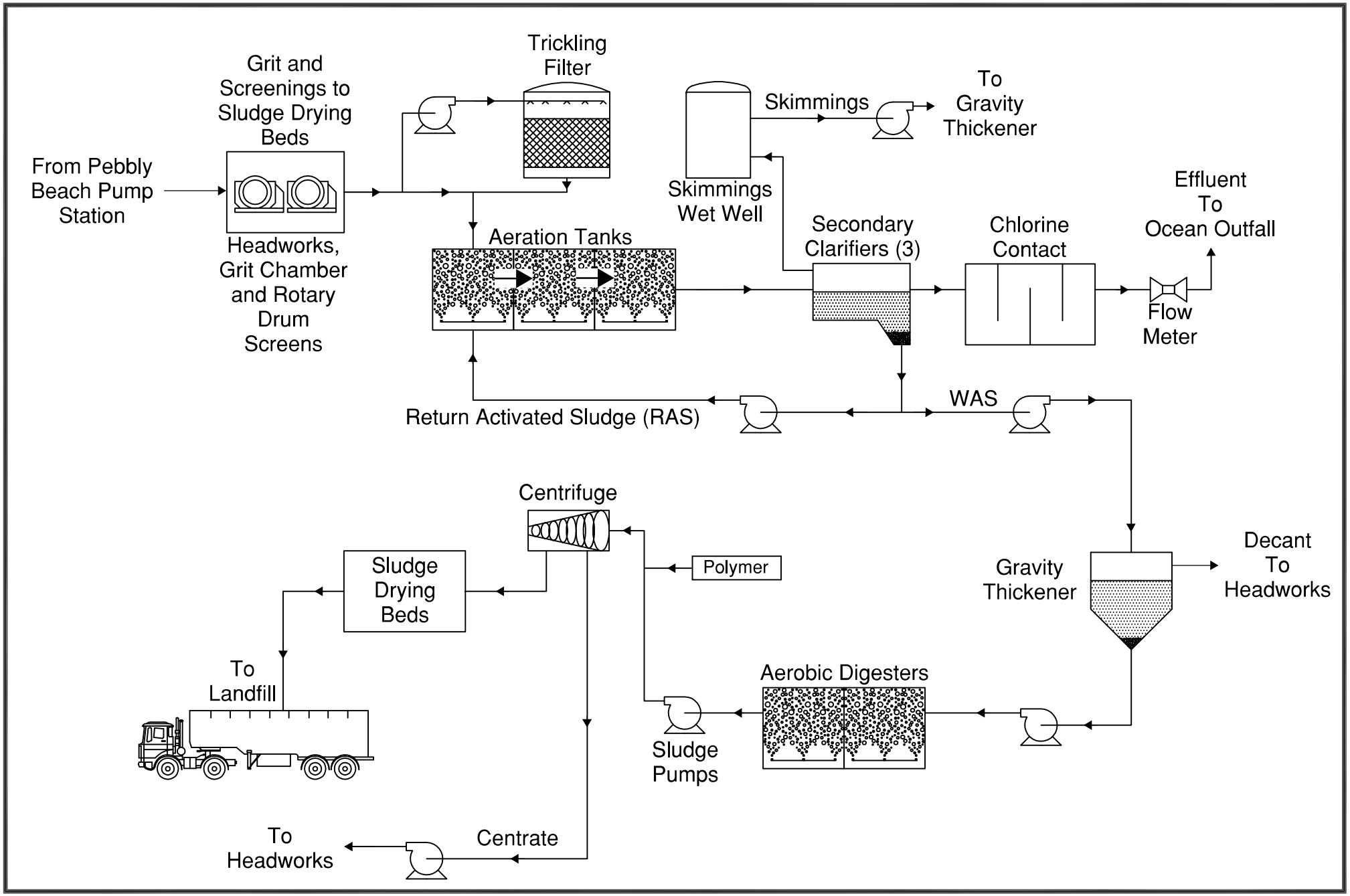
Air is introduced to the process via blowers to provide dissolved oxygen for the microorganisms' growth. Two (2) aerobic digesters (23.5 feet by 25 feet with a depth of 13 feet) treat the thickened sludge from the gravity thickener effluent. The design criteria for the aerobic digesters include solids retention time of 14 days and solids loading rate of 0.07 lb/day per cubic feet.

3.3.7 Solids Processing

Solids processing is a physical unit operation used to reduce the moisture content of the sludge from the aerobic digestion process. This dewatering process is achieved by utilizing a centrifuge system, which is one of the mechanical devices for dewatering. The centrifuge system is a high speed process that uses the force from rapid rotation of a cylindrical bowl to separate solids from liquid. The existing solids processing facilities include centrifuge systems and a polymer feed system. There are two (2) centrifuge systems (1 duty + 1 standby) capable of dewatering sludge to approximately 20-25% (by weight) solids cake. Discharge cake from the centrifuge is conveyed to the sludge drying beds where the material is further dewatered by evaporation for approximately 2-3 weeks (weather permitting) before it can be disposed of in the landfill.

3.3.8 Sludge Drying Beds

The final step of the dewatering process consists of sludge drying beds, approximately 9,000 square feet in size. The beds utilize natural sunlight to evaporate moisture from the sludge to produce a solids content of approximately 50 percent (by weight) for final disposal at the Pebbly Beach landfill. Sand is sometimes added to the sludge to assist in achieving the solid content. If the solids content is 55 percent, the landfill can use it as daily cover.



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Recycled Water Sub-Plan

Existing Wastewater Treatment Facility Process Flow Schematic

Figure 3-4

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Source:

RECYCLED WATER SUB-PLAN

Existing Wastewater Treatment Facility

Figure 3-5

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RECYCLED WATER SUB-PLAN

Sanitary Sewer Collection System

Figure 3-6

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Sanitary Sewer Collection System

Figure 3-7

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4.0 Potable Water System

The potable water system for Santa Catalina Island is owned and operated by Southern California Edison (SCE). Avalon uses both groundwater and seawater desalination as sources for potable water. The major water facilities on the Island that specifically serves Avalon are illustrated in Figure 4-1 and listed below:

- 1 Open top raw water storage reservoir (Middle Ranch Reservoir))
- 3 Groundwater wells for potable use (Middle Ranch Wells)
- 1 Covered treated water reservoir (Wrigley Reservoir)
- 6 Storage tanks
- 2 Seawater desalination units

The other water systems shown in Figure 4-1, including the Toyon well and tank, supply smaller cities/retreats on the island such as Two Harbors, the Catalina Airport (AVX), and Whites Landing which do not affect the Avalon water system.

Figure 4-1. Potable Water System

Source: Southern CA Edison Catalina Island Potable Water System Fact Sheet

4.1 Potable Water Demands

Table 4-1 below provides the potable water demand for Avalon. Potable water resources and their availability in the future are threatened by changing climatological conditions, increasing population growth, potential contamination, and other external factors. As potable water supplies dwindle, the cost

of fresh water continues upward with availability for non-potable water uses steadily decreasing. Several states have adopted or are considering regulations that mandate the use of recycled water for non-potable uses in locations where it is readily available and in close proximity to potential users.

Table 4-1 City of Avalon (SCE) Potable Water Demands

Year 2014													
Utility Category	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Yearly**
Residential	3.0	3.3	3.8	4.3	4.2	4.7	5.9	4.1	4.3	3.1	2.6	2.7	**46.0**
Commercial	3.6	2.9	3.3	4.4	3.9	4.8	5.9	5.9	4.9	3.8	3.0	2.2	**48.6**
Public Agency	0.5	0.3	0.2	0.5	0.4	0.5	0.6	0.6	0.4	0.4	0.4	0.4	**5.2**
*Based on Data from SCE, all values shown in million gallons												**Sum=**	**99.8**

Year 2013													
Utility Category	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Yearly**
Residential	4.0	3.5	4.0	4.4	5.1	5.2	6.7	6.7	5.8	4.7	4.0	3.5	**57.6**
Commercial	2.6	2.6	4.0	4.5	5.5	5.2	6.6	7.0	5.0	6.0	3.5	3.5	**56.0**
Public Agency	0.2	0.2	0.4	0.4	0.8	0.6	0.9	1.1	3.0	0.6	0.4	0.5	**9.1**
*Based on Data from SCE, all values shown in million gallons												**Sum=**	**123**

4.2 Groundwater

Avalon relies on groundwater to supplement the desalination plant on peak demand days of the summer months when thousands of tourists visit daily. Groundwater supply is replenished from rain that either fills the inland reservoir (Middle Ranch), or infiltrates into the shallow alluvium deposits that create the aquifer on Catalina Island. Middle Ranch Reservoir is the main inland reservoir, used to recharge the aquifer. Thompson Dam impounds the ground and surface water runoff into Middle Ranch Reservoir. The reservoir and surrounding aquifer are hydraulically linked. The three (3) Middle Ranch wells pump groundwater from the shallow aquifer to Pump House No. 2 for treatment, and then convey the potable water to Wrigley Reservoir for storage and distribution to the City of Avalon, as shown in Figure 4-1.

Several older wells (non-potable) exist in Avalon Canyon that are being explored as additional groundwater supply due to the current extreme drought as described in further detail in Section 7.0. Currently they are being used for irrigation at the golf course and softball fields. Last year, the Island Company drilled three (3) new wells in bedrock, as potential production wells. As of this study, there is no plan or schedule to connect them to the potable water system.

4.3 Seawater Desalination

SCE began providing desalinated potable water to Avalon in 1991. In December of 2015, SCE added a second seawater desalination unit to supplement Avalon's potable water needs during the extreme drought to avoid escalating water rationing to Stage 3 (50% reduction).

Seawater (feedwater) for the desalination plant is obtained from the two (2) Quarry Seawater Wells on the South-East side of Catalina Island, as shown in Figure 4-1, and conveyed to the Pebbly Beach Generation Station where the seawater desalination units are located. These units utilize reverse osmosis, a process that uses high pressure and membrane filters in order to produce potable water from saltwater.

Several possible operating modes exist for the SCE Pebbly Beach Desalination Facility, as described below:

- **Mode 0:** Base mode or existing mode where the original desalination unit is in operation and the new unit is in standby.
- **Mode 1:** Seawater is first desalinated through the original desalination unit, producing a concentrate (brine) flow, which is a much higher salinity than that of the original seawater. The brine is then conveyed to the second desalination unit to produce additional potable water by using a second stage of reverse osmosis.
- **Mode 2:** Would have the newest desalination unit in operation and the original unit in standby.
- **Mode 3:** Would have both units operating in parallel and would require an additional seawater well, as well as new auxiliary equipment for the new desalination unit. The concentrated brine that is produced is then pumped back out into the ocean and diffused in order to ensure adequate mixing and salinity dilution.

Before the new desalination unit can begin operation, dilution testing must be performed to ensure the diffuser can handle the extra discharge or extra concentrated discharge while maintaining the permitted dilution requirement. The original desalination unit has a maximum potable water production capacity of 200,000 gal/day and the new desalination unit has a maximum capacity of 125,000 gal/day. The combined 325,000 gal/day maximum capacity is capable of providing Avalon's yearly resident population's average potable water demand.

4.4 Potable Water Issues

The need for water rationing in Avalon is determined by the water level in Middle Ranch Reservoir. The total capacity of Middle Ranch Reservoir is 1,149 acre-feet. Due to the limited potable water resources in Avalon, SCE has developed Mandatory Water Conservation restrictions which are described below:

- **Stage 1:** Stage 1 is declared when Middle Ranch Reservoir falls below 600 acre-feet. When this occurs, SCE restricts the use of water through meters that have known leaks for individual private washing of vehicles, structures, lots, sport courts, irrigation and landscaping by means other than drip irrigation, construction purposes, pools, spas, hot tubs, or decorative fountains, water service in restaurants unless requested by patron, and restricts the irrigation times to early mornings and late evenings.
- **Stage 2:** Stage 2 is declared when Middle Ranch Reservoir falls below 300 acre-feet and has the same restrictions as Stage 1 with the added restriction of irrigation times limited to Tuesdays and Fridays from 6 pm-7 pm and users' water usage is cut to 75% of their base water usage amount which is determined from their 12-month water usage prior to the most recent Stage 1 declaration.
- **Stage 3:** Stage 3 is declared when Middle Ranch Reservoir falls below 200 acre-feet and has the added restriction of limiting irrigation to just the one hour in the evening on Tuesdays and users' water usage is cut to 50% of their base water usage.

- **Stage 4:** Stage 4 is declared when Middle Ranch Reservoir falls below 50 acre-feet and prohibits the use of potable water for irrigation completely and users' water usage is cut to 25% of their base water usage. The users that do not comply with Mandatory Water Conservation and Rationing are first given a warning. The second offense results in a $50 fine and the installation of a flow restricting device. The third offense results in a $100 fine and the reinstallation of a flow restricting device. Every offense after that increases by $100 until it reaches a maximum of $500 and the reinstallation of a flow restricting device.

As of April 28, 2016, the water volume in Middle Ranch Reservoir is 185 acre-feet; a water volume below 200 acre-feet would normally cause Avalon to go into Stage 3 Water Rationing of 50% reduction, however, the addition of a second desalination unit and the near 40% reduction in overall water usage across the island has kept water rationing to a 25% reduction.

5.0 Recycled Water

Potable water resources and their availability in the future are threatened by changing climatological conditions, increasing population growth, potential contamination, and other external factors. As potable water supplies dwindle, the cost of fresh water continues on an upward spiral with availability for non-potable water uses steadily decreasing. Several states have adopted or are considering regulations that mandate the use of recycled water for non-potable uses in locations where it is readily available and in close proximity to potential users.

Recycled or reclaimed water by definition refers to water derived from wastewater that has been treated at a wastewater treatment facility to very high quality standards in accordance with state and federal requirements. Recycled water is not drinkable but it is suitable for beneficial and controlled uses that do not require potable water quality. Beneficial uses may include landscape and turf irrigation, agricultural irrigation, toilet flushing, geothermal energy production, natural habitat restoration, recreational impoundments, groundwater recharge, stream augmentation, seawater intrusion prevention, and cooling towers/boiler systems makeup.

5.1 Regulatory Considerations

Use of recycled water for various non-potable applications involves several sets of regulatory requirements. The following subsections provide an overview of the federal and state regulations that govern recycled water use.

5.1.1 Federal Requirements

The Clean Water Act (CWA) requires that all discharges of pollutants to surface waters (streams, rivers, lakes, bays, and oceans) must be authorized by a permit issued under the National Pollutant Discharge Elimination System (NPDES) program. Under the CWA, the EPA has the authority to implement the NPDES program. The EPA may authorize states to implement all or parts of the national program. Once approved, a state would gain the authority to issue permits and administer the program. In the absence of state assumption of NPDES authority, the EPA operates the NPDES program by direct implementation. Because recycled water continues to be treated as a municipal wastewater, it must meet secondary biological treatment standards at a minimum. Beyond this basic level of treatment, there are no other federal requirements specifically related to recycled water use of such water.

5.1.2 State of California Requirements

Regulations for recycled water are defined in Title 22 (Social Security), Division 4 (Environmental Health), Chapter 3 (Water Recycling Criteria) of the California Code of Regulations (CCR). On July 1, 2014, the authority, duties, powers, purposes, functions, responsibilities, and jurisdiction for enforcement of potable water and recycled water regulations was transferred from the California Department of Public Health (CDPH) to the State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW).

California defines four (4) different types of Title 22 recycled water quality, which are:

1. Disinfected Tertiary Recycled Water;
2. Disinfected Secondary-2.2 Recycled Water;

3. Disinfected Secondary-23 Recycled Water; and

4. Un-disinfected Secondary Recycled Water.

Each type of Title 22 recycled water quality undergo a different level of treatment to satisfy end-use requirements. The description of each type of Title 22 recycled water is provided below:

Disinfected Tertiary Recycled Water

Disinfected tertiary recycled water is defined as a filtered and subsequently disinfected wastewater that meets the following requirements:

a. The filtered wastewater has been disinfected by either:

   i. A chlorine disinfection process following filtration that provides a chlorine residual/contact time value of not less than the 450 milligram-minute per liter at all times with a modal contact time of at least 90 minutes, based on peak dry weather design flow.

   ii. A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of plaque forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of demonstration.

   iii. The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 milliliters.

b. In addition, the filtered wastewater must be oxidized and passed through natural undisturbed soils or a bed of filter media pursuant to the following:

   i. At a rate that does not exceed 5 gallons per minute per square foot of surface area in mono, dual, or mixed gravity, upflow or pressure filtration systems, or does not exceed 2 gallons per minutes per square foot of surface area in traveling bridge automatic backwash filters; and

   ii. So that the turbidity of the filtered wastewater does not exceed any of the following:

      1. An average of 2 Nephelometric Turbidity Unit (NTU) within a 24-hr period.

      2. 5 NTU more than 5 percent of the time within a 24-hour period; and

      3. 10 NTU at any time.

Disinfected Secondary-2.2 Recycled Water

Disinfected secondary-2.2 recycled water is defined as recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a MPN of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in 30 days period.

Disinfected Secondary-23 Recycled Water

Disinfected secondary-23 recycled water is defined as recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a MPN of 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 240 per 100 milliliters in more than one sample in any 30 day period.

Undisinfected Secondary Recycled Water

Undisinfected secondary recycled water is oxidized wastewater. Oxidized wastewater is wastewater in which the organic matter has been stabilized, is non-putrescible and contains dissolved oxygen. Each state provides the regulations and guidelines for the type of the recycled water and its non-potable direct use for various applications.

In high population areas where businesses and industries are most likely to be located, the majority of California water recycling agencies produce and distribute recycled water meeting the highest quality in accordance with the Disinfected Tertiary standard. Table 5-1 provides a summary of allowable non-potable uses for each recycled water type.

