City of Beverly Hills

Beverly Hills City Council/
Public Works Commission Liaison Committee
Special Meeting

September 4, 2019
4:00 PM
City Hall
4th Floor Conference Room A
Beverly Hills City Council/Public Works Commission Liaison Committee will conduct a Special Meeting, at the following time and place, and will address the agenda listed below:

CITY HALL
455 North Rexford Drive
4th Floor Conference Room A
Beverly Hills, CA 90210

Wednesday, September 4, 2019
4:00 PM

AGENDA

1. Public Comment
   a. Members of the public will be given the opportunity to directly address the Committee on any item listed on the agenda.

2. Commercial Solid Waste Collection and Residential Solid Waste Processing Franchise Agreement – Update and Summary of Negotiated Contract Terms

3. Stormwater Projects Update

4. Integrated Water Resources Master Plan (IWRMP) Workshop; June 27, 2019 Summary

5. Adjournment

Huma Ahmed, City Clerk

Posted: August 30, 2019

A DETAILED LIAISON AGENDA PACKET IS AVAILABLE FOR REVIEW IN THE LIBRARY AND CITY CLERK'S OFFICE.

Pursuant to the Americans with Disabilities Act, the City of Beverly Hills will make reasonable efforts to accommodate persons with disabilities. If you require special assistance, please call (310) 285-1014 (voice) or (310) 285-6881 (TTY). Providing at least forty-eight (48) hours advance notice will help to ensure availability of services. City Hall, including 4th Floor Conference Room A, is wheelchair accessible.
TAB 1
Public Comment

Members of the public will be given the opportunity to directly address the Committee on any item listed on the agenda.
TAB 2
CITY OF BEVERLY HILLS
PUBLIC WORKS DEPARTMENT

MEMORANDUM

TO: Councilmember Julian A. Gold, M.D. and Councilmember Robert Wunderlich, Ph.D.

FROM: Shana Epstein, Director of Public Works
Gil Borboa, P.E., Assistant Director of Public Works/Utilities
Colonel J. Burnley, Solid Waste Manager

DATE: September 4, 2019

SUBJECT: Commercial Solid Waste Collection and Residential Solid Waste Processing Franchise Agreement – Update and Summary of Negotiated Contract Terms

ATTACHMENTS

1. Public Works Commission Staff Report – July 11, 2019
2. HF&H Presentation – July 11, 2019
3. Public Works Commission Staff Report – August 8, 2019

RECOMMENDATIONS
Staff recommends that the City Council Liaison review and recommend not to release another RFP and to accept the key terms as negotiated by staff and consultants with Athens Environmental Services.

INTRODUCTION
On July 11, 2019, Staff and HF&H Consultants LLC, presented a powerpoint presentation and agenda report to Public Works Commission. On August 8, 2019, a follow-up Public Works meeting occurred for an update on a resolution on the three open items.

DISCUSSION
On July 11, 2019, a staff report and presentation provided the Commission a chronological summary of the Commercial Solid Waste Collection and Residential Solid Waste Franchise Agreement background, which highlighted the following:

- SOLID WASTE FRANCHISE AGREEMENT – CHRONOLOGY
- RATE IMPACTS DUE TO RECYCLING COMMODITY MARKET PRICE DECLINES
- UNFUNDED STATE MANDATES SUCH AS ORGANICS LEGISLATION
- PUBLIC WORKS AD HOC MEETINGS
- AUDIT FINDING AND CONCLUSION
- RATE COMPARISON TO OTHER CITIES
- KEY TERMS NEGOTIATED
- THREE OPEN ITEMS
During the discussion of the issues at the July 11, 2019 Public Works Commission meeting, Commissioners requested postponement of recommendation until the August 8th meeting, pending the resolution of the three open items. At the August 8, 2019 Public Works meeting, staff reported to the Public Works Commission that a resolution for all three items had been reached as indicated below:

- **Recyclable Commodities Revenue Profit Sharing**

  Athens Environmental Services agreed to a 50% split of profit sharing on recycling commodities if exceed $554,000 in commodity revenue annually. This figure was the calculated baseline during the time of the audit.

- **Sunday Service Surcharge**

  City agreed to Sunday service surcharge for accounts that are service less than seven days a week. Business will have the option to adjust their Sunday service to avoid a surcharge, provided there are no sanitary issues with schedule adjustment.

- **Computer Compatibility**

  Company must maintain an interface with the City's Customer Service and Work Order Management system. Company shall be responsible for all costs related to interfacing with the City's Customer Service and Work Order Management system. The interface must provide electronic time stamping of receipt of the request by Company and resolution of the request by Company. The interface must be fully operational six months after the City provides interface access to Customer Service and Work Order Management system (unless such date is extended by written notice to Company from City's Director of Public Works). Company acknowledges that the system must be available for use prior to the Operative Date of this Agreement in order to support customer service and billing functions under the City's Prior Agreement.

Resolutions have been reached for all three open items.

The Public Works Commission recommended moving the item forward to the City Council Liaison.

**NEXT STEPS**

Pending the City Council Liaison's recommendation, the following tentative timeline is anticipated.

**Tentative Timeline**

<table>
<thead>
<tr>
<th>Date</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2019</td>
<td>Bring forward Athens agreement to City Council for approval</td>
</tr>
<tr>
<td>December 2019</td>
<td>Complete rate study.</td>
</tr>
<tr>
<td>January 2020</td>
<td>Present rate study to Public Works Solid Waste Ad Hoc &amp; Public</td>
</tr>
<tr>
<td>February 2020</td>
<td>Works Commission.</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Spring of 2020</td>
<td>Present rate study to City Council Study Session.</td>
</tr>
<tr>
<td>April 2020</td>
<td>Begin Prop. 218 notification process.</td>
</tr>
<tr>
<td>June 2020</td>
<td>Rate recommendation to City Council.</td>
</tr>
</tbody>
</table>

If approved, the proposed Solid Waste Agreement will become effective April 1, 2022, allowing approximately two years from the current date to phase in any rate adjustment options. Before the effective date of the Solid Waste Agreement, a rate study and fund balance impacts will be evaluated to calculate future rate adjustment options.

**FISCAL IMPACT**

If approved, the proposed Solid Waste Agreement will become effective April 1, 2022, allowing approximately two years from the current date to phase in any rate adjustment options. Before the effective date of the Solid Waste Agreement, the cost of service, customer rates, and fund balance will be evaluated to calculate future rate adjustment options. At present date, Solid Waste Fund reserves remain at levels in accordance with the City's adopted policy of 50 percent of annual expenditures. As of June 30, 2018, the Comprehensive Annual Financial Report (CAFR) showed a cash balance of approximately $21.1 million. For FY 2018, operating revenues were approximately $15.4 million and operating expenses were $15.3 million.
ATTACHMENT 1
CITY OF BEVERLY HILLS
PUBLIC WORKS DEPARTMENT
MEMORANDUM

TO: Public Works Commission
FROM: Gil Borboa, P.E., Assistant Director of Public Works/Utilities
        Colonel J. Burnley, Solid Waste Manager
DATE: July 11, 2019
SUBJECT: City of Beverly Hills Commercial Solid Waste Collection And Residential Solid Waste Processing Services – Update and Summary of Negotiated Contract Terms

ATTACHMENTS: 1. Revenue Comparison
                2. Summary of Negotiated Contract Terms

RECOMMENDATION

Staff recommends that the Commission review and recommend not to release another RFP and to accept the key terms as negotiated by staff and consultants with Athens Environmental Services.

BACKGROUND

In 2004, Crown Disposal was awarded the exclusive Commercial Solid Waste Agreement through a competitive RFP process. In 2010, the Agreement was renegotiated and extended until March 31, 2018, with an option to extend the Agreement for up to four additional years at the sole discretion of the City Council, ending the term on March 31, 2022.

Contract Assignment Request from Crown Disposal to Recology

On November 21, 2014, the City received a notice from Crown Disposal informing the City that it was being acquired by Recology, a privately-owned waste hauling company based in Northern California. In that letter, Crown Disposal requested the City consent to Crown Disposal assigning the Agreement to Recology, and on January 6, 2015, the City Council approved a Consent to Assignment and First Amendment, which assigned the Agreement to Recology. On March 4, 2015, transfer of assets from Crown Disposal to Recology was officially finalized.

City of Beverly Hills Released a Request for Proposals

On November 16, 2016, the City of Beverly Hills released a Request for Proposals for Commercial Solid Waste Collection and Residential Solid Waste Processing Services for an eight-year term with an option to extend up to twenty-four months at the sole option of the City. On March 3, 2017, the City received one proposal from Arakelian Enterprises, Inc., dba Athens Services (Athens). The City did not accept nor reject the bid proposal from Athens, and continued services with Recology. Athens Services was the only respondent in the City's request for RFP.
Contract Assignment Request from Recology to Araco Enterprise LLC (Athens)

On April 18, 2017, the City received a letter from Recology, informing the City that it had entered an agreement to sell substantially all of its assets to Araco Enterprise LLC, which is owned by Athens Services. On August 8, 2017, the City approved a Consent to Assignment and Second Amendment to Araco Enterprise LLC.

City staff received direction to renegotiate terms of the contract, but keep the option to re-release an RFP if negotiations are not successful.

Athens Request for Extraordinary Rate Increase

On September 11, 2017, one month after the assignment of the contract, Athens submitted to the City a request for an extraordinary rate increase and provided proposed rates. In this request, Athens provided an incomplete rate matrix, which only included contractor bin rates for once per week service, and did not demonstrate the following items per Section 5.6 of the Agreement, which reads:

"The company must prepare a schedule documenting the extraordinary changes in costs. Contractor shall also submit a schedule showing how its total costs and total revenues have changed over the past three years for the services provided under this agreement."

The City communicated these items to Athens in correspondence dated September 20, 2017.

Athens Revised Extraordinary Rate Increase Request

The City received a subsequent letter from Athens dated October 19, 2017, which nominally described the reasons for the rate increase request and included an updated proposed rate schedule, but did not submit the specific information required under Section 5.6 of the Agreement. Athens stated in the letter dated October 19, 2017 that the proposed rate increase would "still result in this contract being significantly below cost and not sustainable."

Athens Meeting with City and HF&H

On February 21, 2018, City staff and HF&H (the City's rate consultant) met with Athens personnel and requested the company fill out an HF&H prepared data request form and covered any questions Athens had regarding the forms.

Audit for Extraordinary Rate Increase Request

On March 20, 2018, Athens submitted the requested information, and HF&H conducted an audit to validate the data provided by Athens. The requested extraordinary adjustment was not supported by the information provided by Athens due to initial limitations in the company's financial system. Per discussion with Athens personnel, these limitations were subsequently resolved, and the company indicated it was able to provide the requested financial information with the period starting July 1, 2018. Athens proposed that the company resubmit the company's financial data for the City of Beverly Hills for July 2018, and HF&H will conduct a subsequent review to substantiate the financial data provided; however, one month of data
would not be indicative of the expected annual performance of the Beverly Hills contract. During a telephone call with Athens representatives on July 25, 2018, Athens stated it would submit this new information by August 15, 2018.

As of August 15, 2018, Athens' new information was still outstanding.

**Solid Waste Ad Hoc Meetings**

Throughout this process, a series of Solid Waste Ad Hoc (a subcommittee of Public Works Commissioners) meetings occurred. On September 21, 2018, City staff met with the Solid Waste Ad Hoc committee to discuss the initial audit finding and latest rate increase request by Athens. The actions that were to be taken after the Ad Hoc meeting were as follows:

- Request from Athens the rate increase be phased in through the term of a new contract.
- Complete subsequent audit once Athens provides financial data for at least 6-month of operating history.
- Review results of Manhattan Beach RFP process once proposals become publicly available.

**Athens Provides updated Phased-in Rate Increase & HF&H Provides an Analysis**

On October 12, 2018, Athens provided an updated rate proposal with phased-in rate increases through the term of the new contract.

On October 23, 2018, HF&H provided a rate comparison of the Athens RFP proposal from March 3, 2017, the rate increase proposal dated August 20, 2018, and the phased in rate increase proposal dated October 12, 2018. In the comparison, the Athens RFP proposal was $6.4 million to $9.5 million less than the latest two proposals.

**Athens Agrees to honor the RFP Proposed Overall Costs from March 3, 2017**

On November 2, 2018, Athens agreed to honor the proposed overall costs of its RFP response on March 3, 2017, and this included a 61% rate increase in contract expenditures, to be effective April 1, 2022, with new Agreement.

**Solid Waste Ad Hoc Meeting**

On November 13, 2018, City staff and HF&H Consultants met with Solid Waste Ad Hoc committee to discuss Athens agreeing to honor its RFP proposal submitted in March of 2017. The actions that were to be taken after the Ad Hoc meeting were as follows:

- Complete the audit to validate the rate increase proposed, once Athens provides the financial data.
- Begin to update the draft agreement from the RFP.
- Review Manhattan Beach RFP proposals which are anticipated to be publicly available in mid-January 2019.
**Athens Provides Financial Data & Second Audit was Conducted by HF&H**

On March 6, 2019, Athens provided the City with financial data of revenues and expenditures of roll-off and commercial bin services from July 1, 2018, to December 31, 2018. On the week of March 25, 2019, HF&H staff conducted a site visit and traced reported revenues and expenses to the company's internal accounting records in order to validate the reported cost of services.

**Audit Conclusion**

The site visit audit finding resulted in a net loss of 53% ($1,429,000) for the company's commercial collection operations over the six month period of July 1, 2018, to December 31, 2018. This audit included permanent and temporary commercial bin service, and roll-off service. Based on the data analysis, the 61% rate increase would give Athens a 10% net income for the roll-off and commercial bin services net of commercial processing costs. A review of residential processing costs determined that the proposed 61% rate increase would result in an estimated profit of 9%.

**DISCUSSION**

**Solid Waste Recycling Industry – Price Impact**

The Solid Waste Industry has been experiencing a paradigm shift in the recycling market. Recent changes to international policies restricting imports of recyclable materials, coupled with the need to reduce contamination levels in recycling streams and declining global market value for some recyclables, have resulted in significant challenges for the solid waste and recycling industry, local governments, and Californians. The industry has seen an approximate, 90% decrease in recycling commodities prices for mixed paper since 2016.

**State Legislation on Organic Recycling – Price Impact**

In 2006, Assembly Bill (AB) 32, California’s Global Warming Solutions Act, laid the foundation for current legislation by directing the California Air Resources Board to reduce toxic greenhouse gases to 1990 levels by 2020. Specifically, AB 32 requires California to adopt mandates aimed at achieving the maximum technologically and economically feasible greenhouse reductions. To meet the reduction goals set forth, regulations such as mandatory commercial recycling (AB 341, 2011) and organics recycling (AB 1826, 2014) were developed. AB 1594 (2014), mandates that as of January 1, 2020, the use of green material as alternative daily cover (ADC) will no longer constitute diversion through recycling and will instead be considered disposal in terms of measuring a jurisdiction’s annual 50 percent per capita disposal rate. The most recent legislation, signed in September 2016, is the short-lived climate pollutants act known as Senate Bill (SB) 1383. This legislation establishes state targets to achieve a 50 percent reduction in the level of statewide disposal of organic waste by 2020 and a 75 percent reduction by 2025.

**Recycling Market Conclusion**

Recycling challenges for recyclables and organics present a need for local infrastructure investment to handle the demand from the global shift in shipping recyclables overseas, as well as managing organics to address global warming issues. With these challenges, the Solid Waste industry has experienced a rise in pricing.
City’s Expenditures & Customer Rate

Since the fiscal year 2010 to 2018, the City's Solid Waste expenditures for the solid waste contractual services have only increased by 19%. Commercial and Residential Solid Waste rates have not been increased to ratepayers since the fiscal year 2011.

Customer Rate Comparison chart

<table>
<thead>
<tr>
<th>Municipality</th>
<th>FY 2019-20 Commercial 3yd bin 1x week</th>
<th>% Increase Compared to Existing City Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Beverly Hills</td>
<td>$115.80 - Commercial Mixed Waste Processing</td>
<td>-</td>
</tr>
<tr>
<td>City of West Hollywood</td>
<td>$171.27 - Commercial Mixed Waste Processing</td>
<td>48%</td>
</tr>
<tr>
<td>City of Culver City</td>
<td>$177.87 - Municipal Collection</td>
<td>54%</td>
</tr>
<tr>
<td>City of Manhattan Beach</td>
<td>$201.29 - Estimated FY 2020-21 rate under new contract</td>
<td>74%</td>
</tr>
<tr>
<td>City of Santa Monica</td>
<td>$207.43 - Municipal Collection</td>
<td>79%</td>
</tr>
<tr>
<td>City of Redondo Beach</td>
<td>$210.57 - Estimated 5-year compounded rate increase effective 7/1/2023 (excluding COLA)</td>
<td>82%</td>
</tr>
<tr>
<td>City of Los Angeles</td>
<td>$231.20 - Commercial Trash Bin and Recycling Bin</td>
<td>100%</td>
</tr>
</tbody>
</table>

In comparing the City's, current solid waste rates to surrounding Cities, the City’s rates are 48% below the next lowest compared City.

The most recent RFP for the City of Manhattan Beach, yielded a 74% increase compared to the City’s current rate.

Key Terms

The City Attorney’s office, City staff and HF&H Consultant, worked on updating the draft agreement. Athens has agreed to the draft terms in the document, with the exception of three open items – Computer Compatibility, Recyclable Commodities Revenue Sharing, and Sunday Service for customers with less than seven days per week service (see Summary of Negotiated Contract Terms for details). The Agreement is an eight-year term beginning April 1, 2022, with a City option to extend the agreement for up to twenty-four additional months. The terms of this Agreement will not go into effect until April 1, 2022. Some key highlights of the agreement are regulatory reporting on SB 1383, outreach on organics, food rescue and donation coordination with generators, and facility disposal capacity guarantees. See attachment (Summary of Negotiated Contract Terms).
NEXT STEPS

If the Public Works Commission does not approve the recommendation July 11th, the Public Works Commission may request additional time to evaluate and ask for more information to be provided at the August meeting for further consideration, or move forward with recommendation ton July 11. The next steps would be City Council Liaison for recommendation to the full City Council.

FISCAL IMPACT

If approved, the proposed Solid Waste Agreement will become effective April 1, 2022, allowing approximately two years from the current date to phase in any rate adjustment options. Before the effective date of the Solid Waste Agreement, the cost of service, customer rates, and fund balance will be evaluated to calculate future rate adjustment options. At present date, Solid Waste Fund reserves remain at levels in accordance with the City's adopted policy of 50 percent of annual expenditures. As of June 30, 2018, the Comprehensive Annual Financial Report (CAFR) showed a cash balance of approximately $21.1 million. This compares to operating revenues of approximately $15.4 million and operating expenses of $15.3 million for FY 2018.
ATTACHMENT 1
### Table 1: Proposed Rate Increase Percentages

<table>
<thead>
<tr>
<th>Period</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1-2019 Rate Increase</td>
<td>3.0%</td>
<td>18.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>7-1-2020 Rate Increase</td>
<td>3.0%</td>
<td>18.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>7-1-2021 Rate Increase</td>
<td>3.0%</td>
<td>18.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>4-1-2022 Rate Increase</td>
<td>61.0%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>7-1-2022 Rate Increase</td>
<td>0.0%</td>
<td>8.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>7-1-2023 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>7-1-2024 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>7-1-2025 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>7-1-2026 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>7-1-2027 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>7-1-2028 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>7-1-2029 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>7-1-2030 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>7-1-2031 Rate Increase</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

(1) 61% increase on 7-1-2022 estimated based on Athens proposal dated 3/3/17 from City’s RFP dated 11/16/16.

### Table 2: Estimated Rate Revenues

<table>
<thead>
<tr>
<th>Period</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>% Difference vs. Scenario 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Current Annual Rate Revenue</td>
<td>$6,200,000</td>
<td>$6,200,000</td>
<td>$6,200,000</td>
<td>0%</td>
</tr>
<tr>
<td>FY 2020 Rate Revenue</td>
<td>$6,386,000</td>
<td>$7,316,000</td>
<td>$6,758,000</td>
<td>6%</td>
</tr>
<tr>
<td>FY 2021 Rate Revenue</td>
<td>$6,578,000</td>
<td>$8,633,000</td>
<td>$7,366,000</td>
<td>12%</td>
</tr>
<tr>
<td>FY 2022 Rate Revenue (2)</td>
<td>$7,809,000</td>
<td>$10,187,000</td>
<td>$8,029,000</td>
<td>3%</td>
</tr>
<tr>
<td>FY 2023 Rate Revenue</td>
<td>$10,908,000</td>
<td>$11,002,000</td>
<td>$8,992,000</td>
<td>-18%</td>
</tr>
<tr>
<td>FY 2024 Rate Revenue</td>
<td>$11,235,000</td>
<td>$11,332,000</td>
<td>$10,071,000</td>
<td>-10%</td>
</tr>
<tr>
<td>FY 2025 Rate Revenue</td>
<td>$11,572,000</td>
<td>$11,672,000</td>
<td>$11,280,000</td>
<td>-3%</td>
</tr>
<tr>
<td>FY 2026 Rate Revenue</td>
<td>$11,919,000</td>
<td>$12,022,000</td>
<td>$12,634,000</td>
<td>6%</td>
</tr>
<tr>
<td>FY 2027 Rate Revenue</td>
<td>$12,277,000</td>
<td>$12,383,000</td>
<td>$13,266,000</td>
<td>8%</td>
</tr>
<tr>
<td>FY 2028 Rate Revenue</td>
<td>$12,645,000</td>
<td>$12,754,000</td>
<td>$13,929,000</td>
<td>10%</td>
</tr>
<tr>
<td>FY 2029 Rate Revenue</td>
<td>$13,024,000</td>
<td>$13,137,000</td>
<td>$14,625,000</td>
<td>12%</td>
</tr>
<tr>
<td>FY 2030 Rate Revenue</td>
<td>$13,415,000</td>
<td>$13,531,000</td>
<td>$15,356,000</td>
<td>14%</td>
</tr>
<tr>
<td>FY 2031 Rate Revenue</td>
<td>$13,817,000</td>
<td>$13,937,000</td>
<td>$16,124,000</td>
<td>17%</td>
</tr>
<tr>
<td>FY 2032 Rate Revenue</td>
<td>$14,232,000</td>
<td>$14,355,000</td>
<td>$16,930,000</td>
<td>19%</td>
</tr>
<tr>
<td>Total Rate Revenue</td>
<td>$152,017,000</td>
<td>$158,461,000</td>
<td>$161,560,000</td>
<td>6%</td>
</tr>
</tbody>
</table>

(2) See below for calculation of FY 2022 Rate Revenue.

