EVALUATING MUNICIPAL RECYCLED WATER USAGE IN CONCRETE MIXES

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ABSTRACT

Due to the California drought, there has been an effort to evaluate opportunities to decrease potable water demand. Recycled Water (RW) is derived from the City's Wastewater Reclamation Plants and is highly regulated. Using RW for concrete production, can save both energy and money, and reduce dependence on potable water supplies. The topic of RW in concrete arose as a result of an internal One Water LA discussion between two City departments, LASAN and LA World Airports. The goal was to determine the viability for the City before recommending this approach to management. An effort was undertaken by members of City Departments who have jurisdiction over RW use for design and construction projects in the City and by City departments. The initial efforts focused on the water quality requirements. Other information was collected on State regulatory requirements as well as code compliance, particularly for construction practices.

KEYWORDS: Concrete, recycled water, drought, offsetting potable water, cost effective, policy, construction, ready mix companies

INTRODUCTION

The City of Los Angeles proper, home to four-million people, is developing the One Water LA 2040 Plan, which is an integrated approach for water supply, recycled water, wastewater treatment, and stormwater management. It builds upon the success of the City's Integrated Resources Plan, or IRP (2000-2020) to plan towards 2040 for all types of water needs by City departments and regional entities who work in the City, as well as the commercial, industrial and residential sectors. The City of Los Angeles is developing the One Water LA 2040 Plan which is an integrated approach for water supply, wastewater treatment, recycled water, and stormwater management.

The plan looks out over the next 25 years to manage LA's future water needs. As part of the efforts toward completing the planning documents. This Plan sets the bar for a more sustainable and resilient way to manage LA's future water needs. The One Water LA program provides a framework for City departments, regional entities and stakeholders to work together collaboratively on the overall water picture – water supply and demand, environmental needs, and long-term challenges and solutions. Municipal Recycled Water (RW) usage is part of this California drought discussion.

The One Water LA team has had numerous strategic planning discussions with various City departments since December 2013. During one of these meetings, the idea of RW use in concrete was considered. The following City departments subsequently met to further discuss the topic and in particular, to collaborate in determining the feasibility and "next steps" toward requiring RW for concrete mixing:

- Dept. of Public Works, Bureau of Sanitation (LASAN)
- Department of General Services (GSD)
- Dept. of Public Works, Bureau of Engineering (BOE)
- Department of Building and Safety (LADBS)

Internal Study Development And Clarifications

After initial discussions with the core group, there was the understanding that there were four main issues related to potentially using RW in concrete that needed to be addressed:

- Understand the limits and requirements of each regulating organization.
- Determine the water quality from each of the City's Reclamation Plant and verify that it meets the quality requirements stipulated for concrete.
- Research and understand current RW usage in concrete by concrete suppliers in the Southern California.
- Address safety issues by working with construction trade groups as well as City field inspectors.

The One Water LA team led the effort and went about to find information to bring back to the group. Where information was limited, staff reached out to various government agencies and industry representatives. As the initial effort was being finalized, a parallel effort was begun to determine how closely

As the One Water LA team began to meet with other City departments to discuss the main issues, certain topics and ideas began to surface. For one, several of the participating departments wanted to ensure that the group recognized that the Ready Mix Concrete companies (RMC) were going to be the ultimate 'customers' of the City's RW product. As such, these companies needed to have representation in these discussions. In addition, one department noted that the engineer of a Ready Mix Concrete company is typically the one who prepares the actual concrete mix. However, LADBS noted that RMC are usually required by contract to follow the specifications prepared by the project's Registered Design Professional (RDP) in Responsible Charge, whether it is a Structural Engineer, Civil Engineer, Architect, or other authorized design professional. As such, while a particular Code or Standard may permit the use of RW, it is the project's RDP that has the ultimate authority on the content of the concrete specifications and decides on the type of water to be used.

On the subject of Code requirements, BOE stated that applicable Codes and Standards permit the use of RW provided they meet the prescribed criteria. For projects in the City of Los Angeles Public Way, the primary governing "Code" is the Standard Specification for Public Works Construction (SSPWC) or "GreenBook". The GreenBook has established criteria under which

RW may be used to generate concrete. At times, other codes apply such as those prepared by AASHTO or ACI. However, these Standards also permit the use of RW provided the acceptance criteria is met. Furthermore, BOE does use project specific concrete specifications for many of its jobs which are far more detailed than the requirements included in the GreenBook. These are entitled, "Reinforced Concrete" and are referred to as Sections 03300 and 03310 of the BOE's Master Specification Library. These sections have been revised to permit the use of RW in accordance with the SSPWC.

Based upon the issues identified by the focus group and their discussions summarized above, an effort was undertaken to conduct an evaluation and feasibility study that looks closer at RW regulations, quality of potential RW sources, and capture discussions and information obtained from RMC who would be the ultimate City of Los Angeles "customers". This effort or study is presented in this report along with recommendations for implementation, existing roadblocks, and cost effectiveness for implementing the use of recycled water in concrete mixes in the LA basin.

This paper is divided into the following sections based on the study completed:

- Section 1- Concrete Acceptance Criteria for RW
- Section 2 –Analysis of Water Quality for Concrete Use
- Section 3– Interviews and Outreach
- Section 4– Opportunities And Benefits
- Section 5- Actions Taken
- Section 6 - Recommendations And Next Steps

SECTION 1 – CONCRETE ACCEPTANCE CRITERIA FOR RW

Several organizations and regulatory agencies permit the use of RW in a concrete mix, provided specific water quality thresholds are met. Some of the more common regulatory agencies and industry organizations are listed below:

- California Division of Drinking Water (DDW) - part of SWRCB
- State Water Resources Control Board (SWRCB)
- American Association of State Highway and Transportation Officials (AASHTO)
  - AASHTO LRFD Bridge Design Specification.
- American Concrete Institute (ACI)
  - ACI 318: Building Code Requirements For Structural Concrete.
- American Society for Testing and Materials (ASTM)
  - ASTM C 1602
- American Public Works Association (APWA)
  - Standard Specification For Public Works Construction - "GreenBook (SSPWC)
- International Code Council (ICC)
  - International Building Code (IBC)
    - Adopts ACI 318 as referenced concrete document.
      - Adopts ASTM C1602 as the criteria for water quality.

In addition, there are several Authorized Governing Agencies with Corresponding Responsibilities. In California, all schools are governed by the Division of the State Architect. This

entity has complete authority to decide and determine the materials of construction, has their own set of specifications and governs the use of recycled water. The Agencies are listed below:

- California Department of Transportation (Caltrans): State Bridges & Highways.
  - Adopts AASHTO LRFD with amendments.
- California Building Standards Commission: State's Minimum Building Requirements
  - Adopts IBC with revisions => Issues California Building Code (CBC)
  - Division of the State Architect (DSA) => Requires a more stringent "B" version of CBC
- Los Angeles Dept. of Building & Safety: City's Min. Building Requirements (private properties)
  - Adopts CBC with amendments => Issues Los Angeles Building Code (LABC)
- Board of Public Works : City' Public Way Minimum Requirements
  - Adopts SSPWC with amendments => Issues BrownBook
  - Adopts AASHTO LRFD with Caltrans Amendments through Brownbook.

