This section does not provide a clear set of plant targets, specifically target treated flow and water quality. We recommend these be included at the front of any future OMMP document.

Recommendation: This section contains good information that will be useful in plant operation. We recommend that the system be updated to include the current plant configuration. This may be best completed following the upgrade of the plant which is currently under way. We further recommend that some detail items (such as equipment part numbers) be removed from this section and included either in an appendix or in equipment asset registers.

OMMP Section 2 – Process Description

This section provides a brief process description for operation of the plant. This provides a broad process overview and some knowledge particularly of RO system and H2S stripping and scrubbing information. Additionally information detailing the operation of the clearwell to meet CT requirements for 4.0 log virus inactivation is included.

A flow diagram is noted, but not included, in the document.

Recommendation: A process description with a process flow diagram is a useful inclusion to the OMMP. We recommend that this information be updated.

OMMP Section 3 – System Safety Precautions

This is a relatively short section of the document which includes general safety requirements for the plant. It provides a very high overview of requirements, but provides very few specific details on safety. For example, a lock-out tag-out procedure is recommended for electrical devices, however there is no reference to what the procedure is or where it can be found.

PPE is referred to, however there is no specific list of what PPE is required, where it is located and how it is managed.

Chemical safety is discussed briefly however no specific procedures are referred to either later in this document or elsewhere. MSDS documents are referred to as located in the document, but they are not included.

Recommendation: We recommend that this section be entirely re-written to provide a more specific, and detailed safety plan for the site. This should include as a minimum:

- Safety training requirements for staff.
- Hazardous chemicals.
- PPE requirements for site including what is required in specific plant locations, and where PPE is kept.

- Emergency procedures (unless included in a separate plan)
- MSDS sheets for current chemicals.
- Safety incident management.
- Lock/out tag out procedures
- Working with contractors on site.
- First aid

We further recommend that this be consistent with City wide safety management systems.

OMMP Section 4 – Process Controls

This section provides an overview of controls system architecture, control philosophy and a detailed review of plant SCADA screens and functionality.

This information is critical for the operation of the plant, however the material documented within the OMMP does not appear to be consistent with the existing SCADA system. This may be due to a SCADA upgrade that has occurred since the original writing of the document. As this is the only document sighted that details SCADA operation screens – which are at the heart of plant operation – we recommend that this section be extensively re-written to correctly provide operating guidance.

Recommendation: We recommend a significant re-write of this section to reflect the currently configured SCADA controls system.

OMMP Section 5 – System Operations

This section provides both system start up procedures and some limited operating procedures for the RO system only. It refers to other equipment system documents that have not been sighted (for example Volume 2 Equipment Data Sheet and Vendor Manuals) and to sections which may refer to a previous manual.

In general, the procedures to not provide sufficient detail for operation, and do not include significant portions of the plant equipment and process.

Recommendation: We recommend that these procedures be re-written, perhaps stand-alone from the OMMP, and include more specific detail to ensure they can be adequately followed by plant operators. The procedures should include:

- Version and revision dates to ensure they are current.
- A regular date of review.
- Specific valve, equipment and instrument numbers where these are referred to.
- Photographs of equipment, to assist operators identify equipment.

OMMP Section 6 – Operating Permits

This section provides a list of operating permits for the plant. It is a useful summary, and we recommend that this simply be updated regularly to ensure that it is current.

Recommendation: Provide regular update to ensure this is current.

OMMP Section 7 – Monitoring and Sampling

The monitoring and sampling section provides a series of monitoring log sheets and operating schedules for the plant. There are two operating log sheets included:

- A daily log sheet

  The first log sheet is focused entirely on the reverse osmosis unit, with daily logs required of specific analyzers, with some specific samples to be taken also A facility operating log

- Facility Operating Log

  This contains more overall performance measures, however still focuses largely on the reverse osmosis unit. Prior to this log sheet, the OMMP refers to a process monitoring software (OpsWin™) which is to be used to provide operational performance reporting and process optimization.

It appears that these log sheets and the discussion of optimization software may be a remnant of the original DBO operations manual. The log sheets have both been superseded with the current weekly operating log (discussed in section Plant Performance Monitoring and Reporting). To the knowledge of the writer, there is no optimization software currently in use at the facility.

Recommendation: These operating logs be replaced with the updated operating logs based on current operations and modifications based on recommendations. It is important that we are reviewing all aspects of the plant, not only the RO system.

- Process Monitoring Analyzers

  Additional to the log sheets is a list of online process monitoring analyzers. This identifies the analyzer, instrument tag number (important for SCADA identification), manufacturer, model number and importantly calibration frequency. The table provides a useful list of analyzers and identification to allow collection of trends from the HMI computer. The calibration information is a useful list, however many of the frequencies do not appear to be correct for those particular instruments.

Recommendation: We recommend that a separate calibration schedule be developed for on line analyzers, and reviewed against manufacturer's recommendation and experience of other like facilities. Additionally, calibration records should be developed and retained as evidence of calibration.

- Process Daily, Weekly and Monthly Monitoring

  Two tables show a daily and weekly internal process monitoring schedule for on-site water quality analysis. This includes a number of parameters in the influent, RO permeate, RO concentrate and final effluent streams. This is non-regulatory monitoring, and to our knowledge few of the listed items are currently being monitored or reported. On review we believe that some would be helpful, while others may be redundant as they are already adequately managed by on line monitoring.

Recommendation: A revised on site laboratory monitoring document be developed to include important and useful parameters for analysis. This may be considered as part of the overall Water Quality Management Review

- Regulatory Sampling and Analysis

  There are four log sheets covering regulatory sampling requirements. It appears that this list may be somewhat out of date, and does not include all of the regulatory sampling and analysis required.

Recommendation: Revert to the work currently being completed as part of the Sampling Manual (and possible future Water Quality Plan) for regulatory water quality sampling and reporting. This may be integrated at a later stage in the OMMP.