### Table 3: Estimated FY 2022 Rate Revenue and Calculations for Scenario 1

<table>
<thead>
<tr>
<th>Description</th>
<th>Rate Revenue</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue 7-1-2021 through 3-30-2022</td>
<td>$ 5,082,000</td>
<td>=6,578,000<em>1.03</em>1/4</td>
</tr>
<tr>
<td>Revenue 4-1-2022 through 6-30-2022</td>
<td>$ 2,727,000</td>
<td>=6,578,000<em>1.03</em>1.61*1/4</td>
</tr>
<tr>
<td>Total FY 2022 Revenue</td>
<td>$ 7,809,000</td>
<td>=5,082,000+2,727,000</td>
</tr>
</tbody>
</table>
ATTACHMENT 2
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>Term of Agreement</td>
<td>Eight-year term beginning April 1, 2022, with a City option to extend the agreement for up to twenty-four additional months.</td>
</tr>
<tr>
<td>3.1.5</td>
<td>Scout Service</td>
<td>Bins that are placed out in street prior to service, and after service shall not remain on the street for more than one hour in the public right-of-way unless otherwise approved by the City.</td>
</tr>
<tr>
<td>3.2.4.1</td>
<td>Source-Separated Organics Service</td>
<td>Company shall provide 65-gallon source-separated Organics Cart service. (Contractor rate of $45.00 per month for 1x week service, $90.00 per month for 2x week service.)</td>
</tr>
<tr>
<td>3.2.4.2</td>
<td>Mixed-Waste Food Generating Establishment Route</td>
<td>Should CalRecycle deem the mixed waste organics recovery program to be not in compliance with SB 1383 or other regulatory requirements, Company shall offer source-separated food waste bins at the restaurant bin rates and regular refuse at the non-restaurant bin rates.</td>
</tr>
<tr>
<td>3.2.4.3</td>
<td>Organics Outreach and Reporting</td>
<td>Company will provide an organics outreach plan to City for approval. Company shall assist City by gathering required customer data, performing site visits, public outreach, and other requirements in order to comply with State requirements and regulations such as mandatory Commercial Recycling (AB 341) and mandatory Organics Recycling (AB 1826), and control of short-lived climate pollutants (SB 1383). Company shall coordinate food rescue and donation efforts with each customer deemed to generate organics waste as required by CalRecycle.</td>
</tr>
<tr>
<td>3.4</td>
<td>Warning Notice</td>
<td>Warning notices to comply with SB 1383. Contamination fee of $50.00 per occurrence may be charged after three written warnings in a six-month period. Company may remove recycling containers from customers who repeatedly fail to sort properly and to segregate recyclable materials, and Company may increase the customer’s current mixed waste container size and/or frequency.</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>3.6</td>
<td>Diversion Requirement</td>
<td>Minimum diversion rate of 53% for hauler-collected waste. Liquidated damages of $25 per ton for failure to achieve guaranteed diversion.</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Option for Company to Perform Billing and Company Compensation</td>
<td>1% increase to all commercial contractor rates for company to perform commercial billing 1% increase to all roll-off box contractor rates for company to perform roll-off box billing</td>
</tr>
<tr>
<td>5.1</td>
<td>Sale of Recyclable Materials</td>
<td>Company is entitled to retain all proceeds from the sale of recyclable materials, with the exception of recyclables revenues from Rollof box loads direct-hauled to third-party material processors, which is returned to City.</td>
</tr>
<tr>
<td>5.2</td>
<td>Billing Adjustments and Refunds</td>
<td>If City does not bill customer for Company’s service due to Company’s data error or lack of data, Company will not receive compensation for that service.</td>
</tr>
<tr>
<td>5.3</td>
<td>Initial Rates</td>
<td>The maximum rates for the partial rate year April 1, 2022 through June 30, 2022, and the rate year July 1, 2022 through June 30, 2023, shall be the contractor rates effective as of March 31, 2022, under the prior agreement, increased by 61%, less any extraordinary rate adjustments granted by City Council from the approval of the agreement to March 31, 2022. The organics cart rate shall not be increased by the one-time 61% adjustment.</td>
</tr>
<tr>
<td>5.5</td>
<td>Rate Adjustment Method</td>
<td>Beginning with rate adjustment effective July 1, 2023, the annual rate adjustment will be based on the average percentage change in the consumer price index for water, sewer, and trash collection, U.S. City average, subject to a 5% annual cap.</td>
</tr>
<tr>
<td>5.6</td>
<td>Extraordinary Adjustment</td>
<td>Changes in tipping fees for food waste removed from list of unacceptable adjustment requests.</td>
</tr>
</tbody>
</table>
### CITY OF BEVERLY HILLS

#### SUMMARY OF NEGOTIATED CONTRACT TERMS (CONTINUED)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
</table>
| 7.3.4   | Annual Report | Added reports:  
- List of customers and service levels of the customers participating in the mandatory organics recycling programs in compliance with AB 1826, and list of customers and service levels not in compliance with AB 1826.  
- Dates and details of site visits to customers not in compliance with AB 1826 or SB 1383 Requirements.  
- Dates and details of site visits to customers regarding food rescue and donation efforts. |
| Exhibit 6 | Residential Solid Waste Processing and Disposal Agreement | Guaranteed minimum recovery rate of 25% from processing mixed residential refuse and recyclables |

### Items to Be Negotiated/Discussed

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
</table>
| 4.2.6   | Computer Compatibility | Existing Requirement:  
"Company must install and maintain a computer system that is compatible with City’s system. The system must be capable of linking to City’s Customer service system, with read-only access to City’s database and with the ability to receive change orders. System must provide electronic time stamping of Customer interfacing and of request/compliant resolution. The system must be fully operational within 6 months of the start of service under this Agreement." |
| 2.9     | Recyclable Commodities Revenue Sharing | Existing Requirement:  
"Company is entitled to retain all proceeds from the sale of Recyclable Materials, with the exception of Recyclables revenues from Roll-off Box loads, direct-hauled to third-party material processors, which is returned to City.”  
City would like to negotiate recyclable commodities revenue sharing from the sale of recyclable materials. |
| N/A     | Sunday service for customers with less than 7x/week service | Athens requests customers with Sunday service and less than 7x/week service to change their service day to a non-Sunday, or pay a Sundaysurcharge. |
ATTACHMENT 2
City of Beverly Hills Public Works Commission
Proposed Solid Waste Contract Extension
July 11, 2019

Laith Ezzet
Senior Vice President

April Hamud
Project Manager

HF&H Consultants
19200 Von Karman Avenue, Suite 360
Irvine, CA 92612
Current Service Arrangements

- City collects and delivers residential solid waste to Athens MRF
- Athens collects commercial solid waste
- Residential and commercial mixed solid waste is processed by Athens to recover recyclables
Chronology

- Assignment to Recology (2015)
- RFP for Solid Waste Services (2016)
  - One proposal (from Athens)
  - City decided to continue services with Recology
- Assignment to Athens (2017)
- Athens request for extraordinary rate adjustment (One month after assignment)
• Athens agreed to negotiate proposed extension based on its 2016 proposed overall cost (2018)

• City exercised first extension to 3/31/2020

• City may further extend term to 3/31/2022 by providing notice by 12/31/2019
Cost of Compliance

- **AB 939**: Established statewide landfill diversion goal of 50% by 2000.
- **AB 341**: Mandatory Commercial Recycling starting in 2012; and State diversion goal of 75% by 2020.
- **AB 1826**: Mandatory Commercial Organics Recycling Program (phased-in beginning April, 2016).
SB 1383 Air emission and Ed ft. le Food Recovery Programs (approved in Sept. 2016; regulations under development)

AB 1594 No diversion credit for Green cover (ADC) after January 1, 2020

New Regulations in China (National Sword)

• Recycling Market Impacts

City is part of LARA for CalRecycle diversion reporting 61% in 2018

No diversion credit for Green development (Sept. 2016; Regulations under Recovery Programs (approved in Air emission and Edible Food)
Market Impacts of China Sword

China closes the door, prices crash

The average price paid to recyclers for a ton of mixed paper in the Pacific Northwest and across North America has plummeted in the last year.

- July 18: China announces new bans on imported recycling, including mixed paper.
- Jan 1: Import ban takes effect.
- March 1: 0.5% contamination limit takes effect.

Source: RecyclingMarkets.net
Soft Mixed Paper

$120 $100 $80 $60 $40 $20 $0


US$/Short Ton

National Average

Regional Average
Corrugated Containers

![Graph showing the price of corrugated containers with Regional Average and National Average lines. The y-axis represents U.S. dollars per short ton, ranging from $0 to $200, and the x-axis represents months from Jan-12 to Jan-19. The graph indicates fluctuations in prices over the period.]
# Rate Impacts in Other Jurisdictions

<table>
<thead>
<tr>
<th>City</th>
<th>Commercial Rate Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhattan Beach</td>
<td>47% One-time Rate Increase</td>
</tr>
<tr>
<td>Redondo Beach</td>
<td>Compounded annual extraordinary increase of over 60% over 5-years, plus annual price index adjustment</td>
</tr>
<tr>
<td>Santa Cruz County</td>
<td>Compounded 3-Year Rate Increase of over 40%</td>
</tr>
<tr>
<td>Proposal</td>
<td>Total Cost FY 2019 - FY 2032</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>One-time 61% Increase (RFP Response)</td>
<td>$152 Million</td>
</tr>
<tr>
<td>8/20/18 Phase-In Proposal (1)</td>
<td>$158 Million</td>
</tr>
<tr>
<td>10/12/18 Phase-In Proposal (2)</td>
<td>$162 Million</td>
</tr>
</tbody>
</table>

(1) Annual rate increase of 18% for FY 2020 to FY 2022, 8% annually for FY 2023, then CPI thereafter.
(2) Annual rate increase of 9% for FY 2020 to FY 2022, 12% annually for FY 2023 to FY 2026, and 5% annually for FY 2027 to FY 2032.
Proposed Terms

- **Term**
  - Eight years beginning April 1, 2022
  - City option to extend up to 24 months

- **Initial Rates**
  - 61% contractor rate increase
  - New organics cart rate ($45/month for 1x week service)
Proposed Terms (cont.)

- Minimum Diversion Rates
  - 53% for all hauler-collected commercial waste (vs. 60% current requirement)
  - 25% diversion for City-collected mixed residential waste (versus 17% achieved in 2018)

- Recycling containers at 50% of trash rate for same container size and frequency (currently no additional charge).

- Continued recycling collection service to the Beverly Hills School District and its campuses at no additional charge.
• Should CalRecycle deem the mixed waste organics recovery program not in compliance with SB 1383, Athens shall offer source-separated food waste bins at the restaurant bin rates, and regular refuse at the non-restaurant bin rates.

• Processing of residential organics waste (food waste and green waste)

• Organics outreach and reporting requirements

• SB 1383 Compliance

• Solid waste facility capacity guarantee
Open Items

- Computer Compatibility
- Recyclable Commodities Revenue Sharing
- Sunday service for customers with less than 7x/week service
### Average One-Time Customer Rate Increase to Pass-Through Athens Contractor Cost Increase*

<table>
<thead>
<tr>
<th>Sector</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>8%</td>
</tr>
<tr>
<td>Commercial</td>
<td>44%</td>
</tr>
<tr>
<td>Combined</td>
<td>26%</td>
</tr>
</tbody>
</table>

*Assumes existing cost of service by sector is aligned with rate revenues.
## Example of Phased-In Rate Strategy

<table>
<thead>
<tr>
<th>Category</th>
<th>Average Rate Increase</th>
<th>Estimated Reserves in Millions</th>
<th>Estimated Reserve Balance as Percent of Operating Revenues (end of year)</th>
<th>Net Annual Operating Income (Loss) in Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2020-21</td>
<td>9.4%</td>
<td>$15.3</td>
<td>86%</td>
<td>($0.9)</td>
</tr>
<tr>
<td>FY 2021-22</td>
<td>9.4%</td>
<td>$14.3</td>
<td>74%</td>
<td>($2.6)</td>
</tr>
<tr>
<td>FY 2022-23</td>
<td>9.4%</td>
<td>$11.7</td>
<td>52%</td>
<td>($1.3)</td>
</tr>
<tr>
<td>FY 2023-24</td>
<td>9.4%</td>
<td>$10.4</td>
<td>45%</td>
<td>$0.0</td>
</tr>
<tr>
<td>FY 2024-25</td>
<td>9.4%</td>
<td>$10.4</td>
<td>43%</td>
<td>$0.0</td>
</tr>
<tr>
<td>Municipality</td>
<td>Monthly Rate – 3 yd bin 1x week</td>
<td>% Increase Compared to Existing City Rate</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------</td>
<td>------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Beverly Hills - Current</td>
<td>$115.80</td>
<td>-</td>
<td>Commercial Mixed Waste Processing</td>
<td></td>
</tr>
<tr>
<td>Beverly Hills – With 61% Contractor Increase</td>
<td>$166.75</td>
<td>44%</td>
<td>Estimated Rate</td>
<td></td>
</tr>
<tr>
<td>West Hollywood</td>
<td>$171.27</td>
<td>48%</td>
<td>Commercial Mixed Waste Processing</td>
<td></td>
</tr>
<tr>
<td>Culver City</td>
<td>$177.87</td>
<td>54%</td>
<td>Municipal Service</td>
<td></td>
</tr>
<tr>
<td>Manhattan Beach</td>
<td>$201.29</td>
<td>74%</td>
<td>Estimated FY 2020-21 rate under new contract</td>
<td></td>
</tr>
<tr>
<td>Santa Monica</td>
<td>$207.43</td>
<td>79%</td>
<td>Municipal Service</td>
<td></td>
</tr>
<tr>
<td>Redondo Beach</td>
<td>$210.57</td>
<td>82%</td>
<td>Estimated 5-year compounded rate increase effective 7/1/2023 (excluding COLA)</td>
<td></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>$231.20</td>
<td>100%</td>
<td>Bundled rate for commercial trash bin and recycling bin</td>
<td></td>
</tr>
</tbody>
</table>
Not to release another RFP and to accept the terms as negotiated by staff and consultants with Athens Environmental Services.
ATTACHMENT 3
TO: Public Works Commission
FROM: Colonel J. Burnley, Solid Waste Manager
Gil Borboa, P.E., Assistant Director of Public Works/Utilities
DATE: August 8, 2019
SUBJECT: Solid Waste Franchise Agreement Update on Open Items


RECOMMENDATION

Staff recommends that the Commission review and recommend not to release another RFP and to accept the key terms as negotiated by staff and consultants with Athens Environmental Services.

BACKGROUND

On July 11, 2019, Staff and HF&H Consultants presented to the Public Works Commission, the Commercial Solid Waste Collection and Residential Solid Waste Processing Services Agreement contract extension, with a summary of updated terms. In this negotiation process, there were three open items that were still pending:

- Computer compatibility
- Recycling commodities profit sharing
- Sunday service surcharge for customers with less than 7 days a week service

The Public Works Commission asked for the recommendation to be postponed until the August 8th meeting, pending the resolution of the outstanding issues.

DISCUSSION

Contract Term Open Items

On July 19, 2019, Staff and HF&H Consultants met with Athens Environmental Services to discuss the three open items.

- Recyclable Commodities Revenue Profit Sharing

Athens Environmental Services agreed to a 50% split of profit sharing on recycling commodities if exceed $554,000 in commodity revenue annually. This figure was the calculated baseline during the time of the audit.
• Sunday Service Surcharge

City agreed to Sunday service surcharge for accounts that are service less than seven days a week. Business will have the option to adjust their Sunday service to avoid a surcharge, provided there are no sanitary issues with schedule adjustment.

• Computer Compatibility

Company must maintain an interface with the City’s Customer Service and Work Order Management system. Company shall be responsible for all costs related to interfacing with the City’s Customer Service and Work Order Management system. The interface must provide electronic time stamping of receipt of the request by Company and resolution of the request by Company. The interface must be fully operational six months after the City provides interface access to Customer Service and Work Order Management system (unless such date is extended by written notice to Company from City’s Director of Public Works). Company acknowledges that the system must be available for use prior to the Operative Date of this Agreement in order to support customer service and billing functions under the City’s Prior Agreement.

Resolutions have been reached for all three open items.

NEXT STEPS

Pending Public Works Commission approval of the recommendation, the following tentative timeline is anticipated:

Tentative Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2019</td>
<td>Present to City Council Liaisons for recommendation to the City Council.</td>
</tr>
<tr>
<td>October 2019</td>
<td>Present recommendation to City Council.</td>
</tr>
<tr>
<td>December 2019</td>
<td>Complete rate study.</td>
</tr>
<tr>
<td>Spring of 2020</td>
<td>Present rate study to City Council Study Session.</td>
</tr>
<tr>
<td>April 2020</td>
<td>Begin Prop. 218 notification process.</td>
</tr>
<tr>
<td>June 2020</td>
<td>Rate recommendation to City Council.</td>
</tr>
</tbody>
</table>

FISCAL IMPACT

As of June 30, 2018, the Comprehensive Annual Financial Report (CAFR) showed a cash balance of approximately $21.1 million. This compares to operating revenues of approximately $15.4 million and operating expenses of $15.3 million for FY 2018.
TAB 3
This memorandum provides project status updates to the City's Stormwater Compliance CIP Master Plan, La Cienega Park & Frank Fenton Field Regional Stormwater Project and the Burton Way median project. This report is for information and discussion purposes only.

PROJECT BACKGROUND

The City of Beverly Hills is a co-permittee of the 2012 Municipal Separate Storm Sewer System Permit (2012 MS4 Permit). The 2012 MS4 Permit is a regional permit issued by the Los Angeles Regional Water Quality Control Board (LARWQCB) to enforce the requirements of the Federal Clean Water Act by regulating discharges of pollutants into the waters of the United States.

Beverly Hills, Culver City, Inglewood, Los Angeles, Santa Monica, West Hollywood and unincorporated areas of Los Angeles County discharge to Ballona Creek, which is a tributary to Santa Monica Bay. The City and these agencies formed the Ballona Creek Watershed Management Group (BCWMG) to establish regional cooperation in addressing MS4 permit compliance. The group developed an Enhanced Watershed Management Program (EWMP) to meet the requirements of the MS4 permit. The EWMP was submitted to the LARWQCB on February 1, 2016, and was approved on April 20, 2016.

The 2016 EWMP compliance strategy outlined 87 acre-feet (AF) of stormwater management for Beverly Hills at an estimated cost of $72 million using compliance strategies such as Low Impact Development (typically private development projects), Green Streets and Regional Projects strategies.

To assist the City in meeting its stormwater compliance, the City hired Black and Veatch Corporation (B&V) in October 2017 to develop a comprehensive Stormwater Compliance CIP Master Plan (CIP Plan). The goals of the CIP Plan are to identify stormwater-related project
opportunities and develop a CIP program with updated costs including an implementation schedule to help the City achieve its stormwater compliance.

Additionally, as part of its scope, B&V was to assess the feasibility of implementing the regional stormwater project at La Cienega Park & Frank Fenton Field (LCP & FFF) as originally prescribed in the EWMP and to develop a Preliminary Design Report (PDR) summarizing project alternatives, updated project costs and a recommended solution to implement.

Under the Green Streets category of the EWMP, Burton Way median was identified as a potential site for a Green Streets project. To assist the City evaluate its feasibility for implementation, the City hired CWE in June 2016 to conduct the feasibility assessment and to provide engineering design services for the Burton Way median Green Streets and Water Efficient Landscape project.

Provided in this report are the results of the Stormwater Compliance CIP Master Plan, findings of the PDR for LCP & FFF and design progress for the Burton Way median project. Staff and consultants presented the findings of this report to the Public Works Commission on August 8, 2019.

DISCUSSION

The City’s 2016 EWMP identified LCP & FFF as a location for one of the signature projects for the Ballona Creek watershed. The EWMP projected that LCP & FFF location would be capable of capturing and treating 24 acre-feet (AF) of runoff from the cities of Beverly Hills, Los Angeles, and West Hollywood. The EWMP also identified Burton Way median as a potential Green Streets project site. Projects identified in the EWMP are generally intended for planning purposes and requires further engineering evaluation prior to design and implementation.

In October 2017, the City hired B&V to determine the feasibility of developing a subsurface retention and infiltration facility at LCP & FFF as described in the EWMP. The City also tasked B&V with developing a Stormwater Compliance CIP Plan to identify additional project opportunities and help guide the City plan, budget and implement a more comprehensive stormwater infrastructure program to address its EWMP requirements.

Separately, the City hired another engineering firm, CWE, in June 2016 to assess the feasibility of implementing a Green Street project on Burton Way and to provide engineering design services for the project.

Stormwater Compliance CIP Plan

B&V completed the Stormwater Compliance CIP Plan in August 2019. The CIP Plan identifies 94 project opportunities to be implemented over a 20-year horizon with an estimated cost of $110M.

Burton Way median, Santa Monica Boulevard and other Low Impact Development (LID) projects were not included in the CIP Plan as they are either been identified and planned, in design or already implemented.

The total stormwater capture capacity identified in the CIP Plan is 96.0 AF exceeding the required 87 AF identified in the EWMP. Of the 87 AF required, the City has already accounted for 23.6 AF via Burton Way Median, Culver Median (with the City of Culver City), Santa Monica Blvd and projected LID infrastructure on private and public developments as a result of the LID
Ordinance. A summary of the EWMP Compliance Strategies for Beverly Hills is shown in Table ES-1 below, which is also included in the Executive Summary for the Commission’s review.

### Table ES-1. EWMP Compliance Strategies for City of Beverly Hills

<table>
<thead>
<tr>
<th>STRUCTURAL BMP STRATEGY</th>
<th>EMF CAPACITY (AF)</th>
<th>PHASE</th>
<th>TOTAL CAPITAL COST (2019)</th>
<th>ANNUAL O&amp;M COST (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXISTING PROJECTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streets: Culver City Median</td>
<td>4.4</td>
<td>Under Design</td>
<td>$20,233,000</td>
<td>$125,000</td>
</tr>
<tr>
<td>Streets: Burton Way</td>
<td>7.6</td>
<td>Under Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streets: North Santa Monica Boulevard</td>
<td>1</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;LID Ordinances—Public Education Program &amp; Residential Practices</td>
<td>4.6</td>
<td>Ongoing, Ordinance Adopted in 2015.</td>
<td>$69,866,470</td>
<td>$1,986,690</td>
</tr>
<tr>
<td>&quot;LID Public Projects</td>
<td>6</td>
<td>Ongoing, Ordinance Adopted in 2015.</td>
<td>$2,111,690</td>
<td>$110,099,470</td>
</tr>
<tr>
<td><strong>PLANNED PROJECTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Regional Project: La Cienega Park / Frank Fenton Field</td>
<td>21</td>
<td>In Planning</td>
<td>$20,233,000</td>
<td>$125,000</td>
</tr>
<tr>
<td>Street and On-site Stormwater BMPs</td>
<td>51.4</td>
<td>Planned in this Report (2019)</td>
<td>$69,866,470</td>
<td>$1,986,690</td>
</tr>
</tbody>
</table>

*BMP capacities are based on EWMP projections. Ballona Creek EWMP includes institutional measures and assumes that 1% of homeowners implement residential LID practices. No specific funding identified for these categories. **Estimated cost documented in La Cienega Park and Frank Fenton Field Feasibility Study.

In addition to the compliance strategies, refinements to costs and BMP concepts were also developed as part of the CIP Plan. Table ES-2 below summarizes the refinements of projects in the CIP Plan versus the original EWMP. These cost refinements are based on the latest market costs for stormwater projects.

### Table ES-2. Summary of EWMP Refinements to Develop CIP

<table>
<thead>
<tr>
<th>Site Identification</th>
<th>EWMP</th>
<th>STORMWATER CIP REFINEMENTS TO EWMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Project Sites Identified</td>
<td>Project Sites Identified</td>
<td></td>
</tr>
<tr>
<td>Bioretention, Permeable Pavement, Residential Program &amp; Regional Projects</td>
<td>Site-specific BMPs Developed, Curb Extensions, Median Bioretention, Sidewalk Vaults, Permeable Pavement</td>
<td></td>
</tr>
<tr>
<td>Projects not Prioritized</td>
<td>Prioritization Scheme Developed</td>
<td></td>
</tr>
<tr>
<td>87 Acre-Ft</td>
<td>72.4 Acre-Ft in CIP, 13.0 Acre-Ft in Existing Projects, 10.6 Acre-Ft in LID Practices</td>
<td></td>
</tr>
<tr>
<td>$72M (2016)</td>
<td>$110M (2019), Detailed assessment of project components, Vendor quotes and 2018 Los Angeles region pricing, Appropriate contingencies</td>
<td></td>
</tr>
</tbody>
</table>
Furthermore, a portfolio of projects has shifted to include more on-site stormwater BMPs and fewer distributed Green Streets strategies in the CIP Plan versus the EWMP. A comparison of the new strategies is shown in Figure ES-2 below:

![Figure ES-2. EWMP and CIP Proposed Strategies](image)

**Burton Way Median**
Design for the Burton Way median project is near completion. As of August 2019, design is 95% complete. Outstanding issues to be resolved prior to design completion include:

- Final electrical design services from SoCal Edison
- LA County Flood Control District permit review approval

Staff has been coordinating with SoCal Edison planning staff for electrical design services and expect to receive confirmation by end of August to complete electrical design. Coordination with LA County Flood Control District (LACFCD) has started since February 2019. Staff expects design concept approval for diversion structure to be approved by September. LACFCD final permit issuance is expected in February 2020. Final permit is not required to complete design or construction but will be required for operation once project construction is complete.

**Culver Median Project**
The Culver Median Project is a signature stormwater regional project in the Ballona Creek Watershed. The City of Beverly Hills became Culver City’s partner after the City of Los Angeles removed itself from the initial partnership due to lack of funding. The City Council approved this partnership during the March 5, 2019 City Council meeting. The partnership preserved the $7.7M grant monies awarded to the project. As a benefit, the City will be receiving 4.4 acre-ft. of compliance credit for $3.5M cost-sharing contribution to the project without project management and construction burdens.