Table 5-1 Allowable Non-Potable Uses based on Treatment Level

Type of Recycled Water Use	Recycled Water Treatment Level			
	Disinfected Tertiary	Disinfected Secondary-2.2	Disinfected Secondary-23	Un-disinfected Secondary
Urban Irrigation Uses				
Parks and playgrounds	✓			
School yards	✓			
Residential landscaping	✓			
Unrestricted access golf courses	✓			
Cemeteries	✓	✓	✓	
Freeway landscaping	✓	✓	✓	
Restricted access golf courses	✓	✓	✓	
Impoundment Uses				
Source of water supply for non-restricted recreational impoundments	✓[1]			
Source of water supply for restricted recreational impoundments	✓	✓		

Type of Recycled Water Use	Recycled Water Treatment Level			
	Disinfected Tertiary	Disinfected Secondary-2.2	Disinfected Secondary-23	Un-disinfected Secondary
Publicly accessible impoundments at fish hatcheries	✓	✓		
Landscape impoundments that do no utilize decorative fountains	✓	✓	✓	
Cooling Water Uses				
Industrial or commercial cooling or air conditioning that involves the use of a cooling tower, evaporative condenser, spraying or any mechanism that creates a mist	✓2			
Industrial or commercial cooling or air conditioning that does not involve the use of a cooling tower, evaporative condenser, spraying or any mechanism that creates a mist	✓	✓	✓	
Agricultural Irrigation Uses				
Food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop	✓			
Food crops where the edible portion is produced above ground and not contacted by the recycled water	✓	✓		
Food crops that must undergo commercial pathogen-destroying processing before being consumed by humans	✓	✓	✓	✓
Orchards where the recycled water does not come into contact with the edible portion of the crop	✓	✓	✓	✓
Vineyards where the recycled water does not come into contact with the edible portion of the crop	✓	✓	✓	✓
Non-food bearing trees (Christmas trees are included provided no irrigation with recycled water occurs for a period of14 days prior to harvesting or allowing access to the general public	✓	✓	✓	✓
Fodder and fiber crops and pasture animals not producing milk for human consumption	✓	✓	✓	✓
Seed crops not eaten by humans	✓	✓	✓	✓
Ornamental nursery stock and sod farms where access by the general public is not restricted	✓	✓	✓	
Pasture for animals producing milk for human consumption	✓	✓	✓	
Any nonedible vegetation where access is controlled so that the irrigated area cannot be used as if it were part of a park, playground or school yard	✓	✓	✓	
Ornamental nursery stock and sod farms provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access to the general public	✓	✓	✓	✓

Type of Recycled Water Use	Recycled Water Treatment Level			
	Disinfected Tertiary	Disinfected Secondary-2.2	Disinfected Secondary-23	Un-disinfected Secondary
Other Uses				
Flushing toilets and urinals	✓			
Priming drain traps	✓			
Industrial process water that may come into contact with workers	✓			
Structural fire fighting	✓			
Decorative fountains	✓			
Commercial laundries	✓			
Consolidation of back fill around potable water pipelines	✓			
Artificial snow making for commercial outdoor use	✓			
Commercial car washes including hand washes if recycled water is not heated, where the general public is excluded from the washing process	✓			
Industrial boiler feed	✓	✓	✓	
Nonstructural fire fighting	✓	✓	✓	
Backfill consolidation around non-potable piping	✓	✓	✓	
Soil compaction	✓	✓	✓	
Mixing concrete	✓	✓	✓	
Dust control on roads and streets	✓	✓	✓	
Cleaning roads, sidewalks and outdoor work areas	✓	✓	✓	
Industrial process water that will not come into contact with workers	✓	✓	✓	
Flushing water for sanitary sewers	✓	✓	✓	✓

Notes:

1. Requires conventional treatment where conventional treatment utilizes a sedimentation unit between coagulation and filtration and produces an effluent that meets the definition of disinfected tertiary recycle. If conventional treatment is not used, the recycled water must be monitored for pathogens in accordance with Section 60305(b) of Title 22.

2. If a cooling tower is used or if a mist is created that could into contact with employees or the public, the cooling system shall have a drift eliminator whenever the cooling system is in operation and a chlorine or other biocide shall be used to treat the cooling tower recirculation water to minimize the growth of Legionella and other microorganisms.

5.2 City of Avalon Potential Recycled Water Uses

Based on the identification of allowable recycled water uses provided in Table 5-1, the following subsections of this report discuss the potential uses of recycled water for Avalon. The potential uses of the recycled water include:

- Toilet flushing (replacing existing saltwater use) and fire suppression;

- landscape irrigation; and
- Indirect or direct potable reuse (IPR/DPR).

Although the WWTF is designed to produce 1.2 mgd of treated wastewater, the current average wastewater flow is approximately 0.41 mgd with a peak of approximately 0.68 mgd as shown in Table 3-1. This is due to highly encouraged water conservation since the City of Avalon, in addition to the entire State of California, is experiencing an extreme 5-year drought. Therefore, under existing conditions, the recycled water produced would only be able to replace the saltwater system demand of approximately 0.39 mgd for urinal flushing and fire suppression, as shown in in Table 2-1.

5.2.1 Replace Saltwater Use

Recycled water can be used in lieu of saltwater for the toilet flushing and fire suppression purposes. The benefits of replacing saltwater with recycled water would be significant reduction in total dissolved solids (TDS) of the generated wastewater, which assists in reduction of metals corrosion, increase oxygen transfer efficiency of the wastewater treatment process, and increase in efficiency of the sludge dewatering in the WWTF. Title 22 identifies the treatment criteria for use of disinfected tertiary recycled water for toilet flushing as follows:

"Section 60307: Use of Recycled Water for Other Purposes – Recycled water used for the following shall be disinfected tertiary recycled water, except that for filtration being provided pursuant to Section 60301.320(a) coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filter is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes:

1. Flushing toilets and urinals,
2. Priming drain traps,
3. Industrial process water that may come into contact with workers,
4. Structural firefighting,
5. Decorative fountains,
6. Commercial laundries,
7. Consolidation of backfill around potable water pipelines,
8. Artificial snow making for commercial outdoor use, and
9. Commercial car washes, including hand washes if the recycled water is not heated, where the general public is excluded from the washing process.

5.2.2 Irrigation

Recycled water can widely be used for landscape irrigation replacing valuable potable water use. Irrigation water does not need water treated to potable levels, and does not discharge water back into the wastewater system. In addition, site conversions can be achieved with lower risk of cross connections with the potable water system and more control over human contact since separate piping for the irrigation use will be in place. Title 22 identifies the treatment criteria for use of disinfected tertiary recycled water for irrigation as follows:

"Section 60304: Use of Recycled Water for Irrigation – Recycled water used for the surface irrigation of the following shall be a disinfected tertiary recycled water, except that for filtration pursuant to Section 60301.320(a) coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filter is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes:

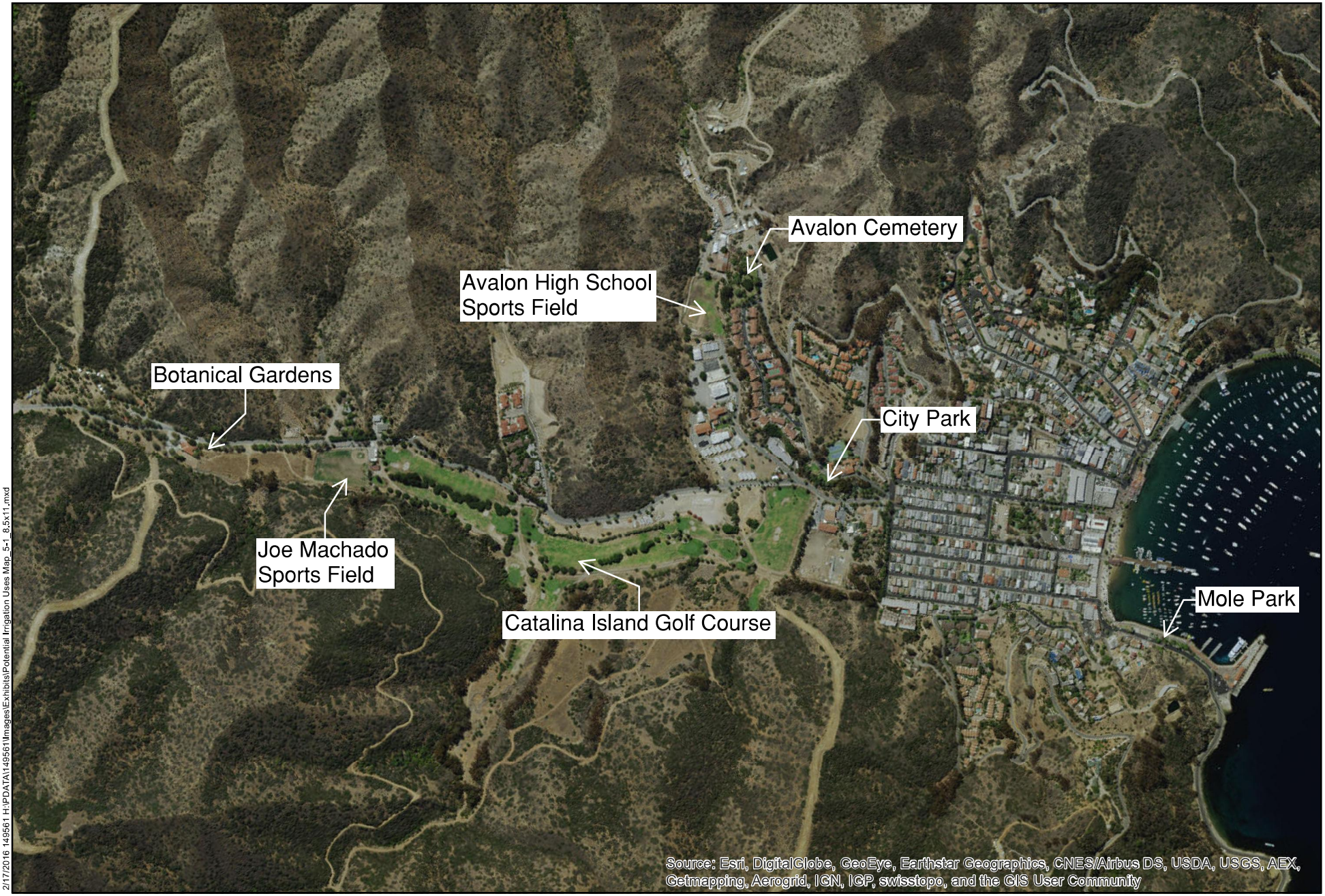
1. Food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop,
2. Parks and playgrounds,
3. School yards,
4. Residential landscaping,
5. Unrestricted access golf courses, and
6. Any other irrigation use not specified in this section and not prohibited by other sections of the California Code of Regulations."

In Avalon, several sites exist that could substitute their use of potable water with recycled water for irrigation purposes. Table 5-2 lists Avalon's largest consumers of water for irrigation. The largest demand belonging to the Avalon Golf Course. In addition to the large irrigation demands, several potential smaller demands exist, like the planters along Crescent Avenue and Casino Way.

Table 5-2 Avalon Irrigation Demands

Location	Quantity (gpd)
Avalon Golf Course	53,600
Joe Machado Field	4,700
Avalon Cemetery	6,800
City Park	3,000
Mole Park	2,000
Total	**70,100**

Based on data from City of Avalon



2/17/2016 149561 H:\PDATA\149561\Images\Exhibits\Potential Irrigation Uses Map_5-1_8.5x11.mxd

Michael Baker INTERNATIONAL

0 500 1,000 2,000 Feet

Source:

RECYCLED WATER SUB-PLAN

Potential Recycle Water Irrigation Uses

Figure 5-1

5.2.3 Indirect or Direct Potable Reuse (IPR / DPR) Considerations

Potable reuse involves treatment of wastewater with the express purpose of converting it into a source of potable water. There are two forms of potable reuse:

(1) **Indirect Potable reuse (IPR),** in which treated wastewater is introduced into an environmental buffer (e.g., a groundwater aquifer or surface water reservoir, lake, or river) before the blended water is introduced into a water supply system; and

(2) **Direct Potable Reuse (DPR),** in which highly treated wastewater is introduced at various locations into an existing potable water supply system.

Indirect Potable Reuse

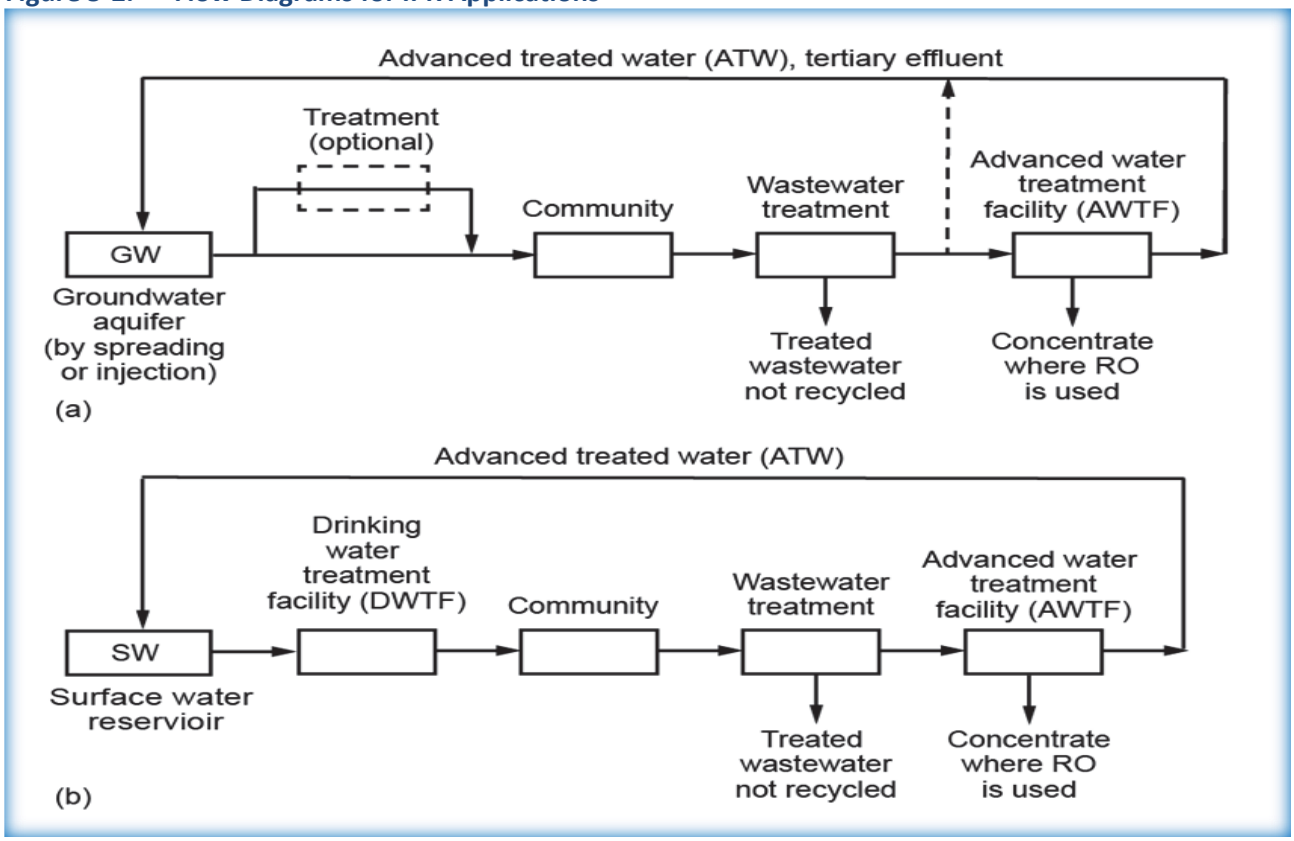
In an IPR process, Advanced Treated Water (ATW) or tertiary effluent is introduced into an environmental buffer before being withdrawn for potable purposes. The purpose of the environmental buffer is to provide storage and transport; however, the environmental storage of highly treated water, if not stabilized or mixed with other water, can also add contaminants and degrade the water (e.g., dissolution of metals from groundwater aquifer or microbial and other contaminants in surface impoundments).

In Figure 5-2(a), the environmental buffer is a groundwater aquifer. The advanced treated water can be applied by spreading or direct injection, whereas tertiary effluent is applied by spreading to take advantage of soil aquifer treatment. IPR through the recharge of groundwater aquifer has been practiced in California for several years, including the Orange County Water District's Groundwater Replenishment System (GWRS). In addition, Padre Dam Municipal Water District is currently conducting the Advanced Water Purification Demonstration Project for potable reuse from recycled water. The Orange County GWRS injection wells are located at the Talbert Gap Barrier area with at least 12 months of retention time for the recycled water in the groundwater basin before the water is extracted for drinking purposes, and a minimum horizontal separation of 2,000 feet between the Talbert Gap Barrier injection wells and all potable water wells. Other Orange County GWRS injections wells are located at the Kraemer/Miller Basin with at least 6 months of retention time and a minimum separation of 500 feet between the Basin and any potable water wells in the area.

In Figure 5-2(b), a surface water reservoir or other water body serves as the environmental buffer. It is important to note that when the volume of the reservoir or other water body does not meet required dilution and storage requirements, the proposed IPR project becomes a DPR project.

California has adopted regulations for groundwater recharge IPR projects that address both pathogen and chemical constituents. For pathogens, the California State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) requires IPR treatment to achieve at least 12-log reduction of enteric virus, 10-log reduction of *Giardia* cysts, and 10-log reduction of *Cryptosporidium* oocysts from raw wastewater. Log reduction credits may be applied to all treatment processes provided. The regulations also include limits for chemical constituents (e.g., MCLs), notification levels (NLs), and other constituents specified by DDW.