- Contractual Reporting

The final part of this section includes a list of contractual reporting requirements. It would appear that these are a remnant from the original DBO operations contract which specified some regulatory, but also some contractual water quality requirement. Some no longer have contractual relevance, and many are already requirements mirrored in existing regulatory requirements. There are, however, some parameters that are important for managing plant infrastructure (such as water stability indices) which we will recommend are added to current water quality monitoring.

Additionally, a single, clear location that outlines water quality targets is very helpful for plant operation. These recommendations are outlined in the discussion on water quality management.

Finally in this section, schematics of regulatory sampling locations, daily plant flow meter logs and a monthly monitoring report are shown as sub-headings, but those schematics and logs do not appear in the report. (The daily plant flow report has been sighted as a spreadsheet in use).

OMMP Section 8 – Chemical Storage and Handling

This section provides a set of standard operating procedures for each of the chemicals used on site. These procedures are provided in a reasonable format, with the majority of important information including safety information contained in each. These procedures are originally from the DBO contract, although have been updated as per 2011 and have a revision included in the document.

It is important to note that the current dosing pump arrangements have been modified since the original design and consequently some of the information contained in these procedures will be incorrect or out of date.

A Fluoride procedure has been included along with this list, in order to meet the requirements of the most recent permit amendment. This appears to be more of a comprehensive manual than a simple procedure, and perhaps consideration could be given to this as a stand-alone section.

MSDS documents are referred to throughout, along with references to other chemical industry training and documentation resources. We recommend that where possible, documents or a document location be provided as a part of this procedure. For external industry information, web addresses and phone numbers are very helpful.

Recommendation: Update and revise standard procedures for chemical handling to reflect current equipment and chemical usage. Ensure that all external information referred to is available in a known location (e.g. MSDS).

OMMP Section 9 – Troubleshooting

This section provides a limited discussion of plant troubleshooting, primarily focused on the RO system. Much of the information is helpful, and can be incorporated along with other troubleshooting material that should be developed for other plant processes. It is general, rather than prescriptive, and can be a useful addition to other training material that should be developed.

OMMP Section 10 – Drawings

Drawings are not included in the OMMP.

Arsenic Blending and Treatment Plan

The final section of the report is an arsenic blending and treatment plan. This plan outlines both sampling and analysis and blending strategies to ensure that the plant final water is compliant with the arsenic MCL of 10 ug/L. It sets out requirements for regular well sampling, including field test kits. Additionally, it refers to an arsenic blending and treatment formula, which could not be found in the document.

During visits to site, we did not see any evidence of records of arsenic test kits in the field (although it is sampled by laboratories). Additionally, other than regulatory sampling we have not seen any reporting along the lines of this plan.

Recommendation: We recommend further review be conducted with a check of compliance against the current arsenic plan. Given that arsenic remains a risk due to levels in Well 4the plan should be in place.

Overall Recommendation OMMP Recommendation

The OMMP is a critically important document for operations, and should contain the key documented elements to operate the plant safely, reliably to meet production, water quality and other regulatory targets. The OMMP is an explicit requirement of the plant permit, and it must be kept current as a compliance requirement.

The current OMMP appears to not be up to date, incomplete in some sections and not in regular use. We anticipate that the version uncovered is the most recent lodged with California SWRCB, however we recommend that this be confirmed.

We recommend that the OMMP be used as the master document for operations, and that the framework within be upgraded and updated to reflect current (and improved) operations of the plant. This is best done in conjunction with the coming plant upgrade.

In its development, we need to strike a balance providing sufficient level of detail to satisfy regulatory requirements in the one document, and developing additional material that may be referenced by the OMMP, but not included with it. For example, some standard operating procedures, sample planning documents and other items may be referenced by the OMMP, but not included specifically within it. This provides flexibility on minor operational system changes that can be captured, but will not require a change to the master OMMP document itself.

Water Quality Monitoring and Reporting

The plant monitors treated water quality both internally to track operations performance, and also specifically for regulatory requirements. There are several sources of water quality information and a number of different reports.

Internal reporting

The internal reporting of treated water quality data at the plant comes from three sources:

- The Weekly Operating Log sheet.
- HMI Reports
- HMI pre-canned trends.

Weekly Operating Log Sheet

The Weekly Operating Log sheet is a comprehensive log sheet that is filled out at each shift. This log sheet contains data covering water quality and other general operational parameters throughout the plant. (More detail on the log sheet overall is discussed in section Plant Performance Monitoring and Reporting). There are approximately 5 on-line water quality analyzers that are regularly logged. (Note that the terminology for final treated water quality used at the plant is typically "Final Effluent"). These include:

- Final plant effluent pH.
- Final plant effluent turbidity (NTU).
- Final total blended product conductivity (uS/cm)
- Plant effluent chlorine residual (mg/L).
- Fluoride analyzer (mg/l)

This data does not appear to be graphed or reported elsewhere from these log sheets, but rather act as a confirmation that operators are conducting routine checks. In addition, there are on site laboratory tests conducted at the plant for:

- chlorine,
- ammonia and
- chloramine

which are conducted for both the clearwell (to check on free chlorine CT) and in the final effluent to confirm chloramine dosing targets and chlorine to ammonia ratios. These latter measures provide a verification of on line instruments.

HMI Reports

There is a HMI report entitled "Effluent Water Quality Report". This report contains final plant effluent pH, turbidity, free and total chlorine and fluoride – taken from on line analyzer data. It provides a daily maximum, minimum and average value.

Additionally, there is a Plant Effluent Chlorine 5 min average report, which provides 5 min average data for total chlorine leaving the plant.

These reports are used for regular reporting, and in particular reporting for free chlorine CT, as part of the 4 log removal requirements noted in the most recent permit amendment (see details below in regulatory reporting).