Use of RW in Concrete

The production, conveyance, and use of RW in California is overseen by The State Water Resources Control Board. The level of water quality of the RW produced determines its use based on Title 22 requirements and the approved purpose. As presented in **Table 1**, Title 22 Water Recycling Criteria, adopted by the Division of Drinking Water in December 2000, approves the use of RW for concrete mixing as long as it is treated to at least secondary-23 recycled water criteria (California Dept. of Public Health, 2014). See Section 2 for addition information and criteria discussion.

Table 1:
Recycled Water Uses Allowed In California (Title22)

Use of Recycled Water	Treatment Level			
	Disinfected Tertiary Recycled Water	Disinfected Secondary-2.2 Recycled Water	Disinfected Secondary-23 Recycled Water	Undisinfected Secondary Recycled Water
Mixing Concrete	Allowed	Allowed	Allowed	Not Allowed

In addition, the State of California's Water Code, §13550, *et seq.* indicates that an industrial user cannot use potable water if RW is:

- Available in an adequate quantity
- Provides sufficient quality for the uses required by the industry
- Is priced appropriately

As presented in **Table 1**, the Regional Water Quality Control Board monitors the quality of RW and sets specific requirements for municipal RW to be "Title 22" water. Except for Hyperion, all of the reclamation facilities produce a minimum of tertiary-treated water and it is this quality of water being recommended to be used for concrete mixing for projects in the City. The following

relevant sections of the Code of Regulations explain the parameters that need to be met for each type of RW that is produced:

- ***Section 60301.225. Disinfected secondary-23 recycled water.***

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

- ***Section 60301.230 Disinfected Tertiary Recycled Water***

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

- ***Section 60301.320 Filtered Wastewater***

(a) Has been coagulated and passed through…a bed of filter media…
(2) … the turbidity of the filtered wastewater does not exceed…
(A) An average of 2 NTU within a 24-hour period.
(C) 10 NTU at any time.

Currently, the WRPs producing Title 22 water treated used in the City of LA to at least tertiary treatment level include; Tillman, LA/Glendale, Terminal Island and West Basin. To ensure the reclamation plants meet the Department of Drinking Water standards, water quality testing is done regularly at each reclamation plant.

Effective disinfection of viruses is believed to be inhibited by suspended and colloidal solids in the water. These solids must be removed by advanced treatment before the disinfection step. The sequence of treatment often specified in the United States is: secondary treatment followed by chemical coagulation, sedimentation, filtration, and disinfection. This level of treatment is assumed to produce an effluent free from detectable viruses (Natural Resources Management and Environment Department, 2015). All of the reclamation facilities, except for Hyperion, follow the same treatment process of chemical coagulation, sedimentation, filtration, and disinfection. TI currently has advanced treatment facilities, which provides water quality that not only exceeds Title 22 water quality requirements, but also meets state and federal drinking water standards.

Tertiary-treated water that meets the Title 22 criteria is considered to be "pathogen-free" for it to be considered Title 22 water. Some of its approved uses include:

1. Food crop irrigation (Section 60304(a) (l))
2. Full body contact, such as swimming (Section 60305(a))
3. Landscape irrigation of areas with access by children (Section 60304 (a)(2,3))
4. Cooling tower with mist (Section 60306 (a))
5. Indirect, potable reuse through groundwater recharge (Section 60320)

RW can be used for almost anything except direct human consumption. One requirement for any RW user is that the proper signage is displayed at every location where RW is used. As long as the proper signage is displayed and the on-site workers properly instructed on the use of RW, there should not be any issue with accidental consumption of RW.

RW in Concrete - Regulations and Specifications

Originally, in discussions with various City Departments, the idea of using RW in concrete seemed rather obvious. Concrete is a large water consuming industry, with approximately 170 gallons of water required per cu. yd. of concrete mixed (Silvia and Naik, 2010). Substituting the use of potable water with RW in the production of one of the most used materials in construction will serve as a benefit for not only the City of LA, but concrete suppliers as well. RW decreases the City's dependence on imported water and RW costs less than potable water. However, this study discovered that while the allowance of RW use in concrete production has been approved for years, its use for this purpose has not been widely adopted. In southern California, only four concrete plants out of approximately 40 in the Los Angeles and Orange County area are known to be currently using RW:

- Santa Fe Springs plant (20+ years)
- Paramount plant (20 years)
- Pomona plant
- Irvine Plant

With policy and legislative approvals to use RW in concrete from State authorities in place, the RW water quality requirements in applicable concrete specifications were developed. The following engineering documents from the construction and building committees and/or governing bodies for the respective organizations listed earlier have produced standards for both the water quality of water used in concrete as well as the concrete itself:

1. American Society of Testing and Materials (ASTM)ASTM C 1602
2. GreenBook
3. Caltrans Bridge Design Specifications (LRFD)

Water Quality Requirements

Table 2 below lists the water quality requirements for water used in concrete for different types and uses of concrete from the above references. These requirements are whether RW is used or not. Each organization has a slightly different limit on the various constituents of interest and how they are represented; however the particular constituents to be monitored (i.e., Chloride, Sulfate, Alkalis, and Total Solids) do not vary significantly. The reason for the variation in limits is not completely understood.

Table 2:
Water Quality Requirements For Use in Concrete

	ASTM 1602[1]	GreenBook[1, 2]	Caltrans	Test
	Limits, mg/L (ppm)			
Chloride as Cl^-				
Reinforced	1,000	1,000	1,000	ASTM C114
Prestressed	500	650	650	
Non-reinforced	-	2,000	2,000	
Sulfate as SO_4				
Reinforced	3,000	1,000	1,300	ASTM C114
Prestressed	3,000	800	1,300	
Non-reinforced	3,000	1,500	1,500	
Alkalies as (Na_2O + 0.658 K_2O)				
Max concentration in combined water	600	-	300	ASTM C114
Total solids by mass				
Max concentration in combined water	50,000	-	-	ASTM C1603
Notes: 1. It is recommended that the most stringent limits be used between ASTM 1602 & GreenBook. 2. SSPWC, Section 201-1.2.3				

The use of RW in concrete mixing is permitted in structural and non-structural concrete. As can be seen in **Table 2**, the limits have been further refined based on the type of reinforcement, including no reinforcement. ASTM has additional testing requirements when any non-potable water is used. Provided the concrete mix complies with the ASTM 1602 water quality requirements, ASTM requires producers to test the non-potable water quality every six months (Division of State Architect, 2014). For many constituents, water quality testing is done daily regularly at the WRPs; however the concrete specific constituents need to be added if not already tested.

Concrete Performance Requirements

In addition to water quality standards, ASTM and the GreenBook have concrete performance specifications for the concrete mixed with non-potable water. The performance specifications are listed in **Table 3** below.

Table 3:
Concrete (Reinforced & Prestressed) Performance Specifications

Characteristic	ACI/ASTM 1602	GreenBook	Test
Set Time (change)	1hr to +1.5hr	25%	ASTM C403
Max. Mortar Strength Reduction @ 7 days	10%	10%	ASTM C31 & C39
Max. Mortar Strength Reduction @ 28 days	---	10%	ASTM C31 & C39
Note: Recommend using the most stringent Limits identified above			

As mentioned before, ASTM requires producers to test the non-potable water quality every six months. Since water quality testing is done regularly at the WRPs, such testing criteria possess no added burden; however the concrete-specific constituents, such as alkalis, need to be added to the water quality testing regiment if not already included.