Currently, the City and Culver City are in negotiations with the terms of the Memorandum of Understanding (MOU) and will be presented to City Council later in 2019.
LCP & FFF Preliminary Design Report

The Preliminary Design Report for LCP & FFF was completed in August 2019. Results of the PDR indicated that infiltration and recharge as prescribed in the EWMP for LCP & FFF were not feasible. The report recommended that a stormwater management project that included a subsurface detention facility and a diversion to sanitary sewer be constructed in lieu of the original EWMP project.

A summary of the updated project parameters identified in the PDR vs. the EWMP are shown below in Table ES-2:

<table>
<thead>
<tr>
<th>Category</th>
<th>EWMP parameters</th>
<th>Updated Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture Volume Goal</td>
<td>24 AF</td>
<td>21 AF</td>
</tr>
<tr>
<td>City Watershed Contribution</td>
<td>City of LA significant contributor</td>
<td>City of Beverly Hills main contributor</td>
</tr>
<tr>
<td>BMP Type</td>
<td>Groundwater Infiltration/Recharge</td>
<td>Subsurface detention and diversion to sanitary sewer</td>
</tr>
<tr>
<td>Use of all baseball fields</td>
<td>Use of all baseball fields</td>
<td>Use of one baseball field</td>
</tr>
<tr>
<td>Project Cost</td>
<td>$32.2 million</td>
<td>$20.2 million</td>
</tr>
</tbody>
</table>

The new recommended project identified in the PDR would only occupy one baseball field at LCP vs. the original project requiring facilities in all three (3) baseball fields. The proposed location and design criteria for the recommended project are shown in Figure ES1-1 and Table ES-3.
Table ES-3. Design Criteria for the Tank and Ancillary Facilities

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Flow into Tank, cubic feet per second</td>
<td>14</td>
</tr>
<tr>
<td>Capacity, millions of gallons</td>
<td>6.84</td>
</tr>
<tr>
<td>Tank Invert Elevation, feet</td>
<td>105</td>
</tr>
<tr>
<td>Tank Height, feet</td>
<td>15</td>
</tr>
<tr>
<td>Tank Foundation</td>
<td>To Be Determined by Basin Manufacturer</td>
</tr>
<tr>
<td>Tank Footprint, feet</td>
<td>276 x 243</td>
</tr>
<tr>
<td>Inlet/Outlet Pipe Diameter, inches</td>
<td>48</td>
</tr>
</tbody>
</table>

An engineer's opinion of probable cost was provided for the recommended project alternative as identified in the PDR. The new estimated project cost is approximately $20.2M as shown in Table ES-4. In summary, the original EWMP project provided 24 Acre Feet of capture credit for an estimated $32.2M, and the current project captures 21 Acre Feet at an estimated cost of $20.2M.

Table ES-4. Level 5 OPCC For La Cienega Park and Fenton Field Stormwater Project

<table>
<thead>
<tr>
<th>Item</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Work</td>
<td>$891,000</td>
</tr>
<tr>
<td>Piping</td>
<td>$188,000</td>
</tr>
<tr>
<td>Site Structures, Including Manholes and Vaults</td>
<td>$298,000</td>
</tr>
<tr>
<td>Pump Station</td>
<td>$963,000</td>
</tr>
<tr>
<td>Storage Structure, Including Excavation and Dewatering</td>
<td>$11,613,000</td>
</tr>
<tr>
<td>Pump Station</td>
<td>$963,000</td>
</tr>
<tr>
<td>Project Construction Cost Subtotal</td>
<td>$13,953,000</td>
</tr>
<tr>
<td>Construction Contingency (30%)</td>
<td>$4,186,000</td>
</tr>
<tr>
<td>Construction Management (5%)</td>
<td>$698,000</td>
</tr>
<tr>
<td>Planning and Design Cost (10%)</td>
<td>$1,396,000</td>
</tr>
<tr>
<td>Total Estimated Project Cost</td>
<td>$20,233,000</td>
</tr>
</tbody>
</table>
FISCAL IMPACT

Funding for the City’s stormwater compliance initiatives are budgeted in the FY 2019/2020 CIP No. 0270 Ballona Creek MS4 Compliance. The current balance for CIP No. 0270 is $5.8M as of 8/27/2019.

Additional funding opportunities include Measure W - $560,000 guaranteed annually for municipal programs and potential grants from $18.1M annually for Competitive Grant Application in Regional Programs.

Stormwater Compliance CIP Plan
The CIP Plan identifies 94 project opportunities to be implemented over a 20-year horizon with an estimated total cost of $110M.

The CIP Plan is intended to serve as a guiding document to assist the City in prioritizing projects for future implementation as it sees fit. It is not expected that the City would implement all projects identified. Results of the Stormwater Compliance CIP Plan will be incorporated as part of the Integrated Water Resources Master Plan and Urban Forest Master Plan for future planning and implementation.

LCP & FFF PDR Report
Results of the preliminary design report indicates that a 21 AF subsurface detention facility can be constructed under one baseball field at La Cienega Park at an estimated cost of $20.2M.

Staff recommends that this project be implemented only in conjunction with the implementation phasing of the City’s La Cienega Park Master Plan.

Burton Way median
Staff to finalize design plans and project specifications for Burton Way median in September and prepare for project bidding in November 2019 with an estimated construction start date in January 2020. Current estimated cost for Phase I construction is $4.0 M which was previously recommended for implementation by the PWC. The City is currently pursuing Prop 1 grant funding from the Department of Water Resources to secure a $2M grant for the Burton Way median project.

Culver Median Project
As stated in the earlier section, the City cost for the Culver Median Project is $3.5 M for a 4.4 acre-ft. compliance credit. The agencies are in negotiations and review of the Memorandum of Understanding (MOU) which is expected to be presented to City Council later in 2019.

RECOMMENDATION

This information is provided as a project status update.
ATTACHMENT 1
The City of Beverly Hills (City) is situated entirely within the urbanized Ballona Creek Watershed. This report provides the City with a recommended 20-Year Stormwater Capital Improvement Program (CIP) to satisfy the Enhanced Watershed Management Program (EWMP) compliance strategy for Ballona Creek. The objectives of the CIP are to identify optimal project sites in the City of Beverly Hills, develop concepts with planning level opinions of cost, and establish a 20-year implementation timeline of prioritized projects.

The 2016 Ballona Creek EWMP compliance strategy outlines 87 acre-ft (AF) of stormwater management for the City of Beverly Hills to help achieve Los Angeles County’s Municipal Separate Storm Sewer System (MS4) permit water quality standards. The proposed stormwater management approach includes Best Management Practices (BMP) and Low Impact Development (LID) strategies. As shown in Table ES-1, a total of 8.6 AF capacity has already been planned, designed, or constructed as part of two existing green street projects: Burton Way and North Santa Monica Boulevard. The City has implemented LID ordinances and programs, thereby addressing 10.6 AF capacity associated with LID in the EWMP. Additional capacity required to achieve EWMP compliance is included in this CIP and summarized in Table ES-1 as Planned Projects. The planned capacity for Street and On-Site Stormwater BMPs slightly exceeds the EWMP requirements.

Upon successful completion of this CIP, it is anticipated that approximately 840 acres of impervious drainage area will be treated through various structural and non-structural BMP and LID strategies.
**Table ES-1. EWMP Compliance Strategies for City of Beverly Hills**

<table>
<thead>
<tr>
<th>STRUCTURAL BMP STRATEGY</th>
<th>BMP CAPACITY (AF)</th>
<th>PHASE</th>
<th>TOTAL CAPITAL COST (2019)</th>
<th>ANNUAL O&amp;M COST (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXISTING PROJECTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streets: Burton Way</td>
<td>7.6</td>
<td>Under Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streets: North Santa Monica Boulevard</td>
<td>1</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LID Ordinances and Public Education Program</td>
<td>1.8</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LID Residential Practices</td>
<td>2.8</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LID Public Projects</td>
<td>6</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PLANNED PROJECTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional Project: La Cienega Park/ Frank Fenton Field</td>
<td>21</td>
<td>In Planning</td>
<td>$20,233,000</td>
<td>$125,000</td>
</tr>
<tr>
<td>Street and On-site Stormwater BMPs</td>
<td>51.4</td>
<td>Planned in this Report (2019)</td>
<td>$89,866,470</td>
<td>$1,986,690</td>
</tr>
</tbody>
</table>

**TOTAL**                                      91.6  |  | $110,099,470 | $2,111,690 |

*Ballona Creek EWMP includes institutional measures and assumes that 1% of homeowners implement residential LID practices. No specific funding identified for these categories. *Estimated cost documented in La Cienega Park and Frank Fenton Field Feasibility Study.*

**Table ES-2 summarizes the refinements made to the Ballona Creek EWMP to develop this CIP.**

<table>
<thead>
<tr>
<th>Site Identification</th>
<th>EWMP</th>
<th>STORMWATER CIP REFINEMENTS TO EWMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Identification</td>
<td>Regional Project Sites Identified</td>
<td>Project Sites Identified</td>
</tr>
<tr>
<td>BMP Concepts</td>
<td>Bioretention, Permeable Pavement, Residential Program &amp; Regional Projects</td>
<td>Site-specific BMPs Developed, Curb Extensions, Median Bioretention, Sidewalk Vaults, Permeable Pavement</td>
</tr>
<tr>
<td>Prioritization</td>
<td>Projects not Prioritized</td>
<td>Prioritization Scheme Developed</td>
</tr>
<tr>
<td>Compliance Strategy Volume</td>
<td>87 Acre-Ft</td>
<td>72.4 Acre-Ft in CIP, 8.6 Acre-Ft in Existing Projects, 10.6 Acre-Ft in LID Practices</td>
</tr>
</tbody>
</table>
BMP IDENTIFICATION PROCESS

The CIP identifies projects that include distributed BMP facilities throughout the City using Green Street and On-Site Stormwater BMP strategies, detailed as the following solutions: Permeable Pavement, Subsurface Storage, Curb Extensions, Median Bioretention, and Sidewalk Vaults. Selection of these sites was informed by key data: topography, existing land use, stormwater infrastructure, soil survey data, and a roadway condition assessment report. Each facility is sized to accommodate runoff from the 85th percentile, 24-hour storm event, per EWMP compliance.

BMPPRIORITIZATION

The projects included in this CIP were prioritized based on a methodology developed in collaboration with the City.

This prioritization method produces a score that accounts for:

- Stormwater volume capture
- Planned or Future CIP Projects
- Property ownership
- Proximity to stormwater drainage infrastructure

The stormwater volume captured by each project is a unique value pertaining to that project. Projects that overlap planned roadway improvements offer an opportunity for coordination that minimizes disturbance to the community and drives cost efficiencies. Similar benefits can be achieved by coordinating stormwater projects with other planned investments through future CIP projects administered by Public Works. City owned properties are preferred due to the ease of access for construction and maintenance. Proximity to existing stormwater drainage infrastructure provides a cost-effective means for stormwater discharge from CIP project sites. An initial prioritization scheme, summarized in Table ES-3, was established to identify the effective BMPs, provide multiple benefits, and ensure a long-term solution for the City.
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
<th>RELATIVE SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Capture</td>
<td>Unique value (AF) for each project site, multiplied by factor of ten (10) to appropriately weight the relative score</td>
<td>Varies: 0.20 to 210</td>
</tr>
<tr>
<td>Multiple Benefit</td>
<td>Overlap with Roadway Improvement Plan</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Overlap with Beverly Hills CIP Project (Parks, Water Mains, Land Acquisition, etc.)</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>No Roadway improvements</td>
<td>0</td>
</tr>
<tr>
<td>Property Ownership</td>
<td>City-Owned Property</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Non-City Owned Property (Schools, Commercial/Business)</td>
<td>0</td>
</tr>
<tr>
<td>Proximity to Storm Drainage Infrastructure</td>
<td>Yes</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

The project team identified concurrent studies and planning efforts that may be used to refine this prioritization scheme as they become available in the future:

- Complete Streets Plan (CIP No. 0100)
- Water Main and Hydrant Replacement Plan (CIP No. 0387)
- Land Acquisition (CIP No. 0647)
- Street Tree Removal (CIP No. 0089)
- Alley Repaving (CIP No. 0080)
- Stormwater Rehab Program (No. 0260)
- Street Paving CIP, Parks Improvement CIP

As the program develops, the City may evaluate several key performance indicators to confirm success.

CIP projects were developed as a comprehensive and connected network of stormwater treatment solutions to help facilitate integrated planning. As part of this study’s identification process, more than 83 AF of storage volume was identified throughout the City. The project sites described in this CIP provide 72.4 AF of storage volume. Additional volume is provided by LID ordinances and Residential Programs. At this site, the historic intersection of Lomitas Avenue, North Canon Drive, and North Beverly Drive, there is the opportunity to capture stormwater runoff in bioretention gardens.
REFINEMENT OF COSTS

For the City of Beverly Hills, the 2016 Ballona Creek EWMP projected a total capital cost of $71.95M with an annual Operations and Maintenance (O&M) cost of $4.87M. This cost includes LID, Green Street projects, Public and Private Regional projects, as presented in the Table ES-4. These costs were established using cost functions in the Ballona Creek EWMP and result in an average cost of $2.54/gallon. These functions were developed by refining the Los Angeles County Flood Control District Watershed Management Modeling cost functions.

Table ES-4. Ballona Creek EWMP Summary of Strategies, Volume and Cost

<table>
<thead>
<tr>
<th>EWMP STRATEGY</th>
<th>STORAGE (AF)</th>
<th>CAPITAL COST*</th>
<th>O&amp;M COST/YEAR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>37</td>
<td>$40.88M</td>
<td></td>
</tr>
<tr>
<td>Streets</td>
<td>39</td>
<td>$26.99M</td>
<td></td>
</tr>
<tr>
<td>LID</td>
<td>11</td>
<td>$4.07M</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>87</td>
<td>$71.95M</td>
<td>$4.87M</td>
</tr>
</tbody>
</table>

* 2016 Ballona Creek EWMP Tables 9-2 and 9-3

The CIP projects prioritized in this study are associated with a total capital cost of $112.2M (2019), providing 77 AF of capture volume at an average cost of $4.47/gallon. The capital costs for projects detailed in this CIP are significantly higher than the costs presented in the Ballona Creek EWMP. These costs were developed by establishing project bid tabs for each project category, providing more detailed assessment of project components. Project costs were informed by average unit costs in the Los Angeles area and vendor costs were obtained for specific items. Additionally, a construction contingency of 30% and a planning/design contingency of 20% were included. The resulting range of cost efficiency of each facility type is summarized in Table ES-5, associated by facility type.

Table ES-5. Cost Efficiency by Facility Type

<table>
<thead>
<tr>
<th>FACILITY TYPE</th>
<th>CAPITAL COST/GALLON</th>
<th>ANNUAL O&amp;M COST/GALLON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk Vault</td>
<td>$7</td>
<td>$0.03</td>
</tr>
<tr>
<td>Median Bioretention</td>
<td>$7 - $9</td>
<td>$0.37</td>
</tr>
<tr>
<td>Curb Extension</td>
<td>$13</td>
<td>$0.28</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>$5 - $7</td>
<td>$0.20</td>
</tr>
<tr>
<td>Subsurface Storage</td>
<td>$3 - $8</td>
<td>$0.10 - $0.24</td>
</tr>
</tbody>
</table>

Note: All facilities are associated with an approximate 20-year design life.
CIP PROJECT SUMMARY

This report identifies an abundance of feasible project sites to comply with the targeted stormwater capture volume requirements. Generally, the cost efficiency was greater for regional solutions that provide large storage volume, such as subsurface storage, than distributed infrastructure, such as curb extensions or sidewalk vaults. Also, based on the prioritization scheme, the portfolio of projects has shifted to include more On-Site Stormwater BMPs and fewer distributed green street strategies. A comparison of the proposed strategies is shown in Figure ES-2. A summary of these projects is presented in Table ES-6. An implementation schedule for the projects identified in this CIP is presented in Table ES-7.

Upon successful completion of this CIP, it is anticipated that an additional 71.4 acre-ft of stormwater runoff will be captured and treated during each storm event greater than or equal to 1.1 inches, the 85th percentile storm event.
ATTACHMENT 2
1.0 Executive Summary

Municipal Separate Storm Sewer Systems (MS4) are publicly owned storm drains, gutters, roadside ditches, grassy swales, sediment ponds, and similar features that function collectively to manage stormwater and non-storm water. Stormwater and non-storm water discharges consist of surface runoff generated from various land uses, which are conveyed via the MS4 and ultimately discharged into surface waters throughout the region including the Ballona Creek Watershed. Pollutants in stormwater and non-storm water have damaging effects on both human health and aquatic ecosystems. MS4 permits authorize public entities to discharge pollutants from public stormwater systems. On November 8, 2012, the Regional Water Board adopted Order No. R4-2012-0175, Waste Discharge Requirements for MS4 Discharges within the Coastal Watershedsof Los Angeles County (LA County), except those discharges originating from the City of Long Beach MS4 (hereinafter LA County MS4 Permit). The LA County MS4 Permit was amended on June 16, 2015 by Order WQ 2015-0075.

The LA County MS4 Permit provides an innovative approach to stormwater compliance through the development of the Enhanced Watershed Management Program (EWMP). The EWMP for Ballona Creek Watershed was developed by the Ballona Creek Watershed Management Group which includes the City of Beverly Hills. In the EWMP multiple regional “Signature” projects are identified to provide a significant portion of stormwater pollution reduction by capturing the 85th percentile, 24-hour (design) storm event. For the location of the project site, an 85th percentile, 24-hour storm event is estimated to have a rainfall intensity of 1.1 inches per hour. Located in the City of Beverly Hills, as shown in Figure 2.1, La Cienega Park and Frank Fenton Field (LCP/FFF) were selected as potential signature regional project sites. The EWMP identified that the LCP/FFF Regional Stormwater Project (LCP/FFF Project) would consist of a belowground retention/infiltration basin, located beneath the existing sports fields. The goal of this project was to capture a stormwater Best Management Practice (BMP) volume of 24 acre-feet (AF). This volume of stormwater runoff was estimated to accumulate from 578 acres of tributary drainage area. During wet weather conditions, up to 24 AF of stormwater runoff would be captured and diverted away from Ballona Creek. In addition, any tributary urban runoff during dry weather conditions would also be captured and diverted, potentially reducing significant pollutants to Ballona Creek.

To evaluate the feasibility of the LCP/FFF Project, the design parameters provided in the EWMP were reviewed for accuracy and applicability. An updated analysis of the watershed and subsurface drainage infrastructure estimates that the project goals be reduced to 21 AF of BMP volume based on the feasible drainage area of 461 acres. This reduction in drainage area from the 578 acres was realized when a closer evaluation of the drainage boundaries was performed using surface contours. Also, the LA County stormwater infrastructure as-built drawings showed that drainage pipelines around the park include diversions which direct stormwater away from the project site.

In addition, the EWMP predicted that a stormwater retention/infiltration basin would be a feasible BMP for the LCP/FFF Project based on reviewing the LA County provided soil type maps and estimating infiltration rate based on soil type. To verify subsurface conditions and in-situ infiltration rates, geotechnical and hydrogeological investigations were performed at LCP/FFF. The results of these investigations show that the soils at LCP/FFF do not meet LA County standards for infiltration, therefore the EWMP proposed belowground retention/infiltration basin is not a viable...
BMP. With retention/infiltration no longer a viable BMP, the City evaluated the following alternative regional project configurations to meet the goals outlined in the EWMP:

- Stormwater diversion, storage, and harvesting for direct use at the LCP/FFF sites
- Stormwater diversion, treatment, and discharge back into the LA County MS4
- Stormwater diversion, detention, and discharge to the City of Los Angeles (LA) Department of Sanitation (LASAN) sanitary sewer system to be treated downstream at the Hyperion Water Reclamation Plant (HWRP)

Inter-Agency meetings with the Cities of LA, West Hollywood, and Beverly Hills were held to discuss which project configuration is preferred. Based on limited water demands at the park and the City’s goals of reducing the complexity and costs of the project, diverting, detaining, and discharging the design volume of stormwater to LASAN’s sewer system was chosen as the preferred option. To divert the stormwater volume as well as dry weather urban runoff and discharge it to the sanitary sewer system, three project alternatives were developed and analyzed. The alternatives evaluated included using a modular precast detention tank, a prestressed concrete detention tank, and a cast-in-place concrete detention tank. All three alternatives take advantage of maximizing storage height to reduce the park footprint required. Table ES-1 shows the estimated cost of each alternative including capital construction cost, design, and construction management. The estimated cost is based on Association for the Advancement of Cost Engineering (AACE) Level 5 Conceptual Cost Estimate criteria. Per the AACE criteria, a Level 5 Conceptual Cost Estimate has a typical expected accuracy range of -20% to -50% on the low end and +30% to +100% on the high end after an appropriate level of contingency is added to the cost.

Table ES-1. Cost Estimates for Stormwater Project Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Cost</th>
<th>Cost per Gallon Detained</th>
<th>Comparison between alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1—Modular Precast Detention Tank</td>
<td>$20.2 million</td>
<td>$2.95</td>
<td>Gravity flow to detention tank results in less pumps / O&amp;M, High excavation volumes, Lowest cost</td>
</tr>
<tr>
<td>Alternative 2—Prestressed Concrete Detention Tank</td>
<td>$25.6 million</td>
<td>$3.74</td>
<td>More pumps / O&amp;M required to pump to detention tank, Less excavation volumes</td>
</tr>
<tr>
<td>Alternative 3—Cast-In-Place Concrete Detention Tank</td>
<td>$37.5 million</td>
<td>$5.49</td>
<td>Less pumps / O&amp;M, High excavation requirements, High concrete requirements, Highest cost</td>
</tr>
</tbody>
</table>

Based on the results of the cost estimate, multiple methods of construction are feasible to construct a stormwater management facility that diverts 21 AF from the 85th percentile, 24-hour storm. Alternative 1 is recommended for implementing at LCP/FFF Park due to its overall lowest cost of
construction. Table ES-2 shows the updated parameters for the recommended alternative project (Alternative 1) at LCP/FFF Park.

Table ES-2. Summary of Updated Project Parameters

<table>
<thead>
<tr>
<th>Category</th>
<th>EWMP parameters</th>
<th>Updated Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture Volume Goal</td>
<td>24 AF</td>
<td>21 AF</td>
</tr>
<tr>
<td>City Watershed Contribution</td>
<td>City of LA significant contributor</td>
<td>City of Beverly Hills main contributor</td>
</tr>
<tr>
<td>BMP Type</td>
<td>Groundwater Infiltration/Recharge</td>
<td>Subsurface detention and diversion to sanitary sewer</td>
</tr>
<tr>
<td>Use of all baseball fields</td>
<td>Use of all baseball fields</td>
<td>Use of one baseball field</td>
</tr>
<tr>
<td>Project Cost</td>
<td>$32.2 million</td>
<td>$20.2 million</td>
</tr>
</tbody>
</table>

This document also includes a Preliminary Design Report for the LCP/FFF Project which consists of constructing a new 6.84 MG underground modular precast detention tank underneath the LCP/FFF park.