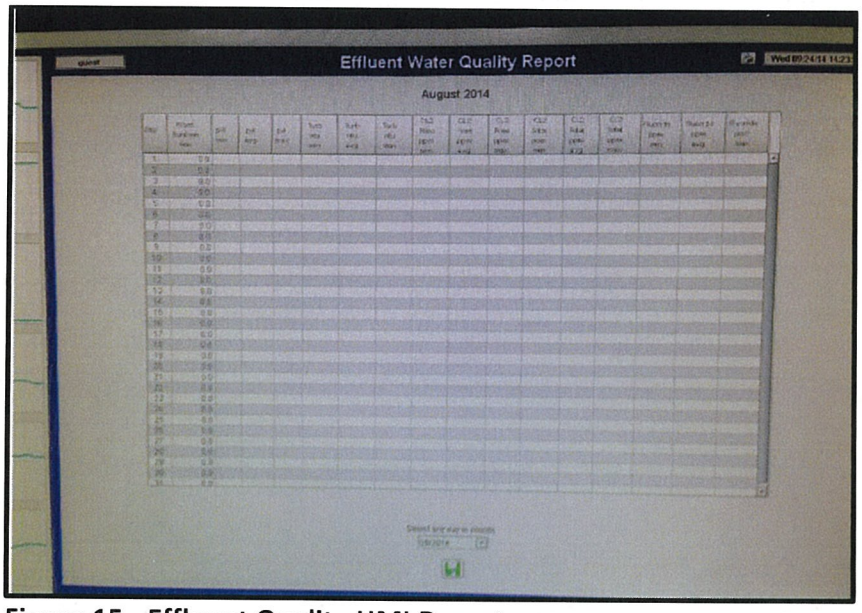


Figure 15 - Effluent Quality HMI Report

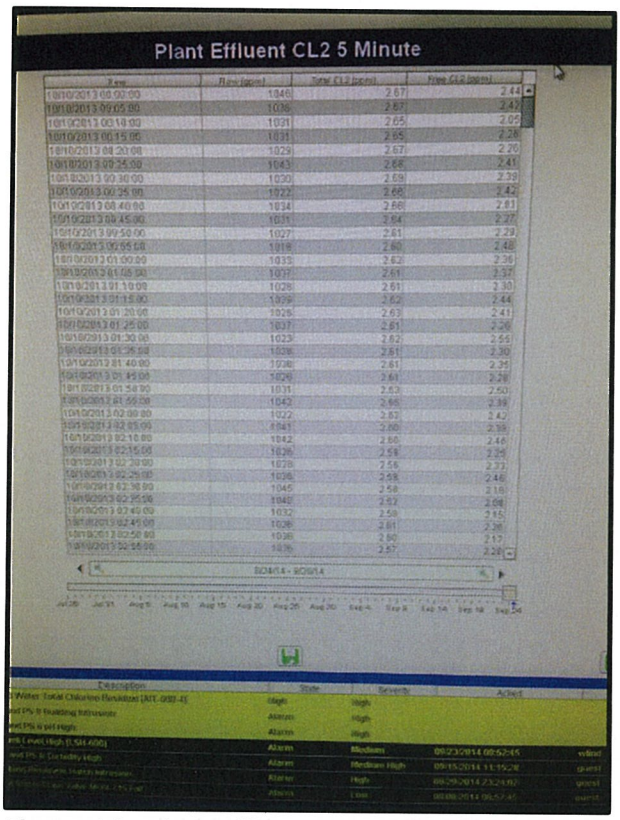


Figure 16 - Plant Effluent Chlorine 5 min Average Report

HMI Pre-canned Trends

There are a set of pre-canned trends that have been developed for final effluent water quality. These include trends of pH, turbidity, conductivity, chlorine and fluoride.

