

6 Potential Other Sources

Other sources of water potentially available to SLVWD include:

- Loch Lomond reservoir
- Water transfers
- Recycled water
- Additional diversions and/or wells

This section addresses the first two items: 1) SLVWD's existing entitlement to a portion of the raw-water yield from Loch Lomond reservoir and 2) the potential for a finished-water transfer from the Santa Cruz City Water Department (SCCWD) in lieu of SLVWD's entitlement to a direct diversion from Loch Lomond. Estimates of potential supply from these sources are included in the water-supply scenarios evaluated in Section 7.3. SLVWD's recent annexation of the Felton system formerly operated by Cal-Am is not within the scope of this report.

Significant use of recycled water is infeasible because San Lorenzo Valley lacks centralized wastewater collection and treatment. Existing on-site wastewater disposal contributes significantly to soil moisture and stream baseflow, however.

Section 5.8 discusses the water-supply potential for additional wells in the Quail Hollow and Olympia areas. A possible increase in groundwater production as a result of such wells is defined for the future-case water-supply scenarios evaluated in Section 7.3.

6.1 Loch Lomond Reservoir

In 1958, SLVWD sold 2,500 acres of its property in the vicinity of the Newell Creek watershed to the City of Santa Cruz with the agreement that SLVWD would be entitled to purchase 12½ percent of the annual safe yield from a future Newell Creek reservoir, up to a maximum of 500 AF/yr. This percentage was roughly equivalent to the portion of the reservoir project area owned by SLVWD.

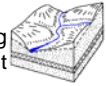
The City created Loch Lomond Reservoir with the completion of Newell Creek Dam in 1960. The drainage area above the dam is approximately 8.3 square miles (Figure 1-3). The reservoir capacity was recently estimated at about 9,000 AF (MacPherson and Harmon, 2000). At capacity, the reservoir has a water surface area of about 180 acres and a length of up to 3 miles. Impounded water first ran over the spillway in March 1963.

As summarized in Table 6-1, the City of Santa Cruz has a Newell Creek appropriative water right licensed by the California Division of Water Rights as follows:

- Maximum storage: 8,624 AF (2,810 MG)
- Maximum annual diversion to storage during September-June: 5,600 AF/yr (1,825 MG/yr)
- Maximum annual direct diversion: 3,200 AF/yr (1,042 MG/yr)
- Maximum annual use: 5,600 AF/yr (1,825 MG/yr)
- Year-round minimum release: 1 cfs (724 AF/yr or 1,042 MG/yr)

Since the 1970s, the City also has the right to divert as much as 20 cfs from September through June from its Felton diversion dam on the San Lorenzo River up to Loch Lomond. However, the existing diversion infrastructure is effectively limited to 9 cfs.

Based on the 1958 agreement, SLVWD began receiving deliveries of Loch Lomond water from the City in 1963 (undated notes in SLVWD files). In 1965 SLVWD constructed the Glen Arbor treatment plant for treating its Loch Lomond deliveries.



The City stipulated in 1965 that SLVWD was entitled to 313 AF/yr (102 MG/yr), or 12.5 percent of 2,500 AF/yr. This was based on Loch Lomond's estimated annual yield of 3,230 AF/yr (Brown and Caldwell, 1963) minus the required constant release of 1 cfs (724 AF/yr).

Table 6-2 provides the record of monthly Loch Lomond deliveries to SLVWD during February 1976 through June 1977, which is the only known delivery record. Monthly deliveries to SLVWD ranged from 4 to 60 AF/month (1-20 MG/month). Total deliveries for the year ending June 1977 were 353 AF/yr (115 MG/yr).

Toward the end of the 1976-77 drought the City lowered SLVWD's allocation first to 165 AF/yr and then to 250 AF/yr. This in turn led to several years of water-right disputes, ending in 1981 when SLVWD began developing its Olympia wellfield as an alternative supplemental supply. Since then, SLVWD has lacked the infrastructure to treat Loch Lomond water in compliance with current federal standards. Thus, SLVWD has not included Loch Lomond among its active water supply sources.