Figure 5-2. Flow Diagrams for IPR Applications



Source: WateReuse Research Foundation; Framework for Direct Potable Reuse

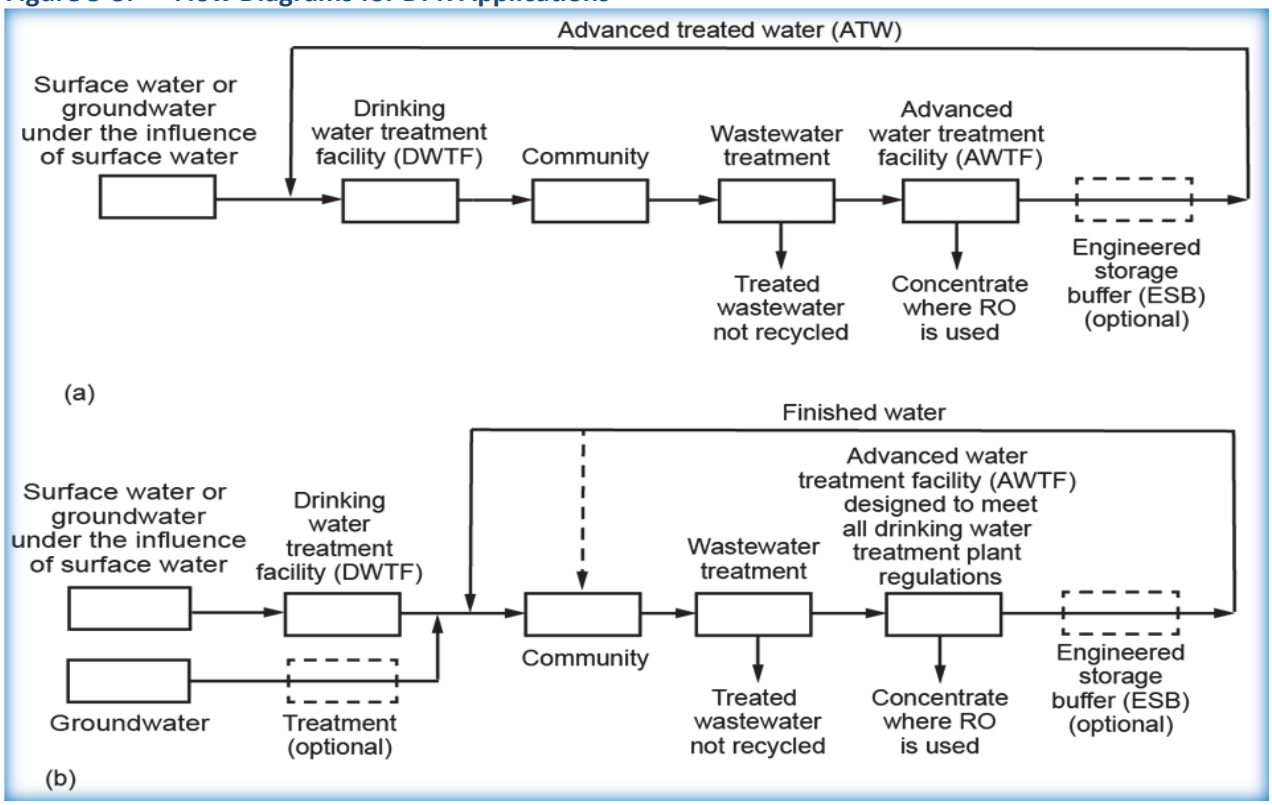
Direct Potable Reuse

There are two forms of DPR in use today: one involves advanced treated water (ATW), and other involves finished water. Both forms are illustrated in Figure 5-3 as follows:

- In Figure 5-3(a), ATW is introduced with or without the use of an engineered storage buffer (ESB) into the raw water supply immediately upstream of a drinking water treatment facility (DWTF). To date, permitted operational DPR projects in the United States involve this form of DPR.
- In Figure 5-3(b), finished water is directly introduced with or without the use of an ESB into a potable water supply distribution systems, either downstream of a DWTF or within the distribution system.

Currently, federal regulations do not exist specifically for DPR, and no state has yet to develop specific regulations for DPR. California has existing regulations for IPR via groundwater recharge and is in the process of developing criteria for surface water reservoir augmentation. The California Water Code (CWC) requires California to adopt IPR regulations for surface water augmentation by the end of 2016. Furthermore, the CWC requires that the Division of Drinking Water (DDW) of the California State Water Resources Control Board (SWRCB) investigate the feasibility of developing criteria for DPR and provide a final report on that investigation to the legislature by the end of 2016.

Figure 5-3. Flow Diagrams for DPR Applications



Source: WateReuse Research Foundation; Framework for Direct Potable Reuse

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6.0 Recycled Water Treatment Alternatives

6.1 Introduction

The secondary treated wastewater at Avalon's WWTF must be further processed to achieve the desired effluent quality before it can be used for beneficial reuse as discussed in Chapter 5 of this report. Tertiary treatment consisting of coagulation, filtration, and disinfection will be required to meet the performance objectives of the California Recycled Water Criteria (Disinfected Tertiary Title 22 Recycled Water) as described in Chapter 5 of this report. The tertiary treatment system will be designed to have an average dry weather design capacity of 1.2 million gallons per day (mgd), which is the current treatment capacity of the WWTF. The potential uses of the 1.2 mgd of recycled water is provided in Table 6-1 below.

Although the WWTF is designed to produce 1.2 mgd of treated wastewater, the current average wastewater flow is approximately 0.41 mgd with a peak of approximately 0.68 mgd as shown in Table 3-1, which is due to highly encouraged water conservation since the City of Avalon, in addition to the entire State of California, is experiencing an extreme 5-year drought. Therefore, under existing conditions, the recycled water produced would only be capable of fulfilling the saltwater system demand of approximately 0.39 mgd for urinal flushing and fire suppression, as shown in in Table 2-1.

Table 6-1 Potential Recycled Water Demand Uses

Potential Use	Demand, mgd
Toilet / Urinal Flushing and Fire Suppression	0.39
Irrigation	0.07
IPR/DPR	0.74
Total	**1.20**

6.2 Tertiary Treatment Processes

In the following subsections, tertiary treatment requirements are described for filtration, disinfection, and solids processing.

6.2.1 Filtration System

Tertiary filters are designed to provide additional polishing of secondary treated wastewater to remove suspended organic and inorganic solids. Addition of coagulant upstream of the filtration system would aid in the removal performance of the filter for suspended solids removal. Four filtration alternatives have been considered for evaluation for this project. These include the following systems:

- Multi-Media Gravity Filters
- Multi-Media Pressure Filters
- Cloth Disk Media Filters
- Immersed Membrane Filters

Each filtration system alternative is discussed in detail in the following subsections. The conceptual design criteria for each alternative are summarized in Table 6-2.

Multi-Media Filtration

Multi-Media filtration is one of the most common and effective methods for removal of suspended organic and inorganic solids from water. Common filter materials used in the filters are silica sand, crushed anthracite coal, and garnet or ilmenite. These media can be used alone or in dual and triple combinations. A number of properties of a filter medium are important in affecting filtration performance and also in defining the medium. These properties include size, shape, density, and hardness. The porosity of the granular bed formed by the grains is also important.

Table 6-2 Conceptual Design Criteria for Filtration Alternatives

Process Component	Multi-Media Gravity Filter	Cloth Disk Media Filter	Multi-Media Pressure Filter	Membrane Filter
Filtration	▪ No. of Filters: 3 ▪ Filtration Rate: 4 gpm/ft^2 w/1 unit offline ▪ Dimensions(each): 10.5' (L) x 10.5' (W)	▪ No. of Units/Disks: 3/6 ▪ Hyd. Loading Rate: 4 gpm/ft^2 w/1 unit offline ▪ Dimensions (each): 12' (L) x 10' (W)	▪ No. of Filters: 3 ▪ Filtration Rate: 4 gpm/ft^2 w/1 unit offline ▪ Dimensions (each): 12' Diameter	▪ No. of Units: 3 ▪ Design Flux Rate: 20 gfd w/ 1 unit offline ▪ Dimensions (each): 12' (L) x 10' (W)
Backwash Waste Stream	▪ Daily Volume: 20,000 – 40,000 gpd	▪ Daily Volume: 10,000 – 20,000 gpd	▪ Daily Volume: 20,000 – 40,000 gpd	▪ Daily Volume: 60,000 – 120,000 gpd

Granular media filtration involves a variety of complex mechanisms to achieve particulate removal. Transport mechanism brings the small particles from the bulk of the fluid within the interstices close to the surfaces of the grains. As particles approach the surface of a grain, or previously deposited solids on the grain, short-range surface forces must be favored for attachment to occur. The collision and attachment process is comparable to coagulation of destabilized particles. Chemical pretreatment with coagulants aids in particulate removal in depth filtration. Coagulants serve to flocculate the colloidal-sized particles into larger particles, which enhance the removal efficiency.

The filters are classified in two basic hydraulic types: gravity and pressure. Gravity filters are open to the atmosphere, and flow through the medium is achieved by gravity. Pressure filters utilize a pressure vessel to contain the filter medium. Water is delivered to the vessel under pressure and leaves the vessel at slightly reduced pressure due to headloss through the system.

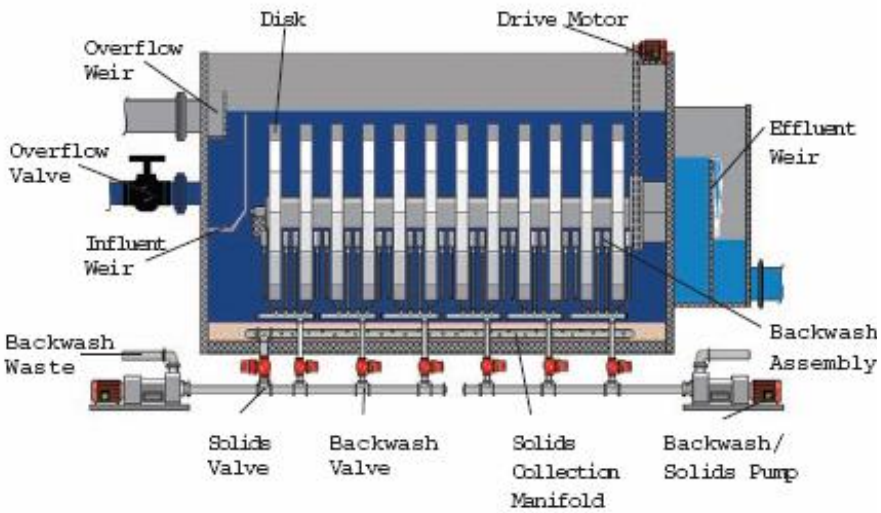
The preliminary design criteria for both gravity and pressure filtration systems are presented in Table 6-2. For this situation, both filters would be designed to backwash once per day, for approximately 20 minutes, with backwash being supplied by backwash supply pumps.

Cloth Disk Media Filtration

The cloth disk media filter involves the use of a cloth membrane as the filter medium. The cloth membrane is a simple random weave fabric that is used to separate the particles from the fluid to be filtered. The density and thickness of the filter cloth is selected according to the characteristics of the influent wastewater and desired effluent quality. Disks covered by the cloth media are mounted vertically to a common hollow tube. The number of disks mounted on the tube can be varied depending on the filtration area required. Wastewater passes through the cloth media, and enters inside the filter disks. Filtered effluent is conveyed through the hollow tube. The filter is quiescent during the filtration operation, which

allows larger particles to settle to the bottom of the tank. The sedimentation of larger size particles within the filter basin decreases the amount of solids to be filtered. Figure 6-1 illustrates a typical configuration of a cloth disk media filter.

Figure 6-1. Cloth-Media Disk Filter Schematic (AquaDisk System)



The pressure loss across the membrane increases as more particles are accumulated and a mat is formed on the surface of the membrane. The backwash operation is started when the terminal headloss (usually 12 inches of water) or a certain run time is reached. Accumulated particles are removed from the surface of the cloth media by liquid suction applied to each side of the disk. Disks rotate slowly (approximately one revolution per minute) allowing each segment to be cleaned. A backwash vacuum shoe is mounted on each side of the filter disk. The accumulated solids are vacuumed from the media as the disk rotates past the shoes. Filtration occurs through the remainder of the filter disk resulting in continuous filtration operation. The vacuuming effect is created through the use of a backwash pump. Filtered water is used for backwash, therefore a separate clean water tank is not required as part of the backwash system. Disks are usually backwashed in multiples of two. Large particles which have settled in the filter basin are removed through sludge assembly piping connected to the backwash pumps. The backwash system typically consists of one to two backwash pumps (depending on the number of disks within the filter basin), sludge assembly piping, motorized valves, and associated piping. The backwash system is often located to the side of a filter basin in a pump gallery at the same elevation as the filter disks.

The conceptual design criteria for the cloth-media disk filter alternative are presented in Table 6-2. The cloth disk filter system would consist of three filter units. These filter units would be programmed so that each filter would backwash approximately 8 hours apart from each other under normal operational conditions.

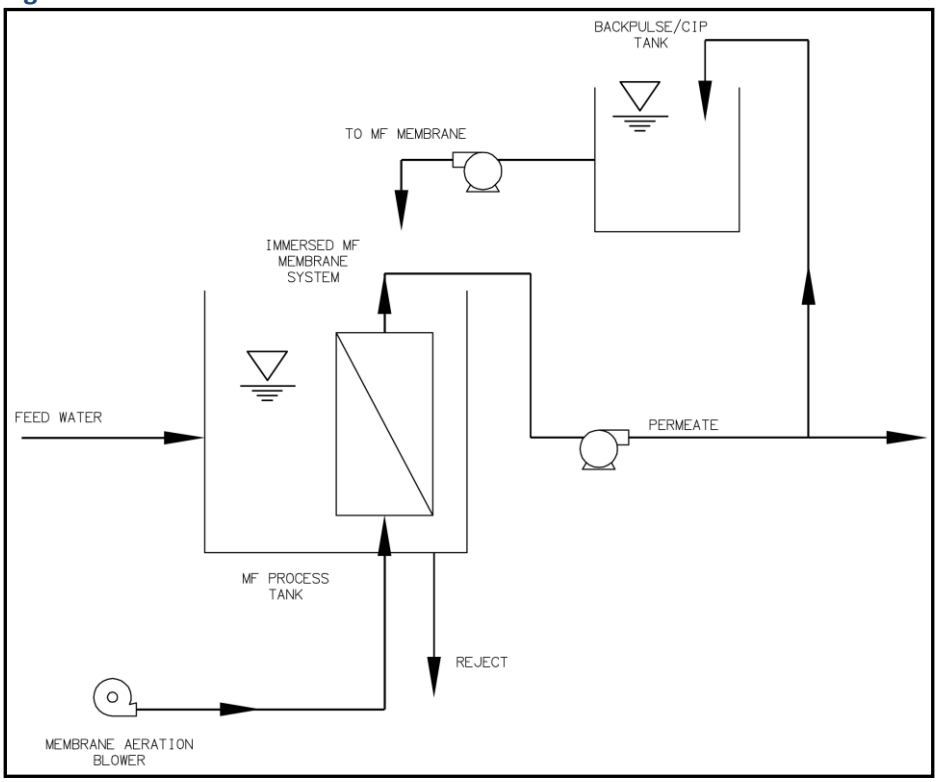
Immersed Membrane Filtration

Micro-filtration (MF) and ultra-filtration (UF) membranes are being widely used as tertiary treatment for secondary effluent. Membrane filtration operates on the principle of particle separation based on a pore size and pore size distribution. Membranes are made of a number of materials such as ceramic, polymers, and sintered metals. Polymeric membranes are the most common membranes in water and wastewater applications.

Membranes require trans-membrane pressure to drive the clean water through the membrane, leaving behind the concentrate containing the separated particles and solids. The trans-membrane pressure required to operate membrane plants can be induced by pressure or by vacuum.

Vacuum driven hollow fiber membranes are configured as outside-in hollow fiber MF or UF modules immersed in the feed wastewater. The membranes operate under a small suction pressure (-2 to -5 psi) created within the hollow fibers by a permeate pump. The treated water passes through the membrane, enters the hollow fibers and is pumped out to distribution by the permeate pumps. Air flow is introduced at the bottom of the membrane module to create a turbulence which scrubs and cleans the outside of the membrane fibers allowing them to function at a higher flux rate.

Figure 6-2. Process Flow Schematic of Immersed Membrane



The membranes are backwashed approximately every 30 minutes, for approximately 3 minutes, with water and air-water mixture. The backwash (or purge) process is staggered to reduce peak flow requirements for back wash pumps and waste back wash handling systems.

Figure 6-2 illustrates a process flow schematic of an immersed membrane system. The conceptual design criteria for the membrane filtration system alternative are shown Table 6-2.

Analysis of Alternative Filtration Systems

The alternative filtration systems as described in the above subsections were analyzed conceptually against the following criteria to be the most feasible and cost-effective:

- Capital Cost
- Annual Operation and Maintenance (O&M) Cost
- Ease of Operation
- Institutional and Regulatory Issues

Each alternative is assigned ranking criteria from High, Medium, and Low for the purpose of the comparison. A summary of alternative filtration systems conceptual evaluation is provided in Table 6-3. The gravity multi-media filtration system and pressure multi-media filtration system have low capital and O&M costs. In this case, the gravity multi-media filtration alternative would be favored due to its long and successful track record and reliability, and its operational stability and ease of operation. The gravity multi-media filtration alternative has a distinct permitting advantage over the cloth disk filtration alternative, in that it will not require pilot testing, and it has been approved many times for Title 22 applications.

