GREENHOUSE GAS EMISSIONS OF WATER USE AND WASTEWATER GENERATION BY MUNICIPAL FACILITIES IN SONOMA COUNTY: METHODOLOGY SUPPLEMENT

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INTRODUCTION

This supplementary report explains the details of the methodology used in the main report, ***Greenhouse Gas Emissions of Water Use and Wastewater Generation by Municipal Facilities in Sonoma County*.**

Greenhouse (GHG) emissions are measured in tons of Carbon Dioxide equivalents[1] (tons-CO_2). The GHG emissions in this supplement and the main report were calculated from energy purchased to operate water supply and wastewater treatment, reclamation, and disposal. The focus on purchased energy is in accordance with the guidelines established by the International Council for Local Environmental Initiatives (ICLEI) for their Climate Protection Campaign. For water and wastewater systems in Sonoma County, purchased energy includes electricity and natural gas[2]. GHG emissions are produced at the electric utilities' generating plants, and from burning natural gas at wastewater treatment plants.

For example, given that the average GHG emissions for PG&E's electricity plants is 0.729 lb-CO_2/KWhr[3], if 1,000 MWhr[4] is purchased from PG&E to pump 100 million gallons (MG) of water from a well, then the well's GHG emissions would be 364.5 tons-CO_2/yr. If 2 MG of this water were used at City Hall, then City Hall's embedded GHG emissions would be 7.29 tons-CO_2.

For water, GHG emissions in this report include energy used by wells and distribution system booster pumps. Some cities receive water from the Sonoma County Water Agency (SCWA), so a fraction of SCWA's GHG emissions are allocated to the city, based on volume.

[1] Other gases, such as methane, also have a greenhouse gas effect.
[2] A relatively insignificant quantity of diesel fuel is used in emergency backup generators, and is not included in this report.
[3] 2,000 lb-CO_2 = 1 tons-CO_2
[4] 1 MWhr = 1,000 KWhr

For wastewater, GHG emissions in this report include energy used by sewage lift pumps, wastewater treatment plants (including natural gas), and pumps for irrigation with reclaimed wastewater. Sebastopol, Cotati, Rohnert Park, and Santa Rosa utilize the Laguna de Santa Rosa Subregional Wastewater Treatment Plant (Laguna Plant), and the plant's GHG emissions are allocated to each city according to wastewater influent volume.

Energy for water and wastewater systems is used and metered for equipment serving an entire city rather than individual municipal facilities. In this report, the embedded energy for an individual facility is estimated from the volumes of water used and wastewater generated by the facility.

Using the same example as before, if 1,000 MWhr from PG&E is used to supply 100 MG of water to the entire city, and 2 MG are used at City Hall, City Hall's embedded water supply energy would be 20 MWhr (the embedded GHG emissions would be 7.29 tons-CO_2).

Wastewater volumes for facilities in all cities were estimated from water usage and from each city's community-wide split between indoor and outdoor usage (water used indoors is overwhelmingly discharged to sewer, while outdoor use is mostly for landscape irrigation, i.e. not discharged to sewer).

Continuing the previous example, if half of the water supplied to the entire city is eventually discharged as wastewater, City Hall's wastewater volume would be 1 MG. If the wastewater treatment system uses 2,000 MWhr from PG&E to treat the city's entire 50 MG of wastewater, City hall's embedded wastewater treatment energy would be 40 MWhr (the embedded GHG emissions would be 14.58 tons-CO_2).

Only Sebastopol had water meter records for municipal buildings and parks; water usage in other cities was estimated from unit water usage in Sebastopol. To check the range of estimated volumes for each facility, unit water usage was calculated per floor area (gallons/ft^2) and per employee or regular occupant (gallons/person).

We recommend that water meters be installed at all municipal facilities, to prevent waste and quantify the effectiveness of efficiency improvements – which should simultaneously reduce costs and GHG emissions.

METHODOLOGY

Overview

The general method for calculating the embedded energy of water and wastewater for each municipal facility used in this report was:

- Obtain unit GHG emissions factors for electricity generation and for natural gas.
- Obtain monthly energy-use data for systems serving the entire city.
- Obtain monthly volumes of water supply, wastewater treatment plant influent, and reclaimed wastewater irrigation for the entire city.
- Calculate for the entire city, the monthly split between indoor and outdoor water usage, and the monthly unit energy use for water and wastewater.
- Determine the floor areas and number of regular occupants for each municipal building, and the irrigated areas of each city park.
- Calculate annual unit water use for Sebastopol municipal facilities (the only city where annual water usage is metered).
- Calculate the annual water use for each municipal facility in other cities by applying Sebastopol's unit values.
- Calculate monthly water supply and wastewater discharge volumes for each facility.
- Calculate monthly embedded energy for water and wastewater for each facility.
- Calculate annual GHG emissions for each facility.

GHG Emissions from Energy Use

GHG emissions for this report are calculated from energy purchased to operate water supply and wastewater treatment/disposal, according to the guidelines established by ICLEI for the Climate Protection Campaign. The GHG emissions for purchased energy are derived from the local electric utility's generating plants, and from burning natural gas sold by the utility.

All cities except Healdsburg obtain electricity from PG&E, which relies mainly on fossil-fueled plants but also utilizes a significant number of hydro-electric plants in the Sierra Nevada Mountains. Healdsburg purchases electricity from the Northern California Power Authority

(NCPA) which relies mainly on hydro-electricity, but has significant component of natural gas fired plants. SCWA obtains 25% of its electricity from the hydro-electric plant of the Western Area Power Administration (WAPA), and 75% from PG&E. Table 1 shows the annual average unit GHG emissions (lb-CO_2/KWhr) for PG&E, NCPA, and WAPA.

Table 1 also shows the unit GHG emission from the combustion of PG&E's natural gas. Natural gas is composed of methane (with trace concentrations of mercaptans to provide odor for safety).