In 1996 the City provided SLVWD with a draft agreement that (a) acknowledged SLVWD's right to purchase 313 AF/yr (102 MG/yr) of raw Loch Lomond water and (b) offered to sell SLVWD the same amount of treated City water with the exception that it would be interruptible during declared water-shortage emergencies (Kocher, May 1996).

In its 2005 Urban Water Management Plan, the City stated that 10 percent of its maximum annual right to divert from Loch Lomond (320 AF or 104 MG) "is technically available to SLVWD, but it has taken no action in recent years and has no current plan to exercise its entitlement" (Godard, February 2006, p. 3-13).

Future deliveries to SLVWD of raw Loch Lomond water or treated City water are included as potential future sources in the conjunctive use analysis presented in Section 7. Additional aspects of the City's total treated water supply are presented in Section 6.2.

6.1.1 Watershed

Newell Creek drains a portion of the central eastern slopes of San Lorenzo Valley and discharges to the San Lorenzo River near Ben Lomond (Figure 1-4). The 8.3-square-mile watershed above the Newell Creek dam ranges in elevation from about 600 to 2,300 ft msl. The main stem of Newell Creek extends approximately 5.5 miles upstream of the dam. The lower watershed south of the Zayante fault is predominantly underlain by Monterey Formation; north of the fault the watershed is underlain mostly by the Vaqueros and Zayante sandstones (Figure 1-5).

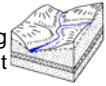
The Newell Creek watershed upstream of the dam receives an average of approximately 43 inches/yr of precipitation, resulting in average streamflow of roughly 7,000 AF/yr (Table 3-12).

The watershed upstream of Loch Lomond is primarily undeveloped and partially protected through City ownership. Land uses include about 2.6 square miles of managed timberland and a minor amount of vineyard. The watershed contains approximately 50 septic tank systems and 15 miles of mapped roads with 8 stream crossings (Johnson, 2002). Recreational use of the reservoir prohibits body contact and motorized boating.

The reservoir's yield is supplemented at times by diversions pumped up from the City's diversion on the San Lorenzo River at Felton. The river's 100-square-mile watershed upstream of the City's Felton diversion contains nearly 9,700 septic tanks and 630 miles of mapped roadway with more than 500 stream crossings (Johnson, 2002).

6.1.2 Infrastructure and Operation

The earthfill dam forming Loch Lomond is 190 ft high and 750 ft long at its crest, with a spillway elevation of 577 ft msl. The spillway capacity was increased in 1985 as stipulated by the California



Division of Dam Safety. Releases of up to 14 cfs occur through outlet works on the upstream face of dam, the lowest of which is at 470 ft msl. These diversions are conveyed by gravity via the 4.3-mile Newell Creek Pipeline to the Felton Booster Station, and then pumped to the Graham Hill Water Treatment Plant. Based on an expected driest year, the safe yield from Loch Lomond has been estimated to be 2,300 AF/yr (749 MG/yr) (SCCWD, 1979-86, as cited by Santa Cruz City Public Library).

Figure 6-1 is a plot of the relation between the reservoir surface elevation of Loch Lomond and its estimated storage. The plotted monthly values were reported by the City for 1962 to 2008 (Table 6-2). The solid line is the elevation-storage relation estimated in a recent USGS study conducted for the City (MacPherson and Harmon, 2000). The approximate 200-to-300 AF difference between these curves may be representative of the reservoir's dead pool. City estimates of end-of-month reservoir storage have averaged nearly 6,700 since 1971, ranging from 2,500 AF in October 1977 to 8,900 AF in December 2005 (Table 6-2).

Loch Lomond serves as a critical source of water storage for the City during the summer dry season, drought years, and following winter storms when other sources are too turbid and/or their intakes are damaged. The City's Urban Water Management Plan states that its management policy is "to retain the maximum amount of water possible in Loch Lomond reservoir to safeguard against future droughts" (SCCWD, 2006, p. 3-4). Since 1971, annual diversions from the reservoir have averaged approximately 2,600 AF/yr and ranged from 280 AF/yr in 1977 to 4,800 AF/yr in 1983 (Table 6-2).