Table 6-3 Conceptual Alternative Filtration Systems Evaluation

Description	Multi-Media Gravity Filter	Cloth Disk Media Filter	Multi-Media Pressure Filter	Membrane Filter
Capital Cost	Low	Medium	Low	High
Annual O&M Cost	Low	Low-Medium	Low	High
Ease of Operation	High	Medium	High	Low
Institutional and Regulatory Issues	Low	High	Low	Medium

The cloth media filtration alternative will require pilot testing and has limited track record of acceptance in the state as a Title 22 alternative filtration technology. Finally, Michael Baker believes that the conventional filtration technology will be more readily accepted by Avalon's WWTF operation staff, and that it is the most reliable process for producing high quality recycled water for various non-potable use applications. Therefore, the gravity multi-media filtration system is selected for the purpose of this study, and the conceptual capital cost estimate for this alternative are provided in the following subsections of this report for the proposed tertiary treatment system.

6.2.2 Filter Backwash Waste Stream

As presented in Table 6-2, for multi-media gravity filters, approximately 20,000-40,000 gpd of backwash waste will be generated from the filters backwash operation. Several locations within the WWTF process could be considered for returning the filters backwash waste stream, including the headworks, aeration basins, or secondary clarifiers. However, the WWTF process design should be further evaluated during preliminary design phase for this additional solids inventory in the biological reactors, and this could cause problems with the solids sedimentation in the reactors, as well as solids overloading of the secondary clarifiers.

6.2.3 Disinfection

The tertiary treated water must be disinfected in order to meet the Title 22 criteria for recycled water use. Disinfection can be achieved by utilizing the existing calcium hypochlorite solution feed system, and enlarging and reconfiguring the existing chlorine contact basin to meet Title 22 disinfection requirements. The chlorine contact basin would need to be designed to provide a chlorine contact time (CCT) value of not less than 450 milligram-minutes per liter at all times with a modal contact time of at least 90 minutes based on peak dry weather design flow rate. The disinfection dosage is the product of total chlorine residual and modal contact time measured at the same point.

The conceptual design criteria for the new chlorine contact basin is presented in Table 6-4. The volume of the new chlorine contact basin can be reduced by achieving the additional contact time in the recycled water conveyance pipeline depending on the location of the first recycled water user.

Table 6-4 Conceptual Design Criteria for Chlorine Contact Basin

Parameter	Value
Type	Concrete Structure
Configuration	Rectangular Serpentine Channel
Design Flow	1.2 mgd
Disinfection Dosage	450 milligram-minutes per liter
Chlorine Contact Time	90 minutes
Assumed Baffling Factor (T10/T)	0.7
Chlorine Contact Basin Volume	110,000 gallons
Water Depth	23 feet
Overall Basin Dimension	32’ (L) x 20’ (W)
Assumed Chlorine Demand	2.0 mg/L as Cl_2
Free Residual Chlorine Dosage	5.0 mg/L as Cl_2
Total Chlorine Dosage	7.0 mg/L as Cl_2

6.3 Conveyance Pumping and Pipelines

A tertiary effluent pump station will be required to convey the disinfected tertiary effluent from the WWTF site to CBS for connection to the distribution system. Due to site constraints at the WWTF, the pump station will be constructed below ground. The conceptual design criteria for the pump station is provided in Table 6-5.

Approximately 7,500 lineal feet of 8-inch diameter PVC conveyance pipeline will be constructed from the disinfected tertiary effluent pump station to the CBS for connection to the existing saltwater distribution system. The conveyance pipeline would be buried a minimum of 3-feet below ground to maintain minimum cover requirements.

The SWRCB Division of Drinking Water (DDW) has prepared guidelines, which govern separation distances between recycled water and potable water pipelines, sewers, and sanitary force mains. Generally, pipelines conveying the recycled water must maintain a minimum 4-foot horizontal separation distance from, and 1-foot vertical distance below, potable water pipelines. A minimum of 10-feet separation distance must be maintained between tertiary disinfected recycled water and sanitary sewers and force mains. These criteria must be considered when reviewing the pipeline alignments to ensure that adequate distance is available between utilities within the road right-of-way. The proposed conceptual pipeline alignment is provided in the following subsection of this report.

Table 6-5 Conceptual Design Criteria for Recycled Water Pump Station

Parameter	Value
Design Flow	1.2 mgd
Number of Pumps	3 (2 duty + 1 standby)
Pump Capacity (each)	450 gpm at 120' TDH
Pump Power (each)	20 HP
Pump Control Type	Variable Frequency Drive

6.4 Recycled Water Storage

The two (2) existing open saltwater reservoirs, Mount Ada and Falls Canyon, can be used to store recycled water as part of the conversion to recycled water in conjunction with the operation of the Catherine Booster Station (CBS). The storage capacity of the reservoirs is approximately 300,000 gallons and 420,000 gallons, respectively.

These reservoirs will be required to be covered once converted to a recycled water storage reservoir due to potential for biological growth and potential need for additional filtration and boosting chlorine residual in the recycled water system. Another option is to abandon the Mount Ada Reservoir and construct a larger storage tank (~ 1 million gallons) at the Falls Canyon reservoir site to provide additional fire flow storage.

6.5 Recommended Recycled Water Project

Based on the results of the discussion and analysis performed in Section 6.2, the gravity multi-media filtration alternative is recommended above the others to proceed to further project development. The proposed project is further described herein.

The proposed disinfected tertiary recycled water treatment system will have a design capacity of 1.2 mgd. Figure 6-3 provides the proposed disinfected tertiary treatment process flow schematic concept. The secondary effluent from clarifiers will be diverted to a new below ground pump station. From the pump station, water will be pumped into the gravity multi-media filtration system. A coagulant will be injected upstream of the filtration system to increase filter performance and minimize filtered effluent turbidity. The gravity multi-media filtration system will have three (3) cells operating in parallel. The filtered water will be collected in the filter effluent distribution box.

The filtered water flows by gravity to the new chlorine contact basin for disinfection utilizing the existing calcium hypochlorite feed system. Once the water is disinfected, the water will flow by gravity into the new below ground pump station. The existing ocean outfall will be maintained as a by-pass during low recycled water demand or any off-spec water quality events. Figure 6-4 presents the conceptual site plan for the proposed tertiary treatment system.

The pump station would convey the disinfected tertiary recycled water to the existing CBS for the connection to the distribution system for non-potable water use. The conveyance pipeline will include approximately 7,500 lineal feet of 8-inch diameter PVC pipeline. Figure 6-5 illustrates the conceptual pipeline alignment from the WWTF to the CBS.

6.5.1 Corrosion Consideration

Based on the review of the historical effluent water quality data from the WWTF, ammonia is present in the water, which could increase the corrosion of copper and copper alloy. The material selection for the pipelines, valves, and infrastructure facilities should be considered during the design in order to extend the useful life of the facilities.

6.5.2 Fire Flow Consideration

A majority of hydrants within the City are served by saltwater. A typical fire flow for a structure within the City limits, as described in Section 2.1, is 1,500 gpm for two hours (180,000 gallons). The total storage volume of both Mount Ada and Falls Canyon Reservoirs is approximately 720,000 gallons, which can provide approximately 8 hours of fire flow at 1,500 gpm. This is adequate for up to four (4) simultaneous structure fires in the City, but in 2007, a wildfire broke out and additional water supplies were needed. The Avalon Fire Department utilized a mobile pumping unit to pump water into the system directly from the ocean near the Mole Pier. If the saltwater system is converted to a recycled water system, this practice may not be feasible. If the City does move forward with a recycled water system to replace the saltwater system, this will need to be addressed in the design. Several options that will need to be explored are:

1. Emergency connection with the potable water system;
2. Utilizing saltwater in the recycled water system in a fire emergency; or
3. Utilizing tanker trucks filled with saltwater.

6.5.3 Capital Cost Estimate

The conceptual capital cost estimate for the recommended recycled water project is presented in Table 6-6 below. The estimates are based on professional experience and judgement, and have an accuracy of -30% to +50% per American Association of Cost Engineers guideline for conceptual level estimates.

Table 6-6 Recommended Recycled Water Project - Capital Cost Estimate

Description	Cost
Contractor Mobilization / Demob / Mark-Up	$1,000,000
Civil Site Work	$150,000
Multi-Media Filtration System	$850,000
Coagulant Storage and Feed System	$75,000
Underground Secondary Effluent Pump Station to Filtration System	$300,000
Demolish and Rebuild Chlorine Contact Basin	$250,000
Underground Recycled Water Pump Station	$500,000
Recycled Water Pipeline (~ 7,500 LF of 8" PVC C900 @ $180/LF)	$1,350,000
Pipeline Connection to Catherine Booster Station	$75,000
Mt. Ada and Falls Canyon Reservoir Improvements (cover & lining)	$900,000
Electrical, Instrumentation and Control	$275,000
Miscellaneous Pipe, Valves, Meters, etc.	$150,000
Subtotal	**$5,875,000**

Contingency @ 30%	$1,800,000
Subtotal Capital Costs	**$7,600,000**
Construction Related Costs (Design, CM, Legal, etc.) @ 25%	$1,900,000
Escalation Factor of 5.5% (assuming that it won't be constructed for 5 years)	$2,100,000
Estimated Total Capital Cost	**$11,600,000**

6.5.4 Potential Funding Sources

The State Water Resource Control Board (SWRCB) and the California Environmental Protection Agency (EPA) provides funding sources to help fund the plan, design, and construction of water recycling projects through both grants and low interest loans. Due to Governor Edmund G. Brown Jr.'s State of Emergency proclamation in 2014 regarding the record breaking drought in California, the SWRCB has continued to expand funding opportunities for projects than can diversify California's water portfolio. The main sources of funding are through the SWRCB's Water Recycling Funding Program and the Clean Water State Revolving Fund. Both of these funding sources are eligible for public agencies such as Avalon.

Water Recycling Funding Program

The Water Recycling Funding Program (WRFP) has provided planning and construction grants for water recycling projects since 1977 in order to offset and augment California's potable water supply and demand. As of January 2014 the WRFP has funded $1.3 billion to projects in California.

Planning Grants can match up to 50% of the planning cost with a maximum of $75,000 and can be used for planning, environmental review of project area, technical review, and legal costs. Construction Grants can take on up to 35% of construction costs with a maximum of $15,000,000 and can be used for construction of treatment facilities needed for reclamation of municipal wastewater, treatment plant upgrades, as well as distribution systems for recycled water including storage. Applications are continuously being accepted. For more information visit the SWRCB's WRFP page at: http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/index.shtml

Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF) was established in the Water Quality Act of 1987 and replaced the Clean Water Act Construction Grants Program. On February 17th, 2016 the SWRCB authorized $960 million in low interest financing to go solely towards water recycling projects. The interest rate is determined by half the most recent General Obligation Bond Rate. As of March 2016, the interest rate is 1.7%. The financing term can be up to 30 years or the useful life of the project. There is no maximum funding limit and repayment does not begin until one (1) year after the completion of construction. Applications are continuously being accepted. For more information visit the SWRCB's CWSRF page at: http://www.waterboards.ca.gov/water_issues/programs/grants_loans/srf/index.shtml

Small Community Wastewater Grant

As a result of Section 79723 of Proposition 1, the CWSRF's Small Community Grant (SCG) Fund has authorized $260 million to fund water recycling projects for small communities with populations less than

20,000. Funding up to 50% of the project cost with a maximum grant of $6 million is available under this program. For more detailed information visit the SWRCB's SCG page:

http://www.swrcb.ca.gov/water_issues/programs/grants_loans/small_community_wastewater_grant/projects.shtml

Financial Assistance Application Submittal Tool

The SWRCB has developed the Financial Assistance Application Submittal Tool (FAAST) in order for applicants to apply for any of these funding options. Through FAAST an applicant can apply for a combination of the available funding opportunities at: https://faast.waterboards.ca.gov/. The SWRCB has set up how-to-videos in order to guide applicants through the process of applying through FAAST online at: http://www.waterboards.ca.gov/videos/video_pages/faast_account.shtml.

6.5.5 5-Year Implementation Plan

This section will look at one potential implementation plan to finance the $11.6 million recommended recycled water project. The project could possibly be built in a 3 year time period, if all the components were built simultaneously. The implementation plan proposed below recommends building the project over a five (5) year period, as described in the following subsections.

Phase 1 – Year 1

Initial construction would begin at the WWTF. This would focus on the above ground multi-media filter basins that are proposed in the sludge drying bed area. This provides time to begin potholing and site investigation for all the underground pipes and conduits in the location of the two proposed pump stations. The pump stations would be the next phase of work, as described in the following subsection. The initial cost for Phase 1 is approximately $2.8 million, as shown in Table 6-8.

Table 6-7 Phase 1 Cost Estimate: Recycled Water Project 5-Year Implementation Plan

YEAR 1: 2017	QTY	UNIT	COST
Mob / Demob / Mark-Up	1	LS	$450,000
Civil Site Work	1	LS	$75,000
Multi-Media Filtration System	1	LS	$850,000
Coagulant Storage and Feed System	1	LS	$75,000
Electrical, Instrumentation and Control	1	LS	$140,000
Miscellaneous Pipe, Valves, Meters, etc.	1	LS	$75,000
Subtotal			**$1,665,000**
Contingency	30%		$500,000
Construction Related Costs (Design, CM, Legal, etc.)	25%		$420,000
Cost Escalation (per year)	5.5%		$190,000
	YEAR 1 – TOTAL:		**$2,800,000**

Phase 2 – Year 2 and 3

The second phase of the project will also be located at the WWTF. This phase will focus on the two (2) underground pump stations, reconstruction and enlargement of the chlorine contact basins, and all associated electrical and instrumentation. The multimedia filters would not be used and the treated water would still be sent to the ocean until the remaining phases (i.e. pipeline and reservoirs) could be completed. The estimated capital cost for Phase 2 is approximately $3.5 million, as shown in Table 6-8.

Table 6-8 Phase 2 Cost Estimate: Recycled Water Project 5-Year Implementation Plan

YEAR 2 & 3: 2018-19	QTY	UNIT	
Mob / Demob / Mark-Up	1	LS	$450,000
Civil Site Work	1	LS	$100,000
Underground Secondary Effluent Pump Station	1	LS	$300,000
Underground Recycled Water Pump Station	1	LS	$500,000
Demolish and Rebuild Chlorine Contact Basin	1	LS	$250,000
Electrical, Instrumentation and Control	1	LS	$140,000
Miscellaneous Pipe, Valves, Meters, etc.	1	LS	$75,000
Subtotal			**$1,815,000**
Contingency	30%		$550,000
Construction Related Costs (Design, CM, Legal, etc.)	25%		$460,000
Cost Escalation (per year)	5.5%		$600,000
		YEAR 2 & 3 – TOTAL:	**$3,500,000**

Phase 3 – Year 4

The third phase of the project will include the installation of approximately 7,500 feet of 8-inch diameter recycled water force main from the WWTF to CBS and new connection to the CBS. The estimated capital cost for Phase 3 is approximately $3.2 million, as shown in Table 6-9.

Table 6-9 Phase 3 Cost Estimate: Recycled Water Project 5-Year Implementation Plan

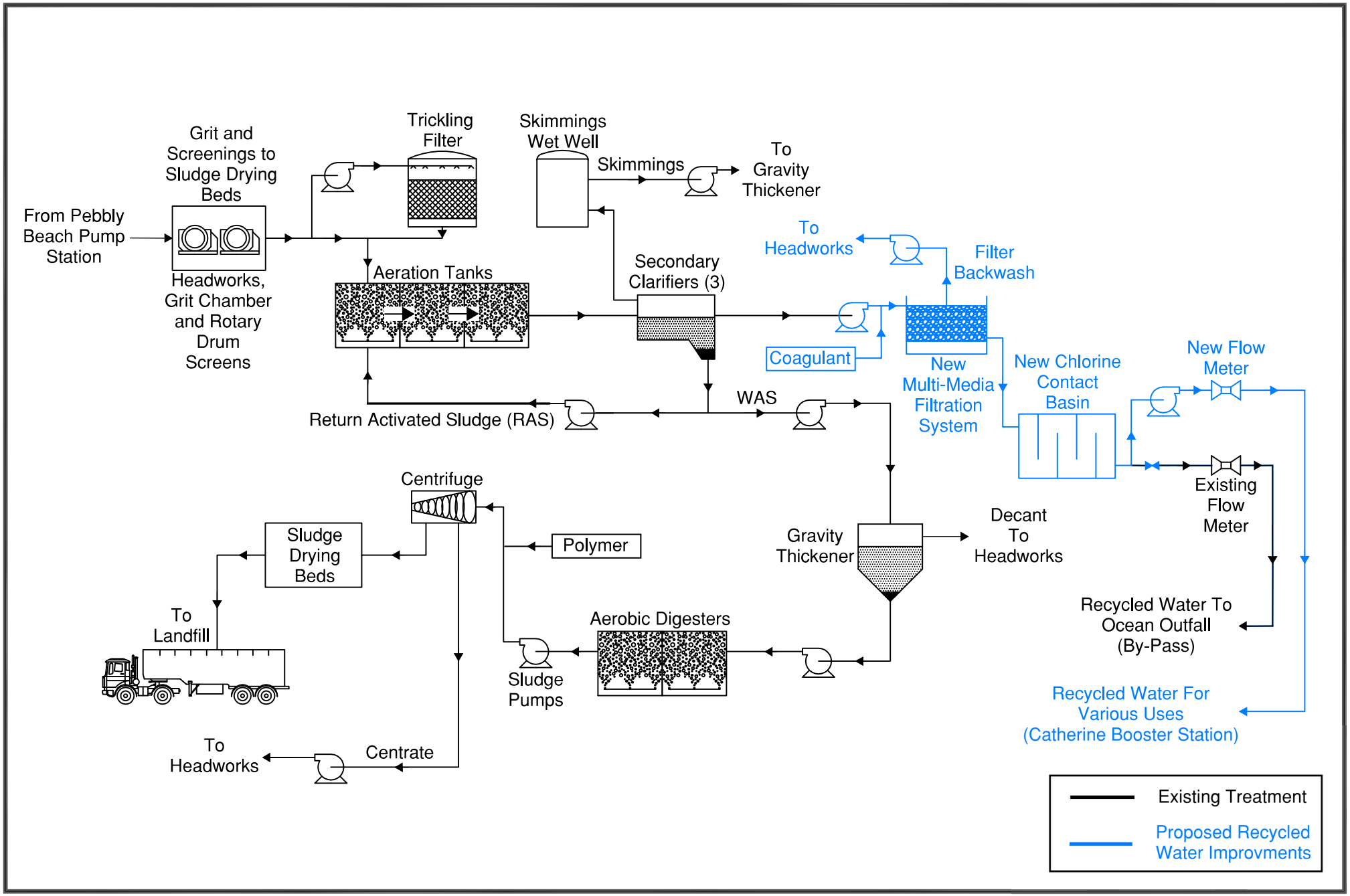
YEAR 4: 2020	QTY	UNIT	
Mob / Demob / Mark-Up	1	LS	$300,000
Recycled Water Pipeline (8" PVC C900)	7500	LF	$1,350,000
Connection to Catherine Booster Station	1	LS	$75,000
Subtotal			**$1,725,000**
Contingency	30%		$520,000
Construction Related Costs (Design, CM, Legal, etc.)	25%		$440,000
Cost Escalation (per year)	5.5%		$480,000
		YEAR 4 – TOTAL:	**$3,200,000**

Phase 4 – Year 5

The fourth and final phase of the project will include improvements at the two (2) water storage reservoirs, Mount Ada and Falls Canyon. The estimated capital cost for Phase 4 is approximately $2.1 million, as shown in Table 6-10.