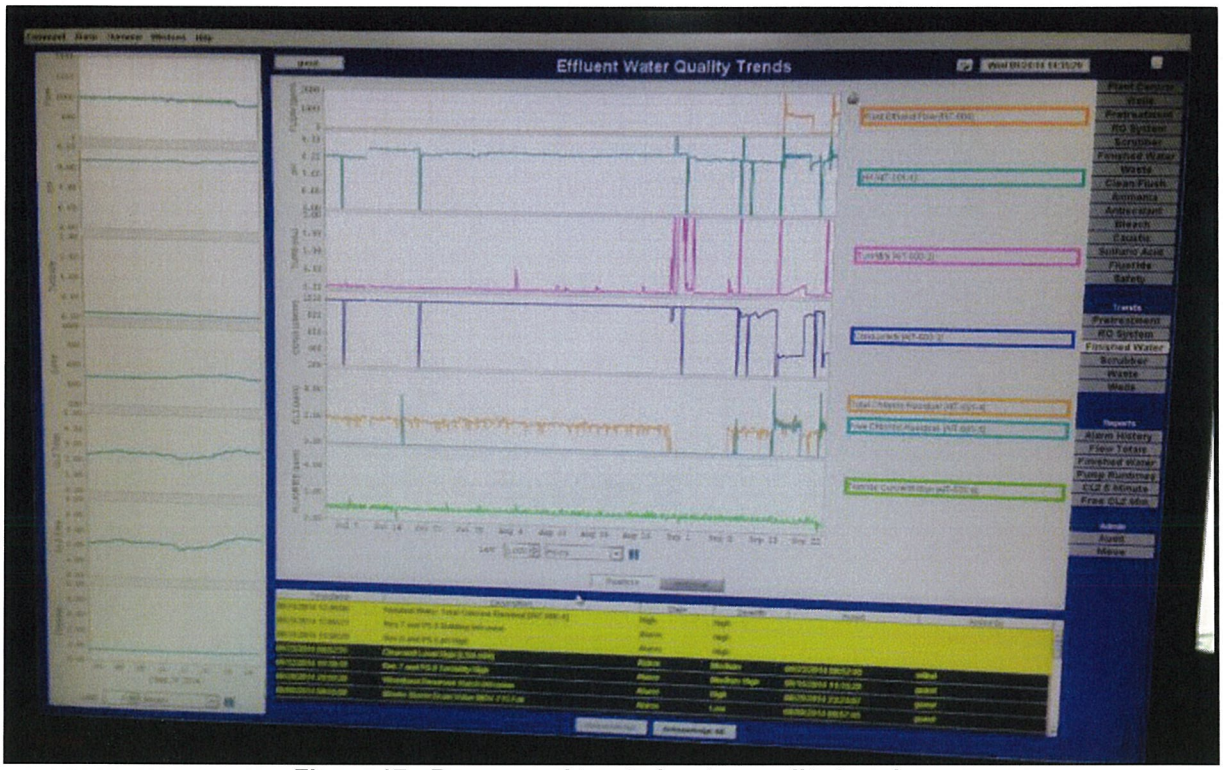


Figure 17 - Pre-canned treated water quality trends.

This data is used by operators for review of performance, but to our knowledge is not included in any other reporting.

HMI Custom Trends

It is possible to generate additional custom trends on the HMI for any of the on line analyzers that provide data in to the SCADA system. On option, regularly used by operators, is a trend that is available when mouse clicking on the analyzer to provide an up to date recent trend. It is typically used for short term operational review or operational troubleshooting.

A second option is the extraction of data via customized trends. It was not clear how this could be extracted from the HMI, although data was provided by the plant SCADA contractor to Hazen and Sawyer to provide membrane system performance trends. It is a typical function of all HMI systems, and may be located at a higher security level than is typically set during plant operation.

Recommendation: Customized trending is a very important diagnostic tool, and we recommend that this feature be enabled and operations staff trained in its use.

Regulatory Water Quality Monitoring

Water quality regulatory requirements for the plant can be complex to navigate, being based on numerous regulatory requirements which are not always documented by agencies in a format that is convenient to navigate. As a part of our review, we worked to cross check that all of the water quality regulatory requirements were being met, and were clearly documented.

In our search, we noticed that there were several internal sources of information that documented the requirements of water quality regulatory reporting. Commendably, the Water Quality Specialist had already begun tackling this issue, and has developed a Water Quality Sampling Manual, to capture all of the required regulatory sampling, monitoring and reporting. This is a work in progress, and we have included a cross-check in the tables below outlining the water quality requirements, and where these are documented, including if this is currently documented in the Sampling Manual.

As discussed previously in this report, we also noted some regulatory reporting requirements noted in the OMMP, although these appeared to be out of date.

In addition to treated water quality, there is also regulatory water quality monitoring required at each of the feed wells, within the water treatment plant, and also within the distribution system. Working with the Water Quality Specialist, we put together the tables below, which document what needs to be reported, how often, for which agency, and where this is currently documented in Beverly Hill's document system.

We have not provided in this section a comprehensive review of water quality performance, but rather focused on ensuring that reporting requirements are captured, and clear. The tables below detail our review of regulatory sampling, analysis and reporting for the water treatment plant, groundwater wells and distribution system. They list:

- What needs to be measured/reported?
- How often does it need to be measured/reported?
- Which agency/regulatory authority requires it, and in what permit/regulation?
- Where is this currently documented in the City's system?
- Is it listed in the new sampling manual?
- Did we sight the corresponding report delivered to the regulatory/permitting authority?

Recommendation – We recommend that the tables below be incorporated into a Water Quality Management Plan or Sampling plan as a checklist of all regulatory requirements.

Water Quality Regulatory Sampling Requirements

Water Treatment Plant Requirements.

Water Treatment Plant	Parameters Measured	Frequency of Sampling (and reporting)	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to SWRCB Sighted?
RO Effluent (Prior to Blending) PS Code 1910156-016	TDS (Total Dissolved Solids) HPC (Heterotrophic Plate Count) Total Coliform Sulfate Manganese Chloride Fluoride Arsenic	Weekly (Reported Monthly)	State Water Resources Control Board (formerly CDPH). Permit 04-15-03P-003 Table 6. Fluoride Permit Amendment 1910156PA-003 Table 6.	Listed in OMMP Page 7-14 for all but Fluoride and Arsenic. Arsenic - covered by Arsenic Blending and Treatment Plan part V Monitoring and Reporting. Fluoride listed in OMMP.	No	Yes
Plant Effluent combined treatment plant effluent after disinfection. PS Code 1910156-017	TDS (Total Dissolved Solids) HPC (Heterotrophic Plate Counts) Total Coliform Sulfate Manganese Chloride Fluoride Arsenic	Weekly (Reported Monthly)	State Water Resources Control Board (formerly CDPH). Permit 04-15-03P-003 Table 6. Fluoride Permit Amendment 1910156PA-003 Table 6.	Listed in OMMP Page 7-14 for all but Fluoride and Arsenic. Arsenic - covered by Arsenic Blending and Treatment Plan part V Monitoring and Reporting. Fluoride listed in OMMP.	No	Yes

Water Treatment Plant	Parameters Measured	Frequency of Sampling (and reporting)	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to SWRCB Sighted?
Plant Influent - combined raw water prior to RO treatment process PS Code 1910156-018	Arsenic Fluoride H_2S	Requirements not clear	Fluoride Permit Amendment 1910156PA-003 Table 6.	OMMP covers arsenic. Fluoride in revised permit. H_2S is by choice of the plant.	No	Yes
4-Log Virus Inactivation	Minimum free chlorine residual by on line analyzer.	Monthly	Permit Amendment 1910156PA-003 Condition 24	There is a CT spreadsheet used for calculation and reporting SWRCB. This is not documented in any procedures to our knowledge. (Note, we uncovered some minor errors in the spreadsheet which we have alerted to the Water Quality Specialist).	No	Yes

Recommendation – we note that HPC and coliforms are currently reported in the RO effluent. An RO unit's prime role in the plant is TDS/hardness reduction, and not microbiological removal. Given the fact that a portion of flow bypasses the RO in any case, and that there is now a CT managed in the clearwell to ensure 4 log virus inactivation, we recommend that the SWRCB be approached to remove this regulatory requirement. It is not uncommon for bacteria to be present in RO systems even in groundwater applications, especially as these usually do not have a continuous disinfection process. As many disinfectants (particularly chlorine) are not compatible with RO membrane materials, it is not practical to manage disinfection across the RO unit. Biological activity at the RO unit should be reviewed instead in the context of membrane fouling.