It should be noted that performance tests related to concrete mixed with RW, similar to the criteria listed in **Table 3,** have been conducted in the past, and with favorable results. Los Angeles Department of Water and Power, along with the Standards Division of the Department of General Services (GSD), conducted a test in 1990-1995.

SECTION 2 – ANALYSIS OF WATER QUALITY FOR CONCRETE USE

To determine if the water quality from the reclamation plants meet the requirements given from each regulating entity, water quality samples were taken from each reclamation plant over a one month period (June-July 2015) and compared to the limits in **Table 2**. This section discusses the methodology used for the water quality testing of the recycled water at each of the City's reclamation plants and partner plant. Results are then discussed.

Los Angeles' Water Reclamation Plants

There are five wastewater reclamation plants (WRP) that produce recycled water that is used within the City of Los Angeles. Each plant has a different wastewater treatment process train and quality of water. **Table 4** presents each plant and the corresponding level of treatment at each.

Table 4:
Water Reclamation Plants And Treatment Levels

Plant	Current Treatment Levels	Capacity (mgd)	Total Recycled Water Produced FY 2014/15 – Potable Offset (mgd)
Donald C. Tillman (DCT)	*Tertiary*	**80**	**33.6**
Los Angeles / Glendale (LAG)	*Tertiary*	**20**	**14**
Terminal Island (TI)	*Advanced*	**30**	**4.9 (12)[1]**
Hyperion Plant (HTP)	*Secondary*	**550**	**45.1**
West Basin Municipal Water District (WB) [2]	*Tertiary (from Hyperion) and Advanced*	**34.2**	**30.8**

Notes:
[1] TI is being upgraded to 12 MGD of advanced
[2] Hyperion provides 34.2 mgd of secondary water to West Basin which produces RW for the region. Assumes 90% of delivered RW is distributed.

Figure 1 displays the RW distribution network within the City of Los Angeles, along with its corresponding reclamation plant. The water quality of the RW depends on its source and the level of treatment used. The different colored lines correlate with distribution lines originating from each reclamation plant. Both existing and future RW lines are presented on the map.

Methodology for Viability

The first step was to determine the water quality from each plant. Four samples were taken from each of the reclamation plants that provide RW within the City of LA, with the exception of Terminal Island (TI). Only two samples were taken from TI due to construction activities. These samples were then taken to GSD's Standards Division lab where the water quality testing was done for each of the following four constituents: Chloride, Sulfate, Alkalis, and Total Solids. Testing methods varied for each constituent. The results were compared to the acceptance criteria.

Results

The results of the water quality testing show that after treatment the recycled water meets or exceeds most limitations. **Table 4** presents the average concentration for each constituent from each reclamation plant. As seen below, all reclamation plants meet the ASTM requirements in all four water quality parameters. Caltrans specifications were also met except for the alkalis requirement at the Hyperion and West Basin facilities.

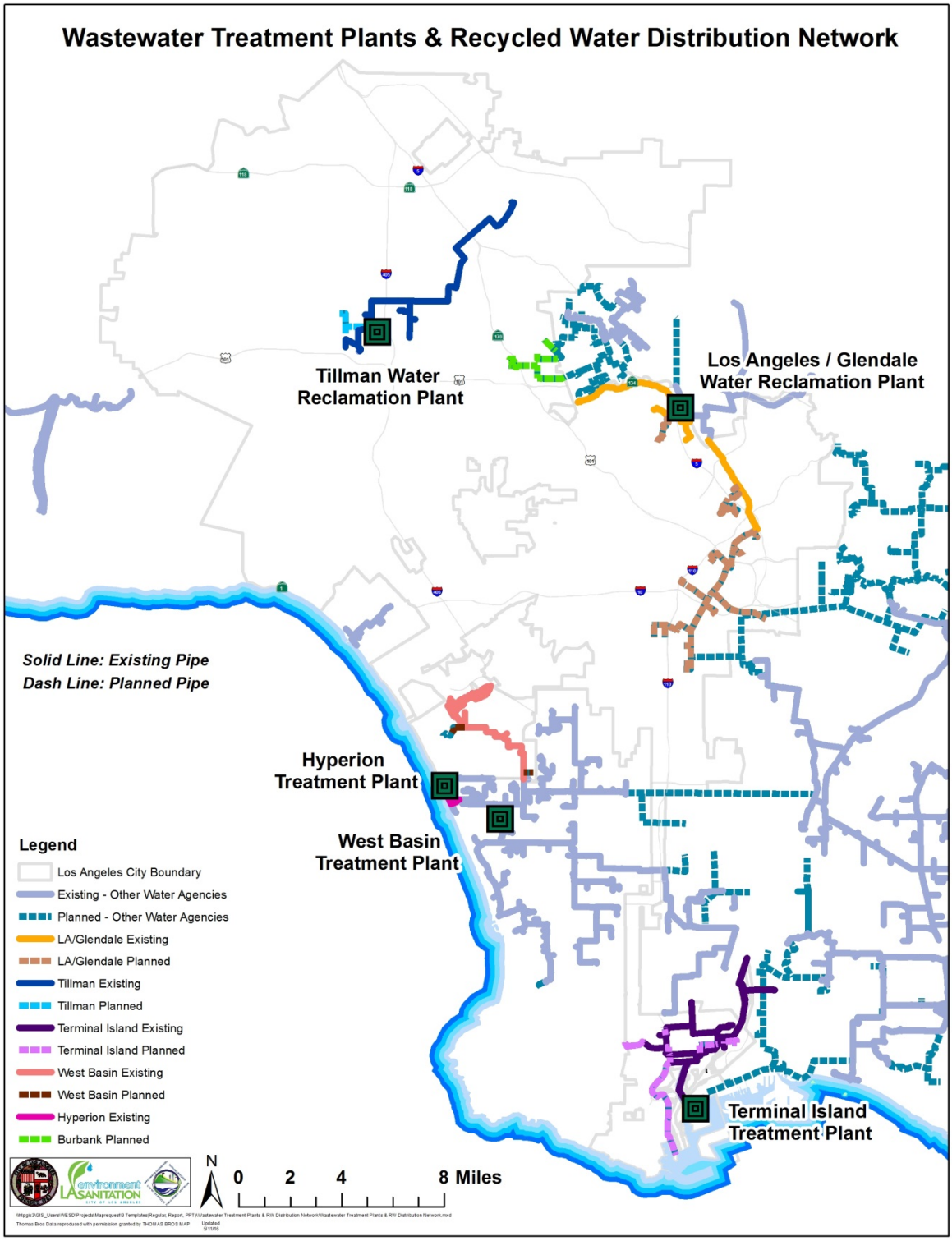

Figure 1: Water Reclamation Plants with Corresponding Recycled Water Distribution Network

Table 5:
Average WRP's Water Quality Data Comparison

	ASTM C 1602	GreenBook	Caltrans	RW Water Quality					
				DCT	LAG	TI	WB-Tertiary	WB-Advanced	Hyperion
	Limits, ppm			Average (mg/L)					
Chloride as Cl^-									
reinforced	1000	1000	1000	153	150	83	395	7	313
prestressed	500	650	650						
non-reinforced	-	2,000	2,000						
Sulfate as SO_4									
reinforced,	3000	1000	1300	124	124	142	154	ND	169
prestressed	3000	800	1300						
non-reinforced	3000	-	1500						
Alkalies as (Na_2O + 0.658 K_2O)									
Max concentration in combined water	600	-	300	216	219	69	356	14	357
Total solids by mass									
Max concentration in combined water	50,000		-	627	760	181	1088	19	1012

Table 6 presents the maximum concentration of each constituent from each reclamation plant. All reclamation plants meet the water quality parameters except for West Basin and Hyperion. West Basin is within 24 percent of Caltrans' Alkalis requirement and Hyperion is within 31 percent of the Alkalis water quality requirement.