Table 6-10 Phase 4 Cost Estimate: Recycled Water Project 5-Year Implementation Plan

YEAR 5: 2021	QTY	UNIT	
Mob / Demob / Mark-Up	1	LS	$200,000
Mt. Ada Reservoir Improvements (cover & lining)	1	LS	$450,000
Falls Canyon Reservoir Improvements (cover & lining)	1	LS	$450,000
Subtotal			**$1,100,000**
Contingency	30%		$330,000
Construction Related Costs (Design, CM, Legal, etc.)	25%		$280,000
Cost Escalation (per year)	5.5%		$370,000
		YEAR 5 – TOTAL:	**$2,100,000**

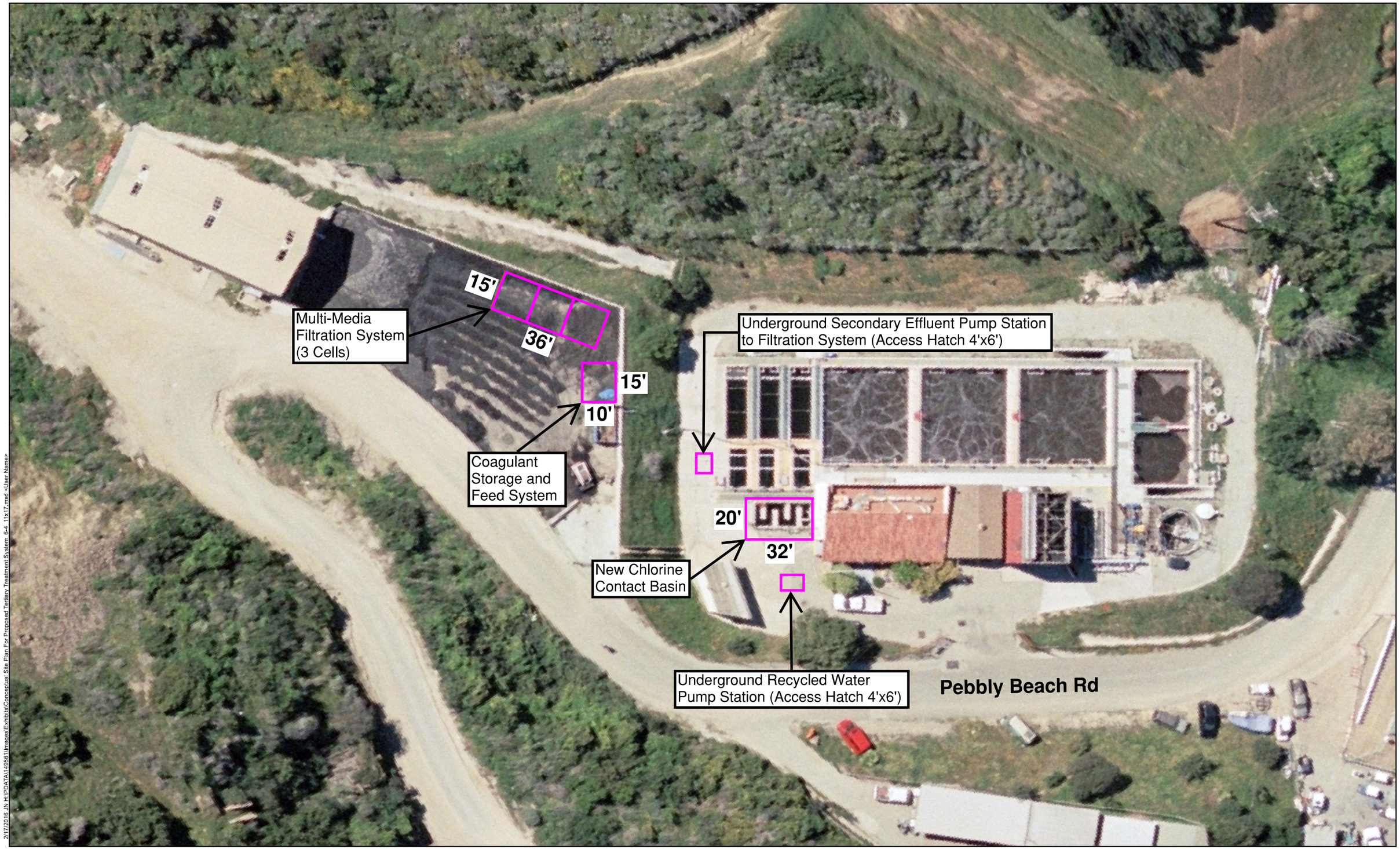


Recycled Water Sub-Plan

Michael Baker INTERNATIONAL

Proposed Disinfected Tertiary Treatment Process Flow Schematic Concept

Figure 6-3



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Michael Baker INTERNATIONAL

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Source:

RECYCLED WATER SUB-PLAN

Conceptual Site Plan For Proposed Tertiary Treatment System

Figure 6-4

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Michael Baker INTERNATIONAL

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RECYCLED WATER SUB-PLAN

Conceptual Recycled Water Pipeline Alignment

Figure 6-5

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7.0 Potable Water Production Alternatives

7.1 Avalon Canyon Wells

The Santa Catalina Island Company is currently performing test well drilling in the bedrock aquifer beneath the Avalon Canyon alluvial aquifer. Recently they completed the construction of three exploratory wells located on the Catalina Island Golf Course in the Bird Park/Golf Links area to determine the feasibility of using this water source as a source for potable water. The test wells were constructed with intake screens and seals so as to completely isolate the bedrock wells from the overlying alluvial aquifer. The wells only obtain groundwater from the deep rock aquifer and there is no hydraulic connection within the well bores between the two aquifers. The wells are listed in Table 7-1.

The initial production of the wells was a combined 70 gpm, with the highest production capacity well pumping at 40 gpm and lowest at 10 gpm. Based on aquifer pumping tests and certified Title 22 water quality tests, it was determined that an overall pumping rate of 33 gpm would be the approximate sustainable pumping yield from these wells, providing a new potable water supply to the Avalon community of approximately 47,500 gpd (53 acre feet/year). There is a significant amount of groundwater stored in the Avalon Canyon bedrock aquifer, and the 33 gpm yield is only a characteristic of the test wells installed in the localized Bird Park/Golf Links area, and not necessarily characteristic of the entire Avalon bedrock aquifer, which encompasses a much larger area.

The water quality is similar to other potable groundwater sources currently utilized on Catalina Island with a Total Dissolved Solids (TDS) concentration of approximately 700 to 820 milligrams per liter (mg/l). A water source of 800 mg/l TDS would require additional treatment, mixing, or dilution, to reduce the TDS concentration to less than or equal to 500 ppm (EPA secondary contaminant maximum concentration).

Table 7-1 Avalon Canyon Test Wells

Well ID	Drill Depth (feet)	Production Rate (gpm)	Total Dissolved Solids (mg/l)
AC-BR-1	640	~20	820
AC-BR-2	650	~10	760
AC-BR-3	589	~40	710

TDS Values obtained from Santa Catalina Island Company - 72 hour Pump Test in Jan-Feb 2016

The hydrogeological studies and aquifer tests performed in conjunction with the test wells have confirmed that groundwater in Avalon Canyon occurs in two distinct aquifers:

1. **Alluvial Sedimentary Aquifer** present along the narrow canyon bottom, extending to depths of 120 feet bgs (depending on location), with non-uniform, mixed-permeability characteristics, and consisting of stream channel and debris flow gravel, sand, silt, and clay; and
2. **Bedrock Aquifer** beneath the alluvial aquifer and within the hillsides surrounding Avalon Canyon.

The source of groundwater in the alluvial aquifer is partially from rainwater percolating directly into the alluvial canyon bottom and leaching downwards through the soil, but more predominantly, the aquifer is fed by continuous leakage from the bedrock aquifer into the alluvial aquifer. This leakage occurs because the bedrock aquifer includes the driving force of bedrock groundwater held in the extensive hillside slopes surrounding and above the floor of Avalon Canyon. Upward flow from the bedrock into the alluvial aquifer

occurs because the bedrock aquifer is under slight artesian pressure, ranging from 3 to 11 feet of upward water pressure, with respect to the alluvial aquifer. Once groundwater reaches the alluvial aquifer, it flows downstream through relatively narrow alluvium channels to Avalon Bay. The alluvial aquifer can be conceptualized as a French drain installed into the bedrock aquifer, facilitating it's drainage to the Bay. The Santa Catalina Island Company is currently in discussions with Southern California Edison on the next steps required to permit the test wells and connect them to the Avalon potable water distribution system.

Alternatively, If Avalon or the Island Company pursue Avalon Canyon as a new potable water source, rather than treating the brackish water pumped from the canyon, the proposed water reclamation facility could be upgraded to produce recycled water suitable for indirect potable reuse (IPR). Refer to Section 5.2.3 for a discussion on IPR. Advanced treated water could be introduced into Avalon Canyon on the upstream end of the basin using injection wells and then recovered from the aquifer through wells in either alluvial aquifer or the bedrock aquifer at the downstream end. The low TDS advanced treated water would "clean up" the basin, reducing the TDS concentration overtime. Detailed studies, incorporating additional extensive subsurface hydrogeological analysis, would be required to determine the feasibility of an IPR project in Avalon Canyon as a new potable water source.

7.2 Seawater Desalination

Although SCE provides potable water service to Avalon, the City could potentially take over that responsibility. One option that could be studied further is providing Avalon with a new potable water source completely from the ocean. Several vendors exist that could design, build, own, and operate (DBOO) a small seawater desalination plant. The City of Avalon would execute a contract with the entity to purchase the potable water at a set cost, based on the length and terms of the contract. The typical business model of this type of endeavor includes the following:

- Entity designs, finances, and constructs the seawater desalination plant;
- Entity pays operating costs, including labor, electricity, and maintenance;
- Entity manages the entire operation and associated risks with a performance guarantee;
- Entity responsible for safety, and environmental and regulatory compliance; and
- Entity can hire and train local personnel.

Avalon would not have to invest any up-front capital and would only pay for the water produced. Avalon may only require a desalination plant capacity of approximately 0.3 to 0.4 mgd. The cost of water is dependent on the contract length. For example, a small desalination plant capable of 0.6 mgd would cost approximately $13.00 per 1,000 gallons of produced water, for a one year contract. The cost would decrease to approximately $5.00 per 1,000 gallons, based on a contract length of 15 years. Economies of scale do factor into this pricing structure, therefore, the cost for a smaller plant, 0.3 to 0.4 mgd, would be more expensive per 1,000 gallons. The above costs are based on a similar sized project, and provided by a seawater desalination production vendor capable of providing these services.

If the City of Avalon took over the potable water system, the City would be responsible for the maintenance of the distribution system. The costs above only include the purchase cost of water and do not take into account annual maintenance costs of the distribution system.

8.0 Energy Production Alternatives

SCE currently generates electricity for Catalina Island using six (6) diesel generators and 23 propane-powered micro-turbines. The power is distributed using three distribution circuits that serve the entire island. The diesel and propane are shipped to the island, which can cause a reliability issue if something goes wrong with the barge/ship offshore. A key focus of this *Sub-Plan* is to provide the City of Avalon with renewable (sustainable) energy alternatives that could fulfill the Cities power needs associated with, but not limited to, the waste water treatment facility, pump stations, City Hall, the Fire Department, Cabrillo Mole, etc., and minimize payment costs to SCE. Table 8-1 below summarizes the energy demands for the WWTF and booster station conveyance requirements of Avalon. Entries are given for the average daily usage between 2013 and 2015 and for the average peak daily usage during any given month in that time period. The peak daily power usage for the WWTF and booster stations is approximately 2,800 kWh.

Table 8-1 Energy Demands for the Wastewater Treatment and Conveyance, City of Avalon

Facility	Avg. Daily Usage, kWh	Avg. Peak Daily Usage, kWh
Wastewater Treatment Facility	1,314.7	1,783
Centrifuge Building	87.8	130
Pebbly Beach Lift Station	317.5	387
Catherine Booster Station	408	493
Total	**2,127.9**	**2,793.0**

Based on usage data from 2013 to 2015

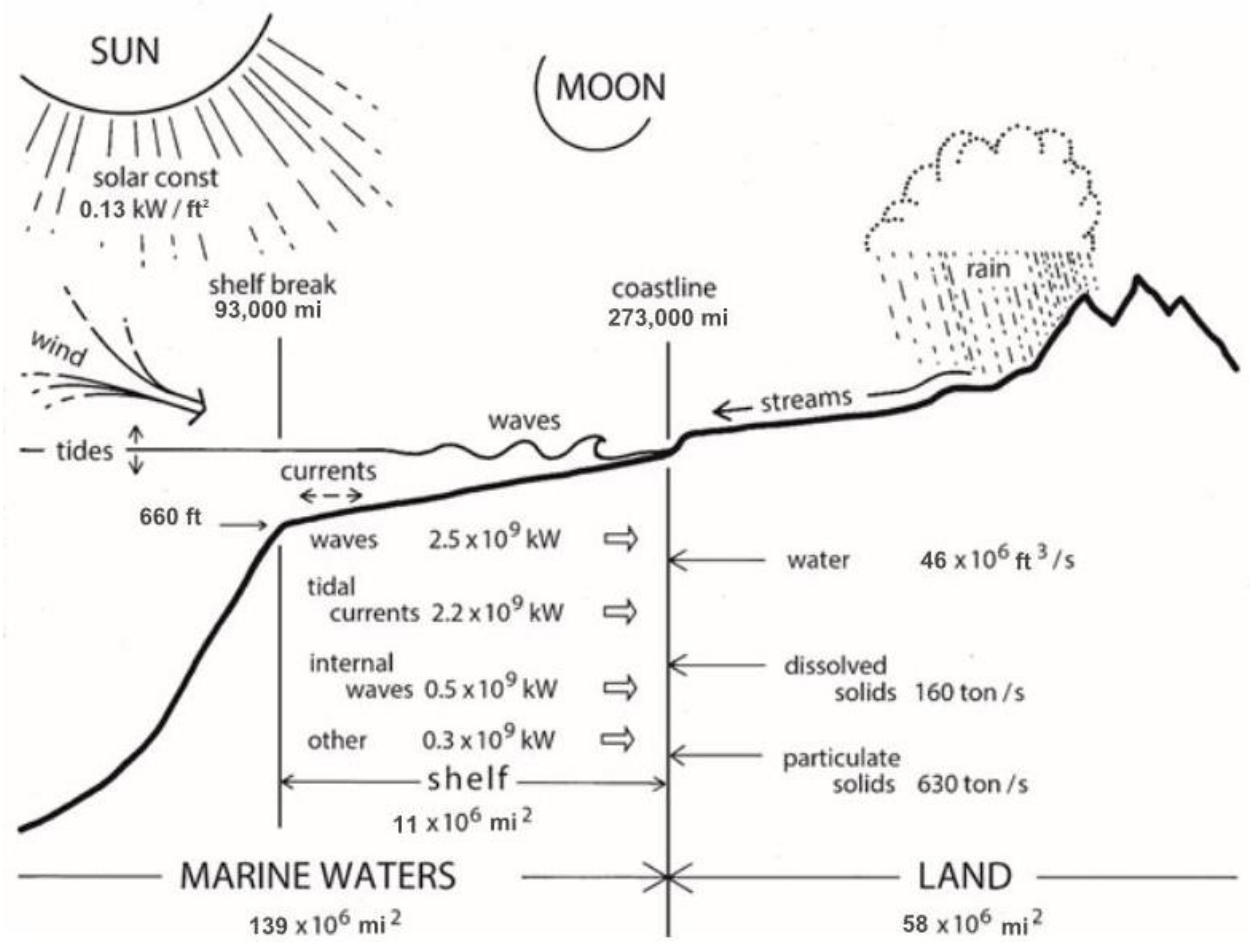
This section provides renewable alternative energy options for Avalon, that have no carbon footprint because they are based on recovery of solar energy or kinetic energy associated with wind, wave and current motion, or potential energy associated with tidal variations in sea surface elevation. The global energy budget of these naturally occurring renewable energy sources are summarized in Figure 8-1.