The City operates its San Lorenzo River Felton diversion only intermittently, typically during the winter months of dry years. Since 1976, Loch Lomond has received an average of about 350 AF/yr from this diversion, with a maximum annual diversion of about 1,600 AF/yr in 1989 (Table 6-2).

6.1.3 Historic Yield

Figure 6-2 is a plot of Loch Lomond monthly water-surface elevation and storage. As shown, the reservoir spills most winters other than drought years. The reservoir has spilled during 30 of the last 48 years (63 percent of all years), and during 18 percent of all months. During years with spills, spills occur during an average of 3.4 months/yr, or 28 percent of the time.

Figure 6-3 is a plot of Loch Lomond monthly storage and diversions. Since 1971, reservoir diversions have averaged about 220 AF/month, ranged up to 650 AF/month in September 1974, and were zero for a total of 15 months (or 3.4 percent of all months).

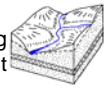
The set of bar charts in Figure 6-4 provides the following water-year records:

- S: End-of-August storage in Loch Lomond
- ΔS: September to August Change in Loch Lomond storage
- I: San Lorenzo River diversions into Loch Lomond
- O: Diversions from the reservoir
- Y: Total Newell Creek contribution to storage replenishment and direct diversions

These terms are related as follows:

$$Y = \Delta S + O - I$$

This definition of yield is consistent with the City's water right, which stipulates maximum collection to storage of 5,600 AF/yr. As shown in Figure 6-4, the City's effective yield from Newell Creek peaked at roughly 5,600 AF/yr during WYs 1973, 1986, 1995, and 1998. Storage replenishment following the severe 1976-77 drought caused the effective yield to reach 6,600 AF/yr in WY 1978. Since 1973, the effective yield of Newell Creek's contribution to Loch Lomond has average about 2,400 AF/yr (790 MG/yr).



On average, an estimated 3,300 AF/yr spills from Loch Lomond as indicated by the following approximate annual water balance:

Newell Creek total streamflow above dam ^a		Felton Diversion to Loch Lomond ^b		Loch Lomond diversion to GHWTP ^c		Release Down- stream of dam ^d		Loch Lomond evapo- ration in excess of native ET ^e		Change in Loch Lomond storage ^f		Loch Lomond spill ^g
<u>AF/yr</u>												
6,500	+	350	=	2,600	+	724	+	270	+	0	+	3,300
<u>MG/yr</u>												
2,120	+	110	=	850	+	240	+	90	+	0	+	1,080

^a Watershed estimated unit streamflow of 14.7 in/yr (Table 3-10; Figure 3-12) across 5,286 acres.

^b 1976-2007 average (Table 6-2).

^c 1972-2007 average (Table 6-2).

^d Continuous 1 cfs.

^e Potential ET (~46 in/yr) minus actual ET (~28 in/yr; see Table 3-10) = 17.9 in/yr x 180 ac reservoir area = 270 AF/yr.

^f Average change in reservoir storage = zero.

^g Estimated from balance of other terms.

Thus, more than half of long-term total Newell Creek streamflow has spilled from Loch Lomond.

Figure 6-5 provides plots representative of Loch Lomond monthly water quality from 1974 to 2002.

6.1.4 SLVWD Expected Potential Yield

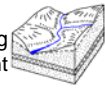
Raw water conveyance from Loch Lomond to SLVWD's Lyon WTP is currently infeasible as well as impractical. In order to take delivery of raw water from Loch Lomond, SLVWD would require a new, favorably situated filtration plant. The site of the former Glen Arbor WTP is no longer available. SLVWD has no plans regarding a new WTP.

If SLVWD were to take delivery of raw water from Loch Lomond, the available record suggests that the District could reliably purchase its 313 AF/yr (102 MG/yr) entitlement during most years. The reservoir has spilled during the wet season of nearly two-thirds of all years since 1961. Such spills tend to occur when City demand is low. Deliveries to SLVWD also would be possible during many of the years when the reservoir does not spill. As occurred in 1977, disputes could arise regarding the allocation of Loch Lomond storage during drought years. As discussed in Section 7, the potential unreliability of Loch Lomond deliveries during dry years could be mitigated through planned conjunctive use with SLVWD's groundwater resources.