Well Monitoring.

In addition to the water quality sampling within the plant, the wells are also monitored in line with permit requirements. The table below summarizes the regulatory reporting requirements for the wells, and again cross checks these with current documentation.

Well Monitoring	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to SWRCB Sighted?
Monthly requirement	TDS (Total Dissolved Solids) HPC (Heterotrophic Plate Counts) Total Coliform Sulfate Manganese Chloride Arsenic Fluoride Dissolved H_2S	Monthly	CDPH Amendment 1910156PA-003 Condition 7 (This refers to Title 22, Chapter 15, CCR and Vulnerability Assessment and Monitoring Frequency Guidelines).	Sampling Plan OMMP Arsenic blending plan (attached to OMMP)	Yes.	Yes

Well Monitoring	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to SWRCB Sighted?
Annual Requirement	Benzene Carbon Tetrachloride 1,2-Dichlorobenzene 1,4-Dichlorobenzene 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethylene cis-1,2-Dichloroethylenetrans trans-1,2-Dichloroethylene Dichloromethane 1,2-Dichloropropane 1,3-Dichloropropane Ethylbenzene Methyl-tert-butyl ether (MTBE) Monochlorobenzene Styrene 1,1,2,2-Tetrachloroethane Tetrachloroethylene Toluene 1,2,4-Trichlorobenzene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichlorofluoromethane 1,1,2-Trichloro-1,2,2-trifluoroethane Trichloroethylene Vinyl chloride Xylenes Nitrates	Annually (Monthly if detected above MCL, quarterly if detected).	CDPH Amendment 1910156PA-003 Condition 7This refers to Title 22, Chapter 15, CCR and Vulnerability Assessment and Monitoring Frequency Guidelines. (Need to confirm most up to date monitoring guidelines. Appendix H in Permit is shown valid until 2004 – with no subsequent permit changes). Recommend regular review prior to each sampling run that	Sampling Manual OMMP	Yes	No

Distribution Monitoring.

Regular distribution modelling is also required. This is probably the highest burden for operators given the number and frequency of sampling, and has been the result of regulatory reporting non-compliance in the past. The table below outlines the routine sampling requirement, the Stage 2 DBP Rule requirements and lead and copper requirements.

The routine sampling in particular is well documented in the new Sampling Manual.

Distribution System	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to SWRCB Sighted?
Routine Sampling The City is required to collect a minimum of twenty one (21) Bac-T samples, seven (7) general physical, seven (7) fluoride and ten (10) nitrite samples each week. DHS has approved a sampling plan that insures at least one sample from each pressure zone is recovered each month.	Bac T at 21 locations.	Weekly (Tuesdays)	2.6.3.4 original permit Permit (original) 12 weekly samples among 19 locations. Now at all 21 locations by choice.	Sampling Manual. Not noted in the OMMP.	Yes	Yes
	General Physical 5 locations in distribution system and additionally 2 MW connections.	Weekly (Tuesdays)	2.6.3.4 Original permit. Requires 4 locations in the distribution system. Includes temperature, color, odor and turbidity.	Sampling Manual.	Yes	Yes
	Fluoride	Weekly Split sample (Tuesday) Daily (one of the four locations)	Condition 33, amended permit	Sampling Manual (to be updated for daily).	Yes	Yes
	Nitrite	Weekly (Tuesdays)	Original permit.	Sampling manual.	Yes	Yes

Stage 2 DBP Rule Samples recovered to insure compliance with the Surface Water Treatment Rule as it applies to the stage II Disinfection/Disinfectants By-Products Rule D/DBPR. Samples are recovered at the same locations as the general physical samples with at least four samples representing water with the maximum residence time in the distribution system.	TTHM, HAA5	Quarterly (taken on third week of the month)	Stage 2 DBPR and letter from CDPH noting that plant is at stage 2.	Sampling manual.	Yes	No
Lead and Copper	Lead, Copper. Based on a certain number of customers	3 years	EPA	Not captured.	No	No

Brine Waste Monitoring.

Brine discharge to the sanitary sewer is sampled quarterly and reported to LA County Sanitation District. Requirements are shown below.

LACSD	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to LACSD Sighted
LACSD (Brine)	pH Oil & Grease Total Dissolved Solids Total Cyanide Amenable Cyanide Arsenic* Lead* Nickel* Copper* Cadmium* Silver* Zinc*	Quarterly Annual summary report.	Self-monitoring for LACSD.	Sampling Plan	Yes.	No

	Total Chromium* *Composite Sample					

National Pollutant Discharge Elimination System (NPDES) Reporting

NDPES sampling is required on a quarterly basis from the wells, and monthly if there is a spill to storm water from wells during that month. This is documented in the Sample Manual.