There appears to be more than ample supply of renewable energy in ocean motion and wind incident around Catalina Island, as shown in Table 8-2, but they reflect only what's available, not what is recoverable or convertible into electrical energy to power the WWTF and booster stations. The figures in Table 8-2 are only attainable if 100% of the nearshore waters, shoreline and hill-tops were covered in energy recovery devices and those devises were 100% efficient in recovering the kinetic energy of ocean motion or wind and converting it to electrical energy. In the following sections we will consider how Catalina's renewable energy supply might be recovered and converted to electrical energy given the present technology in kinetic energy recovery devices and the constraints that the terrain, bathymetry and biological resources of Santa Catalina impose on these devices.

The power available in the nearshore waters of Avalon (including tidal, wind-driven and inertial) totals 2.9 million MW as compared to 2.5 million MW available in wave energy. Wind power, totaling 1.2 million MW is about 1/5 the available power in ocean motion. The decisive questions to be answered are:

1. Whether a useful amount of renewable energy types are available in the nearshore waters around Santa Catalina Island? And;
2. What percentage of these energy types can be recovered using existing technology?

Figure 8-1. Schematic Diagram of the Global Budget of Energy in Nearshore Waters



Source: Modified from Inman and Jenkins, 2002

Table 8-2 Long-term Averages of Daily Ocean and Wind Energy along the Coast of Santa Catalina Island

Waves breaking against the shoreline	2.2 X 10^5 kWh
Tidal currents due to surface tides	4.0 X 10^5 kWh
Wind-driven currents over shelves	9.1 X 10^4 kWh
Inertial currents over shelves	3.6 X 10^4 kWh
Potential energy in sea surface variability	1.8 X 10^4 kWh
Subtotal	**7.65 X 10^5 kWh**
Coastal winds at 500 m MSL	1.1 X 10^5 kWh
TOTAL	**9.85 X 10^5 kWh**

The daily energy requirements (Table 8-1) for the WWTF and booster stations average 2,130 kWh, but can reach peak values of typically 2,800 kWh, which is less than 1% of the available daily renewable energy supply from ocean motion or wind.

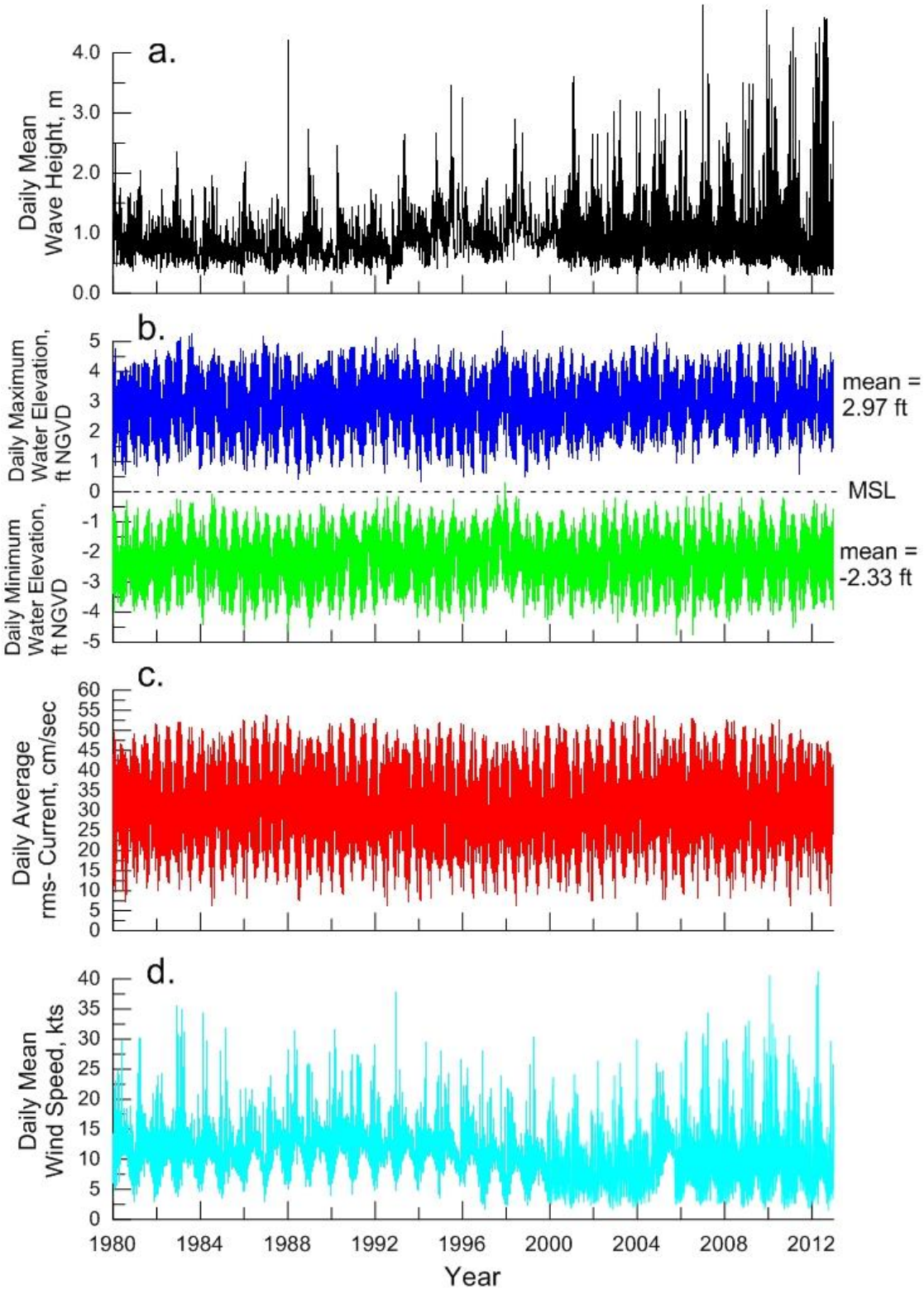
Santa Catalina Island is 22 miles long and 8 miles across at its greatest width, with 103 miles of shoreline. The highest point on the island is 2,097 feet (Mount Orizaba), and about 2/3 of the island is at elevations between 1,300 feet and 1,650 feet above mean sea level (MSL). Figure 8-2 gives a 33 year record of representing typical conditions at Santa Catalina Island for daily mean significant wave height on the west side of the island, daily high and low water levels, daily average root-mean-squared (rms) currents, and daily mean wind speed on top of the island. The wave height data were compiled from the Coastal Data Information Program (CDIP) buoys and arrays. Water elevations are from the NOAA tide gage at Avalon Harbor. Currents are from the Southern California Ocean Observation System (SCCOOS), Santa Catalina Island Isthmus Shore Station, and the wind data are from the FAA Automated Weather Observing System (AWOS) at Catalina Airport (AVX) at 1600 feet MSL. From these data, the long-term daily averages of the energy available in ocean motion in the nearshore waters and winds of Santa Catalina Island are calculated in Table 8-2 using algorithms and statistical averaging techniques presented in Jenkins and Wasyl (2005). A total of 765,000 kilowatt-hours (kWh) of energy is available daily in all forms of ocean motion and 110,000 kWh is available daily from the wind field flowing over the island. Among all these forms of natural mechanical energy on Santa Catalina, the daily mean energy in ocean currents is the dominant form, totaling 527,000 kWh, as compared against 220,000 kWh available daily from wave energy on the west shores of the island.

Wind energy is about half that of wave energy, which is more persistent on the high terrain sections of the island. The least productive source of natural energy at Santa Catalina Island is from tidal elevation changes in the sea surface, which is relatively small due to the modest 5.33 feet mean tidal range which only provides two cycles of sea-surface elevation change every 25 hours and accounts for 18,000 kWh of daily energy when integrated around the 103 miles of Santa Catalina shoreline. All forms of natural mechanical energy available to Catalina Island from ocean and wind sources total 985,000 kWh of energy, or nearly a 1,000 megawatt-hours (MWh) of daily renewable energy supply; or about 10% of the daily production capacity of a legacy Southern California, fossil–fueled, coastal power plant, (e.g. Encina Generating Station, Carlsbad, CA), but without the carbon footprint.

8.1 Environmental Restrictions on Energy Recovery Devices

Most of Santa Catalina is controlled by the Catalina Island Conservancy, a private non-profit organization. The Conservancy protects the natural and cultural heritage of Santa Catalina Island, stewarding approximately 42,000 acres of land (88% of the island) and at least 50 miles of shoreline, about half the total coastline. Additional areas of Catalina's shoreline and nearshore waters are protected Areas of Special Biological Significance (ASBS) managed by the State Water Resources Control Board (SWRCB) or are designated as Marine Protected Areas (MPA) managed by the California Department of Fish and Game and the California Department of Parks and Recreation. Installation of energy recovery devices in the ocean will not be permitted in the ASBS or MPA designated waters of Santa Catalina Island (unless special waivers are authorized by the controlling resource agencies); and wind energy recovery devices will not be allowed on the high-terrain of the island without authorization from the Catalina Island Conservancy. Since special waivers to operate energy recovery devices in areas designated for wildlife conservation appears problematic, we focus on identifying the areas of the island and nearshore that are not regulated by these agencies.

Figure 8-2. Time History of Forcing Functions for Renewable Alternative Energy Sources at Santa Catalina Island



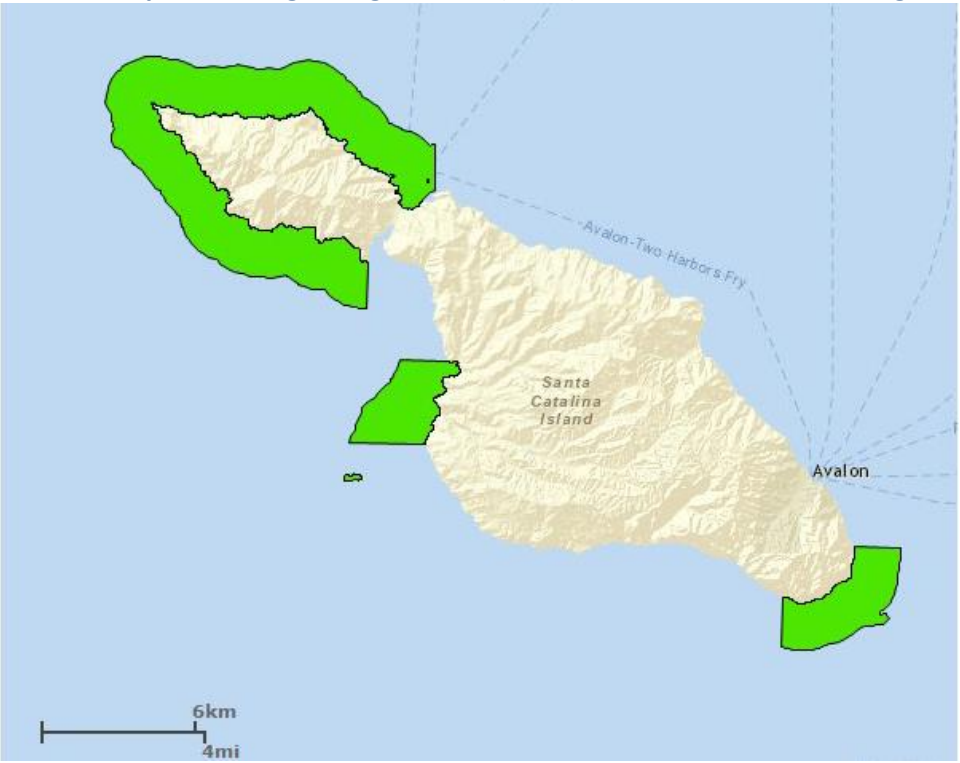
a) Daily mean significant wave height, b) Daily high and low water levels, c) Daily maximum tidal current, d) Daily mean wind speed. (Data compiled from CDIP (2014), Stations 067, 138, 092 and 213, 2012; SIO, 2012; NCEP, 2012, and SCCOOS Santa Catalina Island Isthmus Shore Station).

The ASBS designated areas of Santa Catalina are shown in Figure 8-3. These include: The Northwest Santa Catalina Island Area of Special Biological Significance (Isthmus Cove to Catalina Head), which is the largest of the three ASBS off Catalina Island, with 20.9 miles of coastline, covering 13,236 acres; The Western Santa Catalina Island Area of Special Biological Significance, a relatively small ASBS with four miles of coastline, from the north end of Little Harbor to Ben Weston Point, covering 2,247 acres; and, The Southeast Santa Catalina Island Area of Special Biological Significance which has 2.9 miles of coastline along the east end of the island and covers 2,755 acres.

Figure 8-4 delineates the Marine Protected Areas (MPA) in the marine waters surrounding Santa Catalina Island. California maintains three kinds of MPAs: state marine reserves, state marine parks and state marine conservation areas. They are designated specifically to protect aquatic life, and often are often associated with ASBS.

- **State Marine Reserves (SMR):**
  These restrict all commercial and recreational activities, keeping the area as free from human impact as possible.
- **State Marine Conservation Areas (SMCA):**
  These are areas that have specific goals for conservation and activities are restricted to meet the conservation goals.
- **State Marine Parks (SMP):**
  These allow opportunities for education, research, and recreation, while preventing commercial extractive activities.

Figure 8-3. Areas of Special Biological Significance (ASBS) in the Waters Surrounding Catalina Island



Note: ASBS are shown in green. Source: CA State Water Resources

Figure 8-4. Marine Protected Areas (MPA) in the Ocean Surrounding Santa Catalina Island

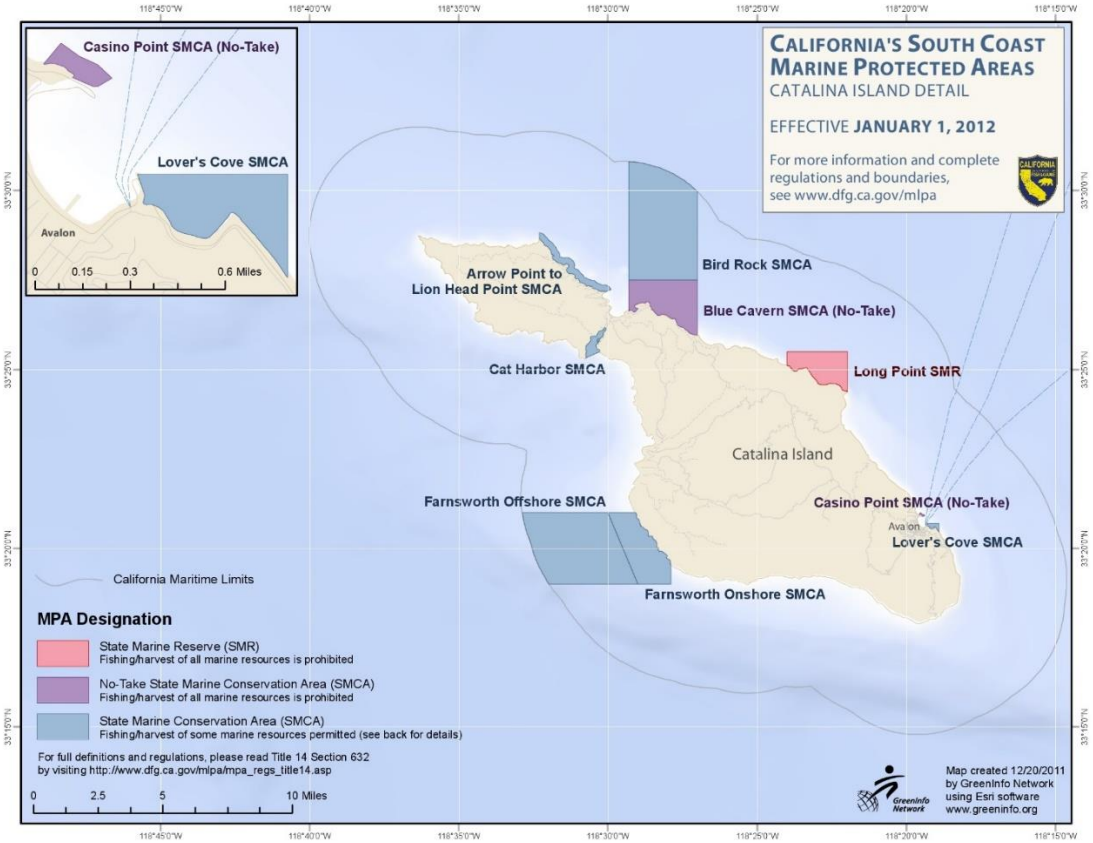


Figure 8-5. Coastal Landmarks of Santa Catalina Island

The only sections of coastline and nearshore waters around Catalina Island that are not already designated as ASBS or MPA are on the west side of the island. Two vacant sections are considerable, which provide 10.1 miles of coast for installation of energy recovery devices:

1. Southwest facing section of coastal waters that extends 6.6 miles between Salta Verde Point and Church Rock (see Figure 8-5); and
2. West facing section of coastal waters that extends 3.5 miles between Catalina Harbor and Little Harbor.

In addition most of the high terrain of Catalina Island that is optimal for wind energy recovery is controlled by the Conservancy, and nesting sites of the bald eagle have resulted in most of that terrain as being designated sensitive habitat under the California Coastal Act. Given the national attention that has been given to the mortality of eagles and other raptors around wind farms, the high terrain of the island must also be considered as problematic sites for energy recovery. Therefore, the limitation of available and terrain coastline imposed by environmental constraints reduces the amount of recoverable energy in Table 8-2 by an order of magnitude. Fortunately, the west side of the island is the windward, high energy side, but also presents specially transmission challenges to Avalon.