TABLE 1

Annual Average Unit GHG Emissions Factors for Purchased Energy[5]

	Electricity	N.Gas
	lb-CO_2/KWhr	lb-CO_2/therm
PG&E[6]	0.729	12.34
NCPA[7]	0.299	-
WAPA[8]	0	-

[5] Derived by Provimetrics (see our companion report, *Electricity and Natural Gas*) from a combination of information provided by ICLEI, PG&E, NCPA, and WAPA. Although the annual average includes higher GHG emissions from "peaker" plants, we did not have sufficient information to calculate unit emissions for different seasons.
[6] Provided by ICLEI.
[7] Specifically for Healdsburg, based on NCPA's allocation of generation plant capacity to the city (reported by Bill Duarte, City of Healdsburg).
[8] WAPA's hydroelectricity has no GHG emissions. WAPA does purchase some peak summer power from other utilities, and beginning in 2005, WAPA will allocate their costs and GHG emissions directly to members (similarly to NCPA).

Calculating Energy Use by Water and Wastewater Systems

A database of all energy (electricity and N.gas) accounts for municipal facilities was complied for each city in Fiscal Years 2000-2001 and 2001-2002. For most cities, this was provided by PG&E; in Healdsburg data about NCPA electricity was provided by the City Utilities department.

The databases were "mined" to extract monthly energy use and cost for wells, booster pumps, sewage lift stations, wastewater treatment/disposal plants, and pump stations for irrigation with reclaimed wastewater.

For SCWA, we obtained data from PG&E, from SCWA's central SCADA system, and WAPA monthly invoices. The energy data from SCWA also covered wastewater operations for the City of Sonoma[9].

For the Laguna Plant, including the reclamation system, we obtained information from PG&E. Besides purchases from PG&E, approximately half of the electricity used at the Laguna Plant is generated on site; the cogeneration system utilizes N.gas from PG&E and biogas[10].

After gathering energy data for water and wastewater systems serving an entire city, allocations must be made to individual municipal facilities. The most rational basis for allocation is by volume of water supplied to, and wastewater generated by, each facility.

Utilizing the city-wide unit energy use (MWhr/MG) for water and for wastewater, the embedded energy for each facility can be calculated. For example, if all the wells and booster pumps use 1,000 MWhr of electricity to supply 100 MG of water, unit energy use for the city's water supply is 10 MWhr/MG. Then if City Hall uses 2 MG, the embedded energy of water will be 20 MWhr.

To calculate city-wide unit energy use for water, we obtained monthly data for volumes supplied
(a) by SCWA to each city, from SCWA's central SCADA computer, and
(b) by each local well, from city records.
Monthly unit energy use for water supply is calculated by dividing monthly energy use[11] by the total monthly water supply volume.

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[9] SCWA operates the Sonoma Valley County Sanitation District, including sewage lift stations, the wastewater treatment plant, and reclaimed wastewater system.

[10] Biogas is produced in anaerobic digestors from biological process solids. Its combustible component is methane, and so it has the same GHG emission per unit of fuel value (tons-CO_2/therm) as PG&E's N.gas.

[11] By all local wells, pressure booster pumps, and SCWA water supply energy (allocated according to the fraction of water supplied to the city, divided by SCWA's total energy use for water supply).

Wastewater volumes for facilities in all cities were estimated from water usage and from each city's community-wide split between indoor and outdoor usage. Water used indoors is overwhelmingly discharged to sewer, while outdoor use is mostly for landscape irrigation, and not discharged to sewer. Indoor use is estimated from the lowest monthly water supply volume in winter, when the demand for landscape irrigation volume is (or should be) insignificant.

For the Sonoma County cities analyzed in this report, indoor use is fairly constant, so it used to represent a constant monthly wastewater volume. By implication, outdoor use varies greatly from month to month as the demand for landscape irrigation changes. Verification of this assumption is discussed in the next section on Quality Assurance.

Continuing the previous example for water, if half of the water supplied to the entire city is eventually discharged as wastewater, City Hall's wastewater volume would be 1 MG.

If the wastewater treatment system uses 2,000 MWhr of electricity to treat the city's entire 50 MG of wastewater, unit energy use for wastewater would be 40 MWhr/MG. City Hall's embedded wastewater treatment energy would then be 40 MWhr.

Only Sebastopol had water meter records of annual water usage by buildings and parks[12], and none of the facilities in any of the cities had wastewater meters[13]. Annual water usage for all municipal facilities was therefore estimated from annual average unit water usage in Sebastopol, from floor area (in gallons/ft^2), and from the number of regular occupants (in gallons/person).

Although the assumption of equal unit water use for similar facilities in different cities seems doubtful, the results from independent calculations based on floor area and occupants were very close (more details in the next section on Quality Assurance). In the absence of measured data, this was the best, and only indication of validity.

Monthly water use by each facility was calculated by multiplying the estimated annual water use for each facility by the monthly distribution factor of water supply to the entire city[14].

Monthly wastewater discharge from each municipal facility was then calculated by multiplying its monthly water use by the monthly distribution factor of indoor water usage for the entire city[15].

[12] Petaluma has water meters at municipal facilities, but records were not available for this report.
[13] The lack of wastewater metering is not unusual, nor necessary if water meters are available.
[14] Each month's distribution factor was calculated by dividing the monthly volume by the total annual volume.
[15] Each month's distribution factor was calculated by dividing the monthly indoor volume for the entire city by the total monthly water supply for the entire city. Although the assumption is that monthly indoor use (and therefore wastewater generation) is fairly constant in volume throughout the year, the distribution fraction is highly variable because of changing outdoor use.

Monthly outdoor usage for landscape irrigation is calculated by subtracting indoor use from total monthly water supply. For city parks, we assume that all water is used for irrigation and none is discharged to sewer.

The penultimate step is to calculate the embedded energy of water and wastewater for each municipal facility. This is done by multiplying the monthly water (or wastewater) usage for each facility by the monthly unit energy use for the entire city, for water (or wastewater).

To prepare for the calculation of GHG emissions, separate calculations must be made for electricity and natural gas. For SCWA water supply, electricity purchased from WAPA must be separated from purchases from PG&E.