Table 6:
Maximum WRP's Water Quality Data Comparison

	ASTM C 1602	GreenBook	Caltrans	RW Water Quality					
				DCT	LAG	TI	WB-Tertiary	WB-Feedwater	Hyperion
	Limits, ppm			**Maximum (mg/L)**					
Chloride as Cl^-									
reinforced	1000	1000	1000	162	157	97.3	431	7.35	333
prestressed	500	650	650						
non-reinforced	-	2000	2000						
Sulfate as SO_4									
reinforced,	3000	1000	1300	177	188	162	162	ND	191
prestressed	3000	800	1300						
non-reinforced	3000	-	1500						
Alkalies as (Na_2O + 0.658 K_2O)									
Max concentration in combined water	600	-	300	224	229	75.8	372	16.1	393
Total solids by mass									
Max concentration in combined water	50,000	50,000	-	652	794	229	1160	23	1070

SECTION 3 – INTERVIEWS AND OUTREACH

Information from several conversations with concrete suppliers and water agencies were conducted during this effort since the need to determine viability and logistical issues was required, if the One Water team was to recommend this for the City of LA. Both interviews and outreach efforts were made with both water agencies and Ready Mix concrete companies. Results are summarized below.

Water Agency Discussions

There were two water agencies that were known to deliver RW to concrete plants and the One Water LA team reached out to both in an interview-style approach. The objective was to learn from them and to understand if they had best practices and knowledge about how to approach the concrete manufacturers. Valuable information was obtained and both were very helpful in understanding how they approached the private sector. Below summarizes discussions with them.

Irvine Ranch Water District (IRWD)

IRWD is a public water agency located in Irvine California. In the late 2000's, IRWD's initial plan was to connect seven concrete suppliers to a RW line; however, due to several factors, the connection was installed only at the North East location (Robertson's Ready Mix) and the other

six have never been connected. IRWD stated that "At the time, Robertson's was more open to the idea because they had used RW in the past."

Irvine Ranch Water District provides 5-10,000 gallons per day of RW to process concrete to Robertson's Ready Mix. The construction of the 738-foot pipeline began in October 2008 and was completed the following year in June. The on-site pipeline is right along an aerial catwalk were the recycled water is delivered in to two 500-gallon tanks. RW provided to the Robertson's Ready Mix plant costs 40 percent less than potable water (Irvine Ranch Water District, 2015).

When asked if any concrete research testing was done, IRWD mentioned that they did not believe research was needed since their RW meets the required water quality levels and the concrete has been approved and used for concrete mixing for years. IRWD did recall giving five gallons of their RW to Caltrans and Robertson's Ready Mix for evaluation. Phone calls were made to Robertson's Ready Mix and Caltrans to determine details of the evaluation (5 gallons), but unfortunately the results of the evaluation or an explanation of what was done was not determined.

Sanitation Districts of Los Angeles County (LACSD)
LACSD's area covers approximately 824 square miles and encompasses 78 cities within the Los Angeles County (Sanitation Districts of Los Angeles County, 2015). According to LACSD, their tertiary recycled water has been used at three concrete mixing facilities for over 20 years. Robertson's Santa Fe Springs location has been using LACSD's RW since 1993, while their Paramount location began using RW since 1995 (both supplied through the Central Basin Municipal Water District's RW distribution systems). In 2009, the Robertson's facility in the City of Pomona was connected to that City's RW distribution system.

After liability concerns regarding the use of RW in concrete mixes with admixtures were brought to attention by LADBS, LACSD was asked if they thought admixtures in concrete were a concern. LACSD stated that the quality of their water meets drinking water standards, and "potable water and LACSD's RW are essentially indistinguishable" in terms of meeting drinking water standards. According to LACSD, the applicability of using any water supply for concrete should be judged on the quality of the water, not its name or its origin. LACSD suggested that if there was a concern using the word "potable" instead of "ASTM 1602 compliant" in any contracts, specifications, and/or agreements, then a revision should be considered.

Concrete Suppliers

Using the recommended approach from water agency interviews, an outreach effort was conducted by the One Water LA team. Both RMC and industry organizations were contacted to determine if there was an interest in using RW at concrete plants. Additionally, perceived or real hurdles were explored to determine any fatal flaws. Treating the concrete suppliers as customers was emphasized during conversations, as recommended by City departments. The following discussions were done through a series of phone calls, emails, and conference call meetings.

Concrete suppliers currently using RW
To understand the usage, or lack thereof, of RW in concrete mixes, an initial call was made to all 40 concrete suppliers within the greater Los Angeles region. The goal was to determine the percentage of concrete suppliers currently using municipal RW in their concrete mix. The initial call was to determine if RW was used at their concrete plants. 100% of the respondents indicated

'no', that they did not use RW in any of their concrete plants. Based on the responses from those contacted, primarily at the corporate office of the concrete suppliers in the Los Angeles area, 0 % used municipal RW in their concrete mix.

However, the team knew that there were some plants using RW. After discussions with Water Agencies, additional calls were made to specific plants and contacts who knew about the use of RW in their concrete plants. The plants using RW are presented in **Table 7.**

Table 7:
Quantity of Recycled Water Used For Concrete Production

Concrete Supplier	City Location	Year RW was in Production	Quantity of Water Used/ Year (MG) in FY 14/15
Robertson's	Santa Fe Springs	1993	4.534
Robertson's	Irvine	2009	1.346
Robertson's	Paramount	1995	1.583
Robertson's	Pomona	2009	4.415
		TOTAL	10.532

Understanding that two of Robertson's plants have been using RW for over 20 years, a follow-up call was placed to the Company. Below summarizes key aspects of the phone discussion (8/17/15):

- There has never been any issue with using RW in the plants.
- The quality of the concrete has never been compromised.
- The reason for switching was purely a financial decision and not due to regulations or client requirements.
- Robertson's would hook up every concrete plant if there was a RW line in front of their property.
- RW is used for batch mixing the concrete in the trucks, rinsing the trucks (which then goes in to a pond for recirculation), and site irrigation.
- If there is a RW connection on-site, then all concrete is mixed with RW on-site.
- They don't distinguish between the use of potable water and RW in mixing concrete and thus not documented anywhere.