6.2 SCCWD Treated Water

As mentioned in Section 6.1, SCCWD has offered to sell SLVWD 313 AF/yr (102 MG/yr) of treated water from its Graham Hill WTP. This would be in lieu of SLVWD's entitlement to a direct diversion from Loch Lomond, with the exception that the supply would be interruptible during declared water-shortage emergencies (Kocher, May 1996). This section summarizes the City's total supply and assesses its potential as a reliable source for SLVWD.

SCCWD serves a population of approximately 90,000 within the City of Santa Cruz, adjoining unincorporated areas (e.g., Live Oak), and the western portion of the City of Capitola. At its northern-most extent along Graham Hill Road, the City service area boundary lies within 2,000 feet of SLVWD's Southern Service Area boundary (Figure 1-2).



Since 1972, SCCWD annual water production has ranged between 10,000 and 14,000 AF/yr (3,300 to 4,600 MG/yr) other than during the 1976-77 drought (Table 6-3; Figure 6-6). The City derives its water supply from a variety of sources, including direct diversions from the San Lorenzo River at Tait Street and Felton; two river-side wells at Tait Street; Loch Lomond reservoir on Newell Creek; diversions from three streams (Laguna, Reggiardo, and Majors creeks) and one spring (Liddell Spring) that drain to the ocean northwest of the City; and a wellfield tapping the Purisima aquifer in the Live Oak area.

Table 6-1 summarizes the City's water rights associated with these sources. Table 6-3 and Figure 6-7 present the record of annual production from all sources since WY 1972. Figure 6-8 presents the City's monthly production record for 1971-2007 relative to monthly storage in Loch Lomond.

Since 1972, the City's annual water supply has been derived approximately as follows (Table 6-3):

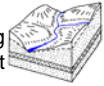
	<u>Percent of Total</u>	
	<u>average</u>	<u>range</u>
Direct diversions from San Lorenzo River	about 40	12 - 65
Loch Lomond releases	nearly 25	6 - 42
North-coast stream and spring diversions	nearly 30	16 - 40
Tait and Beltz wellfields	less than 10	0 - 20

As presented in Table 6-4 and Figure 6-9, SCCWD estimates that its system's leakage of treated water averages about 5 percent.

Table 6-5 presents a summary of SCCWD's 2007 water quality consumer confidence report. Further analysis of SCCWD water quality is beyond the scope of this report.

SCCWD's 2005 Urban Water Management Plan (Godard, 2006) provides the following information:

- The primary factor responsible for potential water supply deficiencies is streamflow variability as a function of the climatic cycle and potential climatic change.
- As of 2006, supply reliability is unaffected by any legal, water quality, or environmental factors.
- However, the City faces uncertainties with regard to its water rights and implementation of state and federal endangered species legislation, which could lead to supply losses relative to existing conditions.
- Although the City's maximum direct-diversion right from Loch Lomond (3,200 AF/yr or 1,040 MG/yr) is available on average, the reservoir's reliable supply is estimated to decline to about 2,150 AF/yr (700 MG/yr) at the beginning of a drought, and 600 AF/yr (200 MG/yr) during the second year of a worst-case drought.
- SCCWD's water supply system is grossly inadequate for meeting current demand under drought conditions. It would experience an estimated 45 percent peak-season shortage in the second year of a drought comparable to 1976-77 (Gary Fiske & Associates, 2003).
- SCCWD estimates that it can meet 100 percent of existing water demand roughly 7 out of every 10 years, and at least 90 percent of existing demand during about 9 out of every 10 years. The likelihood of experiencing a supply deficiency of greater than 10 percent is about one year in ten.



- The City has never exercised its full appropriative right to divert 3,000 AF/yr into Loch Lomond from its San Lorenzo River Felton diversion. The City is seeking an extension to the time allowed to establish full beneficial use pursuant to its permit.
- The City plans to submit filings to the State Water Resources Control Board to modify its Newell Creek water rights, which currently limit maximum use to the collection of storage rather than direct diversion.
- The City has identified seawater desalination as the only feasible alternative for ensuring an adequate water supply during drought. The City is proceeding with plans to construct a desalination plant with an eventual capacity of 2.5 mgd.