The final step is to calculate annual GHG emissions by multiplying the sum of monthly energy use (separated by source) by the GHG emissions factors in **Table 1**.

Data Verification and Quality Assurance

The utilization for independent data sources for energy, water, and wastewater offered several opportunities to verify data quality, validate assumptions, and accurately estimate missing data.

A companion report, ***Electricity and Natural Gas*** by Provimetrics, compared payments by cities to billings by PG&E, and found very close closure. In the PG&E accounts for water and wastewater systems, we added an additional checks to verify that average monthly rates ($/KWhr or $/therm) were valid and within a reasonable range[16]; if not, a more detailed examination was performed.

Frequent issues were:

(a) credit or debit reconciliation of previous bills,
(b) payments made to third parties instead of PG&E[17], and
(c) missing data for both cost and energy.

Items (a) and (b) were resolved with help from PG&E representatives and city accounting departments; item (c) required examination of water and/or wastewater volume data.

[16] The average monthly rates vary significantly because of seasonal differences in energy and power charges. Variation due to fixed costs is much smaller, but will be significant for local wells and reclaimed wastewater pumps in winter, when they are hardly operated.
[17] This happened for SCWA, the Laguna Plant, and the Petaluma Wastewater Treatment Plant during FY 00-01.

Water and wastewater volumes provided additional quality assurance, by verifying that the pattern of monthly energy use matches the pattern of monthly volume. For example, by checking that electricity use is similar in each month that a given well supplies a similar volume of water[18].

In most cases, this check was most useful for filling in missing energy data (although it helped “flag” overlooked problems in the energy database), by providing a means of accurately estimating monthly energy from monthly volume[19].

For water supply from SCWA and wastewater treated at the Laguna Plant, we were also able to check the closeness of unit costs (in $/1000-gal), for different months in the same year· both facilities provided a breakdown of monthly energy-related and total costs (including labor, O&M, and overhead). Unit energy costs were expected to vary according to energy rates, but within the limits of monthly differences in volume.

SCWA provided monthly total costs for each city, allowing a comparison of unit costs between the cities and with SCWA’s average rate for each year[20]. The Laguna Plant provided annual total costs, and the contracted allocation of these costs between cities; unit costs differed only because of these allocations[21].

The relationship between water use and wastewater generation provided an opportunity to validate the assumed split between indoor and outdoor water use. Two independent estimations of wastewater discharge by the entire city can be compared:

(a) as represented by the lowest winter monthly water supply volume, when landscape irrigation is insignificant in Sonoma County, and
(b) as represented by the lowest summer monthly influent volume to the wastewater treatment plant, when extraneous inflows in Sonoma County are insignificant[22].

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[18] Unit energy use per unit volume (KWhr/MG) is not fixed for all months. As more water is pumped through the water distribution system, especially in summer, friction losses increase, and system pressures change. This in turn changes the outlet pressure, flowrate, and power required by pumps.

[19] With two Fiscal Years in the database, there was almost always a month with a very close volume, and several within a similar range, from which an average unit energy use could be calculated. In some cases, such as in Windsor, where the entire FY 00-01 PG&E database was missing, we could utilize only the 12 months of FY 01-02; fortunately the range of volumes (water and wastewater) was similar for both years.

[20] The average rate for all SCWA customers (not only the cities in this report) in FY 00-01 was $0.98/100-gal; in FY 01-02 the average rate was $1.12/1000-gal, a 15% increase.

[21] The contractual allocations for Sebastopol, Cotati, and Rohnert Park are smaller than the volumetric fractions calculated in this report; higher for Santa Rosa and South Park CSD. More importantly, a comparison shows that energy-related costs (including irrigation with reclaimed wastewater) represent only 20% of total costs, while capital depreciation (i.e. repayment of construction debts) is approximately 40%; labor and maintenance each represent another 20%.

[22] In wet weather (winter in Sonoma County), storm water can flow into sewers through manholes and incorrectly connected rain gutters; this is known as inflow. When the soil surrounding the sewers is very wet, groundwater can enter sewers through cracks and separated joints; this is known as inflow. Detailed studies for most cities reveal the

All cities in this report, except Healdsburg, showed close matches (3-10%) between the two values[23]. Healdsburg data had a 30% difference that needs to be further investigated[24], especially since a large investment is being made to upgrade the wastewater treatment system.

Annual water usage for all municipal facilities was estimated from annual average unit water usage in Sebastopol, from floor area (in gallons/ft^2) and from the number of regular occupants (in gallons/person).

Although the assumption of equal unit water use for similar facilities in different cities seemed doubtful, and the results of the two calculation methods for each facility were very different, the overall total for each city (i.e. for all the municipal buildings together) were very close.

In the absence of measured data, this was the best, and only, indication of validity. We strongly recommend installing water meters for all municipal facilities to properly validate the estimates in this report. Besides validation, the meters will also help prevent waste and quantify the effectiveness of efficiency improvements – which should simultaneously reduce costs and GHG emissions.

APPLICATION OF THE METHODOLOGY

To clarify how the methodology was applied, this section presents Rohnert Park as an example. Rohnert Park is the third most populated city in Sonoma County, obtains water from local wells and from SCWA, and discharges wastewater to the Laguna Plant.