Concrete Suppliers not using RW

To understand why concrete suppliers have not modified their operations to the use of RW, the One Water LA team reached out to the California Construction and Industrial Materials Association (CALCIMA) to contact the concrete suppliers in the LA region. A conference call was held, in the fall of 2015, with the following concrete suppliers:

- Robertson's Ready Mix
- CEMEX
- National Ready Mix
- CalPortland (includes Catalina Pacific)

- Sprague's Ready Mix

The conference call was held to determine the concrete suppliers' level of interest to convert from potable water to RW. A questionnaire was created and the One Water LA team obtained insight as to why RW is not used in the City of LA. However, in general, the concrete suppliers were willing to modify their operations to RW if all design specifications related to concrete, not just from public entities, allowed RW in the concrete mixes. In addition, they wanted the guarantee that a Structural Engineer could not require potable water over RW as long as water quality standards are met. If they converted their operations, they wanted to know that they would never be required to use potable water in any concrete mix. The concern was if they had to have two water systems at the concrete plant, such retrofit would not be cost effective. Other concerns conveyed by RMC included the following:

Table 8:
Concrete Supplier Concerns And Issues

Requirement/Concern	Issue
Delivery within 90 minutes	Traffic congestion occurs often in the City of Los Angeles and concrete plants are strategically placed so that any one can supply concrete based on the job and its location
The concrete industry's usage of RW vs potable water	Currently, the concrete industry does not have a policy statement that indicates RW is acceptable for concrete mixes. Potable water often specified in concrete specifications.
All plants need to switch to RW	If a contract requires concrete w/ RW then in the LA area all of their plants need to convert for logistical and practical purposes, including delivery time.
Additional testing and additional cost	Using water that is non- potable (RW, recirculated water, etc.) requires additional testing (ex. Chloride Ions testing) by the concrete batch plant. This takes additional time and effort. A policy or statement by the regulating entities that indicates that the RW testing at the treatment plants is sufficient, is requested by the RMCs.
Liability	Need to address the perception that if there is a problem with the concrete that it is not due to RW. Also, using RW in special mixes that require specific admixtures, temperature, color, etc. should be addressed. If an issue with the concrete were to occur, the concern is that the customer will easily target the use of RW as the cause of the problem
Inconsistent Terminology	The concrete industry interchanges greywater and recirculated water with recycled water on a regular basis and considers the water to be the same
Changing specifications to require RW may limit who bids on the project	Currently, there is only one Ready Mix company using recycled water. The City of Los Angeles cannot mandate the use of RW as that would suggest the City is indirectly sole-sourcing concrete from one supplier

Issues Related to Recycled Water Usage

In the process of reaching out to both City departments and the RMCs, concerns were expressed related to health and safety. For some, this is due to misconceptions as to what RW is and how it can be used. Another issue dealt with the possible effects of RW in the performance of concrete mixed with admixtures. These issues will be discussed below.

Health and Safety

When the possibility of using RW in concrete was first presented, many in the construction industry expressed real fears and concerns related to RW. The following RW health and safety concerns were relayed to the One Water team:

- RW touching skin
- Becoming ill if contact with RW occurs
- Mist of RW on body
- Ingestion and breathing in during concrete production due to spray
- RW touching open wounds or cuts
- Costs and delays in construction due to special gear, clothing, procedures and/or equipment required to maintain safe conditions on the job

There was an acknowledgment that more outreach and education is needed with this sub-group. The Sanitation Districts of Los Angeles County (LACSD) found that to overcome these misconceptions, tours of wastewater reclamation plants and explaining the water quality are extremely helpful.

Terminology

The importance of terminology was discovered when, during a conference call, most of the suppliers used the words greywater, recirculated water, and recycled water interchangeably. After much confusion, there was an 'ah-ha' moment and recognition that terminology needed to be addressed in some way with RMC. In addition, suppliers also used the term Greywater and Blackwater to describe what that the water agencies refer to as recirculated water.

Municipal RW is highly treated waste water that undergoes several treatment steps. RW is monitored daily, and has to meet very specific requirements to be considered Title 22 water.
At a concrete mix site, recirculated water is wash water from the trucks or mixing vessels that is discharged in to a pond or other vessel and then reused on site. However unless this water quality meets the ASTM or other regulating agency requirements, it is not allowed to be used in concrete mixes. The recirculated water is not filtered, but merely, collected and re-used. It is possible that if there are no specifications, that the water could be used for concrete production proposes.

Understanding the difference between RW and recirculated water, in terms of water quality, can help the concrete suppliers and structural engineers become more comfortable with using RW in concrete mixes. Adding a third category (potable water, RW, and non-potable water) to the water quality specifications for concrete mixing in the regulations may improve the perception of RW, especially in the cases where RW is indistinguishable from potable water in terms of water quality (i.e. Terminal Island advanced treated water).

Liability

Early in the discussion phase, LADBS mentioned that each concrete supplier in the City of LA had individual license agreements with the City of Los Angeles. There was a question as to whether or not the agreements relating to concrete specifically stated that the concrete supplier must use "potable" water instead of "ASTM 1602 compliant" water. Since LADBS approves many products via its Research Report process, which is handled by the BOE, there was a recognition of the ability to work together on this topic. These product approvals can also include admixture products. DBS stated that other products are accepted by the Department if they are tested and approved by a nationally recognized testing agency, such as the ICC for example.

LADBS conducted an initial search of these product approvals to determine if any specifically stated "potable water" as the water that must be used in concrete mixing. DBS performed a manual search using the Building and Safety Electronic Catalog (not available to the public), as well as a search on the ICC website looking at their ICC/ESRI approvals. Evaluation of various manufactures looking for more detailed information on their products was also part of the search. Dozens of product approvals were located and not one used the term "Potable Water". Therefore, the use of RW is a non-issue per an email from the Department of Building and Safety.

In addition, BOE reached out to two of the major admixture supplier representatives, BASF and GRACE products. Both responded via email that their products do not require the use of potable water. ASTM C1602 Compliant Water is acceptable.

However, many commercial projects have their own agreements with the concrete suppliers. According to the concrete suppliers that were contacted, these commercial projects often require "potable water", rather than "ASTM 1602" compliant water as a default to avoid any additional liability. The concrete supplier cannot use RW if the Structural Engineer requires potable water, over any other type of water, in the design specifications. Further investigation is warranted.

Agencies Allowing Recycled Water in Concrete

During this process, it was determined that there were only two public agencies that had specifications and language that focused on RW in concrete. The One Water LA team reached out to both to understand better their process and how they encouraged RMCs to use RW.

California Department of Transportation (Caltrans)

Caltrans carries out its mission of providing a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability, with six primary programs: Aeronautics, Highway Transportation, Mass Transportation, Transportation Planning, Administration, and the Equipment Service Center. Their office of Construction Contract Standards develops and revises construction contract standards that include the Standard Specifications, Standard Plans, Standard Special Provisions (SSPs), Standard Item Codes, Bid Book, and the Notice to Bidders (California Department of Transportation, 2015). As mentioned earlier, Caltrans provides specifications to the concrete suppliers on the water quality for concrete mixing. These specifications were started in the 1940-1950's, with the water quality testing section being relevant at that time since people received the water from various sources, such as lakes, ponds, etc. The concern with admixtures initially brought up by LADBS was not a concern at the

time of the development of the specifications since the use of admixtures did not start until the 1970's.