NPDES	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to NPDES Sighted
NPDES (Wells)	pH TDS (Total Suspended Solids) Turbidity BOD (Biological Oxygen Demand) Settable Solids Oil & Grease Total Sulfides Total Phenols MBAS Copper Residual Chlorine Total Total flow to the storm water collection system in Million Gallons (MG)	Monthly (if discharge occurs). Quarterly	NDPES Permit # CI-8509 RO Water Treatment Plant	Sampling Manual Not mentioned in OMMP	Yes	No
	Acute Toxicity (EPA 600/4-90/027)	Annually	NDPES Permit # CI-8509 RO Water Treatment Plant	Sampling Manual Not mentioned in OMMP	Yes	No

In addition to the wells, samples are taken monthly, quarterly and annually from the parking structure on N Crescent Drive from the storm water collection system. Requirements are listed below.

NPDES	Parameters Measured	Frequency of Sampling and Reporting	Agency and location.	Where in Beverly Hills Documentation	Listed in Sampling Manual	Report to NPDES Sighted
NPDES (Site A South Storage Area)	pH TDS (Total Suspended Solids) Turbidity Oil and Grease BOD (Biological Oxygen Demand) Residual Chlorine Selenium Temperature Total Flow to the storm water collection system in Gallons per Day (GPD)	Monthly	NDPES Permit CI-6684	Sampling Manual	Yes	No
	pH TDS (Total Suspended Solids) Turbidity Oil and Grease BOD (Biological Oxygen Demand) Settable Solids Sulfides Phenols MBAS Residual Chlorine Selenium Temperature Total Flow to the storm water collection system in Gallons per Day (GPD)	Quarterly	NDPES Permit CI-6684	Sampling Manual	Yes	No
	Turbidity Total Suspended Solids	Annually	NDPES Permit CI-6684	Sampling Plan	Yes	No

	Oil and Grease BOD Settable Solids Total Sulfides Total Phenols Chlorine Residual MBAS Selenium pH Acute Toxicity EPA 600/4-90/027					

Internal Plant Process Water Quality Monitoring

In addition to regulatory water quality requirements, there are important additional internal water quality sampling and analysis requirements both in well feed water and internal to the process plant that are important to ensure that the systems are operating optimally, and to manage risk to those items.

A number of these are recorded on the weekly operating log sheet, and are available to view as trends on the HMI system (although most are not configured as pre-canned trends). However, there is no regular reporting of these parameters to provide a longer term review of how the plant and systems are operating.

We recommend that the following performance data be recorded and trended over time to monitor ongoing performance of specific plant areas/parameters.

Plant Area/Process	Specific Parameter	Frequency	Importance
Wells	Full Plant feed analysis (1) including cations/anions, suspended solids and pH.	Quarterly	It is important to regularly review a full cation and anion balance of the water to compare water quality against initial design considerations, as well as providing a check for potential RO performance risks (such as risk to treated water quality, and risk of scaling).
RO Feed	Full Plant feed analysis(1) including cations/anions, suspended solids and pH.	Quarterly	As above. Note that a change in well blend ratios will alter feed chemistry to the RO, and hence we need to review the range of possible chemistries that may impact the RO. While this water quality could be estimated based on a mass/flow balance of the operating wells, we recommend that an actual RO feed sample be taken as a confirmation.
RO Feed	Silt Density Index	Daily	This is currently conducted, however is not performed following the standard method (2).
RO Feed	pH	Daily	Important to check to minimize scaling risk and necessary for downstream pH target.
RO Permeate	pH, Alkalinity, H_2S	Daily	Useful as a check in performance of the stripping towers.

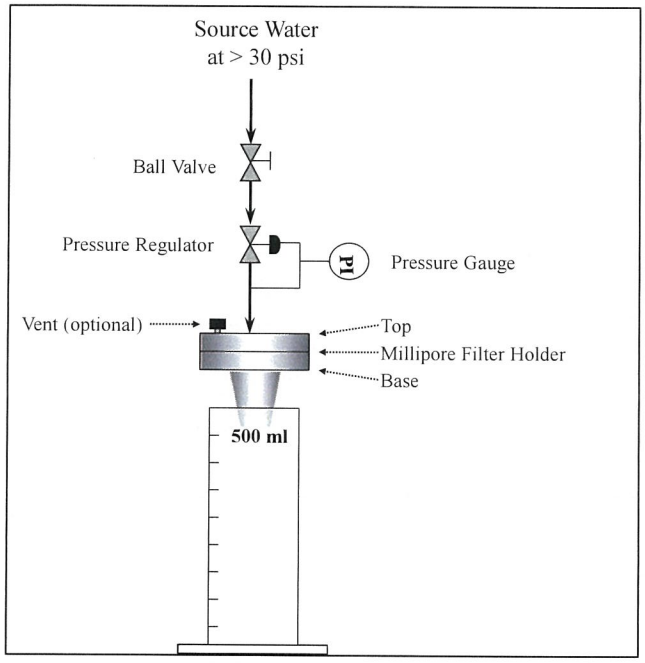
Bypass Stripping Tower Feed	pH, Alkalinity, H_2S	Daily	Useful as a check in performance of the stripping towers.
RO Permeate Stripper Sump	pH, Alkalinity, H_2S	Daily	To ensure performance of H_2S stripping – taste and odor.
Bypass Stripper Sump	pH, Alkalinity, H_2S	Daily	To ensure performance of H_2S stripping – taste and odor.
Scrubber	Hardness	Weekly	Ensure softeners are maintaining sufficiently low hardness to prevent scaling in the scrubber unit.
Plant Effluent	Calcium hardness, alkalinity, pH, TDS	Weekly	Used to calculate water stability index (LSI or CCCP) to ensure risk of concrete erosion is minimized.
Clearwell Effluent	Calcium hardness, alkalinity, pH, TDS	Weekly	Used to calculate water stability index (LSI or CCCP) to ensure risk of concrete erosion is minimized.