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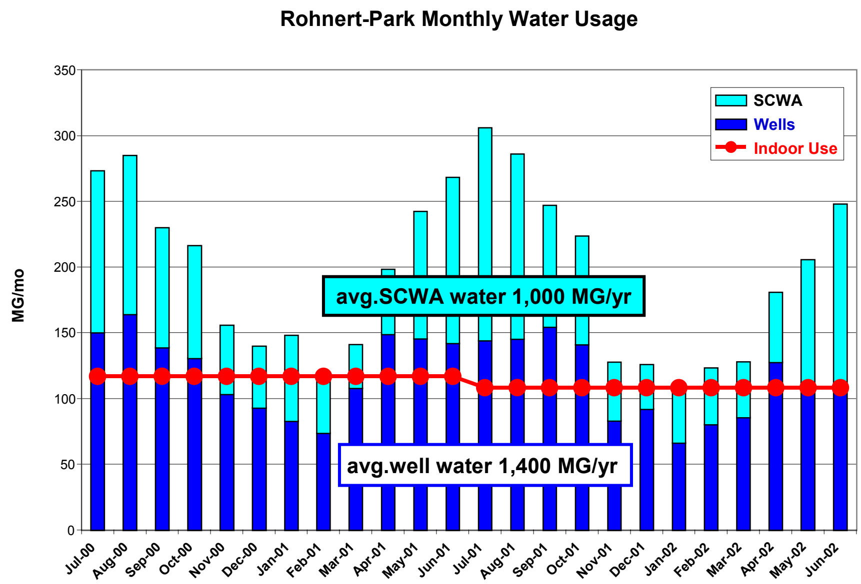
inflow/infiltration (I/I) is quite high, especially in the older sewers of Santa Rosa, Petaluma, and Sonoma. Exfiltration from sewers into the surrounding dry earth in summer is also possible, but not deemed anywhere nearly as significant as I/I in winter (in other words, inflows are the largest factor).

[23] For Rohnert Park, Sebastopol, and Cotati the lowest dry-weather influent to the Laguna Plant was multiplied by the cost allocation fraction for each city to arrive at an estimated dry-weather wastewater volume (the allocation factor was based on measured and estimated flows at several points, and times, in each city's sewer system).

[24] Specifically, 30-40% less influent volume is measured by the flowmeter at the wastewater treatment plant than represented by the lowest monthly water supply volumes in both Fiscal Years (in other words, some of the wastewater seems to disappear before reaching the treatment plant). Staff has suggested that this is because Healdsburg has a very large fraction of industrial users (mostly wineries) within its city limits; their impact cannot be confirmed without further investigation. Another possible cause to investigate is that flowmeters might be out of calibration, at the wells and/or the wastewater treatment plant.

Fig.1 shows a typical pattern of water use in Sonoma County cities, with large peak demands in summer months.

Fig.1



Local wells provide 1,400 million gallons per year (MG/yr) while the SCWA provides 1,000 MG/yr, for a total of 2,400 MG/yr. Indoor demands for both Fiscal Years are also shown in **Fig.1**, to illustrate the huge impact of landscape irrigation in summer.

FIG.2

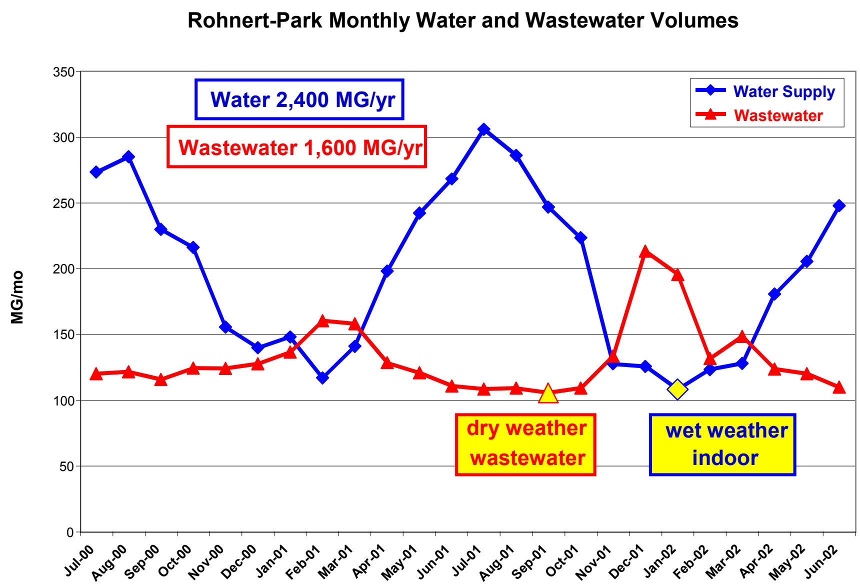


Fig.2 compares water use and wastewater generation, and confirms that wastewater volume is the same as indoor water use.

Annual water use is 2,400 MG/yr, and wastewater discharge is 1,600 MG/yr. The wastewater volume includes I/I, as can be seen from the winter peaks, especially in December 2001 and January 2002. A comparison of the lowest water demand in winter (no significant demand for landscape irrigation) to the lowest wastewater flow in summer (no significant I/I) shows that they are very close[25], which helps confirm the assumption that wastewater generation (before adding I/I) equals indoor water demand.

The 2,400 MG/yr water supply was derived directly from flowmeters at SCWA and the city's local wells, while the 1,600 MG/yr wastewater discharge had to be estimated indirectly. This is because the flowmeter at the Laguna Plant combines influent from all users, of which Rohnert Park is only ~19%.

[25] Within ±4% for both Fiscal Years.

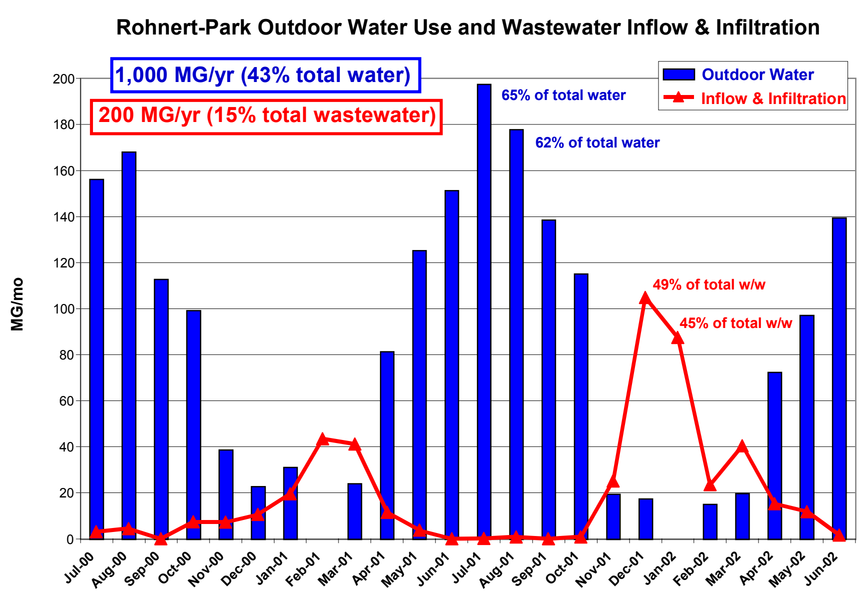
The first iteration of the estimate was to apply the Laguna Plant's contractual allocation fraction for Rohnert Park to the lowest monthly influent flow in summer, to calculate monthly wastewater generation without the influence of I/I.