The model used in the assessment of the feasibility and yield from energy recovery along the available west shore sites of the island and subsequent transmission to Avalon is based on the *Wave Hub* concept illustrated schematically in Figure 8-6. The energy collection devises are moored or anchored in arrays nearshore. The devises may be wind turbines, water turbines or any number of possible reciprocating wave energy recovery devices. The action of the devices will harvest some fraction of the kinetic energy of either the wind or water motion and convert it to electrical energy, either directly in the case of turbines or through high pressure converters at a centrally located wave hub within the array. The efficiency of the energy recovery is typically 75% for propeller-based turbines or turbine wheels, and 25% for reciprocating devices. From the wave hub, the electrical energy is transmitted through a fiber-optic seafloor cable making landfall through a tunnel or duct beneath the seabed created by horizontal directional drilling. After landfall, the electrical energy goes to a shore-side substation for voltage and current conversion for final transmission to Avalon. Energy losses during conversion and transmission are on the order of 10%.

8.2 Wave Energy Recovery Devices

Wave energy collector devices that have been field validated fall into three general categories: *bobbers*, *flappers, linear absorbers, and omnidirectional helical turbines.* There are a multitude of variations on these five classes of devices that have been conceived and tested over the last 30 years, some having a surface footprint and others fully submerged.

Figure 8-7 show the Carnegie CETO 5 and CETO 6 wave energy collector belonging to the *bobber* class. It is a fully submerged point-absorber which the manufacturer claims is capable of absorbing as much as 240 kW to 1,000 kW per mooring. Each mooring consists of a tethered buoyant float attached to a dead-weight anchor or explosive anchor, if sediment on the seabed is thin. The amount of wave power a bobber type collector can absorb is proportional to the size of the float, and manufacturer performance claims suggest the CETO mooring and anchor system is viable in 10 foot high waves. As the float heaves in the wave pressure field it drives a high pressure pump which produces a high pressure water stream to the

Wave Hub (Figure 8-6) where the pressure-volume work in the high pressure water stream is converted to electrical energy via a closed loop turbine driven generator.

Figure 8-6. Schematic for Energy Recovery along West Shore of Santa Catalina Island

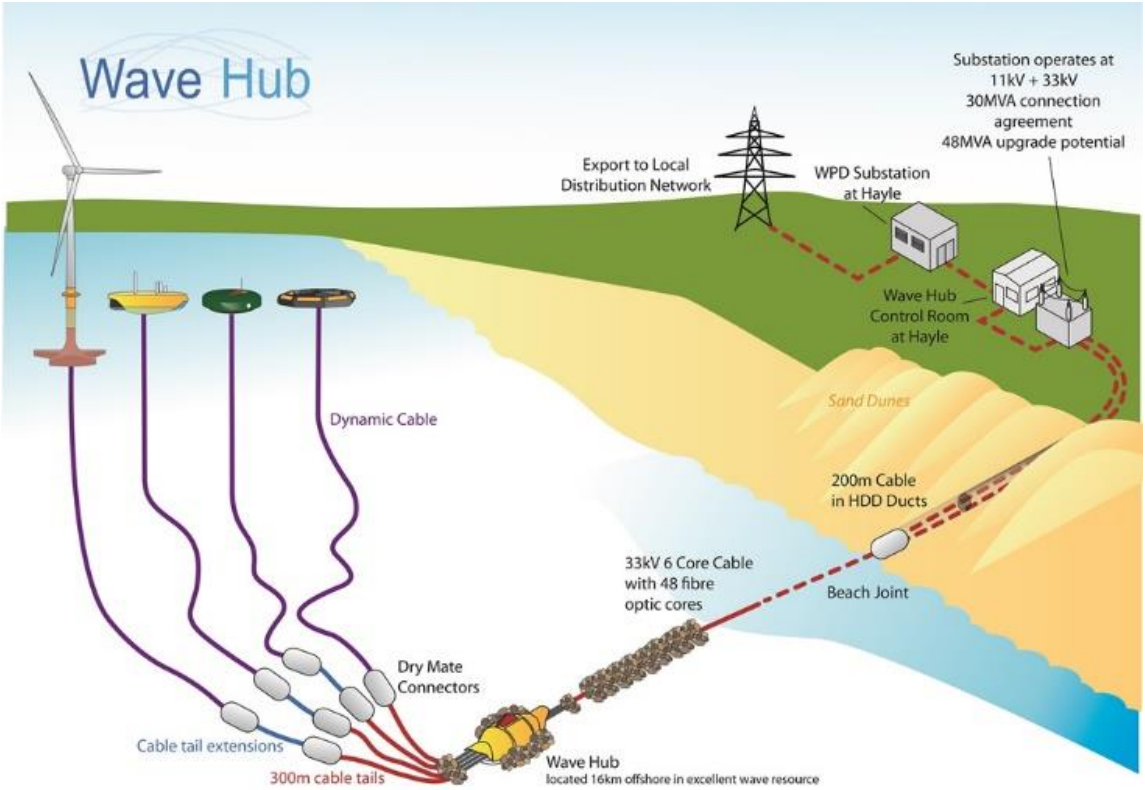


Figure 8-8 illustrates the Langlee *flapper* type wave energy collector, which is a floating type of point-absorber with a pronounced surface foot. Each mooring consists of a hinged buoyant flapper attached to a floating frame which is moored to a dead-weight anchor or explosive anchor on the seabed. Alternatively, Figure 8-9 shows The Wave Roller, *flapper* type of submerged wave energy point-absorber, which rests on a frame anchored to the seabed, with no surface footprint. The amount of wave power a flapper type collector can absorb is proportional to the size of the flapper, and manufacturers' suggest the flappers are capable of recovering 100 - 250 kW per mooring. As the flapper heaves in the wave pressure field it drives a hydraulic ram which produces a high pressure water stream to the *Wave Hub* (Figure 8-6) where the pressure-volume work in the high pressure water stream is converted to electrical energy via a generator driven by a hydraulic motor (Figure 8-9).

Figure 8-10 illustrates the Pelamiswave linear absorber wave energy collector. It is a floating collector device designed to be deployed in a large linear array in the wave shoaling zone. The manufacturer claims capabilities of absorbing as much as 300 kW to 1,000 kW per mooring. Each mooring consists of a series of buoyant tubular floats and connected by hydraulic rams. The entire linear float assembly is tethered to a series of dead-weight anchors or earth screws. As the floats heave differentially on the sea surface the hydraulic rams connecting the floats produce high pressure water streams to the *Wave Hub* (Figure 8-6) where the pressure-volume work in the high pressure water stream is converted to electrical energy via a generator driven by a hydraulic motor.

Figure 8-7. Carnegie CETO 5 / 6 Bobber Type of Fully Submerged Wave Energy Point Absorber

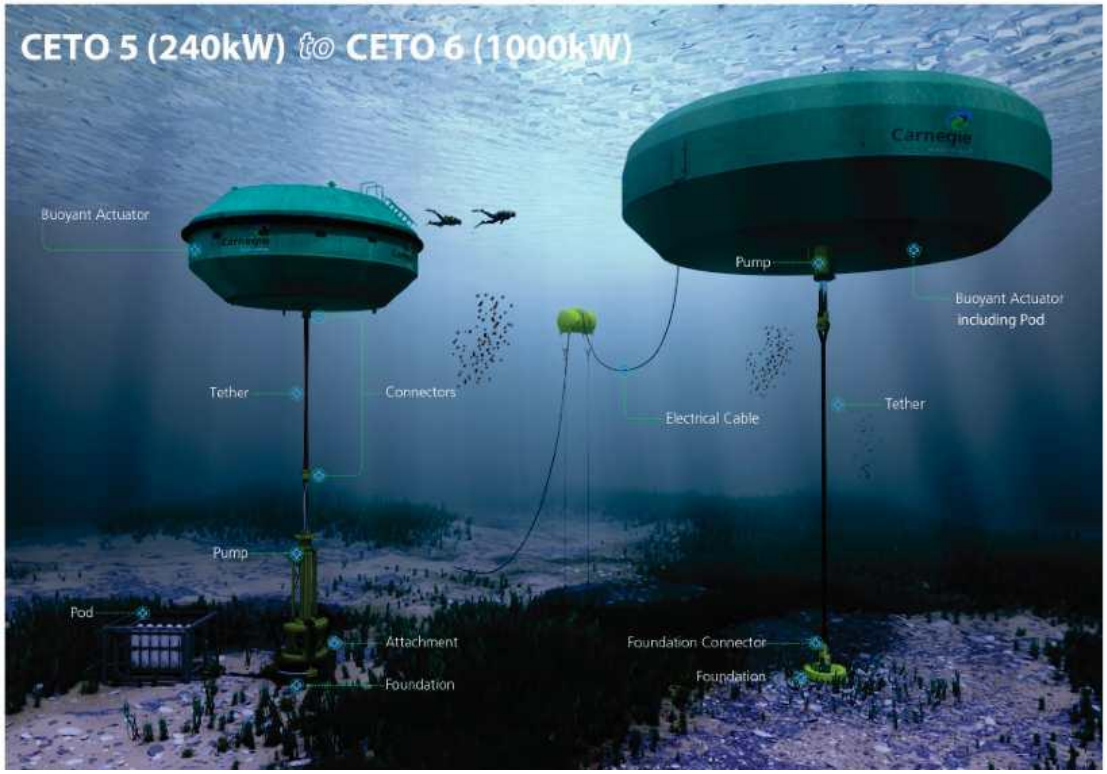
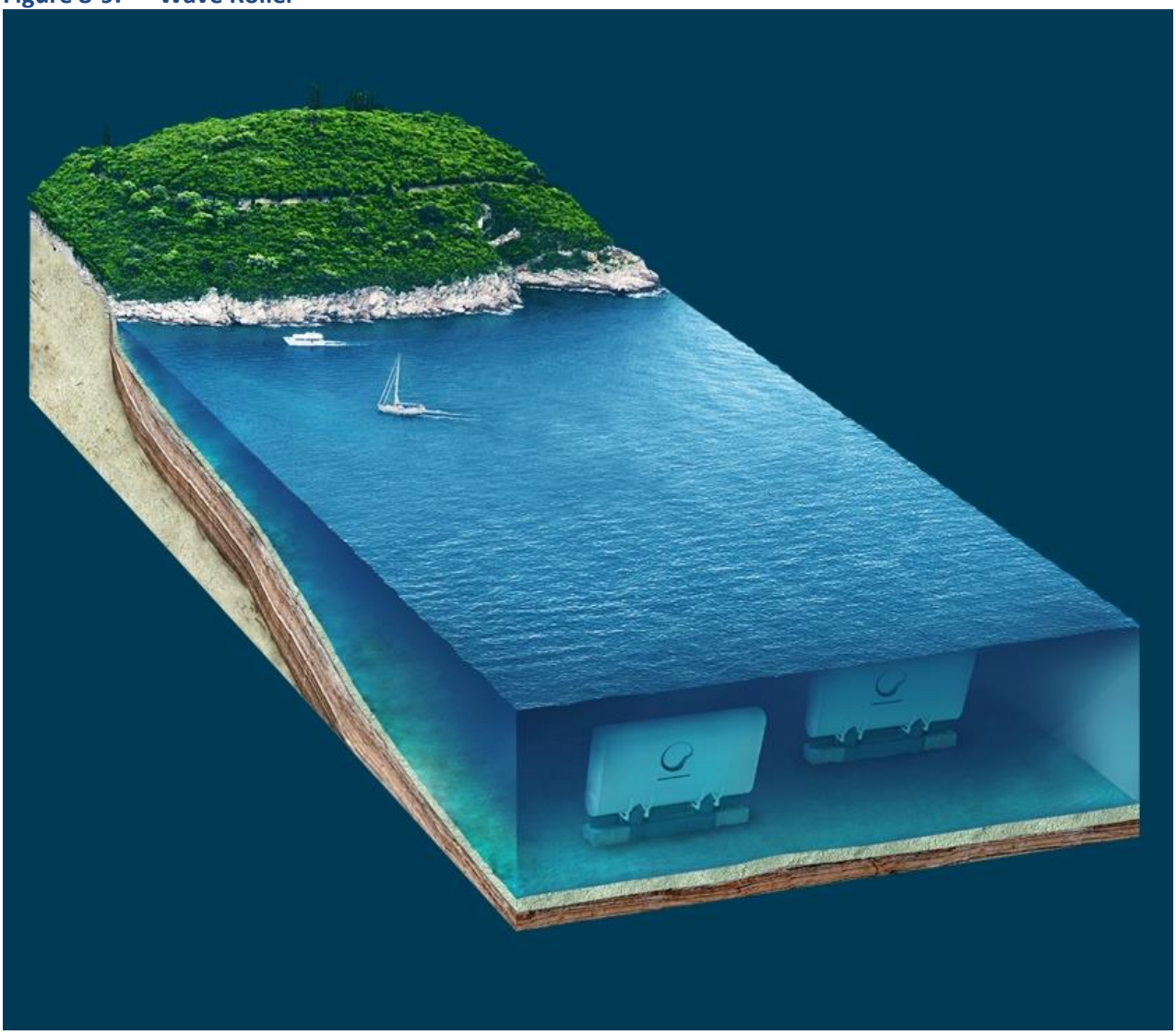
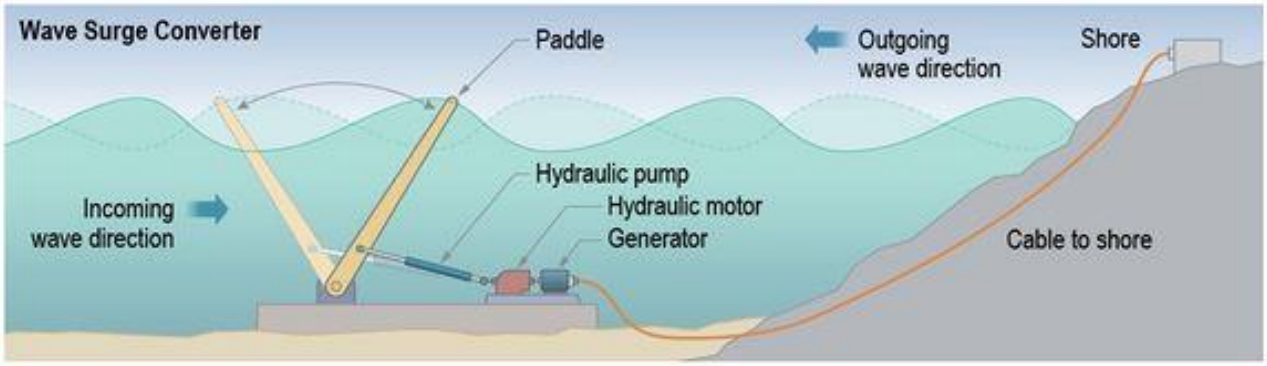


Figure 8-8. Langlee Flapper Type of Floating Wave Energy Point-Absorber

Figure 8-9. Wave Roller





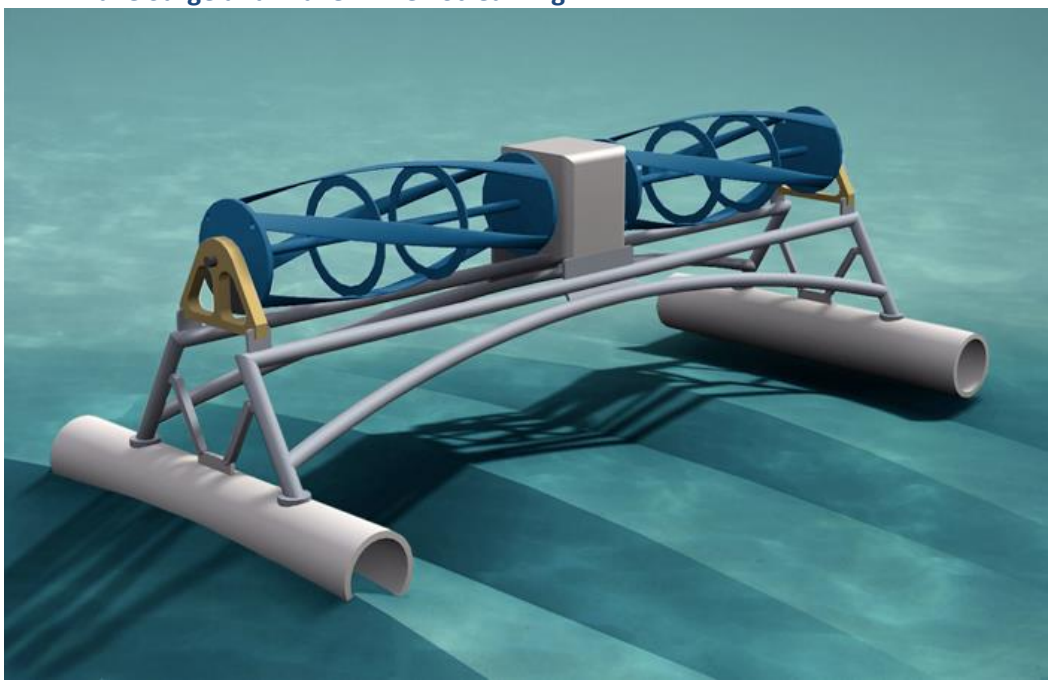
Upper image: The Wave Roller, *flapper* type of submerged wave energy point-absorber.
Lower image: Details of the hydraulic ram/electrical conversion system of the wave hub.

Figure 8-11 shows an entirely different approach to wave energy collection by extracting kinetic energy from the oscillatory currents and streaming excited by wave profiles. This is somewhat difficult because the instantaneous direction of flow under the wave profile is constantly changing. To accomplish this, the Omni-directional helical turbine wheel was invented. The helical turbine wheel is attached to a bottom mounted frame that is secured to the seabed with explosive anchors or earth screws. The turbine wheel drives a multi-directional brushless generator with a power controller in the central frame case, and the electrical power thus produced is sent to the wave-hub (Figure 8-6) via a seafloor mounted cable. Estimated production capacity in approximately 3 feet high sea states is 15 kW per turbine unit, and 150 kW per turbine unit in 10 feet high sea states. One concern with deploying the helical turbine wheel off Santa Catalina will be maintenance and the potential for drifting kelp to become bound up in the turbine wheel and prevent its free rotation.