(1) Recommended Water Quality Plant Feed Analysis

Cations		**Anions**	
Sodium	mg/L	Chloride	mg/L
Potassium	mg/L	Sulfate	mg/L
Calcium	mg/L	Bicarbonate	mg/L
Magnesium	mg/L	Nitrate	mg/L
Iron	mg/L	Fluoride	mg/L
Manganese	ug/L	Silica	mg/L
Barium	mg/L	Phosphate	mg/L
Strontium	mg/L	TOC (Total Organic Carbon)	mg/L
Aluminum	mg/L	pH	
Arsenic	ug/L	Suspended Solids	mg/L
Boron	mg/L	Sulfides	mg/L

(2) Silt Density Index

The silt density index is a standard measure that has been developed to assess the plugging rate of a filter. It is used as a guide to determine the likelihood of fouling of the RO membranes from particulate matter. The test operates using a supply of RO feed water delivered at 30 psi across a 0.45 micron filter. A very simple test, water is run through the filter for 15 minutes. At the start of the test, the time required to fill a 500 mL measuring cylinder is recorded. At the end of 15 minutes, the time required to fill a 500 mL measuring cylinder is again recorded. Note that this is a recognized standard, and hence the pressures and volumes described here must be adhered to.



The SDI is calculated from the following formula:

$$SDI_{15} = \frac{100\,(1 - T_1/T_2)}{15}$$

Where T1 = the time to fill the cylinder at time zero and T2 is the time to fill the cylinder at time 15 minutes.

The RO membrane warranty will usually specify that RO feed water remains below a specific SDI value, which is typically between 3.0 and 5.0 depending on the water source and warranty provisions.

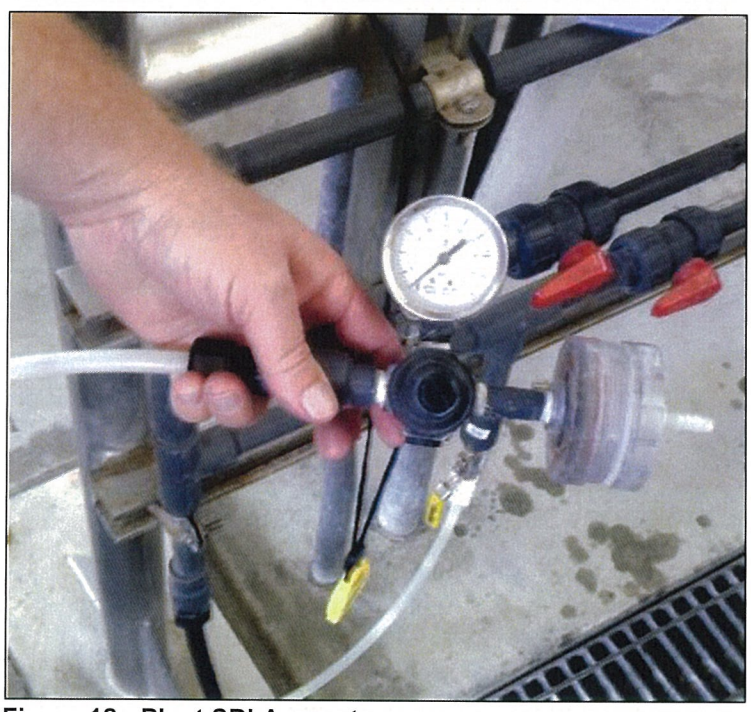


Figure 18 - Plant SDI Apparatus

Analyzer Calibration and Verification

Highly automated plants such as this RO plant rely heavily on the accuracy and reliability of water quality analyzers. It is very important, therefore, to be confident that the analyzers are reading correctly. Therefore, it is important that there is regular calibration of the instruments (where the analyzer is reset against a known standard) and regular verification (where the analyzer is regularly checked against a probe or on site laboratory test).

As previously discussed, a list of calibration frequencies have been listed in the OMMP.

Recommendation: We recommend that a calibration and verification schedule be established for analyzers, based on vendor recommendation and operational experience. This should include both a schedule of calibration and verification, and check sheets for each analyzer which can be kept as a record.

Water Quality Reporting

There is a great deal of water quality information that is reported both on the weekly operating log, from on line analyzers at the HMI, and in regulatory reports – mentioned above.

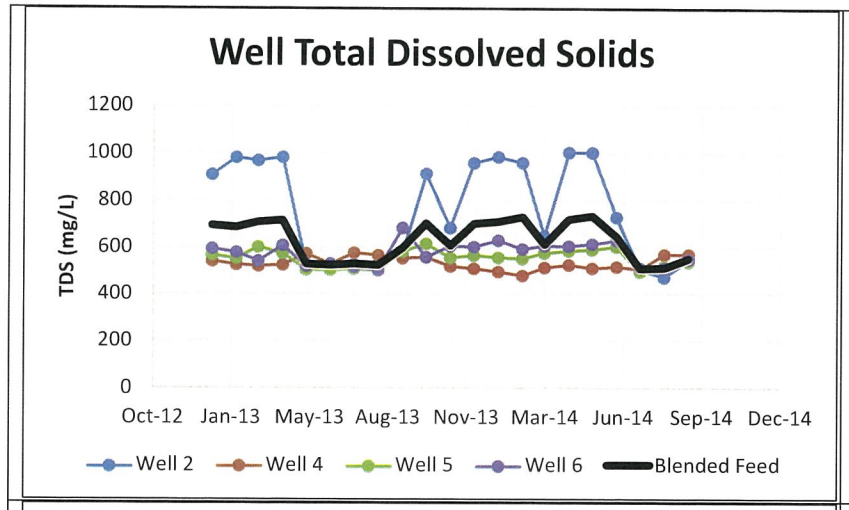
However, the data is not easily available, and is not regularly trended (except for the limited data at the HMI). We recommend that important water quality data be produced in trended reports to allow identification of any potential issues, and assistance for troubleshooting and optimization.