The second estimate of wastewater generation was derived from the assumption that wastewater generation equals indoor water use, which in turn is represented by the lowest monthly water demand in winter. A comparison of both estimates showed very small differences[26], well within the expected error in monthly flowmeter records.

Assuming that half the difference could be attributed to the flowmeters, the estimate of the Laguna Plant's dry weather influent from Rohnert Park was adjusted by +4% in FY 00-01 and by –4% in FY 01-02.

Fig.3 confirms that outdoor water use is closely related to irrigation demand, with large peaks in summer and zero demand in wet months. Outdoor use consumes 43% of annual water supply, and in summer months, this fraction rises to 65%.

FIG.3



[26] Within +7% for FY 00-01 and –7% for FY 01-02.

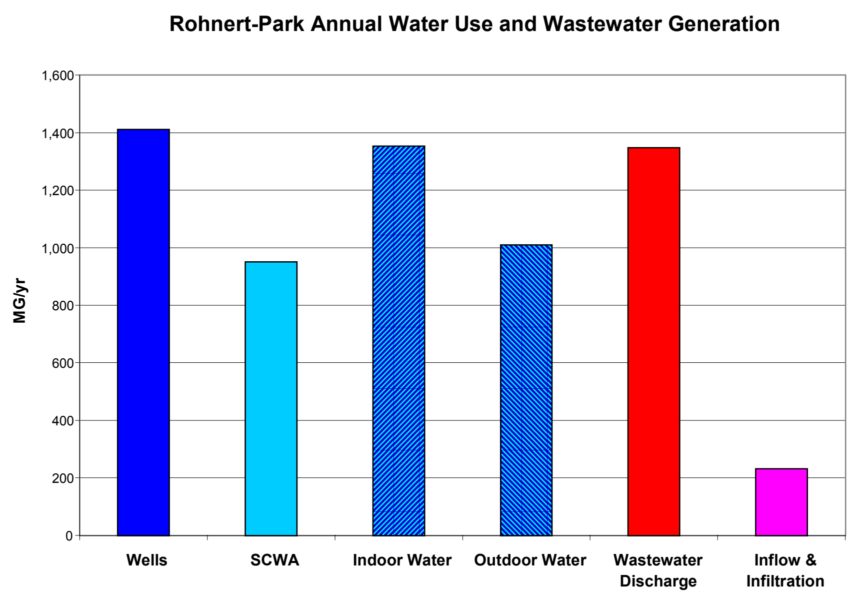
Fig.3 also confirms that I/I is directly related to wet weather, with peaks in winter and plunging to zero in summer. Although only I/I is 15% of the annual wastewater volume, it rises to almost 50% in wet months[27].

Monthly outdoor water use was calculated as the difference between the measured total monthly water supply and the estimated indoor water use (which is assumed constant for each Fiscal Year).

In general, I/I volume can be calculated from the difference between each month's wastewater influent volume and the plant's lowest monthly influent in summer[28], both measured at the treatment plant's influent flowmeter. For cities discharging to the Laguna Plant, I/I volumes had to be estimated because the flowmeter at the Laguna Plant combines influent from all users. The first assumption that had to be made for this report was that I/I measured at the Laguna Plant was distributed between the different cities according to their relative dry weather wastewater flows (adjusted as explained previously). It is very likely that Rohnert Park's newer sewer system has far less I/I than Santa Rosa's[29], but quantification is beyond the scope of this report. Monthly I/I was therefore calculated by multiplying each city's dry weather wastewater volume by the monthly ratio of the plant's I/I[30] to the plant's dry weather influent.

Fig.4 shows the relative annual volumes of water supply sources, indoor and outdoor water demands, wastewater generated, and I/I to the sewers.

FIG.4



[27] The same pattern, reflecting the large storms of December 2001/January 2002 was found in all the wastewater treatment plants included in this report.
[28] Dry weather flow changes from year to year, according to population trends, industrial activity, and implementation of water efficiency/wastewater reduction programs. Tracking of dry weather flow trends is required by State and Federal regulations.
[29] As implied in Santa Rosa's recent EIR for the Incremental Recycled Wastewater Project.
[30] Plant I/I = monthly influent volume – dry weather influent.

Besides summarizing the previous calculations, **Fig.4** also illustrates the value of irrigation with reclaimed water. Reclaiming 75% of the wastewater (without I/I) could provide the entire outside water demand. This in turn would could eliminate water purchases from SCWA, and/or a very large fraction of water supply from local wells.