The baseball field and open space at the southwest corner of La Cienega Park were determined to be the best location for the subsurface storage facilities (Figure ES1-1) due to their proximity to existing 7'-0" tall storm drains and a sanitary sewer line, as well as their relatively larger size compared to FFF. Stormwater and non-stormwater (urban runoff) flows will be diverted from the LA County’s storm drain system through a diversion structure including a berm and side drain penetration. After diversion, flows will pass through trash racks for removal of large debris and pass through a low flow diversion manhole to send dry weather urban runoff directly to low flow diversion pumps. During a storm event when flows exceed the dry weather design flows, stormwater (wet weather flow) will enter the detention reservoir by gravity. The stormwater volume will be stored for the minimum duration required by LASAN recommended as 24 hours after the storm event. Then, pumps located on the downstream side of the subsurface detention facility drain the tank at a controlled rate to the City of LA’s sanitary sewer system.
Based up on the site constraints and preliminary discussions with precast modular basin manufacturers, the design criteria shown in Table ES-3 is recommended for the tank and ancillary facilities:

Table ES-3. Design Criteria for the Tank and Ancillary Facilities

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Flow into Tank, cubic feet per second</td>
<td>14</td>
</tr>
<tr>
<td>Capacity, millions of gallons</td>
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</tr>
<tr>
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<td>105</td>
</tr>
<tr>
<td>Tank Height, feet</td>
<td>15</td>
</tr>
<tr>
<td>Tank Foundation</td>
<td>To Be Determined by Basin Manufacturer</td>
</tr>
<tr>
<td>Tank Footprint, feet</td>
<td>276 x 243</td>
</tr>
<tr>
<td>Inlet/Outlet Pipe Diameter, inches</td>
<td>48</td>
</tr>
</tbody>
</table>

The AACE level 5 opinion of probable cost (OPCC) for the LCP/FFF Project is estimated to be approximately $20.2 million as shown in Table ES-4. The cost is shown divided per major work item for clarity. The OPCC has a contingency included to account for the preliminary design level and the contingency will be reduced appropriately as the design progresses. The total project cost includes the additional estimated cost for Engineering, and Construction Management Services.
### Table ES-4. Level 5 OPCC For La Cienega Park and Fenton Field Stormwater Project

<table>
<thead>
<tr>
<th>Item</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Work</td>
<td>$891,000</td>
</tr>
<tr>
<td>Piping</td>
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<td>Site Structures, Including Manholes and Vaults</td>
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<tr>
<td>Pump Station</td>
<td>$963,000</td>
</tr>
<tr>
<td><strong>Project Construction Cost Subtotal</strong></td>
<td><strong>$13,953,000</strong></td>
</tr>
<tr>
<td>Construction Contingency (30%)</td>
<td>$4,186,000</td>
</tr>
<tr>
<td>Construction Management (5%)</td>
<td>$698,000</td>
</tr>
<tr>
<td>Planning and Design Cost (10%)</td>
<td>$1,396,000</td>
</tr>
<tr>
<td><strong>Total Estimated Project Cost</strong></td>
<td><strong>$20,233,000</strong></td>
</tr>
</tbody>
</table>

The PDR also presents a high-level assessment of potential funding options for the LCP/FFF Project. Additional analysis of dry weather flows, the geotechnical design requirements, and confirmation of permitting requirements will be required prior to advancing the LCP/FFF Project into detailed design.
TAB 4
MEMORANDUM

TO: Councilmember Julian Gold, M.D., and Councilmember Robert Wunderlich, Ph. D.

FROM: Shana Epstein, Director of Public Works
       Gil Borboa, P.E., Assistant Director of Public Works/Utilities

DATE: September 4, 2019

SUBJECT: Integrated Water Resources Master Plan (IWRMP) Workshop; June 27, 2019 Summary


RECOMMENDATION

This report is for discussion, informational purposes, and summarizes the key outcomes of the IWRMP workshop conducted on June 27, 2019.

DISCUSSION

The City hired Hazen & Sawyer (H&S) to prepare an Integrated Water Resources Master Plan (IWRMP) for the City’s water, sewer, and storm drain systems. As part the data gathering effort, H & S conducted three workshops to date for the potable water, sewer/storm drain, and groundwater systems.

The workshops were primarily focused on staff-level project discussions, local system needs, and operations. The key primary outcomes for each of the water, sewer, and storm drain utility workshops included an in-depth operational focus on identifying localized and anticipated deficiencies as well as an emphasis on preventative maintenance to address aging infrastructure. Other key outcomes included discussions on anticipated development growth and its impacts on the existing infrastructure and future Capital Improvement Program (CIP). It was noted that historically, the City’s emphasis had been primarily on water infrastructure improvements with fewer improvements to the sewer and/or storm drain systems. However, there are now increasingly more sewer replacement and rehabilitation projects currently being implemented. Storm drain projects including current storm water capture and other potential future projects will be further identified at the conclusion of the storm drain hydraulic model currently being developed.

Additionally, the groundwater workshop focused on the current state of the existing available groundwater basins and the feasibility of developing local groundwater supplies in the existing Hollywood, Santa Monica, and Central Basins (La Brea Subarea). Other local supply opportunities for recycled water and aquifer recharge and recovery were also discussed.
At the June 27 workshop, H & S facilitated a discussion on developing ranking and selection criteria for priorities related to the City's overall water resources including water, sewer and storm drain systems. The main priority discussion topics, and questions developed to facilitate discussion, included:

- **Local water supply**
  - What is the local water supply goal (percentage)? Near term? Long term?
  - To what extent should the City consider other water supplies including recycled water or other?

- **Emergency storage**
  - How much emergency storage should the City have? How many days to plan for? What is the expected level of conservation during an emergency?
  - To what extent should catastrophic emergencies be factored into the decision?

- **Demand projections**
  - Are there desired analyses or outcomes for new development considerations in the IWRMP?
  - How often should current new development ordinances be evaluated and updated?

- **Water efficiency**
  - Should the City develop additional programs to further reduce water loss?
  - Should the City implement a proactive leak detection program?
  - Should the City implement measures to increase passive water conservation, like plumbing fixture rebates?

- **Addressing aging infrastructure**
  - Where does addressing aging infrastructure rank compared to other priorities?
  - Should the City's infrastructure upgrades prioritize one system above another? For example, should the water system be prioritized over sewer and stormwater?
  - Assuming projects for each system are implemented each year, what percentage should be allocated to water, sewer, and stormwater?

Some key outcomes from the workshop included the following consensus among Commissioners:

- Priorities above were unranked but essentially had equal weighting. All priorities have some component of water efficiency built-in. Priorities should strive to be more water efficient when feasible.

- Priority selection criteria was clarified or amended to include:
  a. **Cost** - Is the project cost effective in terms of total cost and cost per unit? Are there outside issues driving costs that are beyond the City's control?
  b. **Reliability** - To what extent does this project increase the system's reliability?
  c. **Timeframe** - Can the project be implemented in the near future? Can the project be implemented within a reasonable timeframe?
  d. **Feasibility** - Is the project within the City's control or are there outside agencies involved? Will permits or other regulatory requirements impact implementation? Is the required technology available?
  e. **Emergency Resiliency** - Does the project make the system more resilient to emergencies? Does the project prevent potential emergencies from occurring?
f. Risk Factors - What is the risk of either deferring, or not implementing this project at all? What are the risks of implementing this project?

- Emergency storage priority was clarified to include at minimum 7 days of storage at peak demand (with low reservoir storage levels)

- Demand forecasting methodologies were discussed, however, the PWC asked that the demand estimates be very conservative in nature.

NEXT STEPS
The key outcomes established in the workshop, and project status, will be presented at an upcoming City Council meeting, for consensus to continue development of the Integrated Water Resources Master Plan
ATTACHMENT 1
June 20, 2019

To: Public Works Commission of the City of Beverly Hills
From: Cindy Miller, Project Manager for Integrated Water Resources Master Plan
cc: Shana Epstein, Director of Public Works
    Gil Borboa, Assistant Director of Public Works
    Vince Damasse, Water Resources Manager
    Vincent Chee, Project Manager

Integrated Water Resources Master Plan Workshop

Introduction

The purpose of this memorandum is to introduce the workshop format, expected outcomes, and project priorities for the Integrated Water Resources Master Plan (IWRMP) Workshop to be held on June 27, 2019.
What is the Integrated Water Resources Master Plan?

The Integrated Water Resources Master Plan (IWRMP) is a comprehensive analysis of the water resources systems in the City of Beverly Hills. The IWRMP will provide an actionable and achievable capital improvement plan for the existing water system, sewer system, and stormwater system. It will address key issues such as local water supply, emergency storage, and aging infrastructure. The IWRMP will be the roadmap for addressing the needs of the City's water resources systems.

The City has contracted with Hazen and Sawyer to prepare the IWRMP. The Hazen and Sawyer team is led by Cindy Miller and Steve Bucknam, with Mike Rudinica in an advisory role. The Hazen and Sawyer team is working under City staff including Shana Epstein, Gil Borboa, Vince Damasse, and Vincent Chee.

With the proposed PWC workshop on June 27th, the IWRMP team is concluding the data collection and workshop phase, and moving into analysis and final report preparation. The IWRMP is scheduled for completion in April 2020.

Workshop Format

The IWRMP team will facilitate an open discussion on priorities related to the City's water resources systems. The priority discussion topics include:

- Local water supply
- Emergency storage
• Demand projections
• Water efficiency
• Addressing aging infrastructure
• Other (as-needed)

A presentation will be used to facilitate discussion on each priority. A brief background on each will be provided, with questions posed.

**Expected Outcomes**

The expected outcomes for the workshop are the following:

- Establish a prioritization ranking for each of the IWRMP priorities: local water supply, emergency storage, demand projections, water efficiency, aging infrastructure, or others as identified in the workshop.

- Establish criteria to evaluate project implementation feasibility. Potential criteria include cost, reliability, schedule, emergency resiliency, risk of doing nothing, or others as identified in the workshop.

- Answer questions related to each priority that will dictate project implementation.

It is expected that the following table will be completed by the conclusion of the workshop.

**IWRMP Priorities Ranking and Project Criteria Table**

<table>
<thead>
<tr>
<th>IWRMP Priorities</th>
<th>Ranking</th>
<th>Cost (or TBD)</th>
<th>Reliability (or TBD)</th>
<th>Schedule (or TBD)</th>
<th>Emergency Resiliency (or TBD)</th>
<th>Risk of Doing Nothing (or TBD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Water Supply</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
</tr>
<tr>
<td>Emergency Storage</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Demand Projections</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Addressing Aging Infrastructure</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Other</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
</tbody>
</table>
A description of each criterion is described below.

- **Cost** – Is the project cost effective in terms of total cost and cost per unit? Are there outside issues driving costs that are beyond the City’s control?
- **Reliability** – To what extent does this project increase the system’s reliability?
- **Schedule** – Can the project be implemented in the near future? Is the project within the City’s control or are there outside agencies involved? Will permits or other regulatory requirements impact implementation?
- **Emergency Resiliency** – Does the project make the system more resilient to emergencies? Does the project prevent potential emergencies from occurring?
- **Risk of Doing Nothing** – What is the risk of either deferring, or not implementing this project at all?

**IWRMP Priorities**

A brief background on the IWRMP priority to be discussed at the workshop is included below.

**Local Water Supply**

Local water supply means water supplied to the City from sources other than imported water from Metropolitan Water District. This primarily includes local groundwater available to the City from the Hollywood Basin, Central Basin (La Brea Subarea), and Santa Monica Basin. Key questions to be answered include:

- What is the City’s local water supply goal (percentage) for the near term? long term?
- To what extent should the City consider other water supplies including recycled water, water exchanges, or other?
Emergency Storage

Emergency storage is the amount of available water in the City’s reservoirs that can be used to supply water to the service area in the event of a short-term disruption in water supplies. The difference should be noted between catastrophic emergencies, and short-term disruption of supplies. Urban water systems are typically not designed for catastrophic emergencies, like regional wildfires or major earthquakes. However, water systems should be designed for short-term disruption of water supplies. An example of a short-term disruption of supplies was when the primary pipeline from Metropolitan Water District experienced a leak in December 2018 and was temporarily taken out of service.

Key questions to be answered include:

- Should catastrophic emergency scenarios be prioritized in project evaluations? If so, what type of catastrophic emergency scenarios?
  - Wildfire
  - Earthquake
  - Widespread contamination
  - Other

- How much emergency storage should the City maintain in their reservoirs (number of days)?

- What is the expected level of water conservation during a short-term disruption in supplies when the City implements public outreach?
Demand Projections

Demand projections are used for water supply planning, financial planning, capital improvement planning, and operations analysis. Developing an appropriate methodology for demand projections is part of the analysis for the IWRMP. The Beverly Hills water system service area has seen several significant developments planned and built since demand projections were completed for the 2015 Urban Water Management Plan.

### New Developments within Last 3 Years (Top 15 Projected Water Usage)

<table>
<thead>
<tr>
<th>Address</th>
<th>Usage</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>9900 Wilshire Boulevard</td>
<td>Multi-family Residential &amp; Hotel</td>
<td>BH</td>
</tr>
<tr>
<td>9040 West Sunset Boulevard</td>
<td>Multi-family Residential &amp; Hotel</td>
<td>WH</td>
</tr>
<tr>
<td>9876 Wilshire Boulevard</td>
<td>Multi-family Residential &amp; Hotel</td>
<td>BH</td>
</tr>
<tr>
<td>9200 Wilshire Boulevard</td>
<td>Mixed Use</td>
<td>BH</td>
</tr>
<tr>
<td>9060 Santa Monica Boulevard</td>
<td>Mixed Use</td>
<td>WH</td>
</tr>
<tr>
<td>8899 Beverly Boulevard</td>
<td>Mixed Use</td>
<td>WH</td>
</tr>
<tr>
<td>702-714 North Doheny (completed)</td>
<td>Multi-Family Residential</td>
<td>WH</td>
</tr>
<tr>
<td>8600 Wilshire Boulevard</td>
<td>Mixed Use</td>
<td>BH</td>
</tr>
<tr>
<td>9001 Santa Monica Boulevard</td>
<td>Mixed Use</td>
<td>WH</td>
</tr>
<tr>
<td>627 North La Peer Drive</td>
<td>Hotel</td>
<td>WH</td>
</tr>
<tr>
<td>121 San Vicente Boulevard (completed)</td>
<td>Commercial</td>
<td>BH</td>
</tr>
<tr>
<td>563 North Alfred Street</td>
<td>School</td>
<td>WH</td>
</tr>
<tr>
<td>8750 El Tovar Place</td>
<td>Park</td>
<td>WH</td>
</tr>
<tr>
<td>837-850 North San Vicente Boulevard</td>
<td>Hotel</td>
<td>WH</td>
</tr>
<tr>
<td>948 &amp; 954 North San Vicente Boulevard</td>
<td>Mixed Use</td>
<td>WH</td>
</tr>
</tbody>
</table>

Key question to be answered:

- Are there desired analyses or outcomes of the IWRMP in regard to new developments within the City’s service area? Potential analyses could include:
  - Forecasted demand compared to actual demand
  - Emergency storage impacts
  - Demand projections for new development compared with 2015 Urban Water Management Plan projections
  - Are any new developments significantly changing the current land use?

### Water Efficiency

Water efficiency is a measurement of water losses compared to water produced for a particular system. Water losses occur through system leakage and pipe breaks, but also through accounting errors, meter
inaccuracies, and unauthorized consumption (AWWA Manual M36). All utilities experience a certain level of water loss.

Water efficiency also involves evaluations on water conservation. Passive water conservation include measures that do not change user habits, like using low-flow plumbing fixtures. Active water conservation is a change in user habits, like the City’s current water conservation measures that residents are encouraged to follow.

The Department of Water Resources (DWR) requires all urban water systems to quantify and report water loss statistics and water loss management measures, however, there is no specific performance target required by DWR. Water loss statistics for Beverly Hills and some other southern California agencies are shown below.

<table>
<thead>
<tr>
<th>City/Agency</th>
<th># of Connections</th>
<th>Water Loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beverly Hills</td>
<td>10,600</td>
<td>7.6%¹</td>
</tr>
<tr>
<td>LADWP</td>
<td>712,000</td>
<td>5.2%</td>
</tr>
<tr>
<td>Moulton Niguel Water District (Orange County)</td>
<td>55,000</td>
<td>8.7%</td>
</tr>
<tr>
<td>Simi Valley</td>
<td>25,000</td>
<td>6.0%</td>
</tr>
<tr>
<td>Culver City</td>
<td>9,000</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

¹ 2017 Water Loss Audit per SB 555 performed by Psomas.

It should be noted that water loss for the City of Beverly Hills was 9.6% in 2005, 8.4% in 2010, and 6.0% in 2015 (2015 Urban Water Management Plan).

It is generally accepted as a best management practice that water loss of under 10% is acceptable for urban water systems. For systems with water losses exceeding 10%, there are leak detection technologies that can be implemented that provide the benefit of the early detection of leaks to reduce emergency pipe breaks, and the reduction in water loss.

Key question to be answered:

- Should the City develop additional programs to further reduce water loss?
- Should the City implement a proactive leak detection program?
• Should the City implement measures to increase passive water conservation, like plumbing fixture rebates?

Addressing Aging Infrastructure

The City owns and operates the existing water system, sewer system, and stormwater system within their service area. The water system includes 173 miles of pipelines, ten reservoirs, and ten pump stations. The sewer system includes 98 miles of pipelines. The stormwater system includes 47 miles of pipelines, culverts, and channels. Data on the age of pipelines for the water and sewer system is shown in the following table.

<table>
<thead>
<tr>
<th>Decade</th>
<th>Water Percent of System</th>
<th>Sewer Percent of System</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1930</td>
<td>31%</td>
<td>1%</td>
</tr>
<tr>
<td>1930</td>
<td>10%</td>
<td>49%</td>
</tr>
<tr>
<td>1940</td>
<td>&lt; 1%</td>
<td>7%</td>
</tr>
<tr>
<td>1950</td>
<td>12%</td>
<td>11%</td>
</tr>
<tr>
<td>1960</td>
<td>5%</td>
<td>13%</td>
</tr>
<tr>
<td>1970</td>
<td>14%</td>
<td>15%</td>
</tr>
<tr>
<td>1980</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>1990</td>
<td>12%</td>
<td>0%</td>
</tr>
<tr>
<td>2000</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>2010</td>
<td>5%</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

Through the first 3 quarters of FY 18/19, the City reported eight (8) sanitary sewer overflows. The City’s goal is to have less than four (4) overflows per year. Through the first 3 quarters of FY 18/19, the City reported twenty-six (26) waterline breaks. The City’s goal is to have less than seventeen (17) breaks per year. The current year data shows the recent deferrals in addressing aging infrastructure may be the cause for not meeting the City’s goals in minimizing sewer overflows and waterline breaks.

From the 1990s to early 2010s, the City has historically carried out an aggressive waterline replacement program, replacing older and undersized pipelines on an annual basis. During that same period, the City has implemented minimal pipeline replacements for the sewer or stormwater system.

Key question to be answered:

• Where does addressing aging infrastructure rank compared to other priorities?

• Should the City’s infrastructure upgrades prioritize one system above another? For example, should the water system be prioritized over sewer and stormwater?

• Assuming projects for each system are implemented each year, what percentage should be allocated to water, sewer, and stormwater?
Other

It is understood that there may be additional priorities that will be addressed in the IWRMP. Key question to be answered:

- Are there any other priorities that should be addressed in the IWRMP?

Conclusion and Next Steps

In summary, the expected outcomes for the workshop are the following:

- Establish a prioritization ranking for each of the IWRMP priorities: local water supply, emergency storage, demand projections, water efficiency, aging infrastructure, or others as identified in the workshop.

- Establish criteria to evaluate project implementation feasibility. Potential criteria include cost, reliability, schedule, emergency resiliency, risk of doing nothing, or others as identified in the workshop.

- Answer questions related to each priority that will dictate project implementation.

It is expected that the following table will be completed by the conclusion of the workshop.

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</tr>
</thead>
<tbody>
<tr>
<td>Local Water Supply</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight/%</td>
</tr>
<tr>
<td>Emergency Storage</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Demand Projections</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Addressing Aging Infrastructure</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
<td>Weight%</td>
<td>Weight%</td>
<td>Weight%</td>
</tr>
<tr>
<td>Other</td>
<td>#</td>
<td>Weight/%</td>
<td>Weight/%</td>
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- **Emergency Resiliency** – Does the project make the system more resilient to emergencies? Does the project prevent potential emergencies from occurring?
- **Risk of Doing Nothing** – What is the risk of either deferring, or not implementing this project at all?

As a result of this workshop, the IWRMP team will move forward in developing the optimal projects that align with the IWRMP priorities and project criteria rankings. These projects will be incorporated into a capital improvement plan identifying project costs and implementation year. The IWRMP will be a comprehensive document addressing the IWRMP priorities and recommended capital improvement plan.

### Additional Reference Information

Additional documents and research papers are attached to this memorandum to provide a background on the topics to be addressed in the IWRMP. The following documents are attached:


Adapting Urban Water Systems to Manage Scarcity in the 21st Century: The Case of Los Angeles

Stephanie Pincetl, Erik Porse, Kathryn B. Mika, Elizaveta Litvak, Kimberly F. Manago, Terri S. Hogue, Thomas Gillespie, Diane E. Patak, Mark Golub

Abstract

Acute water shortages for large metropolitan regions are likely to become more frequent as climate changes impact historic precipitation levels and urban population grows. California and Los Angeles County have just experienced a severe four year drought followed by a year of high precipitation, and likely drought conditions again in Southern California. We show how the embedded preferences for distant sources, and their local manifestations, have created and/or exacerbated fluctuations in local water availability and suboptimal management. As a socio technical system, water management in the Los Angeles metropolitan region has created a kind of scarcity lock-in in years of low rainfall. We come to this through a decade of coupled research examining landscapes and water use, the development of the complex institutional water management infrastructure, hydrology and a systems network model. Such integrated research is a model for other regions to unpack and understand the actual water resources of a metropolitan region, how it is managed and potential ability to become more water self reliant if the institutions collaborate and manage the resource both parsimoniously, but also in an integrated and conjunctive manner. The Los Angeles County metropolitan region, we find, could transition to a nearly water self sufficient system.

Keywords Water scarcity · Socio-technical systems · Integrated water management · Water self-reliance

Introduction

The 2018 water supply crisis in Cape Town, South Africa, once again focused attention on the acute consequences of failing to plan for future water needs in cities. Throughout the globe, many urban areas face water scarcity in coming decades. Cities in Mediterranean climates, which experience highly seasonal precipitation, have particular challenges to meet year-round water demands and growing populations (Padowski and Jawitz 2012; McDonal et al. 2014; Padowski and Gorenlick 2014).

This is not a new challenge. Cities in many types of climates have long imported water from distant watersheds to provide clean and reliable supplies (Baker 19-48; Tarr et al. 1984; Melosi 2001). In the arid regions of Western North America, such imports occur at grand scales. The

Salt Lake City, UT 84112, USA
4 Civil and Environmental Engineering, Colorado School of Mines, Golden, CO 80401, USA
5 Geography Department, University of California, Los Angeles, 619 Charles E. Young Dr. East, Los Angeles, CA 90095-1496, USA
6 Institute of the Environment and Sustainability and Sustainable LA Grand Challenge, University of California, Los Angeles, 619 Charles E. Young Dr. East, La Kretz Hall, Suite 300, Los Angeles, CA 90095-1496, USA

Published online: 09 November 2018
prospect of accessing readily available freshwater sources in faraway places led cities in California, Arizona, and Nevada to build pipelines over long distances to deal with regular seasonal scarcity. Such actions, undertaken in the early and mid-twentieth century, helped mitigate regular water shortages and set the stage for long-term growth in the regions (Davis 1993; Reisner 1993; Hundley 2001).

But during drought, available water in these semiarid and arid regions is especially limited. In California, for instance, urban population growth through the mid-twentieth century was enabled by vastly expanded water transfer infrastructure. But severe droughts in the 1970s and 1990s showed that many cities were unprepared for the water cutbacks resulting from water shortages. Cities instituted emergency measures and imposed significant cutbacks, reinforcing rationing as a standard approach to periodic drought (Bruvold 1979; Shaw et al. 1992; Dixon and Pint 1996; Mitchell et al. 2017).

California cities have made progress in the past decades to promote conservation and diversify supply sources, but they once again faced challenges during the 2011–2016 drought, the most severe on record. Larger cities fared better, though they were still mandated to cut water up to nearly 40% of 2013 consumption, depending on prior conservation actions (Office of the Governor of California 2016). But smaller communities with limited supply sources, such as Healdsburg and Cloverdale in Sonoma County, faced the risk of running out of water in 2014 (Gore and Bourbeau 2014).

Expectations of water availability for all these urban areas will likely continue to change in coming years, with more cities spending more money to ameliorate the effects of drought (MacDonald 2007; McDonald et al. 2014). But emphasizing the role of climatic drought, or the high variability in rainfall, as a driver of scarcity (both current periodic drought and future more prolonged events with climate change) misses the important role of societal expectations of water availability. In particular, engineered water conveyance systems bred confidence in the availability of nearly unlimited water supplies for many end-uses, despite a historic record that clearly shows long periods of aridity in the southwest US. In cities, this translated to security of indoor, commercial and industrial uses, but especially supported highly irrigated landscapes full of nonnative species. Perceiving water shortages as caused by natural events like drought deflects attention from the ways that current conceptions of scarcity has been constructed over many decades, driven by the reliability of infrastructure that facilitates continued water use.