The fundamental engineering problem with all classes of wave energy collector devices has been mooring failures, with the devices inevitably winding up on the beach after sufficiently long periods of deployment. The cyclical loading induced by wave oscillation eventually causes fatigue failures in the connectors between the device, tether, and anchor systems. When anchors cannot be driven into bed rock due to thick sediment cover, the cyclical wave loading also cause liquefaction of the sediments bearing the mooring stresses. If these devices are considered in the nearshore waters of Catalina Island, it is recommended that a pilot installation first be tested to evaluate these difficulties, and whether adequate remedial measures can be implemented. In addition, permitting of any such pilot or full scale production system will be challenging. Clearly, any floating wave energy recovery system with a surface footprint will present hazards to navigation, and submerged systems will have to provide adequate keel clearance for the types of vessel traffic that is present in Catalina's inshore waters.

Figure 8-10. Pelamiswave Linear Absorber Type of Floating Wave Energy Absorber

Figure 8-11. Omni-directional Helical Turbine Wheel for Extracting Wave Energy from Near-Bottom Wave Surge and Wave-Driven Streaming



8.3 Ocean Current Energy Collection Devices

Present technology in ocean current energy collectors has focused on the underwater wind-mill concept. Figure 8-12 gives specifications of the Verdant underwater turbine for extracting current energy from near-bottom tidal and inertial currents. Each 16 foot diameter 3-blade turbine unit is capable of providing 35 kW of electrical power from a gear driven generator hosed in the shaft fairing behind the propeller hub. With an array of such devices in a tidal stream spread across the seafloor (Figure 8-13), several thousand kilowatts of electrical power can readily be supplied to the wave-hub for transmission to shore via buried fiber optic cable (Figure 8-6). The generating capacity of these underwater windmills scales in proportion to the square of the propeller diameter, and very large tidal turbines generating 5,000 kW each have been built by the Norwegians and deployed in the North Sea (Figure 8-14).

The fundamental problem with deploying presently demonstrated tidal turbine technology in the waters off Catalina Island will be environmental permissibility. The central issue will be marine life mortality due to *blade strike*. This issue is no different than what the hydro-electrical industry is already facing with fish-passage through its generating facilities, only in the present context, the interaction between machinery and wildlife occurs in the open sea. The central focus of the blade strike issue will be on juvenile fish and larvae passing through the propeller arc and suffering contact with the turbine blades. These tiny marine organisms are fragile and blade strike will likely cause lethal injury. The California Coastal Commission (CCC) will very likely require some form of mitigation for blade strike mortality when granting a coastal development permit (CDP) for and underwater tidal turbine farm. A secondary concern with deploying tidal turbine farms in the waters off Santa Catalina Island will be maintenance; and the potential for drifting kelp, particularly macrocystis kelp, to become bound up in the turbine and either prevent free rotation, or cause unbalanced rotation of the turbine wheel, that in turn could damage the turbine gear drive mechanism of the generators.

Figure 8-12. Specifications of the Verdant Underwater Turbine Array

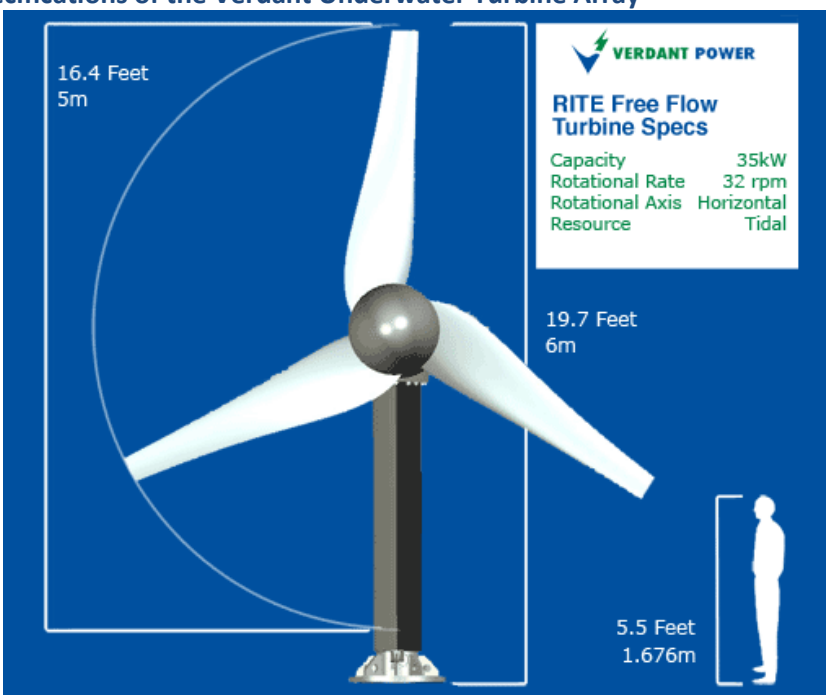
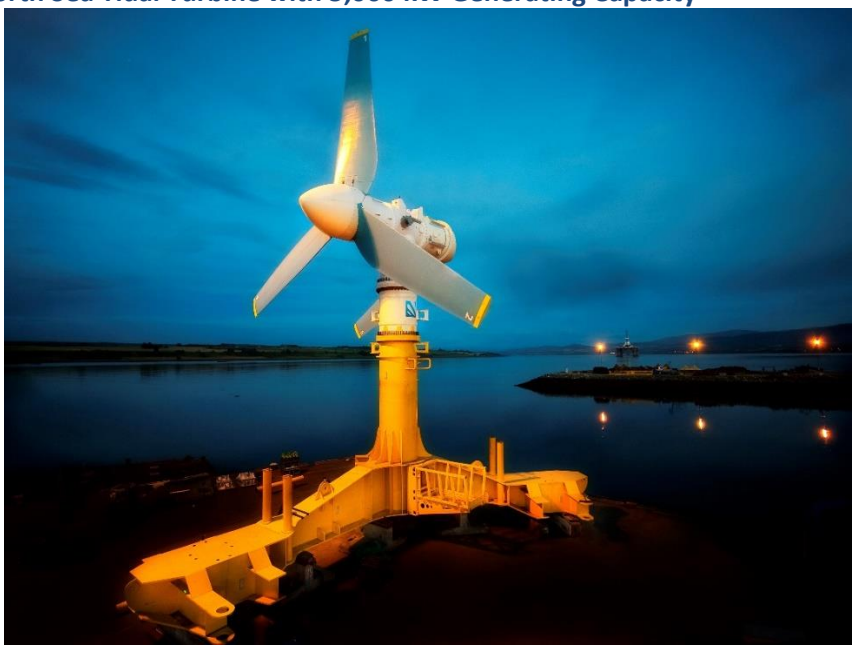


Figure 8-13. Bottom Arrays of Verdant Underwater Turbine Array for Extracting Current Energy from Near-Bottom Tidal and Inertial Currents

Figure 8-14. North Sea Tidal Turbine with 5,000 kW Generating Capacity



8.4 Wind Energy Collection Devices

Modern direct-drive wind turbine generators are remarkably advanced technology, capable of producing as much as six (6) MW of power from a single turbine. The problem encountered with wind farms in California has been with rare or endangered birds establishing nesting sites atop the wind turbines (Figure 8-15), resulting in blade strike mortality with both adults and juveniles when accessing or egressing the nesting site. Given the substantial bald eagle population and other rare or endangered bird species that inhabit Catalina Island, construction of a wind farm anywhere on the high terrain of the island will be problematic from an environmental permit standpoint. Therefore, we look to the innovations of offshore wind farms that have been built in Europe.

Figure 8-15. Osprey nesting site atop wind turbine, Altamont, CA

Figure 8-16 shows an array of Siemens D7 direct drive wind turbines in the North Sea off Blavandshuk, Denmark, producing 6 MW per platform. A single platform of this type could satisfy all the electrical demand for the WWTF and lift stations of Avalon. Because the bald eagle has never been known to establish nests on offshore platforms

or other structures, because its nests are built from materials of terrigenous origin, it is believed the offshore windfarm concept will prevent nesting mortality.

The only apparent issue with employing offshore wind turbines in a wave-hub power distribution concept (Figure 8-6) is potential interference with navigation. The site of the wind farm would have to be carefully chosen from among the 10 miles of unrestricted waters on the west side where ship traffic is minimal while avoiding frequent anchorages near Catalina Harbor or Little Harbor. Planning and coordination with the US Coast Guard during the siting analysis is mandatory, as that agency will ultimately make determinations of navigation buoy requirements and other permitting issues.

Figure 8-16. Siemens D7 Direct Drive Wind Turbines in the North Sea off Blavandshuk, Denmark, Producing 6 Megawatts per Platform

8.5 Avalon Ocean and Wind Energy Potential

This section focuses on the alternative energy potential options for Avalon based on implementing wave, current and wind energy recovery devices in a Wave-Hub power network concept (see Figure 8-6). Implementation is considered only in sections of coastline and nearshore waters around Santa Catalina that are not already designated as ASBS or MPA on the west side of the island. Two such vacant sections exist that we can consider, which provide 10 miles of coast for installation of energy recovery devices:

1. Southwest facing section of coastal waters that extends 6.6 miles between Salta Verde Point and Church Rock (see Figure 8-5); and
2. West facing section of coastal waters that extends 3.5 miles between Catalina Harbor and Little Harbor.

The estimates are based on the recoverable energy in waves, currents and wind on the assumption of a 10% mooring density in these two reaches of unrestricted coastal waters. Recoverable wind energy is based on a marine layer interpolation of winds at Catalina Airport (Figure 8-2) with an assumption of a 33 foot thick air-sea boundary layer. These results are listed in Table 8-3. Inspection of Table 8-3 indicates that offshore wind farms have the potential to exceed Avalon's daily peak demand for power for its waste water facilities by more than an order of magnitude, and that there exists ample opportunity to scale down the wind farm to match closer with Avalon's present needs. Current energy recovery has the potential to exceed Avalon's peak demand for power by 50%; while wave energy recovery can be engineered to match that demand if the entire 10 miles of unrestricted coastline were fully populated with wave energy recovery devices. The Pelamiswave linear absorber is the most efficient wave energy recovery device; but also the most intrusive in terms of sea surface footprint.

Table 8-3 Long-term Averages of Daily Recoverable Ocean and Wind Energy along Catalina Island Coast

Wave energy from The Carnegie CETO 5	2.9×10^3 kWh
Wave energy from The Wave Roller	1.5×10^3 kWh
Wave energy from The Pelamiswave linear absorber	3.2×10^3 kWh
Wave energy from The Helical Turbine Wheel	1.1×10^3 kWh
Currents energy from The Verdant underwater turbine	4.0×10^3 kWh
Wind energy from The Siemens D7 direct drive wind turbines	9.1×10^4 kWh
Daily Average Demand for Wastewater Treatment and Conveyance	2.1×10^3 kWh
Peak Daily Demand for Wastewater Treatment and Conveyance	2.8×10^3 kWh

8.6 Avalon Solar Energy Potential

Solar or photovoltaic (PV) power is becoming an increasingly popular option among renewable power alternatives for small to midsize applications due to its ease of installation, relatively predictable economics, and minimal environmental impacts (low visual and sound impacts). PV performance is dictated by two key variables:

- Solar resource availability at the site; and
- Installation arrangement of the panels – either flat or tilted. While panels installed flat use less space for the same kW installation (since there are no shading issues between rows of panels as with tilted installations), the annual kWh generation is less since the panels are not optimally oriented to the sun. Typically, a tilted arrangement will be used for ground-mounted systems.

PV production typically starts around 7:00 am (sunrise), peaks from 11:00 am to 2:00 pm, and diminishes to zero between 4-5 pm (sunset). During the wintertime, solar resource availability is typically reduced, but the data shows relatively consistent solar availability. The days that resulted in the lowest production can be attributed to overcast or rain days, but even for the typically bad weather months of November and December, there are encouraging levels of solar insolation.

Using standard power densities currently used in the industry for a tilted system of approximately 6 watts per square foot of real estate, the total area required for a PV installation suitable to provide adequate power (approximately 88.6 kW) for Avalon is approximately 15,000 square-feet (0.34 acres) of available

space. This conceptual sizing is based on the power demands for the WWTF and conveyance pumping requirements as presented in Table 8-1 in order for the PV system capable of generating 88.6 kWh. The average cost of photovoltaic solar panels is approximately $7.00 to $10.00 per watt of rated power. Therefore a solar array would cost approximately $1 million for Avalon's needs.

Figure 8-17. Typical Photovoltaic (PV) Panel Array (Solar Farm versus Solar Rooftops)

Source: http://www.thegazette.com/storyimage/GA/20151024/ARTICLE/151029786/EP/1/2/EP-151029786.jpg&MaxH=1400&MaxW=1306

Source: https://gigaom.com/wp-content/uploads/sites/1/2014/02/solarcity_copper_ridge_school.jpg

Obtaining a single parcel of land to construct a PV system would be difficult for Avalon since most of the island's land is owned by the Conservancy and much of the island is environmentally sensitive. However, the installation of multiple PV systems on rooftops of buildings and structures owned by Avalon that could generate a combined 88.6 kWh could be feasible. An estimate of available roof top area is shown in Table 8-5. It is important to realize that although there is an estimated 40,600 ft^2 available, not all of that area

would be ideal for a PV system because of the amount of sunlight a roof receives each day varies depending on the direction it faces and the landscape around it. A detailed power study is required to determine actual PV power generation values based on the location, angle, time of year, etc.

Table 8-4 Available City Owned Rooftop PV System Area

Facility	Area, sq. ft.
WWTF and Solids Handling Building	2,900
Mole Harbor	2,700
Fire Station	5,300
City Hall	4,700
School Buildings (Falls Canyon Road)	25,000
Total	**40,600**

8.7 Sustainable Energy Funding Opportunity

The California Energy Commission (CEC) offers different grant funding opportunities, low interest financing, as well as other incentives in order to promote innovation and implementation of renewable energy projects throughout California. The CEC has previously funded programs such as the California Solar Initiative, but funds through this program are no longer available.

8.7.1 Grant Funding Opportunity (GFO) 15-323

In 2016, the CEC took applications for Grant Funding Opportunity (GFO) 15-323. This GFO, titled, *Innovative Water and Energy Efficiency Demonstrations for the Commercial, Industrial or Water/Wastewater Sectors,* is focused on funding pre-commercial technologies that will increase energy efficiency of an industrial or water/wastewater facility. GFO-15-323 offered grant funding ranging from a minimum of $500,000 to a maximum of $2 million with a minimum matching requirement of 20% of the CEC requested amount.

If Avalon wanted to pursue this GFO through the CEC, it is recommended that Avalon partner with one of the companies mentioned in Sections 8.2 and 8.3, such as Carnegie, Wave Hub, Langlee, Verdant Power, etc. By partnering with one of these innovative companies, Avalon could implement a renewable energy source for a much lower cost than providing their own funding and implementing solar or wind power technologies that are already widely commercially available. The application deadline for this GFO is June 2016. Therefore, it is not feasible to apply this year, but Avalon could begin discussions with these innovative energy companies to create a partnership and apply in the future.

8.7.2 Energy Efficiency Financing PON-13-401

The CEC also provides low interest financing for renewable energy generation projects. Cities such as Avalon are eligible for a 1% interest rate loan for up to $3 million through the CEC's PON-13-401. The repayment terms for this loan are based on the estimated annual energy cost savings from the implementation of the project with a maximum term length of 20 years. Before applying for this loan a feasibility study must done that includes descriptions of the energy projects, discussion of facility energy usage, calculations that show the technical feasibility and energy savings of the project, a detailed proposed budget, and a detailed proposed schedule. More information on this loan program can be found at: http://www.energy.ca.gov/efficiency/financing/index.html.

9.0 Recommendations

Based on the evaluation performed in this report, the following recommendations are provided:

1. Convert the WWTF to a reclamation facility, to be able to utilize recycled water in lieu of saltwater for toilet / urinal flushing and fire suppression purposes. Based on current wastewater flows, there is no surplus water for additional purposes, but if there were, the surplus of recycled water could be used for irrigation or an IPR project (i.e. Avalon Canyon).

   The benefits of replacing saltwater with recycled water would be significant reduction in total dissolved solids (TDS) of the generated wastewater, which assists in reduction of metals corrosion, increase oxygen transfer efficiency of the wastewater treatment process, and increase in efficiency of the sludge dewatering process in the WWTF. In addition, it will increase the useful life of the distribution system.

2. Recommend implementing the proposed wastewater reclamation facility conversion to produce recycled water at the existing WWTF. The next step would include developing a schematic detail, layout drawings, capital costs, and operation and maintenance costs for the proposed treatment facilities, conveyance pump station, and pipeline to distribute the recycled water. The capital cost estimate to implement this project is approximately $11.6 million over five years.

3. Recommend proceeding with a Solar Power Study that will provide a conceptual design and cost estimate of one large solar array or several city owned rooftops (i.e. City Hall, Fire Station, WWTF, etc.) that could be fitted with solar panels to offset the City of Avalon's power needs. The study will cost approximately $20,000, with the cost of implementing a PV system approximately $1 million.

4. Although many environmental constraints exist for Avalon to utilize wind, wave, or tidal power generation, an offshore wind turbine is feasible (minimal environmental impact) and could provide a majority of Avalon's power usage, compared to other kinetic power generation options. The capital cost estimate to implement an offshore wind turbine project is approximately $3.0 million.

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