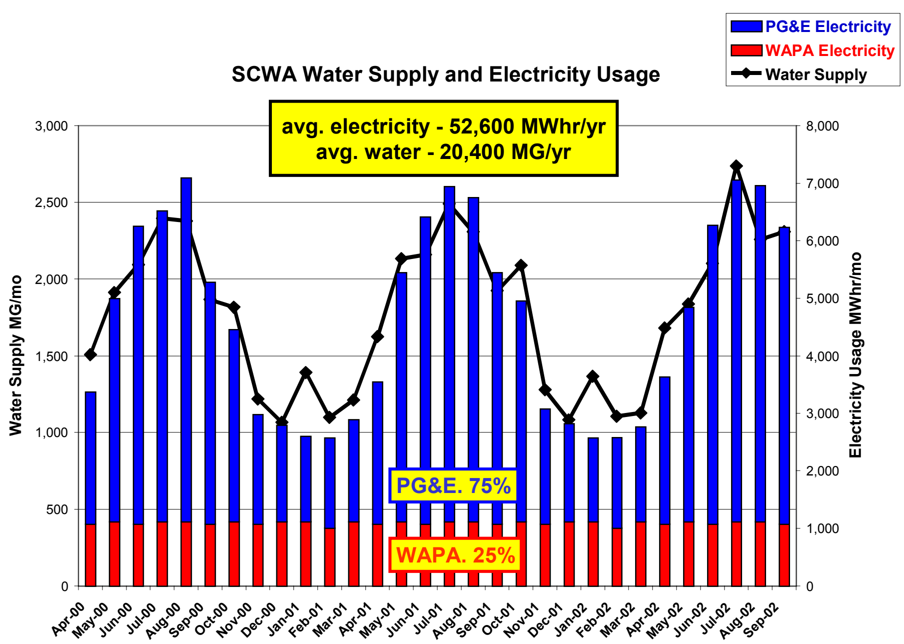
Rohnert Park's wastewater is treated at Santa Rosa's Laguna Plant, which is already reclaiming 40-50% of its influent flow, so a relatively small increase in reclamation, which is under consideration in the most recent wastewater EIR issued by Santa Rosa, could have a large impact on water supply.

The record of Rohnert Park's purchases of electricity from PG&E for local wells, booster pumps, and sewage lift stations was almost complete except for 2 months that were easily estimated from water and wastewater volumes.

For SCWA water supply, the PG&E database was reliable for energy and costs only from November 2001 through December 2002; only energy data was reliable from June 2001 through October 2001. Data for SCWA's water supply volumes were valid for both Fiscal Years, so it was possible to extrapolate electricity use for the missing months (FY 00-01), for the entire system and for Rohnert Park's fraction.

Fig.5 shows the resulting electricity use and water volumes for the entire SCWA water system.

FIG.5



(**Fig.1** shows the volumes supplied to Rohnert Park). Although the energy split between PG&E and WAPA is 75% to 25%, the split in costs is 91% to 9% respectively. The most important implication of **Fig.5** is that peak supply of water and peak use of PG&E electricity coincide with the PG&E's highest rates in summer – the calculated energy cost of water delivery in summer is $314/MG, while the winter cost is only $127/MG – in other words, landscape irrigation is very costly.

Rohnert Park's embedded energy for wastewater treatment and irrigation with reclaimed wastewater is calculated from the ratio of Rohnert Park's wastewater, shown in **Fig.2**, to the entire Laguna Plant influent, shown in **Fig.6**.

FIG.6

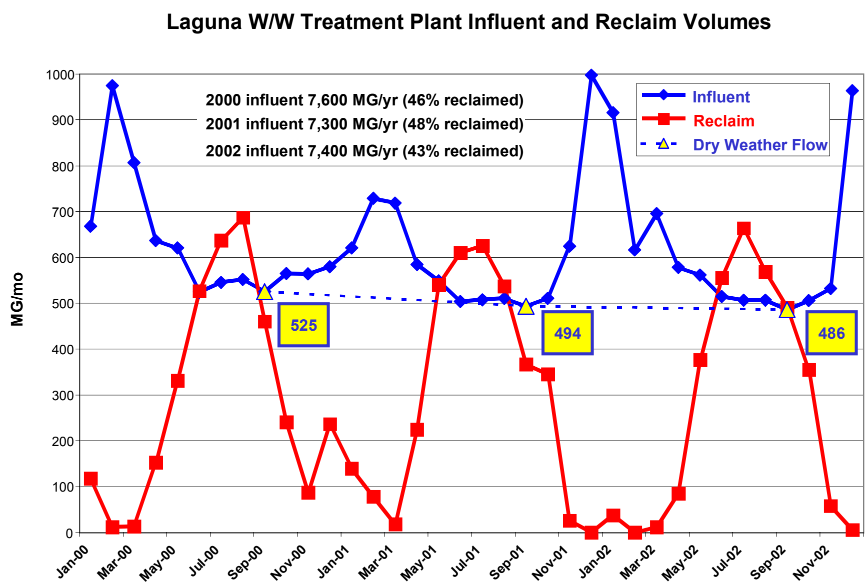
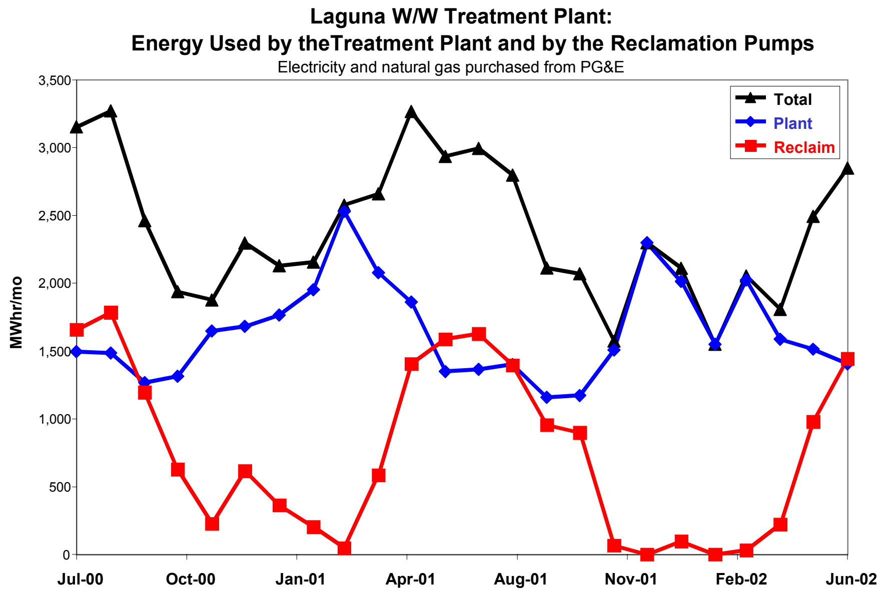


Fig.6 also shows monthly irrigation with reclaimed wastewater; on an annual basis, 40-50% of the wastewater influent is reclaimed for irrigation, a very high percentage compared to most other San Francisco Bay Area wastewater treatment plants.