Modern water management systems are comprised of both technical systems and organizational hierarchies. Within social science literature, such combinations of human social structures and technologies are characterized as sociotechnical systems (Pincetl et al. 2016a). For urban water management, sociotechnical systems include municipal governments and regulatory organizations, associated rules, regulations, codes and procedures, and the technical systems comprised of dams, reservoirs, pipes, and water treatment plants. Sociotechnical systems interact with environmental resources, such as groundwater basins that provide water storage (Poster et al. 1999; Gelé and Howard 2002). These in turn connect to larger systems of dams and water conveyance, along with the rules that regulate how those systems operate. Understanding water systems in cities as comprised of both social and technical aspects reveals how periodic water scarcity may result from existing management systems, rather than solely attributable to climatic drought. Many problems of urban water management result from governance failures at multiple levels, rather than scarcity of the resource itself (Pahl-Wostl 2017). Such governance failures are inscribed in the operation of infrastructure systems that reflect assumptions about water quantity and distribution. Policy innovations must engage with historically developed hard infrastructure and its management (Kiparsky et al. 2013).

This paper examines the social and technical adaptations necessary for one Mediterranean-climate urban region, Los Angeles County (LA), to adapt to future water management challenges. Like many modern cities, LA’s water management systems were designed to exploit highly available imported water from remote places to supplement regional water sources such as groundwater. Such local sources, while long-utilized, have not necessarily been managed to ensure long-term sustainability (Blomquist 1992). Summarizing results from research spanning a decade, we synthesize the findings of empirical investigations into the sociotechnical water system, elucidating potential actions for long-term water reliability in LA. We show how the embedded preferences for distant sources—and their local manifestations—have created and/or exacerbated fluctuations in local water availability due to changes in climate. This case study offers insights for other cities across the globe about sociotechnical system lock-in that creates water scarcity, and also pathways forward toward potential water self-reliance.

Sociotechnical systems

Urban infrastructure, and how it is connected to supply chain infrastructures is critical to providing necessary

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1 Drought is, of course, a term that implies a kind of referent of about rainfall normalcy. In the US southwest, dry periods are not uncommon historically. We use the terms shortage, scarcity, or aridity in some places to convey this concept.

2 Springer
goods and services to urban populations. Cities are products of complex interactions between sociopolitical, cultural, institutional, and technical networks, which are all dependent on infrastructures that can be configured in different ways (Swilling 2011). Sociotechnical systems co-produce each other (Trist 1981), and rely on an elaborated social network of agencies for structure and organization. Pahl-Wostl (2017) argues that the understanding of water governance is underdeveloped, with much work being descriptive. This is, in part, due to a failure to recognize how decisions, agency networks, and other social factors intimately influence the evolution of the physical infrastructure network. Early work in sociotechnical systems was developed for energy systems, such as the grid (Hughes 1993), which pointed to the importance of institutions and people in determining the trajectory of infrastructure development.

A sociotechnical perspective highlights that systems are not only comprised of technical artifacts, but also include economic, political, scientific and legislative components (Hughes 1993). Together, the social and technological elements form a web of interactions that contribute to the process of system building. The technological parameters and rules devised as part of system operations create a kind of “lock-in” (Unruh 2000), which is not only physical and regulatory, but also conceptual. That is, once systems are in place, patterns of expectations and notions of possibility also become fixed, limiting opportunities for system change even in the face of significant evidence. Aspects of this concept of lock-in, where previously-taken actions affect future decisions, are noted across many disciplines, including innovation economics (Liebowitz and Margolis 1995). Institutions build expertise that grows obdurate. Funded projects become sunk investments, perpetuating them as they are generally cheaper to use over short-term planning horizons. This pattern is often reinforced by budgetary rules. Legal and regulatory frameworks develop and generally solidify current practices.

Established practices within resource-exploiting sociotechnical systems may also mask potential resource availability, despite the paradox of overallocated systems—that is a resource may be available that is obscured by established measurement or allocations. Existing laws, rules, and expertise can also inhibit opportunities for doing things differently—a simple self-censorship in seeing other ways of constraining the future and systems of implementation. Another way of stating this concept is to understand that information incorporated by sociotechnical systems is the result of a process of selection by which the system decides what is meaningful and what is disregarded; sociotechnical systems create a set of implicit filters (Luhmann 1984).

Water Systems in Los Angeles County

In 2015, Los Angeles County and its 10.5 million people used approximately 810 million cubic meters (1.4 million acre-feet) of water. Over the past decade, over half LA County’s demands (55–60%) were consistently met by imported water from three main import infrastructures: reservoirs that store water from the Colorado River Basin that spans western North America, the California State Water Project (SWP) that brings water from mountain rivers in northern California, and finally the Los Angeles Aqueduct that brings water from the Owens Valley to the City of Los Angeles (Fig. 1). These water conveyance systems were built in a time of confidence in climate patterns—primarily the predictable presence of alpine snow pack that, melting slowly through spring and early summer months, is captured and dispatched through the drier summer and fall months to support the state’s agricultural regions and its cities. Paleo and historic records of precipitation were either unavailable or ignored in these twentieth century infrastructure development projects.

In Southern California, the primary water importer, the Metropolitan Water District of Southern California (MWD), was created through state legislation in 1927 and approved by local voters to import water to the region, first from the Colorado River federal complex and subsequently from California’s SWP. MWD distributes imported water to over 100 different water delivery entities within a hierarchy of agencies in LA County (Pineo et al. 2016b). In addition, there is one area of the county with its own water district organized to also contract with the SWP for water imports.

For local sources of supply and water storage, LA County benefits from significant groundwater resources. The basins were adjudicated through agreements that set pumping rights, established governance structures, and guided long-term management actions to maintain yield (Ostrom 1990; Blomquist 1992; Porse et al. 2015). In support of the agreements, considerable investigations of hydrogeology and capacity were undertaken, though many of the findings upon which the adjudications were based are now likely out-of-date, as the LA metropolitan area overlying the basins has grown more urbanized. Reduced imported availability also led MWD to significantly cut its allocation of imported water for basin recharge. In response to such changes, pumps, and groundwater managers in several basins have recently taken actions to incentivize recharge through groundwater storage pools or collectively limit pumping (ULARA Watermaster 2013; CB/WCB Amended Judgment 2013; LADWP 2015).

The modernist-era water infrastructure that currently supplies much of urban California will be strained as future climate change reduces seasonal snowpack storage.
The severe multiyear drought showed vulnerabilities of reliance on imported water. In Los Angeles, the availability of imported water affects not only direct water supplies, but also groundwater recharge in LA’s groundwater basins that provide critical sources for many communities. Increased conservation over recent decades has allowed the city and county populations to grow without increasing total water use, but such conservation—over time—may reduce the viability of acute water use restrictions alone to deal with dry climate cycles over time (Mitchell et al. 2017).

In the past 2 decades, new water awareness has been building in the region, urging better water management (Green 2007), including distributed stormwater infiltration zones, water recycling and reuse, water conservation and turf removal, and greater use of groundwater basin storage potential (Hughes and Pincetl 2014; Porse et al. 2015; Mika et al. 2017a). But these strategies must take hold across a highly diverse, fragmented, and complex water management system that combines natural features, such as the groundwater basins, rivers and run-off, and human-created institutions such as water districts and groundwater adjudications. These are all interconnected by technical infrastructure like pumps, pipes, and filters. There exist multiple human, engineered, and environmental systems that overlap to form hierarchical structures and interact in distinct ways that solidify dependent relationships between natural and human systems (Fig. 2).

The LA metropolitan region spans five major watersheds and over twenty groundwater basins with significant storage capacity (MWD 2007). Management decisions are dispersed among hundreds of agencies who lack

Fig. 1 Major conveyance systems for importing water to the Los Angeles metropolitan region. Two aqueducts, the Colorado River Aqueduct and the California Aqueduct, serve the greater Southern California region.
Fig. 2 Visualizing the layers of water management in Los Angeles. Each layer, including social, environmental, and engineered systems, is represented and linked through modeling.
comprehensive region-wide quantifications of local water reliance potential (Supplemental Data File). Historic and contemporary ways of thinking, the disjointed institutional architecture of water management, and successful reliance on water imports, has meant the development of region-wide water resources quantification, has not been undertaken; it has not been seen, or perceived, as necessary. The most recent 4-year dry period points to the need for better quantification and modeling of this system under different scenarios and flows. We suggest the same applies to most urban areas across the globe with high reliance on imported water and poor understanding of local water flows.

**Constructing the Empirical Basis for Change in LA Water Management**

Analyzing complex systems driven by both human and environmental factors often requires composite assessments that draw on multiple modeling approaches based on extensive empirical data. To this end, we compiled methods and findings via a decade of interdisciplinary research to systematically deconstruct the complex and layered water system in the county metropolitan area using modeling, data collection and interviews, and field studies. Methods and key findings are summarized below. Full descriptions of the new modeling methods and results are provided in the Supplemental Data section.

**Study Methods**

We integrated operations research modeling, urban hydrologic modeling, field experiments, interviews and stakeholder outreach, policy and scenario analysis, historical and institutional analysis, and program evaluation to assemble a comprehensive understanding of the potential for local water reliance in the Los Angeles metropolitan area. Studies focused on LA City and LA County. The sections below briefly summarize key methods. Further details are included in the appendix and associated references.

1. **Field experiments and program evaluations of tree and turf water use in Southern California**: Tree and turf water needs in LA were estimated based on experimental measurements taken between 2010–2011 (Litvak et al. 2012, 2017a, 2017b; Litvak and Pataki 2016). In particular, evapotranspiration (ET) in urban landscapes during pre-drought conditions (before the 2011–2016 record drought) was systematically estimated. For lawns, ET of irrigated turf lawns was measured using small chambers across lawns with varying levels of shading and irrigation (Litvak et al. 2011). For trees, transpiration rates, a reasonable proxy for tree ET in LA, was measured using thermal dissipation probes (Granier 1987) that recorded sap flux in urban trees species common in LA (Pataki et al. 2011). The experiments sampled trees of varying species across a variety of land use types, working with public and private landowners to gain access. These experiments provided an empirical basis for understanding landscape water conservation potential through a water budgeting approach for urban retailers.

Additionally, we evaluated the effectiveness of turf replacement programs in LA County through work funded by MWD. We examined participation trends in MWD’s 2014–2016 turf replacement program and developed a landscape classification typology using openly-available imagery to evaluate changed landscapes (Pincetl et al. 2018). The findings from this project provide important context to understand whether turf replacement programs can be a successful strategy for promote landscape change and outdoor conservation to reduce urban demand.

2. **Urban hydrology modeling to understand stormwater and water quality actions**: Through a multiyear project funded by the LA Bureau of Sanitation, we performed watersheds-by-watershed analysis of stormwater capture potential from distributed green infrastructure to assess potential water supply benefits and water quality implications. Results from calibrated models, built using the US EPA’s SUSTAIN modeling platform that supports multi-objective optimization (Lai et al. 2007), we investigated the maximal potential for stormwater capture via distributed stormwater control measures to augment groundwater recharge given available data. Associated effects on key surrogate pollutants were also examined to understand water quality outcomes and potential pollutant load reductions (Read et al. 2018; Mika et al. 2017b) (Mika et al. 2017a–2017c).

3. **Systems analysis with optimization for integrated water management**: For both LA City and LA County, integrated systems analyses with quantitative and qualitative assessments were developed to understand relationships among water supply reliability, water conservation, alternative supply sources, current policy goals, and existing regulations. For the city of LA, results from the urban hydrology modeling with SUSTAIN were combined with systematic data collection and analysis of groundwater pumping, wastewater treatment, and water supply operations. The potential role of stormwater and recycled water to augment existing supplies was evaluated in the context of stated goals for local water reliance in LA City (Mika et al. 2017a). For the county of LA, a comprehensive network flow model of water management (Artes) was developed to simulate and optimize promising actions (and associated tradeoffs) for local water supply across more than a hundred institutions with existing allocations and water rights, environmental features, and engineered infrastructure (Porse 2017; Porse et al. 2017). For both study areas, economic
Environmental Management

Table 1: Nine themes toward water self-reliance for semi-arid cities

<table>
<thead>
<tr>
<th>Theme</th>
<th>Use Scientific Knowledge for Outdoor Water Conservation</th>
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<tbody>
<tr>
<td></td>
<td>Measure water use for outdoor vegetation, including, for each, trees, shrubs and lawns</td>
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<th>Theme</th>
<th>Maximize Use of Groundwater Basins</th>
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<tr>
<td></td>
<td>This includes detailed hydrologic analysis, recharge capacity and users</td>
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<tr>
<th>Theme</th>
<th>Upgrade Water Reuse Systems for Water Quality and Reuse</th>
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<td>Wastewater is a mini water going forward in the 21st century. This is important water supply</td>
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<th>Theme</th>
<th>Emphasize New Water Cycles</th>
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<td>Develop closed loop systems where water is reused and kept in the urban system, including groundwater</td>
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<th>Theme</th>
<th>Import Water only in Wet Years</th>
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<td>Many semi-arid regions do have high rainfall years. Maximize storage to take advantage of these years.</td>
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<th>Theme</th>
<th>Capture Stormwater in Large and Small Infrastructure</th>
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<td>Stormwater is an important water supply that needs space to infiltrate. Maximize that capacity throughout the urban system.</td>
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<th>Theme</th>
<th>Recognize Tradeoffs in Water Uses</th>
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<td>Irrigation flows versus infiltration is an issue that can have aesthetic and recreational implications</td>
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<th>Theme</th>
<th>Integrate Old and New Infrastructure</th>
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<tr>
<td></td>
<td>Take advantage of existing infrastructure, adapt and re-purpose as well as create new infrastructure</td>
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<th>Theme</th>
<th>Recapitalize and Consolidate Retailers</th>
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<td></td>
<td>In places where there is a proliferation of small providers and segmented systems, cost effectiveness and coordination is enhanced by consolidation.</td>
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Key Findings

Findings from the research (Table 1) detail the changes in system governance, along with the investments in existing infrastructure, which will be necessary to achieve water self-reliance in a region such as Los Angeles. Additionally, such changes are not without potential consequences that must be considered in advance to understand ripple effects throughout the system. The findings are organized into key themes below.

Theme 1: Use Scientific Knowledge for Outdoor Water Conservation

Urban vegetation of Los Angeles, like most of Southern California, is predominantly characterized by lawns and plants from more humid parts of the world. Substituting this vegetation for California/Mediterranean ecosystem plants that are adapted to dry summers and extended dry periods would potentially reduce regional water use by 30% (Litvak et al. 2011, 2012, 2013, 2017b; Litvak and Fatoki 2016).

Field experiments derived a dataset of tree water use by particular species, including variance within a single species across locations and water availability. Such pertinent scientific knowledge can help drive regional tree planning and landscape conversion programs. In particular, to maintain LA’s urban tree canopy in a future locally reliant water supply regime, the current canopy composition must be converted to trees that are adapted to Mediterranean climate conditions (winter precipitation and dry, hot summers) that are also drought-tolerant (can survive dry periods), a long-term conversion process. Additionally, this will involve not only changing perceptions of what an attractive yard looks like, but plant offerings of local nurseries will need to evolve so as to support a change toward different resident decisions (Pincetl et al. 2013). For example, promoting wider availability of native plants can provide options for changing decades-old landscape types.

But regional water managers have limited understanding of species-specific water use by trees in LA and other landscape elements. Landscapes are outside of the domain of responsibility and expertise, though multiple agencies offer turf replacement incentive funding. Some agencies, notably the City of Long Beach, provide more robust guidance in good designs for replacement landscapes, but resident and contractor expertise is sparse. To date, a few local nonprofits have spearheaded the task of piloting programs that engage residents in the process of remaking the urban landscape of Southern California cities. Much more needs done in transforming water agency practices to recognize the value of promoting landscapes that are appropriate to the region in partnership with property owners.
Theme 2: Maximize Use of Groundwater Basins

The groundwater basins of LA currently provide up to 40% of annual supplies across the county. The adjudicated basins have a pumping limit of approximately 555 million cubic meters (mcm, or 450,000 acre-feet) annually and are LA's most critical natural resource for achieving local water reliance. Groundwater basins provide readily available local storage capacity that would otherwise not exist in a highly urbanized basin where land prices outstrip the value of building reservoirs. Urban areas without such groundwater basins face greater challenges from imported water reductions.

But current groundwater management practices must adapt to future conditions. Recent assessments have estimated that 985mcm (800,000acre-ft) of unutilized available storage capacity exist in three of the region's larger basins: The Central and West Coast Basins 407mcm (330,000acre-ft) and the San Fernando Basin 555mcm (450,000acre-ft) (ULARA Watermaster 2013; CB/WCB Amended Judgment 2013). This constitutes approximately half of the LA metropolitan region's historic annual water use, which has been approximately 2000mcm (1.6 million acre-feet), but less during drought. Additional storage may be available in other groundwater basins as well. In the Central and West Coast Basins, the new groundwater master for the basins, the Water Replenishment District of Southern California, led basin stakeholders to develop a regional storage pool, whereby infiltrated water could fill the depleted void and provide pumping over-year storage capacity. Such agreements can encourage greater utilization of local groundwater basin resources, bringing back into production depleted aquifers to offer pumping rights to more parties, though current adjudications will need to be significantly revised to do so.

Many retailers throughout the county do not have current rights to pump or store groundwater in underlying basins (Porse et al. 2015). To benefit the region, current management regimes with adjudicated storage and pumping rights need updating. Restructuring groundwater pumping rights can provide greater access to groundwater resources among agencies, especially those that have no existing rights and would suffer significant supply shortages with imported water cutbacks. In addition, implementing groundwater storage pools that open up water rights to more parties could significantly reduce the effects of imported water cutbacks by allowing vulnerable retailers access to alternative sources of supply (Porse et al. 2018a). Yet, even as key regional agencies are promoting more recharge to address overdraft, past industrial operations have also left many parts of LA with underlying contaminated groundwater plumes. Pumping, treating, and using or reinjecting water from these plumes will be critical in opening up greater access to available groundwater resources.

The state of current groundwater basins is also a challenge. A number of aquifers in the metropolitan region are contaminated, a legacy of past industrial practices from aerospace and other industries that disposed of chemicals on-site. In some areas, such as the upstream San Gabriel Valley, remediation activities have taken place for years. But much more needs done. Groundwater basin managers are concerned about disturbing current contaminant plumes, which restricts wider pumping (ULARA Watermaster 2013). New "pump-and-treat" technology investments will be necessary to remediate contaminated groundwater pockets and mitigate risks of spreading plumes (Mika et al. 2017a). Such actions could help open more groundwater areas to active management, supported by robust modeling to ensure that infiltration and pumping activities do not pose undue risks for water supplies.

Theme 3: Upgrade Wastewater Systems for Water Quality and Reuse

Recycled water (treated and disinfected to regulatory standards) comprises approximately 10% of current supplies in LA County. But this source is only for non-potable uses (e.g., outdoor irrigation) or indirect potable reuse (groundwater recharge). Due to its consistent output, recycled water provides critical reliability in a future water regime dependent on local sources. New water reuse projects are already underway throughout the county, (detailed in the Supplemental Data section), but could be vastly expanded as sewage flows and water treatment capacity are relatively predictable and could thus be a stable source of water going forward.

Current recycled water operations deliver nonpotable water at affordable prices in comparison to the rising cost of imported water supplies (Mika et al. 2017a; Porse et al. 2018b). Storing recycled water in LA's substantial groundwater resource capacity provides a critical supply chain for future water management in LA. Direct potable reuse, which is the subject of statewide policy development proceedings in California, would provide, if enacted, additional options for creating closed loop urban water management (SWRCB 2016).

Water reuse is an important emerging supply source that requires new infrastructure, but the changing dynamics of urban water in Southern California will affect current systems. The large existing wastewater treatment plants in LA, in particular, will see lower inflows as a result of water conservation and reduced imports. This serves to concentrate waste streams, leading to increased costs of treatment. Results of our systems modeling in LA County showed that this prospect would likely continue if advancing goals of local water supply and increased conservation (Fig. 3). This phenomenon represents one of the perhaps
undesired, but predictable, outcomes of changing the urban water systems of coastal Southern California. Additionally, the increasing concentration of effluent waste streams flowing into treatment plants, resulting from less dilution from imported water and stormwater, will also require new investments in aging facilities. But while these issues are definitely challenges for future infrastructure management, in the context of historical actions to bring water to the region, they seem manageable given the economic prowess of the region.

Theme 4: Emphasize New Urban Water Cycles

A water supply regime more dependent on local sources requires reconfiguring the ways regional agencies conceive of and manage supply sources and the cycles of water management in LA. Most water is predominantly imported, used, treated, and disposed to the ocean. In the future, flows need to form closed loops, with in-basin or imported sources undergoing treatment and reuse that retain much more of the volume within the basin, either through direct use or recharge. Moving towards a greater closed loop perspective of urban water management is a significant change in historic operating practices and is known as One Water. It means the development of a new sociotechnical system with integrated planning at the watershed scale and regional institutions and/or collaborations, transcending the fragmented historical system. The network flows, illustrated in Fig. 4 for a modeled scenario with significantly reduced imported water, would change current operations significantly.

Within the complex water management regime in LA, with its many agencies and bureaucratic silos, closed loop projects can be accomplished through either: (1) laboriously negotiated, bilateral agreements among agencies with detailed plans for funding new infrastructure, or (2) systematic, multilateral, and regional strategies that aim to create a water system that relies on local water resources by water recapture and reuse. This latter approach would entail crafting new regional water analysis for optimizing reuse, reinjection and treatment and management structures to ensure full use of groundwater basins with equitable access to water by all areas in the urbanized Los Angeles basin.

Theme 5: Import Water Only in Wet Years

Importing water during only “wet” years, used to supplement local water resources and recharge groundwater, is a novel strategy for mitigating potential shortages from over-reliance on continual imports. Such a configuration enables
developed alternative models to create scenarios to help understand the balance between conservation potential and imported supply being cut back. Using several scenarios of imported water availability and water conservation. Reducing water use to 280–380 l per capita per day (75–100 gallons per capita per day, gpd) across the county metropolitan area (total water use) would go far in promoting cutbacks in imported water (Porse et al. 2017, 2018b). With investments in infrastructure and landscape conversion to drought-tolerant species, this means importing water in only the 25% wettest years, which would significantly reduce upstream environmental impacts of water diversions (see Supplemental Data). Water conservation to achieve 75 gpd is on par with other global industrialized cities, and would allow for completely cutting water imports in LACity (4 million inhabitants) when coupled with other infrastructure improvements (Mika et al. 2017a), though not for the rest of...
the region. Reconfiguring state agreements to use risk-based procedures that promote timely importation of water from distant sources during wet years, rather than consistent imports that are only curtailed by drought, would require significant changes in current operating conditions and agency practices, at all levels: federal to state and local. The primary purpose of the imported water would be to recharge regional groundwater basins and reservoirs, which would be carefully managed between years of high precipitation. The region would then be largely living within its means. This would have the additional benefit of alleviating ecosystem impacts in regions of origin.

Theme 6: Capture Stormwater in Large and Small Infrastructure

LA currently has an extensive network of large stormwater capture basins that capture 246mcm (200,000acre-ft) of runoff annually, and have captured as much as 800mcm (650,000acre-ft) in a year (LACDPW 2014). Agencies are looking at cost-effective and achievable options for increasing these values, including re-operating flood control release schedules, building new pipelines for recycled water, and even inflatable dams to temporarily capture runoff. Going forward, both regional and distributed stormwater capture systems will be necessary to promote reliability and achieve stringent Clean Water Act regulations that municipalities must currently meet as part of regional stormwater discharge permits (LA RWQCB 2016).

The results from multiple models indicated that existing centralized stormwater recharge infrastructure is a key regional asset. It provides a cost-effective way to recharge a significant volume of water on an annual basis. Modeling indicated that they could infiltrate much more water with changes in land use, management practices, and additional infrastructure that connects recycled water facilities with recharge basins. But distributed stormwater capture facilities, including low-impact development strategies such as bioswales, retention basins, and others, can also significantly contribute to groundwater recharge. In three of the main river basins, the Los Angeles River, Ballona Creek, and Dominguez Channel, runoff for potential capture totaled 121mcm (150,000acre-ft) in a dry year and more than 810mcm (1 million acre-ft) in a wet year. This is before implementing any distributed BMPs to capture and retain runoff throughout the landscape, which can also significantly improve water quality.