Caltrans requirements for water used in concrete mixes are in Section 90-1.02D of the 2010 Standard Specifications and apply to all water that is non-potable. According to Caltrans, as long as the water meets these specifications, any water can be used for concrete mixing. To make sure the producers of concrete adhere to these specifications, Caltrans visits the concrete plant's site and takes a sample of the concrete. They also test the water quality source, unless the source is a WRP. WRP's test the water on a regular basis to confirm the water quality meets Title 22 standards. No additional water testing is required, if the WRP tests, for RW.

Division of State Architect (DSA)
The Division of the State Architect (DSA) provides design and construction oversight for K–12 schools, community colleges, and various other state-owned and leased facilities. The Division also develops accessibility, structural safety, and historical building codes and standards utilized in various public and private buildings throughout the State of California. In April 2014, DSA issued the Interpretation of Regulations (IR) 19-5. This Interpretation of Regulations (IR) provides general requirements for the acceptance and use of mixing water from various sources of water used in concrete mixes for projects under the jurisdiction of the Division of the State Architect (DSA). Water sources may include:

- Potable water
- Non-potable water
- Water for concrete production operations
- A combination of potable water, non-potable water and/or water from concrete production operations.

When speaking with DSA's supervising structural engineer, he mentioned the IR was simply done as a reminder that non-potable water use is allowed as long as it meets ASTM 1602 Standards. The ASTM 1602 Standards are highlighted and required to be meet in the IR 19-5. The reminder was necessary since a few of the concrete producers complained that their concrete mixed with non-potable water wasn't being accepted by architects, construction managers, and those overseeing school construction projects. The DSA mentioned there have been no issues reported since the IR 19-5 was issued. However, within the City of LA, the regional DSA manager did not understand that RW was allowed and told the One Water LA team that RW could not be used for LA Unified School District projects. Later, the Structural engineer from the DSA headquarters informed him that RW was allowed.

SECTION 4-OPPORTUNITIES AND BENEFITS

There is significant potential for additional RW use in the City. With the cost for imported water increasing and its availability diminishing, the use of RW for non-potable purposes is not only cost efficient, but a great use of the City's current resources.

Figure 2 displays the current concrete suppliers around the Los Angeles area, the current and future RW lines, and the current recycled water fill stations. The RW lines shown are those owned

or proposed by the City of Los Angeles and a variety of other RW producers and purveyors throughout Los Angeles County. Based on **Figure 2**, the potential for RW was estimated based on the proximity to an existing or future RW line. There are currently 25 concrete suppliers within 3 miles of a RW line.

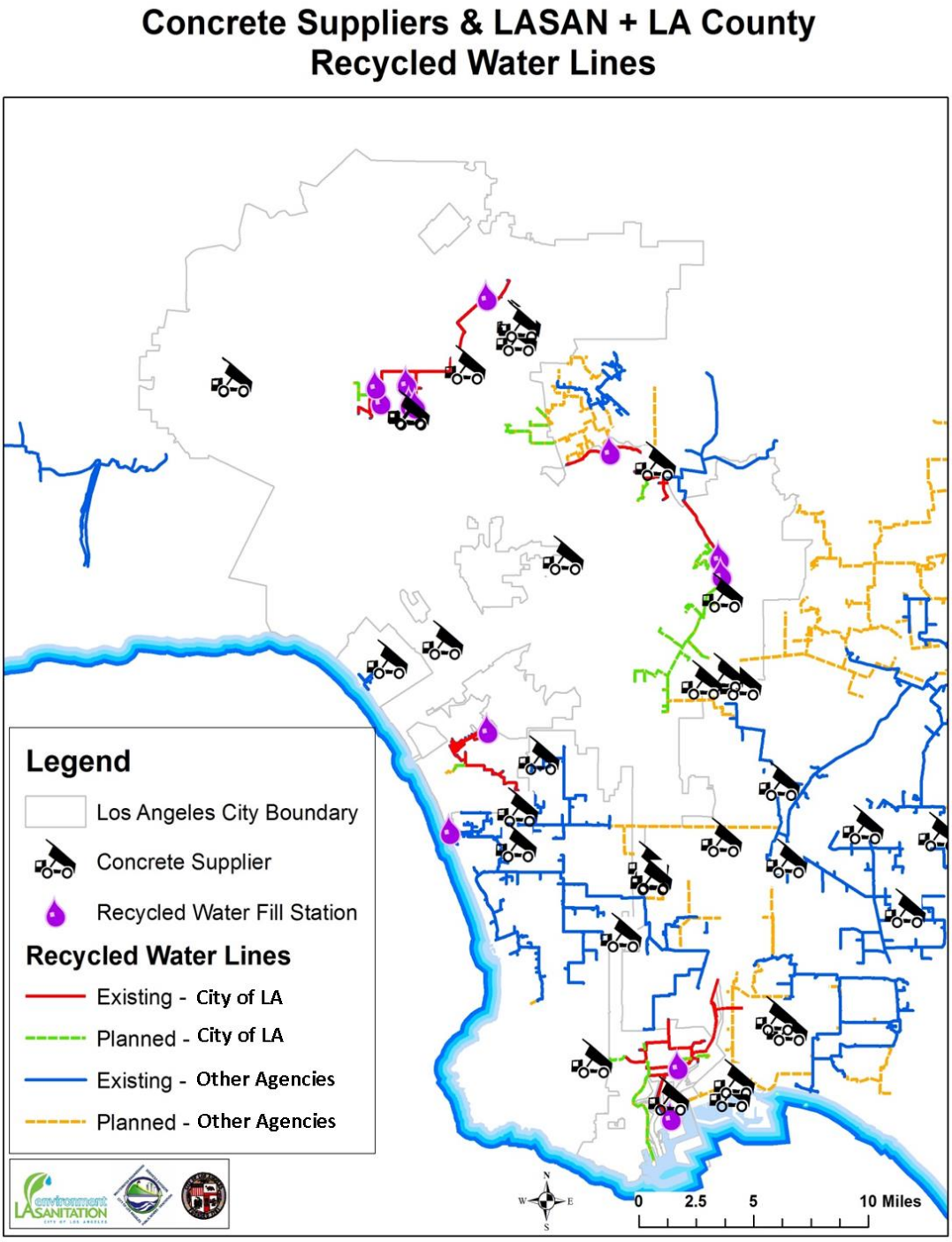

Figure 2:
Concrete Suppliers Map

Cost

Once **Figure 2** was developed, the One Water LA team looked at all concrete suppliers within a 5 km (3 mile) distance to either a City's existing or planned RW line or a RW line from other water agencies. All 25 concrete suppliers were within a 5 km radius of a recycled water pipeline. The distance of necessary pipeline needed to connect the concrete supplier to the nearest RW line, along with its estimated cost was calculated.

Table 9 summarizes the distance and cost for a connection to a City RW line. For existing RW lines, there are total of 8 concrete suppliers within a 5 km distance. Assuming $1 million/mile of pipeline, the total cost to connect the concrete suppliers to an existing City RW line is approximately $10,310,000.