As an encouraging aside, **Fig.6** shows that the Laguna Plant's dry weather influent is declining even though population has increased. The latest EIR for the plant's Incremental Recycled Wastewater Project attributes this to Santa Rosa's aggressive water efficiency program, that could be expanded to other subregional members (i.e. Rohnert Park, Cotati, and Sebastopol).

Fig.7 shows electricity purchased from PG&E by the Laguna Plant, to operate the treatment plant and to pump reclaimed wastewater for irrigation.

FIG.7



In summer, more electricity is purchased (at higher rates) for reclamation than for treatment, closely following the monthly flow patterns shown in **Fig.6**.

Electricity purchases from PG&E represent only 60% of the electricity used annually at the Laguna Plant; the other 40% is cogenerated on site, using a combination of biogas produced by the treatment process, and natural gas purchased from PG&E.

Based on fuel value, biogas and natural gas are utilized almost equally for cogeneration (49% and 51% respectively). Even though they contribute the same GHG emissions upon combustion, only the purchased natural gas is accounted for in ICLEI's guidelines for the Climate Protection Campaign[31].

[31] The claim is that natural gas is a fossil-fuel extracted from the earth, releasing sequestered carbon to the atmosphere. Biogas is produced by biological process from carbon that has not been sequestered.

FIG.8

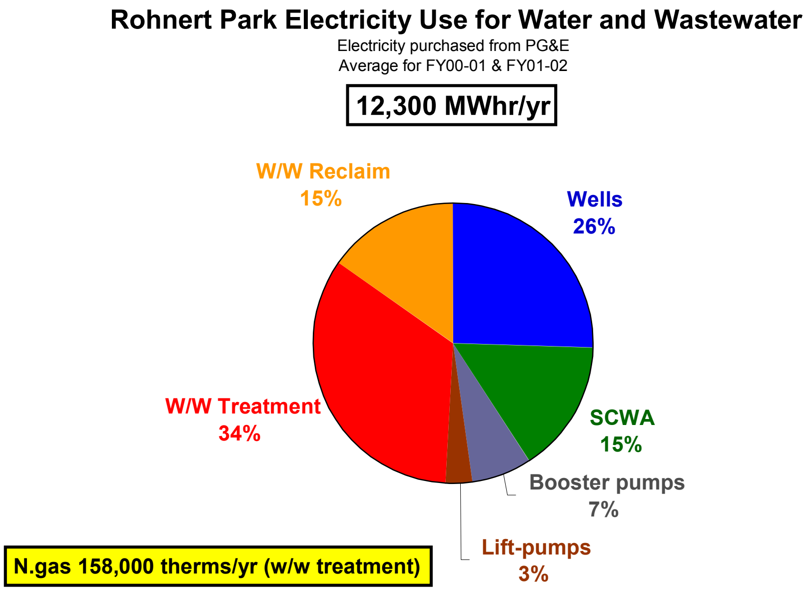


Fig.8 shows Rohnert Park's embedded purchased energy use for water and wastewater[32], including local wells, SCWA, booster pumps, lift stations, wastewater treatment at the Laguna Plant, and irrigation with reclaimed wastewater from the Laguna Plant. Natural gas used for wastewater treatment is shown in a separate side box.

[32] Averaged for both Fiscal Years.

FIG.9

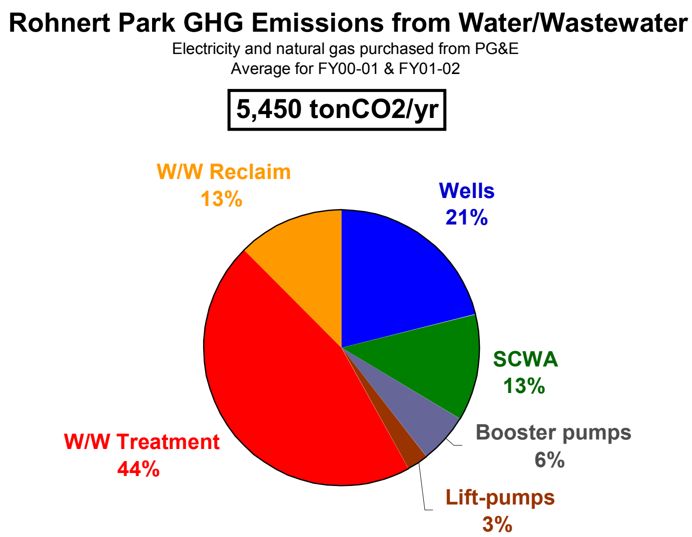


Fig.9 summarizes Rohnert Park's 5,450 tons-CO_2/yr GHG emissions[33], showing a significant redistribution compared to electricity, turning wastewater treatment into the largest element (60%).

This happened because the GHG emissions of natural gas can be combined directly with the GHG emissions of electricity.

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33 Averaged for both Fiscal Years.

Table 2 shows the embedded energy and GHG emissions for both Fiscal Years, derived from purchases from PG&E.

TABLE 2

Energy Use and GHG Emissions for Rohnert Park

Electricity and natural gas purchased from PG&E.

	WATER	WASTEWATER		WATER+W/W
	Electricity MWhr	Electricity MWhr	N.Gas therms	GHG emissions tons-CO_2
FY 00-01	6,020	6,920	138,700	5,570
FY 01-02	6,070	6,360	177,800	5,630

After calculating the embedded annual energy use and GHG emissions for water and wastewater for the entire city, unit usage is calculated by dividing them by the total annual water supply volume, to help estimate energy use and GHG emissions for individual facilities.

Table 2 summarizes the results for Rohnert Park for both Fiscal Years. For buildings, the values for both water and wastewater are combined; for parks, only the value for water is used.