However, many regional agencies view such distributed capture as too expensive and plagued with challenges regarding siting and maintenance. These management realities are valid. Promoting more broad-based accounting procedures for projects can help in this regard. As an example, stormwater projects that capture and infiltrate runoff to groundwater basin supplies can consider the averted costs of imported water as a project benefit. But stormwater utilities typically do not sell water and cannot directly include these benefits as part of project planning. In jurisdictions where stormwater and water supply agency boundaries differ, assembling projects becomes a complex negotiation that requires activities outside the norm of agency mandates. New accounting structures and multi-lateral agreements, such as large water supply agencies funding distributed stormwater capture that has both water quality and supply benefits, would help open latent investments in stormwater capture. Alternatively, as has been proposed, water retailer, stormwater and sanitation agency duties should be merged or better coordinated under one roof as a way to achieve goals of local “One Water” initiatives.

For many regional agencies, however, enhancing water supply through stormwater management is secondary to regulatory realities in the region. LA municipal agencies with stormwater management duties face steep bills to build new stormwater capture measures (SCMs) that meet water quality goals (Upper LA River Watershed Management Group 2015). Detailed plans outline millions of dollars of spending that will be necessary, according to modeling, to meet water quality targets is downstream watersheds. For these places, incorporating multibenefits accounting procedures, which recognize the benefits to social, economic, and environmental systems from better stormwater management, is a well-documented strategy, though its enactment has been slower to emerge.

But even if distributed SCMs became widespread, there is no single best type of stormwater capture device to use, and some water quality targets will be hard to meet, especially for some contaminants such as heavy metals (Mika et al. 2017a). For instance, the watershed modeling for LA City showed that scenarios with distributed SCMs could manage up to the “design storm” runoff (85th percentile of the historic distribution of precipitation events), but trade-offs existed. Some SCMs achieved runoff mitigation targets more cheaply, while others were more effective at reducing water quality exceedances or peak flows. Still others provided greater water supply benefits. Modeling scenarios that emphasized SCMs that treated and released stormwater, such as vegetated swales and dry ponds, resulted in fewer exceedances of the regulatory stormwater exceedance limits for metals. But treat-and-release SCMs provided less potential recharge than those that emphasized infiltration to groundwater. Thus, both types of distributed infrastructure provided the most economical solution to achieving both water quality and supply goals for the region. Agencies with significant financial capacity are, at present, most likely to have sufficient capital to invest in such measures. Such
trade-offs are likely in most regions, with or without strong water quality regulations.

**Theme 7: Recognize Tradeoffs In Water Uses**

Water supply regimes dependent on local sources can have many benefits. But tradeoffs exist. For instance, capturing, and using more stormwater for groundwater recharge may reduce flows in the highly channelized urban streams of LA County (Porse and Pincetl 2018). The LA River basin, in particular, is a useful case study in examining these tradeoffs. Currently, a broad planning has been examining opportunities for the channelized Los Angeles River to promote economic development and multibenefit uses such as recreation. But water conservation and cuts to imported water reduce treatment plant outflows that constitute a significant percentage of the artificial summer stream flows, would be reduced (Manago and Hogue 2017).

In addition, promoting more stormwater infiltration in upstream basins would decrease downstream urban stream flows across the county in most seasons and years (Porse and Pincetl 2018; Mika et al. 2017). These infiltration projects would recreate the historic predevelopment water regime in the region where water infiltrated rather than being captured by stormwater systems to send the storm flows out to sea.

**Theme 8: Integrate Old and New Infrastructure**

Existing infrastructure in LA will not go away. It will continue to be used and likely adapted and reoperated to meet current management needs. Current assets, such as LA City's Hyperion Water Treatment Plant or LA County's Joint Water Pollution Control Plant that provide sewage treatment and disposal, can be retrofitted to support greater water reuse. Yet, many assets key for a local water supply regime of urban water are not located in optimal locations. For instance, some of the regional sewage treatment plants lie in locations where water recycling opportunities would need new pumping infrastructure. Local applications—or decentralized infrastructure—may reduce the need for new construction or expensive retrofitting of recycled water distribution systems. A major question will be the scale (centralized, decentralized and size) and cost/benefit of such retrofits.

Additionally new areas for large-scale stormwater capture in the highly urbanized basin are limited. Public lands that are well situated can serve hybrid purposes, including stormwater retention and infiltration, will need to be identified and strategies developed to optimize the opportunity. New approaches will require shifting the modernist-era sociotechnical system toward gray/green infrastructures to enhance local sustainability and resilience. Opportunities for distributed stormwater infrastructure exist in stormwater channels (some of which are already soft bottomed, but others could be unpaved), parking lots, alleys, parks and more, but have not been seen as such due to the lock-in thinking of the current system. The barriers to these alternative systems include cost, fear of failure in increased flooding risk, lack of experience in assessing the infiltration potential, and inadequate experience in such alternatives in the region. However, repurposing such areas for multiple use is an important component of achieving greater local water self-reliance (Goldetirli et al. 2015; Mika et al. 2017a–2017c). This type of opportunity exists in cities throughout the globe but requires new approaches and funding mechanisms.

**Theme 9: Recapitalize and Consolidate Retailers**

The complex hierarchy of water management agencies in LA developed slowly over time. It is not the result of any single act of planning. The agency network includes municipal utilities, special water districts, private investor-owned utilities, nonprofit landowner-controlled mutual water companies, and irrigation districts. The agency network spans over 100 sizeable water delivery entities and, when including extremely small retailers, more than 200 (Ostrom et al. 1961; DeShazo and McCann 2015; Pincetl et al. 2016).

All of these agencies make policy and investment decisions based on an existing system, where revenues are predominantly tied to water sales (volumetric). This creates a structural disincentive for conservation, including turf removal. Some larger and more financially secure agencies have systematically invested in conservation, but not to the extent possible. But without long-term planning and changes in rate structures, conservation detracts from revenues, causing economic ramifications for risk-averse utilities.

The agencies most prone to status quo management serve hundreds of customers only and are managed by property owners who vote according to property share. Many of these are poorly capitalized and cannot finance basic infrastructure repairs such as leakage (Naik and Glickfeld 2017). Consolidating water utilities is seen as an enormous uphill battle and impossibly expensive. Small water utilities' infrastructure would have to be upgraded, and any private utilities would have to be purchased. Yet consolidation into regional utilities could be more effective at implementing wastewater reuse facilities, a systematic approach and funding of landscape change, and planning and implementation of stormwater capture and infiltration projects, in addition to infrastructure repair and upgrading. Such larger scale entities would also have greater capacity to revise revenues and strategies to decouple infrastructure funding needs from volumetric water sales, which has
proven a significant constraint to investment. Going forward, one-water agencies, combining stormwater, sanitation, supply and groundwater, are a strategy toward greater fiscal health and moving toward integrated water management.

**Theme 10: Promote Openly Available Data and Models**

Studies of water management in LA County, like many places, benefit from agencies that publish significant amounts of data. One example of openly available data in LA is LA County's hydrologic model, the Watershed Management Modeling System (LACDPW 2013). This open-source model and its underlying data has facilitated numerous studies for government planning processes and external research. LA-area agencies that publish data and models to date have significantly contributed to integrated water management in the region. Through this research, we similarly sought to contribute to available data by publishing reports and open source repositories of results and contributing data, such as a Github repository with databases of countywide local water reliance analysis (Purse 2017). For other regions in the world, implementing and facilitating data collection and access will be important to addressing water planning for shortages.

**Discussion**

The key themes elaborated above offer a framework for policy goals and necessary actions to achieve greater local water supply reliance across LA County and can provide a template for replication. They draw on an integrated perspective of urban water management from a socio-technical systems perspective, to understand how infrastructure, management regimes, and behavior all interact to influence future trajectories.

The water supply regime transformation that emerges from the synthesized findings has the following key components: (1) Water conservation, supported by scientifically informed transformations of the urban landscape, is critical to reducing demand to levels that can be supplied locally; (2) groundwater basins have hundreds of thousands of acre-feet of capacity for additional water storage, but the current agreements for pumping are based on 20th century assumptions of imported water availability. Conjunctive use can be tied with timely storage of imported water in years of high rainfall to keep basins productive and adequately supplied; (3) water reuse, including wastewater and increased opportunities for stormwater infiltration are part of this trajectory toward regional water self-reliance; (4) transformation of current siloed water management systems toward a One Water management regime that integrates water supply, groundwater management, water infiltration and recycling will shift the system toward water self-reliance. This is likely the most difficult change of all, requiring overcoming the 20th century establishment of single-purpose agencies for each jurisdiction.

While the synthesized results from modeling, analysis, and interviews show the possibility for a regional future of water sufficiency, the sociotechnical system’s lock-in makes the transition challenging. We suggest this is the case for many cities and regions that have developed over the course of the 20th century. Rules, codes and conventions, piping and infrastructure coupled with expectations of water use and landscapes, create obdurate circumstances that effectively create water shortages amidst the potential for there being enough water.

Current groundwater adjudications, in particular, are highly codified and pose challenges for quickly adapting LA’s water systems. For example, if agencies without pumping rights invest in stormwater capture and recharge, they do not benefit from opportunities for seasonal or annual storage. Moreover, the status of captured stormwater in many adjudications is even in question. It is seen in some basins as part of the natural recharge regime, which is only available to pumpers with current rights. In this way, additional water storage, including the injection of treated sewage water in locations where groundwater basins are adjacent to those plants, faces a sociotechnical conundrum. This social construction of groundwater management and water rights, impedes the full utilization of the groundwater basins to their maximum potential for water storage and use. Thus they are a physical water resource in the region which the sociotechnical system has marginalized.

**Planning for Climate Variability and Change**

Climate change is often noted as a contributing driver of local water reliance efforts in LA, but precipitation in Los Angeles is already highly variable. In a given year, LA receives a handful of storms, often via large events driven by atmospheric rivers that inundate the Pacific Coast. This type of rainfall will likely grow in frequency and intensity in coming years (Dettinger et al. 2011; Warner et al. 2015; Gao et al. 2015). But climate change will also intensify drought in a region that already experiences seasonal and annual periods of extreme dryness (MacDonald 2007; Diffenbaugh et al. 2015; Allen and Liptowitz 2017). Studies indicate that the alpine sources of runoff in the Sierra Nevada that feed much of LA’s imported water will likely experience decreased snowpack accumulations in future years. This increases spring runoff volumes and, without additional surface storage or groundwater recharge, changes the timing and availability of imported water during the late summer and early fall months (Costa-Cabral et al. 2013).
Within the LA basin, increases in mean surface temperatures associated with climate change will affect hydrologic cycles and water supplies that support aquatic habitats, irrigated landscapes, and protected areas. In particular, more extreme rainfall events will require infrastructure capable of capturing larger storms to recharge groundwater basins to meet future water supply goals (USBR 2015; Purse et al. 2017). Aquatic habitats and marshlands will be affected by water conservation, imported water losses, and precipitation changes that reduce runoff (Read et al. 2018; Thorne et al. 2016; Manago and Hogue 2017), themselves artifacts of the current engineered system. Urban trees may suffer in future years without conversion of the tree canopy to low-water species (Fataki et al. 2011; Litvak et al. 2013, 2017a, 2017b; Vahmani and Ban-Weiss 2016).

Many of the adaptation actions for dealing with the effects of climate change align with research findings for enhancing local reliance. First, promoting continued outdoor water use conservation is key. Residential lawns constitute half of all urban water use throughout much of California, including LA (Hanak and Davis 2006; Mini et al. 2014b). Some parts of LA, notably coastal areas with high-density urban development and small yards, have much lower use, while other parts of LA, especially inland areas and affluent neighborhoods with sizable well-irrigated yards, use more (Mini et al. 2014a; Litvak et al. 2017a, p 20; Purse et al. 2017). Smarter investments in lawn replacement programs, driven by scientific knowledge and community engagement, are the best strategies for achieving long-term water savings and enhanced urban landscapes. Second, agencies must enhance supplies that are resilient to climate change. This includes increasing groundwater recharge and storage capacity for drought contingency, reducing reliance on distant imported sources, enhancing investments in alternative sources, and promoting capacity for timely use or storage of distant water during wet years.

Conclusions

Going forward, a closer understanding of the ways in which sociotechnical systems evolve to construct resource availability and/or scarcity and vulnerability in cities is called for (Pincetl et al. 2016a). The idea that Los Angeles or Cape Town face natural water shortages due to climate change, rather than those that result from how these systems are constructed and managed over time, preclude the possibility of change. California’s water systems, which are highly capital intensive, engineered, and technocratic, are similarly the products of expectations and rules constructed to support those systems and twentieth century modernist assumptions. Water was assumed to be plentiful, with the only obstacle being proper conveyance systems and management of the new engineered infrastructure. With the impacts of a shifting climate that result also from human decisions, we cannot afford to simply accept the conditions of those systems and must tackle unlocking them—rules, regulations, and pipes and pumps. They are coupled and self-reinforcing and work together.

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Conflict of Interest The authors declare that they have no conflict of interest.

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Water Distribution System Efficiency

An Essential or Neglected Part of the Water Conservation Strategy for Los Angeles County Water Retailers?

Prepared by
Dr. Kartiki S. Naik and Madelyn Glickfeld

UCLA Water Resources Group
Institute of the Environment and Sustainability
University of California Los Angeles

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Executive Summary

The water governance system in Los Angeles County is complex and fragmented. Potable water supply in metropolitan Los Angeles County relies on over 100 water retailers, both public and private. It is unclear how the current system with many small water retailers will succeed in promoting integrated water resource management. Among other changes, there will need to be a shifting of water supply sources from predominantly imported to more local resources through conservation, recycled water usage, stormwater capture and groundwater management. The institutional capacity of water retailers to instigate this transition will depend heavily on their capacity to maintain reliable water deliveries without significant losses from leakage and failing infrastructure. Additionally, with drought conditions prevalent in eleven of the last fourteen years in California, and increasing evidence of climate change impacts on all water resources in California, it is crucial that water retailers minimize water losses through their distribution systems to match the increasingly stringent conservation efforts required of their customers, and to efficiently utilize scarce supplies.

Until this year, existing regulations for water agencies in California only requested information about system losses for potable water systems with more than 3000 connections. These numbers were reported through Urban Water Management Plans every five years. However, loss estimates through breaks and leaks have not been separated out from other non-revenue uses of water. To date, the most effective efforts to monitor water losses in California are voluntary and limited to members of the California Urban Water Conservation Council. To understand water distribution efficiency in urban Los Angeles County, we developed a questionnaire regarding leakage monitoring, system-wide water losses, and the implementation of pre-emptive best management practices. We surveyed 10 of the approximate total of 100 water retailers. The sample was representative of retailers of many types, sizes, and geographical locations in metropolitan Los Angeles and divided into tiers of size (small, mid-sized and large) based on the number of connections served. The survey questionnaire also addressed other metrics including per capita water consumption, leakage volumes, water loss estimation methodology, water loss estimates and infrastructure monitoring and replacement.
The survey indicated several findings. First, the percentage of water loss due to breaks and leaks, though possibly misrepresentative, is still a widely used metric to measure water losses. Sixty percent of the agencies sampled still monitor only 'unaccounted for water' and not 'real losses'. Retailers that do measure real losses reported them to be between 3-4% of total water supplied, which is an improbably low compared to international estimates as elaborated in the literature review section. Different water retailers were divided on the efficacy of leak detection technologies, which demands more education on available leak detection technology and their usage.

Larger retailers reported greater use of most of the best management practices addressed by our survey to maintain storage and distribution systems. Most small retailers did not report prioritizing adoption and implementation of best management practices to minimize water loss. Also, small Mutual Water Companies that we contacted did not have information on distribution water losses available publicly. To improve water efficiency, small retailers could pool resources and expertise to better detect, monitor and reduce distribution water losses. Investor-owned utilities and special water districts serve a large customer base, but as a group, they were least responsive of all the sample water retailers we contacted. In summary, California water regulations should aim at recommending crucial best management practices, ensuring accurate and verifiable water loss monitoring and prescribing an effective water loss metric and maximum acceptable standard as a roadmap for water retailers.
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Introduction

The largely varying precipitation and large population of Los Angeles County renders it dependent on imported water for majority of its water supply. The County of Los Angeles imports more than 60% of its water supply from three major sources, the Los Angeles Aqueduct supplied by the Eastern Sierra watershed, the Colorado River Aqueduct, and the California Aqueduct supplied by the Sacramento-San-Joaquin River Delta (Bay Delta). Groundwater forms 35% of the total water supply in the region (Los Angeles Department of Public Works, 2014).

Twelve of the last sixteen years have been drier than normal for California.¹ The Sierra snowpack has been reduced to a historically low 5% (California Department of Water Resources, 2015). For the Eastern Sierras, global climate models predicted a temperature rise of 2 to 5 °Celsius, leading to an increase in the mean fraction of precipitation falling as rain (Costa-Cabral, Roy, Maurer, Mills, & Chen, 2013). Recent work by Diffenbaugh (2014) finds that anthropogenic warming has increased the risk of severe drought in California. Such warming outweighs the increased soil-water availability due to early runoff during the cooler low evapotranspiration period (Diffenbaugh, Swain, & Touma, 2014). Global climate models have consistently predicted that runoff in the Colorado Watershed will reduce by 10-30% and have already translated as reduced storage levels in Lake Mead and Lake Powell (Barnett & Pierce, 2009). The Bay Delta is threatened by future rise in sea levels as predicted by climate models, which might lead to restrictions in water allocations to southern California via the State Water Project. Additionally, dramatic increases in “permanent” versus “annual crop” irrigated agriculture (United States Department of Agriculture, 2011), all have increased water demand, creating a potentially chronic water shortage across a state with widely variable precipitation.

Because of the drought emergency, California has quickly moved into a new era of water management. The Governor issued an executive order on April 1, 2015 that will require every water user, from farm to industry to urban users to cut back on water use (Governor of California, 2015). The State Water Board is preparing to issue emergency regulations for mandatory cutbacks averaging 25% to all urban water suppliers (State Water Resources Control Board, 2015). In response, the Metropolitan Water District of Southern California which serves region of 18 million people, passed a mandatory allocation reduction on April 14, 2015, averaging 15% to all of their member agencies, with heavy fines for excess delivery (Metropolitan Water District, April 2015).

While some of these drastic cuts will be reduced when the drought abates, major changes in water use will be expected and water suppliers will need to pay new attention to their distribution efficiency as well as customer conservation. Retail water systems in Southern California can lose a significant amount of water and thus, revenue through leaks and breaks in their distribution systems. Large main breaks can also cause severe property damage. For instance, in July 2014, the 93 year old main on Sunset Boulevard in Los Angeles not only lost

¹Personal Communication, William Patzert, Climatologist, NASA’s Jet Propulsion Laboratory
10 million gallons\(^2\) (2% of the daily use of 3.4 million customers in Los Angeles city), but also caused tremendous damage to university property and hundreds of parked vehicles at the University of California Los Angeles campus. Based on an assessment of over 11,000 miles of water mains, the deterioration in the potable water infrastructure is evident across Los Angeles County (American Society of Civil Engineers, 2012). As part of conservation efforts, water retailers need to monitor their distribution systems to manage them for efficiency.

The Environmental Protection Agency describes water efficiency as the “long term ethic of saving water resources through the use of water-saving technologies and practices” (United States Environmental Protection Agency, 2015). The state of a retail water distribution system determines the retailer’s efficiency in conveying it to their customers. The water distribution efficiency of a given water retailer can be evaluated by their competence in maintaining, operating and monitoring the storage and distribution system, and developing their financial resources to rehabilitate infrastructure. This capacity can be as significant a determinant in the retailers’ contribution to water conservation as consumer efforts are. The 2007 US Conference of Mayors assessed that revenues collected by city departments, account for about 80-90% of the capital required to replace their sewer and water infrastructure. This backlog combined with the financial implications of regular rehabilitation and maintenance of old infrastructure can lead to a high increase in monthly service charges to customers (Sedlak, 2014). Retailers should gauge their water distribution efficiency by measuring the loss of water during conveyance to their customers and take steps to reduce revenue losses via water leakages.

In this study, we investigated the water distribution efficiency of a sample of water retailers in metropolitan Los Angeles County. The study consists of reviewing prior research, developing a survey for water retailers, and analyzing results. Much work exists regarding water efficiency. To inform the interpretation of our survey results, we surveyed the literature on water efficiency and the development of best management practices related to losses from breaks and leaks, as well as practices to manage systems to minimize losses. The American Water Works Association releases a manual on best management practices to reduce water loss reduction. In this study we considered recommendations such as monitoring breaks, leak detection, infrastructure testing and replacement. In particular, we overview the existing reporting requirements for the State of California and voluntary reporting solicited by the California Urban Water Conservation Council.

The entire agglomeration of water retailer jurisdictions that we sampled from in urban Los Angeles County are shown in Figure 1. Thus, water service in urban Los Angeles County is highly fragmented and involves many small retailers (Cope & Pincetl, 2014; Cheng & Pincetl). We developed a stratified sample survey, including in depth interviews with approximately 10% (10 out of about 100) of the water retailers in urban Los Angeles County. We examined how they measure water losses from leakages or breakages in their systems, as well as technical expertise and financial investments to reduce leakage. We have considered leakages as subsurface water losses, whereas breaks are water losses above the ground surface. The survey was designed to obtain a balanced stratified sample. The stratified sample ensured

that the number of participants in each category based on size, type and geographic location of water retailers, was proportional to those in the corresponding categories of the population. The survey was designed to collect information on the estimation and reporting of typical water loss, existing infrastructure maintenance and replacement strategies and distribution system failures.

Figure 1 Study area and potable water retailers in metropolitan Los Angeles County (Deshazo & McCann, 2015)

Literature Review and Background

Emergence of Global Water Efficiency Standards and Practices

Water loss through distribution systems is a global issue. In 1987, the American Water Works Association (AWWA) addressed the issue of loss of revenue for agencies via water distribution leakages. Dr. L.P. Wallace and his students from Brigham Young University, overviewed techniques of monitoring and minimizing losses in an AWWA Research Foundation report (Wallace, 1987). In the early 1990s, AWWA released Water Audits and Leak Detection manuals after which it joined the International Water Association (IWA) Water Loss Task Force in 1996. AWWA released manuals of water supply practices in 1991, 1999, 2009 describing benefits of water balance audits, their water audit method and recommended measures for water loss control (Fanner, et al., 2007).

The IWA Water Loss Task Force (WLTF) was a small group of water utility professionals from around the globe which was formed in 1996, Allan Lambert from the United Kingdom was the Chair. The American Water Works Association (AWWA) was one of its members
from 1997 to 2000 (American Water Works Association, 2009). The goal of the WLTF was to create a common global framework for water loss performance indicators using common terminology and a standardized water balance equation. The IWA published Performance Indicators for Water Supply Service which described this global methodology developed by the IWA WLTF (Alegre, 2000).

The IWA methodology was based on the original Water Audits and Leak Detection Manual published by the AWWA in 1990 (American Water Works Association, 1990). The IWA WLTF published a series of 8 articles on a ‘Practical Approach’ for global best management practices in water loss assessment and reduction strategies in the Water21 magazine in through June 2003 to December 2004. In this second article, they separated various water loss components and proposed this as ‘best practice’ standard water balance as shown in Fig. 2. (Lambert A., 2003).

The IWA conducted surveys across many geographic regions to gather data from water retailers to develop a framework for determining water losses. The primary motivation for this study was to reduce losses in revenue from water losses. They compared water retailers across England, Wales, California, the Nordic countries, Japanese and German cities, Australia, Singapore and Malta in terms of water losses. The data from various nations was collected by the IWA Water Loss Task Force in the form of an International Dataset and was presented in

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2 Denmark, Norway, Sweden, Iceland, Finland

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their report from 2001 (Lambert A. O., Water Losses Management and Techniques, 2001). They discouraged using the term “unaccounted for water” to designate losses from a distribution system due to its varying interpretations globally. They discussed that real losses represented as percentage can be ambiguous. They observed that an equivalent real loss volume expressed as percent appears higher for regions with lower water consumption per connection. The percent water loss reported was about 15% for Australia and 6% for California, which may be heavily skewed by the difference in their daily water consumption per connection. Lambert (2002) summarized the motivation behind this study, resulting conclusions and recommendations by the IWA Task Force.