Table 9:
Distance and Cost of City of LA's Concrete Supplier Connection

RW Line	Concrete Supplier	Address	Water Reclamation Plant Source	Distance to RW line (km)/ (mi)	New RW Line Cost
Existing					
	A&A Ready Mixed Concrete	8946 Bradley Ave	DCT	2.86/ (1.78)	$1,780,000
	Alliance Ready Mix	9048 Bradley Ave	DCT	2.62/ (1.63)	$1,630,000
	Bonanza Concrete	15115 Oxnard St	DCT	0.58/ (0.36)	$360,000
	CalPortland Company	401 Canal St	TI	0.89/ (0.55)	$550,000
	Catalina Pacific	8981 Bradley Ave	DCT	2.85/ (1.77)	$1,770,000
	Holiday Rock	11420 Penrose St	DCT	3.23/ (2.01)	$2,010,000
	National Ready Mix Concrete	9010 Norris Ave	DCT	2.83/ (1.76)	$1,760,000
	National Ready Mix Concrete	15203 Oxnard St	DCT	0.72/ (0.45)	$2,450,000
Planned					
	Robertson's Ready Mix	13132 Raymer St	DCT	1.16/ (0.72)	$720,000
	A&A Ready Mixed Concrete	2730 E Washington Blvd	LAG	0.92/ (0.57)	$570,000
	Cemex	625 Lamar St	LAG	0.18/ (0.11)	$110,000
	Robertson's Ready Mix	26311 Palos Verdes Drive	TI	3.09/ (1.92)	$1,920,000
			Subtotal	21.94/ (13.63)	$13,630,000

Table 10 summarizes the distance and cost for a connection to a RW line other than the City of LA. For existing RW lines, there are a total of five concrete suppliers within a 2.5 km distance. Assuming $1 million/mile of pipeline, the total cost to connect the concrete suppliers to an existing RW line is approximately $1,480,000.

Table 10:
Distance and Cost of Connecting To Other Concrete Suppliers

RW Line	Concrete Supplier	Address	Distance to RW line (km) / (mi)	New RW Line Cost
Existing				
	A&A Ready Mixed Concrete	1620 19th St	0.19/ (0.12)	$120,000
	Catalina Pacific	19030 S Normandie Ave	1.77/ (1.1)	$ 1,100,000
	Cemex	505 Railroad Pl	0.24/ (0.15)	$150,000
	National Ready Mix Concrete	4549 Brazil St	0.16/ (0.1)	$100,000
Planned				
	A&A Ready Mixed Concrete	100 E Redondo Beach Blvd	1.58/ (0.98)	$980,000
	A&A Ready Mixed Concrete	134 W Redondo Beach Blvd	1.56/ (.97)	$970,000
	Catalina Pacific	1862 E 27thh st	0.74/ (0.46)	$460,000
	Cemex	601 Pier D Ave	0.69/ (0.43)	$430,000
	Robertson's Ready Mix	301 W Rosecrans Ave	0.39/ (0.24)	$240,000
	Robertson's Ready Mix	1605 Pier D St	0.45/ (0.28)	$280,000
	Robertson's Ready Mix	3365 E 26th St	2.11/ (1.31)	$1,310,000
		Subtotal	9.88/ (6.14)	$6,140,000

A total cost of $19,770,000 is needed to connect all 25 concrete suppliers, those close to RW lines, to both existing and planned RW lines.

Benefits

There are several benefits associated with using RW in concrete, if implemented, including: economic savings in the public and private sectors due to reductions in water cost, demonstrating to the public that the City of Los Angeles is evaluating numerous opportunities to save potable water per State mandates, and decreasing the demand on its limited imported water supplies.

There is a market within the Los Angeles area to use RW for concrete mixing at the 40 concrete plants in the region. With the improvement in the economy, there is an increase in construction, including concrete production. For example, Metro alone is expected to pass a transportation bond in 2016 that ranges between $40-120 billion. These projects will definitely have a concrete component and the demand for RW for these construction projects will increase.

According to California Construction and Industrial Materials Association (CalCIMA), 9.86 million cubic meters (12.9 million cubic yards) of concrete were produced in Southern California in the year 2014. This is broken down by county as follows:

1. Los Angeles – 3.67 m^3(4.8 yd^3)
2. San Bernardino – 1.45 m^3 (1.9 yd^3)
3. Riverside – 1.38 m^3 (1.8 yd^3)
4. Orange – 1.30 m^3 (1.7 yd^3)
5. San Diego – 1.61 m^3 (2.1 yd^3)
6. Santa Barbara/Ventura – 0.38 m^3 (0.5 yd^3)
7. Imperial – 0.038 m^3 (0.05 yd^3)

Below, **Table 11** presents an estimation on the amount of savings per year, assuming 2014 rates of concrete production. Accordingly, there is a potential to save more than 8 billion liters of water (2 billion gallons) each year in Southern Ca and 3 billion liters in the City of LA if potable water is switched to RW in concrete mixing by all concrete manufactures in Southern California. Given the public works projects expected in the transportation sector, this is a conservative number and expected to increase significantly.

Table 11:
Example of Annual Water Benefits

Region	Concrete Produced (Million m^3)	Potential Potable Water Saved (Million L)[1]	Min. Annual Savings to Concrete Industry due to using RW instead of Potable[3,4]
Los Angeles	3.67	3,087	$751,665
Southern California[2]	9.86	8,294	$ 2,012,270

Notes:
[1]170 gallons per 1 yd^3 of concrete produced (Silvia and Naik, 2010) is the same as 643.5 Liters of water used per 0.765 m^3
[2]Assumes all concrete mixing, in Los Angeles and Southern California, is done using RW (12.9 M cu yd)
[3]Assumes $1,000/acre-foot. (There are 1,233,000 L/acre-foot)
[4]An assumed 30% cost savings is presented – this can vary

For concrete suppliers, the benefits can include:

- Industry-related economic savings-Cost for recycled water is lower than potable water
- Potable water resiliency- Decreases demand on imported water and water supplies
    - Assists in meeting the Mayor's potable water reduction targets by 2035
    - Is in alignment with Executive Directive #5
    - Marketing benefits- Public and private entities can brand their concrete as: "Green Concrete" or "Sustainable Concrete" to promote sustainability practices

SECTION 5 - ACTIONS TAKEN

Since the beginning of this evaluation and effort, it was noted that there were some very simple and straight forward actions that could take place. To expedite the City wide adoption of RW use in concrete mixing, the LASAN recognized that there were two areas that required immediate action. This included additional water quality testing and updating specific specifications, which are used by all design and construction professionals. Both efforts took place in the Public Works department and are described below.

Additional Water Quality Testing

To make sure that all constituents could be evaluated to meet the regulations for concrete mixing, additional constituents are now tested. This should assist with RMCs not having to take additional water samples and will allow them to be able to present results that are relevant to concrete mixing. Therefore, the City has added the following constituents to its regular quality testing of treatment plant effluent:

- Sodium
- Potassium

These constituents need to be tested to determine the level of Alkali in the Recycled Water. Alkali is one of the monitored constituents needed as part of the concrete water quality requirements. The testing for these two constituents began in January 2016 and will be tested regularly from now on. The testing will assist in keeping track of the Alkali level in the RW.