Rohnert Park's municipal facilities do not have water meters, so estimates of water demand were based on unit demand for similar facilities in Sebastopol (where there are meters). Rohnert Park does have water meters for parks irrigated with the Laguna Plant's reclaimed wastewater; the recorded volumes were deducted from calculations. Their embedded energy and GHG emissions are included in Rohnert Park's proportional use of the Laguna Plant (treatment and reclamation systems).

To account for seasonal variations in irrigation demands and the influence of I/I on wastewater, the estimated annual water demand needs to be distributed into monthly water demands and wastewater discharges.

The monthly distribution of water use by each facility was calculated by multiplying the estimated annual water use for each facility, by the monthly water distribution factor[34] for the entire city.

[34] This distribution factor is derived by dividing each month's water supply volume shown in Fig.2, by the 12-month total (2,400 MG/yr average shown in Fig.2).

For wastewater, first annual indoor water use by the facility was calculated by multiplying the estimated annual water use by the annual split between indoor and outdoor water use for the entire city. **Fig 3** shows that the annual split for Rohnert Park is 43% outdoor use, and 57% indoor use[35].

The monthly distribution of wastewater discharges from each municipal facility was then calculated by multiplying its annual indoor water use by the monthly wastewater distribution factor for the entire city[36].

Estimates of water demand in each of the municipal buildings were made separately according to floor area and according to the number of regular occupants. Although the separate calculations for each building were far apart, the summaries for all municipal buildings were very close (the same was also true for all other cities).

The embedded energy of water and wastewater for each municipal facility is calculated by multiplying the monthly water (or wastewater) usage for each facility by the monthly unit energy use for the entire city, for water (or wastewater).

To prepare for the calculation of GHG emissions, separate calculations must be made for electricity and natural gas. For SCWA water supply, electricity purchased from WAPA must be separated from purchases from PG&E.

TABLE 3

Unit Energy Use and GHG Emissions for Rohnert Park

Electricity and natural gas purchased from PG&E.
Per unit of water supply (wells and SCWA).

	WATER	WASTEWATER		WATER+W/W
	Electricity MWhr/MG	Electricity MWhr/MG	N.Gas therms/MG	GHG emissions tons-CO_2/MG
FY 00-01	2.5	2.8	55	2.3
FY 01-02	2.6	2.9	77	2.4

Using **Table 3**, the embedded energy was calculated for all the municipal buildings combined (water and wastewater) and for all the parks combined (water only).

[35] In each Fiscal Year, indoor use equals the lowest monthly water supply volume in winter, which can be extracted from Fig.2. The annual split for indoor use is calculated by multiplying this indoor use by 12 (to distribute across the year), and dividing by the total of monthly water supply volumes shown in Fig.2 for each Fiscal Year (2,400 MG/yr average shown in Fig.2).
[36] This factor is derived by dividing each month's wastewater volume shown in Fig.2, by the 12-month total (1,600 MG/yr average shown in Fig.2).

TABLE 4

Embedded Energy Use and GHG Emissions of Water and Wastewater in Rohnert Park Municipal Facilities

Electricity and natural gas purchased from PG&E.
Total GHG emissions from Table2.

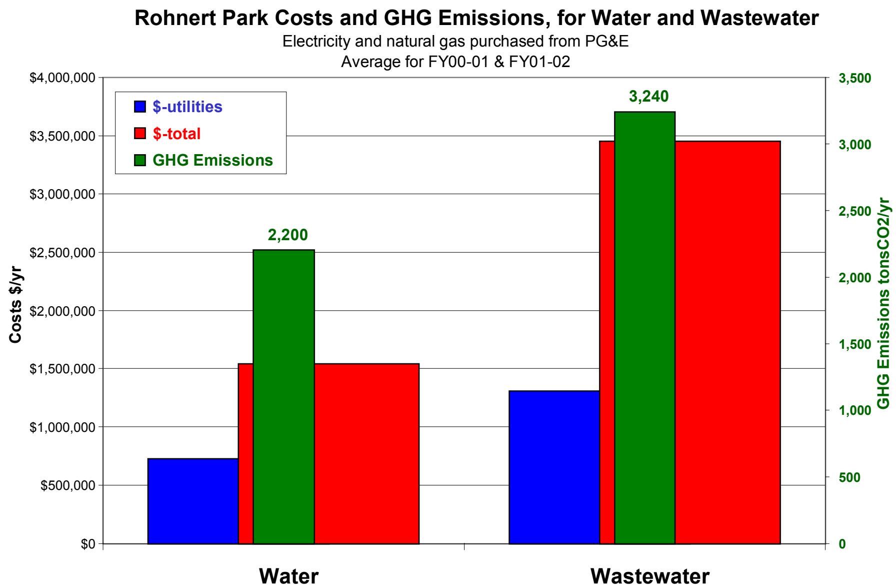
	PARKS	BUILDINGS		COMBINED GHG emissions	
	Electricity MWhr	Electricity MWhr	N.gas therms	tons-CO_2	% of total
FY 00-01	221	99	1,063	123	2%
FY 01-02	234	100	1,425	130	2%

Table 4 shows the results, and the very small fraction of Rohnert Park's total water/wastewater GHG emissions represented by the municipal facilities.

The implication is that municipal activities and decisions regarding water and wastewater systems for the entire city will have a far greater impact than focusing only on municipal facilities.

Examples include upgrading well pumps, expanding the use of reclaimed wastewater, and developing city-wide water efficiency programs.

FIG.10



For a final perspective, **Fig.10** compares Rohnert Park's embedded energy costs to the total costs paid by the city for water and wastewater.

The total annual costs include approximately $3.5 million to the Laguna Plant and $1.5 million to SCWA[37]. Energy costs are approximately 50% of total costs for water, and 40% for wastewater. This confirms that energy costs are an important factor, and with almost inevitable rate increases, they could seriously impact city budgets for water and wastewater. On the positive side, energy and water efficiency improvements could reduce this risk and simultaneously reduce GHG emissions.

[37] The O&M costs for the wells, booster pumps, and lift stations were not available for this report, but are probably very small relative to SCWA and Laguna Plant costs.