Many global efforts exist regarding improved water auditing technology. McKenzie et al (2005) overviewed standard water audit software in South Africa, Australia and New Zealand and the methodology. Soon, after its joint efforts with the IWA, AWWA Water Loss Committee Control launched a free Water Audit Software in 2006 followed by several updated versions. The latest version available now is version 5 released in 2014. The software uses a top-down approach to calculate the real losses, that is, the actual leakage from the system—what is left after all other losses are accounted for (American Water Works Association, 2009). Real losses are defined as the volume lost “the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering” (Lambert A., 2003). The AWWA Water Audit Software can be a good indicator of water distribution system losses if used accurately. The model used in the software includes certain assumptions for the user, such as, an ability to extricate different kinds of authorized and unauthorized usage from the supply volume and a high confidence level in reporting unmetered usage. The end product grades the water distribution system with the corresponding Infrastructure Leakage Index value, which represents the condition of the distribution system as compared to a system in “perfect” condition (American Water Works Association, 2009).

The software lists recommendations for overall and immediate measures to improve the system’s condition and reduce water losses based on the “Infrastructure Leakage Index” which is a “grade” that the system receives based on its water losses and efforts such as efficiency of repairs, leakage control and upgrades calculated in the AWWA Water Audit. This methodology then formed the backbone of many water audit software packages globally. Fantozzi et al. (2006) discussed the common approach for leak detection and control efforts in North America, Canada, Australia and Europe. The observations in this study were based on the authors’ experience in these regions.

The AWWA released a report in 2007 to provide guidelines on how to use appropriate performance indicators for losses, conduct a water audit, determine leakage and formulate and execute loss reduction programs (Fanner, et al., 2007). The IWA WLTF has now evolved into the Water Loss Specialist Group, a consulting firm offering software and other tools aims at reducing water losses from urban water systems.
Studies on Infrastructure Rehabilitation Strategies

Simultaneously, several studies focused on the cost-effectiveness of infrastructure replacement and influential factors. Colombo and Karney (2002) determined the economic consequences of leakages in a system and deduced that energy costs increase with increasing leakage volumes. Southern California Edison conducted a study to determine water and energy savings through leak detection and repairs for three utilities and demonstrated the economic significance of minimizing water losses. They used the AWWA methodology for water auditing and field leakage measurement to obtain data on water losses. The engineering consulting organization implementing the study, selected suitable cost-effective leakage intervention tools for each water utility, while an independent team evaluated the water and energy savings. These intervention tools were based on the guidelines to calculate the 'Economic Level of Leakage', provided by this consulting organization and Alliance for Water Efficiency (Sturm, Gasner, Wilson, Preston, & Dickinson, 2014). They estimated cumulative water savings of 83 million gallons per year (255 acre-feet per year) and cumulative energy savings of about 500 Mega Watt-hours per year for the three utilities via this leak detection study. Engelhardt et al. (2000) discussed physical causes for deterioration of pipes, such as soil and water corrosivity, traffic loading and high alkalinity in pipe material in the United Kingdom. They described the regulatory process for the privatized water industry in the U.K., which consists of an external agency that regulates the economic and water supply performance. They reviewed distribution system rehabilitation decision models adopted in the U.K.

Several studies proposed optimization models for strategizing rehabilitation. Dandy and Engelhardt (2001) proposed using the Genetic Algorithm to optimally schedule replacement of water mains in a distribution system. They optimized with respect to available funds and applied it to a pressure zone in metropolitan Adelaide in Australia. Nafi and Kleiner (2010) used the Genetic Algorithm to optimize for economies of scale and road improvements and applied it to a community in Ontario, Canada as an example. Dandy and Engelhardt (2006) followed up their study in 2001 by suggesting a multi-objective genetic algorithm approach for constraints such as replacement and repair cost and reliability (lack of interruptions). Bogardi and Fulop (2012) used a space-time probabilistic model to minimize cost and pressure drops in the distribution system. Roshani and Filion (2014) optimized the timing of water main rehabilitation and replacement using a sorting genetic algorithm. Li et al. (2015) developed a decision-making algorithm based on a sorting genetic algorithm for pipeline replacement minimizing cost and service interruptions.

Global Evaluation of Water Distribution Efficiency

The U.S. Environmental Protection Agency and the Water Research Foundation jointly funded a study by an engineering consulting firm, Water Loss Optimization to review of water loss reporting guidelines for state agencies, and organizations in Austria, New Zealand and Australia. The study also reviewed guidelines and standards for nine North American state agencies and organizations (including California). According to the review, Austria and

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Australia achieved very low levels of real losses in their distribution systems. They also reviewed literature for frequency of breaks in the system and observed large variance in the collected data. The study found a weighted average annual frequency for main breaks in North America of 25 failures for every 100 miles of pipeline. Nine North American utilities participated in this study to demonstrate the use of AWWA’s Component Analysis Tools. For California, the understanding of the usage of the tool and the quality of collected data was less than satisfactory. About 35% of the water audits from member water agencies of the CUWCC shows implausible results, out of which 28% of the utilities claimed that their distribution system was in better condition than the ‘theoretically perfect condition’ prescribed by the water audit. (Sturm, Gasner, Wilson, Preston, & Dickinson, 2014).

National Water Efficiency Standards and Regulations

Beecher obtained information on water loss policies for forty-three states in the U.S.A. addressing the existence of policies, terminology defining water loss, monitoring methodology, targeted maximum losses, planning and technical assistance, data collection and performance incentives. From the seventeen jurisdictions defining “unaccounted for” water, only three state agencies provided a method of calculating it. Twenty-three states and three regional authorities reported the use of a standard for water losses which varied from 7.5-20%; most commonly 15%. Only fifteen state agencies required some form of auditing to enforce standards. (Beecher, 2002).

Recommendations regarding water loss targets are scarce. The only target or recommendation for maximum water losses found in literature dates back to an article published by AWWA in 1957 (American Water Works Association, 1957). It noted that the water losses from well-maintained systems with a consumption of 100-125 gallons per capita per day (GPCD) can vary from 10-15% (Liston, et al., 1996). AWWA later refuted this value in their committee report in 1996, deeming the loss value obsolete due to significant changes in operating costs and technological resources. The average losses from a system depend on system age, size, material and population density, which calls for a more customized cost-benefit analysis (Alegre, 2000). We observed in our interviews of water retailers in urban Los Angeles County, that this standard has been followed by most of these retailers who practice leakage monitoring and use the AWWA software. According to Beecher’s survey in 2002, the California Urban Water Conservation Council (CUWCC) mandates that the member agency conduct the complete Water Audit if their unaccounted for water exceeds 10% of the total volume supplied. (Beecher, 2002).

In 2002, US EPA completed seventeen case studies of water conservation and efficiency by urban water utilities across the country, and in Canada (United States Environmental Protection Agency, 2002). Of those seventeen case studies, leak detection and repair is named as a key strategy in six locations: Ashland, Oregon; Gallitzin, Pennsylvania; Houston, Texas; the Massachusetts Water Resources Authority; New York City and Seattle, Washington. 46% of the utilities studied outside California reported leak detection and repair as a major strategy, while none of the five utilities studied in California had this focus.
In 2012, The Alliance for Water Efficiency\(^6\) conducted a survey of all states to collect information on State regulations for water efficiency and conservation. While the study mostly targeted conservation policies, one of the twenty questions asked if “the state has regulations or policies for water utilities regarding water loss in the utility distribution system” (Alliance for Water Efficiency, 2012). They concluded that though most states have regulations for monitoring utility distribution water loss, some states do not rely on state-of-the-art methodologies for water auditing, whereas others lack in legal foundation for their requirements. For California, the Department of Water Resources is the agency authorized to require water retailers to submit distribution water loss estimates.

**Existing Measures for Water Loss Monitoring in California**

The California Department of Water Resources (DWR) released a workbook in 1986, which contained a manual and a guidance tool for estimating the value of the leak volume\(^7\). The latest version of the Workbook was released in 2002. The overall goal of this project was to prepare a comprehensive guidance document which can be used by water utilities to: (1) ensure accurate measuring of supplied water and meter and billing accuracy, (2) prepare an accurate water audit (and water balance), (3) evaluate the economic implications of leakage, plan and (4) suggest water loss-reduction programs (Fanner et al., 2007). This guidebook is different from the new AWWA Water Audit, as the main focus of the Workbook is to guide the utility in accurately estimating the total water supplied subject to meter and billing inaccuracies. The Guidebook does not specify methods to estimate all these values, but suggests general measures to correct leak issues. It also overviews leak detection techniques.

Since 1990, DWR has collected Urban Water Management Plans (UWMP) from Urban Water Suppliers every five years. Urban water suppliers are defined by the most recent amendment of the Urban Water Management Act\(^8\) as “a supplier, either privately or publicly owned, providing water for municipal purposes either directly or indirectly to more than 3000 customers or supplying more than 3000 acre-feet of water annually”. The aim of the UWMP is to help urban water suppliers plan for a 20 year horizon of water supply and include a reliability study for existing and planned water sources for normal, dry, multiple dry years.

The Water Act of 2009 adds deliverables such as a map of the water supply area, methods for estimating conservation targets and baseline water usage, population estimation methods and sources, metered or measured flows, groundwater management plans, description of the groundwater basins and an report on the location, amount and sufficiency of the groundwater pumped by the supplier in the past five years and a schedule of implementation for water management measures. To comply with the Water Act of 2009, agencies included plans to decrease per capita water usage by 20% by 2020 in the 2010 UWMPs. DWR assesses these plans based on the Urban Water Management Planning Act.

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\(^6\) Alliance for Water Efficiency. [http://www.allianceforwaterefficiency.org/](http://www.allianceforwaterefficiency.org/), a nonprofit organization focused on the efficient and sustainable use of water


\(^8\) California Water Code Division 6. Part 2. Section 10610-1/0610.4
Up to this year, the Water Code required reporting “system losses” in the UWMP. The term system losses has not been defined, except as the general loss of water through any method from the supplier’s distribution system. In California and elsewhere, water losses from potable distribution systems are primarily being measured by many utilities as “unaccounted for water”, which represents the deficit between the purchased and metered supplied water volumes. This term encompasses various types of water losses in addition to actual leakages, such as demand for fire-fighting water, fire training, routine testing and maintenance of fire hydrants, street cleaning or municipal parks, billing errors, meter errors and water theft. Losses from storage leaks, pipe leaks and breaks have been hard to isolate with current approaches.

The Water Act of 2009 required an Independent Technical Panel (ITP) to advise the DWR on new demand management measures, technologies and approaches to improve water use efficiency every five years after 2010 (Senate Bill AB 1420, California Water Code 10631.7). The DWR convened the ITP in May 2013. The ITP recommended reporting of distribution water loss by urban water suppliers supported by water loss audits based on past ten years as part of the UWMPs. They also recommended a standardized reporting system for the UWMPs (Independent Technical Panel, 2014).

This recommendation became law this year. SB 1420 (Wolk) was effective on January 1, 2015, requiring that all water retailers submitting 2015 Urban Water Management Plans use the American Water Works Association Water Audit Methodology (AWWA) to specifically report on pipe leaks and breaks. This methodology and the method of interpreting its results and estimates are described in the AWWA M36 Manual with their recommended Best Management Practices. SB 555 (Wolk) was introduced in February 2015 and then amended in April 2015 for water loss management. This bill would require each urban water supplier to submit completed water audit reports based on the AWWA water audit methodology and provide information on measures adopted toward water loss reduction. These reports would need to be validated and posted on their website for public viewing and comparison. It would also require the DWR to provide technical assistance for water loss detection programs conducted by urban water suppliers. The DWR would also require to develop rules for performance standards, validation process and metrics for the reporting of annual water loss reduction by urban water suppliers with the State Water Resources Board. After 2015, water loss from leaks and breaks would have to be reported on for each year and included in the next five year update.

California Urban Water Conservation Council: An Independent Approach

The California Urban Water Conservation Council (CUWCC) is a membership organization of water retailers and suppliers that has developed Best Management Practices for water usage efficiency. The CUWCC has three groups of members, water suppliers, businesses and public advocacy organizations. Water retailers that are members are required to report their Best Management Practices (BMPs) for water conservation and loss with AWWA water audits every two years. Reclamation Contractors or members of Bureau of Reclamation are required

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9 Ch. 490, California Water Code, amending Sections 106331 and 10644
10 Ch. 450, California Water Code, amending Section 10608 34
to submit these BMPs annually\(^\text{11}\). California’s Urban Water Management Plan (UWMP) Act allows urban water suppliers that are CUWCC members and that comply with CUWCC’s BMPs can submit audits in addition to the Demand Management Measures suggested by the DWR.

Member water retailers include an assessment of real (leaks and breaks) and “apparent” losses and the economic value of real loss value of real loss recovery in terms of avoided cost of water. The CUWCC adopted the AWWA Water Audit Software based the AWWA/IWA methodology and requires members to use it for their analysis. The estimated losses require data validation by methods recommended by the AWWA methodology. The CUWCC also requires a Component Analysis every four years which analyzes the estimated losses and their causes\(^\text{12}\).

These BMPs were formulated using the 10% maximum standard for unaccounted for water recommended by the AWWA Leak Detection and Water Accountability Committee (Dickinson, 2005). The above mentioned full-scale water audit is mandated by the CUWCC for the member utilities, provided the deficit or unaccounted for water exceeds 10% of the total distributed volume. The conditionality of the full-scale audit is not stated on the CUWCC website, but it is stated in the original BMP Retail Coverage Report input sheets used by the member utilities\(^\text{13}\). The full scale audit using the AWWA audit methodology would provide clear leak and break loss estimates.

To summarize, the most advanced efforts toward water loss reduction in California are voluntary (by CUWCC members). Water auditing relies on the method of data collection and accuracy in reporting and water retailers are not required to report on other best management practices to reduce water loss from their distribution system. There are no regulatory standards for maximum allowance of water loss and high quality data to create a benchmark.

**Survey of Real Water Losses for Water Retailers in Urban Los Angeles County**

Current regulatory and reporting standards in California raised certain issues on their effectiveness which are described as follows.

1. Are real water losses measured by water retailers, and if so, are these verifiable?
2. Are crucial Best Management Practices followed by water retailers to minimize water losses?
3. How regularly do water retailers monitor and maintain their distribution system for water loss reduction?

\(^\text{13}\) The Long Beach Department of Water BMP Coverage Report (2009-2010)
http://www.water.ca.gov/urbanwaternagement/2010uwmp.Long%20Beach%20Water%20Department/Attachment_K.pdf
4. How publicly accessible are data and measurements of water losses from a distribution system made by the water retailer?
5. How do water retailers of different sizes and types compare in addressing the above issues?
6. What is a reliable and accurate metric for real water losses for a water retailer irrespective of its size and type that can be validated via available data?
7. Do California's legal and regulatory requirements under the Urban Water Management Act ensure accuracy in reporting and accomplish real water loss reduction?

Improving water distribution efficiency relies on aspects such as an effective water loss metric and standard, accuracy and frequency of monitoring and reporting, and data quality. The currently available literature, and collected data from the CUWCC and DWR were not sufficient to address these issues. We conducted this survey aiming to answer these questions and provide a snapshot of the current practices in urban Los Angeles County.

Methodology

Study area and Sample set

The Urban Los Angeles Region includes all areas south and west of the Angeles National Forest in Los Angeles County, as shown in Figure 1. It includes approximately 100 retail water systems (serving water to customers) with between 15 and approximately 680,000 connections\(^\text{14}\) (Cope & Pincetl, 2014; Cheng & Pincetl). Many types of water retailers exist in the county, including city water departments and city water utilities, county water districts, county waterworks districts, municipal water districts, irrigation districts, nonprofit mutual water companies and private independently owned water utilities (IOU). Each has its own authorizing legislation, state oversight, governance, and customer accountability. Within the study area, water retailers include 41 Cities, 26 Mutual Water Companies, 10 County Water Districts, 8 Investor Owned Utilities, 3 Irrigation Districts, 3 County Waterworks District, 1 Municipal Water District (uniquely, also retailers), and 1 California Water District (Cope & Pincetl, 2014; Cheng & Pincetl). We based our sample selection on this population of retailers and the geospatial database cited above.

The number of connections that each retailer serves in this population follows a Gaussian distribution in the logarithmic form. The population has a large number of smaller retailers in our study area, and a portion of them are not urban water suppliers (serving more than 3000 users), and thus, are not required to submit UWMPs. We used percentile ranking to bin the population into three size-based categories depending on the number of service connections: Retailers ranking below 50 percentile in size as small, between 50 and 75 percentile as mid-sized, and above 75 percentile as large retailers.

To represent the population of water retailers accurately, we developed a stratified sample set based on type, size and location of the retailers. We considered a sample size of 10 retailers, that is, 10% of the statistical population for our analysis. We offered the choice of anonymity

\(^\text{14}\) We were not able to contact water retailers which served under 200 connections.
and confidentiality to the participating agencies. We only report results and not names to protect confidentiality of survey respondents. To accommodate and correctly represent all types of retailers, we did not include the type 'California Water District', as there exists only one such retailer in our study area. We represented Irrigation Districts, County Waterworks District and Municipal Water Districts as 'Special Districts' (SD) to maintain anonymity.

We contacted 20 retailers and received responses from 10, indicating a 50% response rate. When water retailers decided to not participate in the study, we substituted with other similar retailers to maintain the unbiased distribution in size, location and type. We contacted three mid-sized retailers, while sustaining our requirement for different types and locations of retailers, but did not receive a response from these mid-sized retailers. Hence our analysis will reflect performance of small and large retailers only. We had a low response rate from Special Districts, hence the low representation. Figure 3 shows the final sample set after the replacements. The two tables on the bottom-left show the categorization in our sample. The percentages in the parentheses are the percent representation of such retailers from the entire population in our sample. The pool of participants was dependent on the will for participation and legal binding of the water retailers that we contacted.

![Final sample set for study](image)

**Data Collection and Analysis**

We conducted reconnaissance interviews with the local water system experts who manage, work with or oversee water retailers to better understand how to develop the interview instrument. Through literature research and these preliminary interviews, we determined that performance of retailers is dependent on monitoring of their distribution system and planning of investments in infrastructure maintenance and replacement. We hypothesized that the institutional capacity and competency of a water retailer can be indicated by their ability to management its water distribution system efficiently, without excessive loss of water due to
leaks and breaks and other system defects. We also concluded that maintaining public data is necessary for each retailer to develop an effective strategy for water distribution efficiency improvement. Based on these conclusions, we formulated a set of interview questions to collect data from water retailers in our sample. The interview questions are presented in Appendix A.

We evaluated the retailers' responses using the following criteria and allotted performance indices to each sample retailer:

Table 1 Performance indices allotted for Best Management Practices for water distribution

<table>
<thead>
<tr>
<th>Best Management Practices</th>
<th>Indices allotted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor GPCD</td>
<td>1</td>
</tr>
<tr>
<td>Awareness and regularity of usage of AWWA Water Audit Methodology</td>
<td>3</td>
</tr>
<tr>
<td>Existing or future programs for smart meters</td>
<td>1</td>
</tr>
<tr>
<td>Preventive maintenance (exercising of valves and flow testing of meters)</td>
<td>2</td>
</tr>
<tr>
<td>Infrastructure replacement (for pipes, valves and meters)</td>
<td>3</td>
</tr>
<tr>
<td>Monitoring of annual number and location of pipe breaks and implementation of leak detection programs</td>
<td>2</td>
</tr>
<tr>
<td>Monitoring of age and material usage on GIS</td>
<td>1</td>
</tr>
</tbody>
</table>

We also assessed the participating water retailers based on their own target parameters. In addition to prescribing any of above measures, their proposed and achieved targets reflect their efficiency in water distribution. We also conducted a statistical t-test between each type and size of retailer with the rest of the sample.

- Water losses
  - Annual Real Losses in volume or percent i.e., true losses or leakages from transmission and distribution mains, leakage and overflows at utility storage tanks up to customer meters
  - Annual Unaccounted for water in volume or percent
- Percent of distribution pipeline replaced annually
- Number of main breaks for every ten miles of distribution pipeline

During data collection, we asked participating retailers for information that would verify the data, such as reports, monitoring charts and urban water management plans. We awarded points to retailers that provided us with documentation that verified the data. The documentation was either directly provided by the retailer or obtained from the website, urban water management plan, or water master plan. We also examined the accessibility of information through responses to the interview and follow-up questions and available or provided documentation and awarded the retailers points.

Since some respondents did not respond to all of the questions, we followed up with the individual respondents via, email and phone. In case of a lack of response from a retailer after several attempts, we were compelled to remove that retailer from the sample for this particular analysis of overall performance. Owing to this process we could assess the overall performance for 8 water retailers.
Results and Discussion

The survey results yielded findings regarding the responsiveness of different types of entities to participate in the survey public availability of data on distribution system water loss, infrastructure replacement standards, adoption of best management practices and water loss estimates and metrics. All the following results and discussion are based on our sample of water retailers. Any reference to entire population is included explicitly.

Responsiveness and Public Water Losses Reporting

To determine the transparency, accessibility and verifiability of various types and sizes of retailers, we assessed the retailers that we contacted, including the ones not participating, based on their responsiveness to the interview and follow-up questions. Figure 4 depicts the accessibility of these 20 water retailers that we contacted to researchers or citizens seeking information, without the use of the Right to Information Act.

There significant differences in the willingness of retailers to respond to survey request as shown in Figure 4. Three large IOUs that we contacted refused to participate in the study declared legal issues. Together, these IOUs serve a large number of consumers in Los Angeles County, but out of the 6 we contacted, only 2 participated in the survey. It was also very difficult to verify the information that large IOU A (from our sample) provided due to lack of responsiveness to follow-up questions. On the contrary, Large IOU B (from our sample) was very responsive and was transparent about its methods of monitoring breaks, impediments and current infrastructure status, and has also formulated its own water audit tool to determine real losses. Overall, IOUs as a group were not responsive to requests for information.

Large retailers serving cities were very responsive and provided documentation to verify their data. Small City B provided incomplete information and showed a lack of responsiveness to follow-up questions. Small City B also discussed several economic issues and political hurdles with respect to infrastructure maintenance and replacement. Another small city did not respond to our several requests for participation.
The MWCs were responsive to attempts of contacting them, but could not provide validating documentation to verify information. Small MWC A could not provide us with complete data and small MWC B could not verify the data they provided on the number of main breaks, reflecting their poor monitoring practices. Thus, though two out of the three MWCs were responsive in this study, due to lack of verifiability, it was difficult to rely on the data that all three MWCs provided. The Large SD (from our sample) was very responsive and provided verifiable information promptly. Other smaller retailers that we contacted included two special districts, an MWC and a City which were not responsive to our request of interview. Overall, we had a 50% success rate in obtaining information from the retailers we contacted, not including the ones unresponsive to follow-up questions.

**Infrastructure Replacement Schedule**

Most of the participating retailers allocate annual budget funds for replacing a fixed number of miles of distribution pipeline. In our sample set, six out of ten retailers allotted some budget for the same, whereas the other four replaced their distribution pipeline 'as needed'. Figure 4 shows the number of years it will take to replace the entire distribution pipeline based on their current targeted rate of pipe replacement for 2013.

![Figure 4: Infrastructure Replacement Schedule](image)

**Figure 5: Number of years to replace distribution system for participating retailers**

The timelines for replacing current systems are long. Four out of six retailers that replace a fixed number of miles every year will take about 190-330 years to replace their entire distribution pipeline. The typical life in years of the pipes used in their systems was reported to be 100-120 years. For very highly maintained pipes using state-of-the-art materials (e.g. ductile iron), they report the maximum lifespan to about 140 years. Only two participating retailers successfully replacing their pipelines by estimated pipe lifespan. With reliance on pipes potentially beyond their usage life, the water distribution system in urban Los Angeles is
susceptible to further pipe failures with tremendous amounts of water loss and significant property damage.

Figure 5 shows the number of breaks for all 10 water retailers. We normalized the number of main breaks for each sample water retailer by the water distribution length of the system, which makes them comparable. Factors such as age of pipes and storage facilities, the pipe materials and construction quality, the valves, meter accuracy, soil acidity, high operational pressure and variation due to undulating topography or acute diurnal variation can strain distribution system components. According to some water suppliers from the study sample, the longevity of distribution system components is also determined by overlying traffic density.