Concrete Specification Modifications

With the City of LA Bureau of Engineering participating in the evaluation and validity of using RW in concrete, the One Water LA team was able to move forward in modifying specific specifications that are used in designs and construction. The following specifications have been revised, as of 2016, to allow recycled water in concrete mixing:

- Section 03300 Cast in Place Concrete [long form], Article 2.1.D.5
- Section 03310 Cast-In-Place Concrete [short form], Article 2.8.D.3
- Section 03314 Surface Cleaning & Preparation, Article 2.01.A

These specifications are part of the City of Los Angeles, Bureau of Engineering's (BOE) Master Specifications Library. Below summarizes the modified and/or additional language in each specification.

- **Section 03300 Cast in Place Concrete [long form], Article 2.1.D.5:**
  - *Notice To Specifier: For Municipal Facilities Projects - recycled water is an acceptable alternative to potable water. While different levels of recycled water purity exists, depending on the intended end use, the Building Code and various other standards have for some time now published acceptable thresholds under which it can be used for constructing concrete facilities.*
    - "Water for mixing shall conform to ASTM C 1602 and be clean and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities. The use of qualifying recycled water is encouraged."

- *Notice To Specifier: All Others using SSPWC – recycled water is an acceptable alternative to potable water. For some time now, the Standard Specifications For Public Works Construction (SSPWC) has published the purity thresholds that recycled water must meet under which public works concrete structures can be constructed. These limits meet or exceed those of ASTM C 1602.*
  - "Water for mixing shall conform to the SSPWC, Section 201-1.2.3, "Water". The use of qualifying recycled water is encouraged."

- **Section 03310 Cast-In-Place Concrete [short form], Article 2.8.D.3:**
  - *Notice To Specifier: Recycled water is an acceptable alternative to potable water. While different levels of recycled water purity exists, depending on the intended end use, the Building Code and various other standards have for some time now published acceptable thresholds under which it can be used for constructing concrete facilities.*
  - "Water for mixing shall conform to ASTM C 1602 and be clean and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities. The use of qualifying recycled water is encouraged."

- **Section 03314 Surface Cleaning & Preparation, Article 2.01.A:**
  - *Notice To Specifier: All Others using SSPWC – recycled water is an acceptable alternative to potable water. For some time now, the Standard Specifications For Public Works Construction (SSPWC) has published the purity thresholds that recycled water must meet under which public works concrete structures can be constructed. These limits meet or exceed those of ASTM C 1602. Since the primary use of the water under this Section is intended to clean the inner surface of an existing sewer, more generous thresholds should be considered.*
    - "Water: Water for mixing shall conform to the SSPWC, Section 201-1.2.3, "Water". The use of recycled water is strongly encouraged."

SECTION 6 – CONCLUSIONS AND RECOMMENDATIONS

The collaboration between City departments, the willingness of industry and manufacturers to explain to the City their concerns, made this effort possible. The results include specific steps one must make to allow the use of RW in concrete, which is in addition to policy and legislation. There are clarifications for industrial improvements for better implementation of RW in concrete. And, there are recommendations for education and outreach to specific groups in construction for better and improved usage.

The reclaimed water from the City's reclamation plants comply with the water quality requirements for RW in concrete. Tests were conducted and the results were found to meet regulatory requirements. Besides the progress being made on the technical issues, an outreach effort was made to the Ready Mix Concrete community, which included companies and trade organizations. The goal was to understand their current participation in the use of RW in concrete as well as to identify any potential roadblocks.

Based on discussions and interviews performed, it was determined that the interest in RW exists among concrete suppliers, primarily due to economic reasons and reliability. However, there

seems to be a liability concern due to contractual agreements, usually in the design specifications. In some instances, only potable water in the concrete mix is allowed. The practice to specify potable water could also be due to lack of more publicly available documentation that no negative effects have been observed when RW is used in concrete. In addition, the lack of economically accessible RW continues to be a deterring factor.

Overall, this research clearly shows that the use of locally available RW in concrete can be a viable means of potable water conservation and economic savings for owners, contractors, and the public. However, there are still some recommended policy and legislative changes to insure the industry does not have roadblocks for implementation. Concrete suppliers would like certain steps taken to make RW more physically and contractually available.

In conclusion, BOE pointed out that the use of RW in Public Works projects is fully supported and approved. However, due to limited RW access, BOE does not explicitly require the use of RW, but it does encourage it. It should also be noted that from an outreach effort through this study, at least one of the commonly used Ready Mix Concrete suppliers of Public Works jobs, already uses reclaimed water in some of its plants.

In understanding the above discussion, it should be noted that concrete requirements for construction projects in the Public Right-of -Way are established by the governing agency such as BOE. For projects on private property, they follow project specific specifications prepared by the RDP as noted earlier. While LADBS administers and enforces the latest Los Angeles Building Code, the RDP (usually composed of a Structural Engineer) has the authority, and typically does, require the use of potable water for concrete mixing. As noted earlier, efforts were made to include RMC in this discussion. In so doing, one of the key comments made by RMC was that they would be more willing to change and to use RW if the private development Structural Engineers allowed it, instead of typically specifying potable water. As such, further outreach is needed to help Structural Engineers of private development projects to become more comfortable with using RW in concrete.

On the basis of this study, the following recommendations to facilitate the use of RW in concrete mixing are presented:

- Work with the Department of Consumer Affairs to distribute the information to all Engineers and Architects so that specifications are not written requiring potable water.

Educate Structural engineers or anyone else writing concrete specs re: Recycled Water, Recirculated Water, Greywater, etc.

- Educate City staff , both field and office, as well as contractors, and construction workers about the safety of RW
    - Develop a RW user manual
    - Incorporate WateReuse Association materials
- Determine if additional language needs to be written in policies or if legislative action is required for liability purposes so that contractors & manufacturers can use recycled water in concrete.
- Identify what it will take to require RW in concrete for ALL City/County/State contracts (or if even possible)
- Determine what is needed to address safety concerns to educate concrete plant workers, contractors, City staff (field,etc), and construction workers.
- Reach out to other public entities (counties, cities, and others letting construction contracts) about RW opportunities in concrete (model after Caltrans).
- Determine opportunities to connect concrete suppliers to a RW supply line with effluent coming from a WRP that meets all ASTM, GreenBook and Caltrans water quality requirements.
- Identify previous concrete performance testing studies to improve the perception of RW use for concrete production.
- Consider public-private funding or other types of funding of the RW line to the concrete mixing plants
- Change "Potable" to "ASTM 1602 complaint" in all design specifications (see City of LA's BOE revised concrete specs).
- Understand how to make sure that Structural Engineers, both public and private, such as a Developers structural engineer, cannot choose potable water over RW, if RW is available in an adequate quantity and meets specified quality. This means that potable water cannot be written in to the concrete specifications for the project.
- Reach out to U.S Green Building Council to consider points for RW use for concrete production as a part of LEED Certification.
- Determine if extra 'points' are to be given or a preference is given by a public entity to construction bids with concrete produced with RW.
- Work with Regional entities, such as Metro, High Speed Rail, Metropolitan Water District, etc., to determine if their specifications currently state "ATSM 1602 compliant" or "potable water must be used" in their concrete mix. If specifications state "potable water", determine how the specifications can be changed to "ASTM 1602 compliant".
- If there are there any contracts, specifications, and/or agreements that state that potable water has to be used for concrete production, instead of "ASTM 1602 compliant" then a revision should be considered.
- Determine how to address commercial and private entities whose structural engineer prefers potable water over ASTM 1602 complaint when writing the concrete specifications.

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