Small MWC A and small MWC C claimed to have zero and one break in the entire year of 2013. The other small retailers had 22-26 main breaks every 100 miles of pipeline, which is high compared to large retailers had 3-16 main breaks every 100 miles. Sturm et al. (2014) estimated the weighted average of failure frequency in main and distribution lines for North American water utilities from previous literature as 24.68 failures every 100 miles per year. The estimates by our sample water retailers are lower than the national average as these do not include sub-surface leaks.

Age of pipes and storage facilities, the pipe materials and construction quality, the valves, meter accuracy and pumps all matter, Soil types also affect system efficiency, as corrosive soils reduce pipe life. High operational pressure and variation in hillside areas can further strain distribution system components. According to some water suppliers from the study sample, the longevity of distribution system components is also determined by overlying traffic density.
Small MWC A and small MWC C claimed to have zero and one break in the entire year of 2013. The other small retailers had 2-3 main breaks every 10 miles of pipeline, whereas large retailers had 0.3-1.1 main breaks every 10 miles. The largest retailer had higher number of breaks.

We asked the sample water retailers for their estimates of real water losses. Table 1 shows water loss estimates and the verifiability of these estimates. Only four out of the ten sample water retailers estimated real losses for their distribution system. All the retailers that measured real losses were large. These retailers reported having 3-4% of real water losses, which are improbably low as compared to estimates all over the nation (United States Environmental Protection Agency, 2010). The rest still use the metric of 'unaccounted for water' to assess their distribution system efficiency. The nation-wide average estimate for “unaccounted for” water for Israel was 10-12% in 2011 (Planning Department of the Israeli Water Authority, 2011). The national average for Australian water utilities with more than 100,000 connections is 18 gallons per connection per day in 2011. (Real Loss Component Analysis: A Tool for Economic Water Loss Control, 2014).

**Table 2 Estimates for water losses by sample water retailers**

<table>
<thead>
<tr>
<th>Sample Retailer</th>
<th>Real Losses (%)</th>
<th>Unaccounted for water (%)</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large City C</td>
<td>Not measured</td>
<td>2.8 % (18.1 gal/connection/day)</td>
<td>No</td>
</tr>
<tr>
<td>Large City B</td>
<td>3.4 % (19.9 gal/connection/day)</td>
<td>4.5 %</td>
<td>Yes</td>
</tr>
<tr>
<td>Large City A</td>
<td>4.1 % (31 gal/connection/day)</td>
<td>Measures real loss</td>
<td>Yes</td>
</tr>
<tr>
<td>Small MWC A</td>
<td>Not measured</td>
<td>3 % (16.7 gal/connection/day)</td>
<td>No</td>
</tr>
<tr>
<td>Small MWC B</td>
<td>Not measured</td>
<td>11.35 % (67.4 gal/connection/day)</td>
<td>No</td>
</tr>
<tr>
<td>Large SD</td>
<td>4 % (40.5 gal/connection/day)</td>
<td>Measures real loss</td>
<td>Yes</td>
</tr>
<tr>
<td>Large IOU A</td>
<td>No response</td>
<td>1 % (5.6 gal/connection/day)</td>
<td>No</td>
</tr>
<tr>
<td>Small City B</td>
<td>No response</td>
<td>6.5 % (32.3 gal/connection/day)</td>
<td>No</td>
</tr>
<tr>
<td>Large IOU B</td>
<td>4.02 % (11.6 gal/connection/day)</td>
<td>Measures real loss</td>
<td>Yes</td>
</tr>
<tr>
<td>Small MWC C</td>
<td>No Response</td>
<td>No Response</td>
<td>No</td>
</tr>
<tr>
<td>Responders</td>
<td>7 out of 10</td>
<td>9 out of 10</td>
<td>4 out of 10</td>
</tr>
</tbody>
</table>

*Overall Performance - Best Management Practices*
We used survey results to develop an index of performance based on the criteria described in the Methodology section: monitoring per capita water consumption, awareness and usage of the AWWA water audit tool or equivalent analysis, usage of smart meters, infrastructure testing and replacement, leak and break detection and monitoring, age and material of infrastructure on Geographic Information Systems.

Figure 6 summarizes the performance of different types of retailers from our sample set in these categories.

![Figure 6](image)

Figure 7 Scoring of participating retailer with respect to best management practices followed

Large cities in our sample reported adhering to most of the best management practices, but their targeted pipe replacement is low. Small city B lags in these practices and also had a high number of main breaks in 2013. The IOUs were almost at par with the cities in implementing these Best Management Practices. The California Public Utilities Commission requires IOUs that are Class A utilities\(^{15}\) to conduct and submit the results of a water loss audit in their General Rate Case applications (CPUC, 2006). The IOU respondents conducted water audits as they are members of the CUWCC but did not share information about this CPUC rulemaking. The MWCs had a low performance in preventive maintenance, awareness and usage of the AWWA Water Audit and infrastructure replacement. The performance score for the sample increases as the number of service connections increases.

Table 3 T-test results for performance based on size and type

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall performance</td>
<td>Large retailers</td>
<td>MWCs</td>
</tr>
<tr>
<td>(high, (p=0.0034))</td>
<td>(low, (p=0.0035))</td>
<td></td>
</tr>
</tbody>
</table>

\(^{15}\) Utilities serving 10,000 customers or more
Statistical analysis indicates that the large retailers had a significantly higher overall performance with respect to following best management practices (p=0.0034). The MWCs had a lower overall performance than the rest of the sample (p=0.0035). It is difficult to isolate the performance by type in this reduced sample, as there were not sufficient number of MWCs with complete information and monitoring. The t-tests were conducted with a significance of 5%.

**Monitoring and Quantifying Real Water Loss**

The AWWA M36 Manual (American Water Works Association, 2009) calculates that underground leakages, which are usually undetected, can lose more water than surface main breaks if not repaired over a period of several days. Leak detection to locate small underground leaks is necessary to reduce continuous, undetected water losses. Yet, only 4 out of the 10 water retailers in our sample invest in installing or leasing leak detection technology. Moreover, one city commented that small leaks do not lose as much water as large main breaks. Based on our interviews, water retailers in our sample who cannot afford to buy leak detection equipment find it more suitable to lease basic equipment (of high quality), which provide an accurate location of the underground leak within a few feet.

**Recommendations and Discussion**

Out of the 10 in our sample, 6 water retailers still used the term 'unaccounted for water', which is now an obsolete term to quantify water losses as it lumps real losses together with other non-revenue water. Only 3 out of 10 regularly use the AWWA Water Audit to determine real losses. They cited several reasons for their inability to estimate real losses: (1) Monitoring consumption over uncoordinated billing cycles among their connections (2) Lack of metering for non-revenue water uses (for instance, parks and fire hydrants) (3) Difficulty in tracking water volumes in interconnected networks with other retailers. One solution for estimating non-revenue water is to install meters at locations using non-revenue or unbilled water and avoid under-reporting.  

The AWWA Water Audit relies heavily on self-reported data, which is subject to non-standardized data collection, especially for non-revenue water volumes. For example, in 2014, 35% of the audits submitted to the CUWCC were invalid, whereas in our survey, two small MWCs reported to have had zero and one main break in year of 2013 in their distribution system. Mandating submission of the completed AWWA Water Audit without verification of data may provide us with underestimated water loss values, thus pre-empting any vigorous attempts to improve water infrastructure in Los Angeles. For effective auditing and distribution efficiency, it is practical to verify the submitted data of randomly selected water suppliers with monitored data records, similar to the functioning of the CUWCC or the privatized water industry of the United Kingdom (Engelhardt, Skipworth, Savic, Saul, & Walters, 2000).

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**Personal communication. Mary Ann Dickinson**
Further, in the current CUWCC procedures, the detailed AWWA Water Audit is not required if the non-revenue water is less than 10% of the total supplied volume based on a preliminary audit. Since this is an obsolete recommendation, we suggest and prescribing realistic maximum water loss standards for retailers. Post Senate Bill 555, the data collected from valid water audits should be used to develop a benchmark for the average real water losses across California. This database can also be used to recommend a more realistic maximum real water loss standard. All the sample retailers measured real losses as a percent of total supply. For large retailers, expressing water loss as a percent of the total volume supplied can mask the actual volume of water lost. While comparing a large and small retailer, a similar percent water loss for a larger retailer implies a large volume of loss, as shown in Table 2. Measuring the losses in volume units, such as 'gallons per connection per day' is a more representative measure, especially for a stringent conservation framework as California's.

Auditing water losses, while an improvement on current practices of many retailers, is not a complete solution to planning systematic allocation of resources for different parts of the distribution system. It is equally important to strategize infrastructure replacement based on these independent factors affecting the distribution system. The occurrence of a leak or break can be caused by the age of pipeline or peripheral infrastructure such as valves and meters, wear and tear due to traffic and pressure and flow variation at that location. We suggest developing a compendium of the best management practices to reduce water losses that pertain to various deficiencies in distribution systems from which water retailers can adopt measures crucial to their system.

The AWWA M36 Manual (American Water Works Association, 2009) estimates that undetected subsurface leakages can lose more water than surface main breaks if not repaired over a period of several days. Leak detection technology is necessary to reduce continuous, undetected water losses. Yet, only 4 out of the 10 of our sample water retailers invest in installing or leasing leak detection technology. The sample water retailers were divided on the validity of leak detection equipment. In case of restricted budgets, small retailers could pool resources to buy leak detection equipment, and set up a regular schedule based on the size of the distribution system. Leak detection needs to be an ongoing process with water auditing. subject to the cost-effectiveness of repairing specific leakages, to obtain returns in revenue on the water saved.

Last, water retailers with less than 3000 connections are now exempt from submitting an urban water management plan to the state, which is now the reporting vehicle for real water loss. Similarly, the PUC exempts IOUs under 3000 connections from their water loss analysis. However, in large urban areas, there are many small retailers and many small irrigation districts that now serve water, as do mutual water companies and small IOUs. In fact, in Los Angeles County, over 46,000 connections are served by retailers with less than 3000 connections. Currently, these retailers are exempt from the requirements imposed on larger systems, including reporting on losses from leakage and breaks. The state needs to think about how retailers who cumulatively serve a large number of customers in an urban area can pool

\[17\text{ Personal Communication. Reinhard Sturm}\]
resources and receive technical assistance to do water audits, and to use best management practices to replace old pipe, clean and repair inaccurate meters and monitor breaks and leaks, thus reducing real water losses.

Conclusions

To support intensifying conservation requirements in California, minimizing water losses from infrastructure is crucial. Some recent and upcoming legislation in California is looking to prioritize this issue. For instance, state Senate Bill 1420 mandating the use of the AWWA Water Audit aims to reduce water losses from infrastructure. After interviewing several types and sizes of water retailers distributed across various geographical locations in urban Los Angeles, we conclude that assessing the efficiency of a water distribution system only via the AWWA Water Audit will be insufficient and may underestimate actual losses. Sixty percent of our sample still relies on monitoring only “unaccounted for” water to control water losses. Using an external authority to validate data and metering for non-revenue water can improve the efficacy of the AWWA water audit methodology. Another effective metric of infrastructure quality is consistency in following prescribed best management practices customized to the size and type of retailers.

Water retailers should invest regularly in water infrastructure to avoid loss in revenue and damage claims. Decision-making for rate increases can be more informed with detailed knowledge of the state of the distribution system and the investments and practices necessary to minimize water, losses and economize water distribution. In Los Angeles, many pipelines are past their useful life, with leakages or points of imminent failures, potentially causing tremendous water loss.

As suppliers of potable water to the public, the Investor-Owned Utilities must be responsible to provide more accessibility and transparency to information about their respective distribution systems. This can also facilitate proposing capital improvements to the CPUC as more transparency can garner public support. The MWCs can bolster their cooperation in water conservation by maintaining verifiable information on water losses in their system in the form of reports or monitored data. The MWCs are organized in the state, and could develop a mutual assistance and cost sharing agreements with other mutual or with adjacent retailers. Such verifiability will aid them in addressing concerns from the State and water quality authorities, as well as in monitoring their system efficiently. Smaller retailers can improve their performance by coordinating their efforts in leak detection and minimization.

In conclusion, strategizing best management practices and assessing cost-effectiveness of leakage repairs based on the accurate infrastructure assessment for retailers can improve management of water infrastructure and reduce water losses. These strategies have been made available by AWWA M36 Manual (American Water Works Association, 2009) and other literature reviewed in this study. Transparency and verifiability in information is crucial to implement such a system. With this paper, we have provided a glimpse of the current status water loss reporting state wide, of water retailers in urban Los Angeles County and have thrown light on their deficiencies while outlining their strengths. This paper also provides a context for
upcoming policy decisions to reduce water losses through infrastructure, thus supporting conservation efforts.
Acknowledgments

This research was sponsored by the California Water Foundation (part of the Resources Legacy Fund). We thank Dr. Stephanie Pincetl, Dr. Deborah Cheng and Dr. Erik Porse for their extensive work on the water supplier database used for this study and their valuable feedback. We thank Keith Mertan and Paul Cleland for their contributions to the statistical analysis and water supplier database respectively. We thank Ken Manning and Adan Ortega for their time and insights. We especially thank the participating agencies for their co-operation and the information provided.
References


Department of Water Resources. (2015, 03 02). Notice to State Water Project Contractors.


Appendix

Document of Interview Questions for Study

In this interview, we are asking you to respond to questions about water distribution efficiency and related measures in your water agency, company or department.

[At this point, read and sign consent form and begin responding]

*Urban Water Supplier: According to the Urban Water Management Act, it is "a supplier, either privately or publicly owned, providing water for municipal purposes either directly or indirectly to more than 3000 customers or supplying more than 3000 acre-feet of water annually."

1. Which service does your water agency provide? *Indicate all options that apply.*
   a. Water Distribution to End Users
   b. Raw Water Treatment to Drinking Water Standards
   c. Water Reclamation or Ground Water Replenishment
   d. Stormwater Treatment
   e. Power

2. What is your agency’s annual water distribution volume for potable/recycled water in acre-feet, as most recently monitored?

3. What is the residential population in your service area? If your service area is geographically divided into isolated segments, please give totals for each segment.

4. How many residential service connections do you have?

5. How many business service connections do you have?

6. How do you measure/calculate the volume of water in acre-feet that is being brought into your system, either through local or imported sources? How do you measure this?

7. Do you know your agency’s average per capita per day usage for potable water for residential users in your service area? (Y N) *If yes, please answer Q8, if not go to Q9.*

8. What is the per capita per day use for residential customers? (GPD) How do you calculate it?

9. What is the per capita equivalent usage for businesses? How do you calculate the usage? *If you don’t know, please indicate and move to the next question.*
10. Are you a member of the California Urban Water Conservation Council (CUWCC)? (Y/N)

11. Have you used the AWWA tool for estimating all real losses? (Y/N) If yes, when was the last time you used it? If not, skip to Q14

Real Water Losses are defined by the AWWA Water Audit Tool as “true losses of water from the utility’s system, up to the point of customer metering. They consist of leakage on transmission and distribution mains, leakage and overflows at utility storage tanks, and leakage on service connections up to the point of customer metering.”

12. What is the current estimate of the Real Water Losses associated with your distribution network for the 2013-14 year? (July 1st 2013 to June 30th 2014). If you don’t know please indicate and move to Q15.

13. Can you give an estimate in volume or percent, the real losses in various parts of your agency’s distribution system? If you don’t know, please indicate below and move to Q15.

<table>
<thead>
<tr>
<th>Estimated Volume</th>
<th>Estimated Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Transmission/distribution mains</td>
<td></td>
</tr>
<tr>
<td>b. Overflows at storage tanks</td>
<td></td>
</tr>
<tr>
<td>c. Service connections</td>
<td></td>
</tr>
<tr>
<td>d. Don’t know</td>
<td></td>
</tr>
</tbody>
</table>

14. If you have not used the AWWA tool, do you calculate your real losses? (Y/N) If so, how? Can you give an estimate of your real losses? If you can’t estimate losses, please indicate and move to the next question.

15. How much of your agency’s distributed volume is metered? (Volume or percentage of total) Do you have smart meters?

16. Does your agency have a regular schedule for water distribution system replacement and upgrades? (Y/N)

17. If so, do you have a standard number of miles of distribution system that you replace/repair each year?

18. Do you have a schedule for checking and replacing valves? Do you have a schedule for checking meters for accuracy and replacing them?

19. Does your agency have a Leak Detection Program? (Y/N) If yes, can you describe it?

If yes then go to Q20 and skip Q21; if not, go to Q21.
20. If you do have a leak detection program, do you use it to plan budgets and investments in pipe and other distribution system replacement? (Y/N)

21. If you don’t have a leak detection program now, do you think that you will be developing one in the next year? (July 2014-June 2015)? (Y/N)

22. Do you keep records of the number of line breaks per year? (Y/N)

23. Do you keep records of the material and age by location of various parts of your distribution system? (Y/N) What is the pipe material that your system uses?

24. What is the average life in years for pipes in your system? Which specific factors affect pipeline life in your system? (E.g. corrosion, material, earth movement, etc.)

25. Do you report your system losses from water supply to any government agency in addition to the DWR? If yes, what parameters pertaining to system losses do you report?

*If yes, please name the agencies below:*

26. What other current or past measures has your agency implemented to prevent or reduce real losses?

27. Can you tell us if your agency is thinking about new future measures to prevent or reduce real losses?

28. Are you able to secure enough revenues out of your annual resources to prevent or reduce real system losses? (Y/N) If not, what kind of assistance would you need to minimize system losses through monitoring, rapid response and replacement?

29. In your opinion, what requires to be done to improve water distribution efficiency across various agencies in urban Los Angeles?
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Uncertainty in Long-Term Water Demand Forecasts: A Primer on Concepts and Review of Water Industry Practices

Project #4558
EXECUTIVE SUMMARY

Long-term water demand forecasts serve as critical inputs to water utility planning efforts and decision making, and they play many roles in those processes. Uncertainties about the future, as well as about the causes of historical and recent trends in water usage patterns, can affect how long-term water demand forecasts are constructed and why they are seldom realized with very high degrees of accuracy. Inaccurate forecasts can lead to costs to water utilities, water rate-payers, and the environment. For example, over-building of supply and water treatment capacity can lead to stranded capital assets, higher water rates than might otherwise be necessary, and additional stress on watersheds. On the other hand, under-investment could result in imposition of water shortage restrictions, economic damages from water shortages, and harm to the credibility of utility management. These risks, the ways they are affected by planning uncertainties, and how utilities cope can be perplexing and present complex challenges for the drinking water community.

This study conducted a review of the uncertainties related to forecasting long-term demand for water resource and infrastructure planning, including strategies to account for and manage these uncertainties. The study resulted in a primer on risk and uncertainty as they relate to long-term water demand forecasting, a corresponding annotated bibliography, and a categorized reference list pointing to additional literature resources. The project team conducted a web-based survey of water utilities and a project workshop involving utility professionals and other practitioners with experience in long-term forecasting. These efforts addressed current water utility practices and perspectives regarding risk and uncertainty. Readers are strongly urged to review the main body of the report to absorb important concepts related to risk analysis and how uncertainty can be addressed in the context of water demand forecasting. The following summarizes some of the key findings of the study.

SYNTHESIS OF WATER UTILITY SURVEY RESULTS

- System size (as defined in terms of population served) seems to be positively related to the overall level of attention devoted to long-term water demand forecasting.
- Aside from future growth in customers, future climate, the condition of the economy, and water efficiency top of the list of key future uncertainties.
- Many utilities would like to include additional variables in their respective forecast models, but cannot due to data limitations.
- The development of qualitative scenarios is the most common method for addressing uncertainty in long-term forecasts, though the likelihood of using statistically-based forecast intervals increases with system size.
- In the context of infrastructure planning, the risks of under-predicting future demands tend to outweigh the risks of over-predicting future demands. This risk attitude may be naturally at odds with risk attitudes associated with financial planning objectives.
- Monitoring water demand and periodically adjusting forecasts with new information were the most frequently indicated strategies for coping with uncertainty.
- Utilities employ additional structural strategies that provide flexibility for coping with forecasting inaccuracies, such as building facilities that can be easily expanded and phasing supply development projects into smaller increments.
Recent declines in water use rates, coupled with past over-predictions of demand, could be providing a luxury of time to monitor demand trends and more carefully assess future supply needs.

**EMERGENT THEMES FROM THE DEMAND UNCERTAINTY WORKSHOP**

- There isn’t a single prescriptive approach everyone should follow for forecasting. The best approach for any utility depends on its situation, and there are aspects of certain methods that make them better or worse than other methods.
- More complicated models are not necessarily better for reducing uncertainties. The addition of more variables to explain historical variability in water use could superficially increase uncertainty about the future, since their future values are unknown, or at least lead to diminishing marginal returns with respect to forecast accuracy. On the other hand, the addition of more variables may be reflective of better knowledge and provide a more complete picture of why demands may vary in the future.
- Understanding recent causes of historical demand variability appears to be the focus of water agencies, but some are beginning to incorporate uncertainty into forecasts. The best approach to incorporating uncertainty into forecasts depends on a utility’s specific situation, including technology, data availability, staff expertise, and uncertainties about available budget resources.
- There are greater appetites for accepting the risks of over-predicting long-term demands. In practice, the perceived costs associated with water shortages tend to outweigh the perceived costs of having excess supply capacity (and some degree of stranded assets).
- Concepts, perceptions, and appetites for risk can vary within a utility organization. Discussions confirmed that tensions can exist between the forecasting needs of financial and infrastructure planning, and that each planning element could have its own forecasting biases and appetites for risk.
- There is a lack of experience in estimating risks, defining risk metrics, and evaluating the costs of risk reduction. The consequences of forecasting inaccuracies tended to be well understood and articulated. However, there appears to be limited experience in assigning financial (or monetary) costs from forecasting inaccuracies, which would help decision makers.
- Communication of demand forecasting uncertainties is just as difficult as, and perhaps more important than, incorporating uncertainty into forecasts. The value of making “risk-informed” judgments needs to be better articulated, along with educating decision makers and public stakeholders about forecast uncertainties and the potential risks at stake.

**REACTIONS AND RECOMMENDATIONS**

Uncertainty in water demand forecasts can affect a utility and lead to exposure to risks in all of the following areas:

- Strategic
Addressing long-term demand uncertainty, in consideration of the impacts of demand uncertainty among all of these areas, would present a more complete and holistic basis for decision making. One model for doing this is to adopt an “enterprise risk management” approach to decision making that cuts across organizational silos. Water utilities should take advantage of existing enterprise risk management models and tailor them accordingly.

Simple forecasting models may be preferred for many reasons. If planning objectives are broad enough to consider alternatives to supply expansion and generate information to assess appetites for risk, then more advanced models and forecasts are both desirable and practical, especially because of the value of the information they provide. Water utilities should identify and evaluate key forecast uncertainties and examine whether their current long-term forecasting models adequately incorporate these factors.

Examples of probabilistic demand forecasting, robust scenario development, and risk-based level of service metrics already exist, but these efforts cannot yet be considered the norm. Efforts should continue to demonstrate how uncertainty can be incorporated into various water demand forecasting methods, comparing data requirements and contrasting the advantages and disadvantages of different approaches. Water utilities should seek out ways to improve their knowledge of water demand trends and look for opportunities to make incremental improvements to forecasting models and methods.

Some utilities manage risks through multiple strategies, including periodic monitoring of water demand trends, incremental or phased planning of facilities, demand management alternatives, and more flexible or innovative financing. Based on the literature and experiences shared during the course of this study, there seems to be a heightened interest in adaptive management strategies such as these. Further assessment of risk attitudes in water supply planning could examine how attitudes have evolved and whether they have the potential to change. Water utilities should consider whether and how their demand forecasts and underlying forecasting methods reflect their attitudes about risk.

Effective communication of forecast uncertainty is a stumbling block at multiple levels. Incorporation of uncertainty into forecasting and decision making is still foreign to many, and adopting the risk analysis paradigm carries with it new analytical processes, terminology, and ways of thinking. It takes time for modelers, forecasters, water managers and others to not only learn how to gather and process this information, but also to appreciate its usefulness. Additional guidance is needed on effective ways to portray and explain forecast uncertainty and to translate this information into actionable knowledge for decision makers. Water utility decision makers need to be receptive to this guidance.

Finally, water utilities should direct more attention to measuring risks, and, to the extent possible, monetizing the full costs of managing forecast uncertainty and communicating these costs to the public. Improvements along these lines could ideally result in a process where water planning and management actions represent a clearer and more traceable expression of the risk attitudes of water utilities that are sensitive to the desires of a risk-informed public.