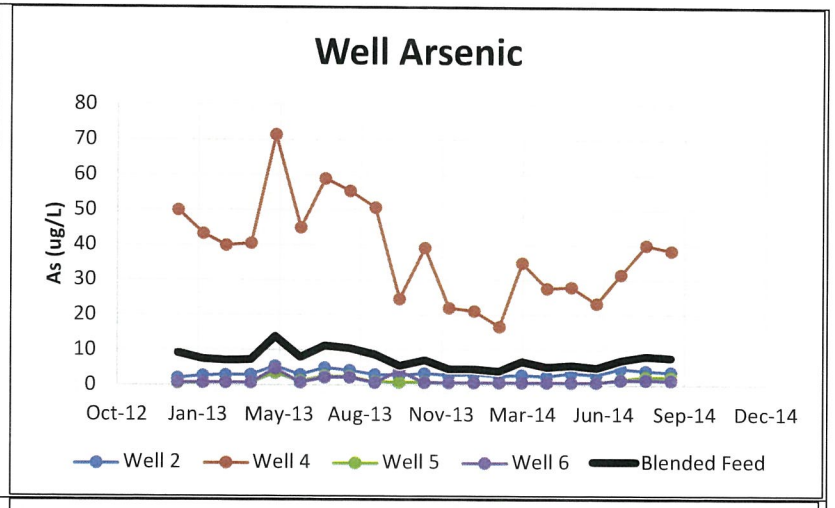
Well Water Quality

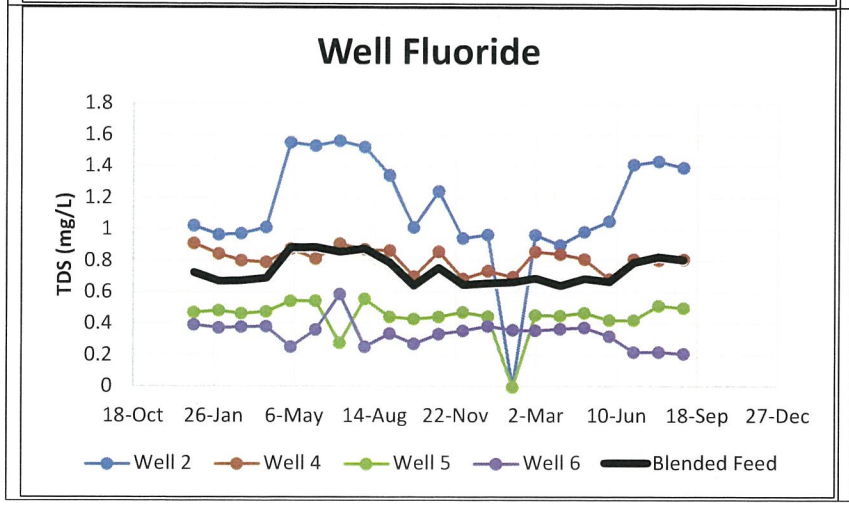
Water quality from each of the wells is analyzed monthly as described previously. We recommend that this data be regularly trended, to allow identification of some of the main water quality risks to performance, and to contrast water quality against original from plant design assumptions.

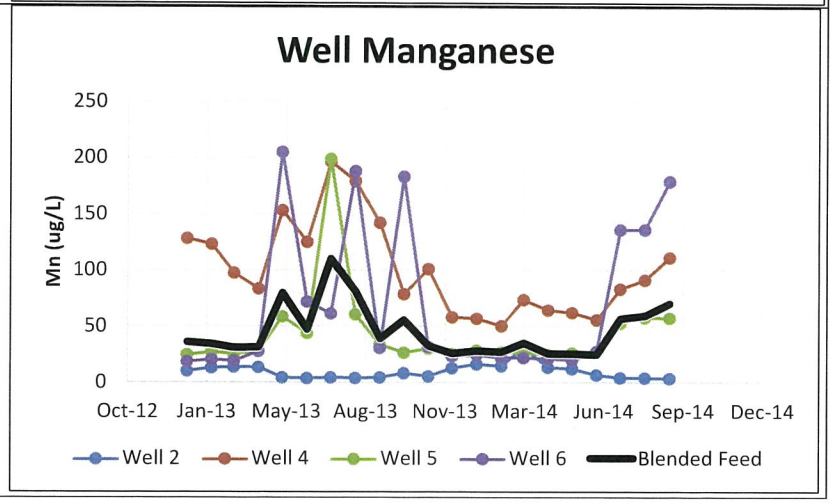
The data below shows trended feed water quality from each of the four operating wells. This is particularly useful, for example we can see significant fluctuation in the level of arsenic in well 4, which is vitally important as a part of the plant's arsenic management strategy. By presenting the data in a graphical format, it is easier to identify any trends and understand the extent of possible fluctuations.

On each chart, a black line provides an estimated theoretical blended value, calculated from a simple mass balance based on the flow contribution from each well. This provides estimated concentrations for plant feed water, and will be helpful where this is not already measured.


Well Total Dissolved Solids
TDS (mg/L)
1200
1000
800
600
400
200
0
Oct-12
Jan-13
May-13
Aug-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Well 2
Well 4
Well 5
Well 6
Blended Feed


Well Arsenic
As (ug/L)
80
70
60
50
40
30
20
10
0
Oct-12
Jan-13
May-13
Aug-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Well 2
Well 4
Well 5
Well 6
Blended Feed


Well Fluoride
TDS (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
18-Oct
26-Jan
6-May
14-Aug
22-Nov
2-Mar
10-Jun
18-Sep
27-Dec
Well 2
Well 4
Well 5
Well 6
Blended Feed


Well Manganese
Mn (ug/L)
250
200
150
100
50
0
Oct-12
Jan-13
May-13
Aug-13
Nov-13
Mar-14
Jun-14
Sep-14
Dec-14
Well 2
Well 4
Well 5
Well 6
Blended Feed

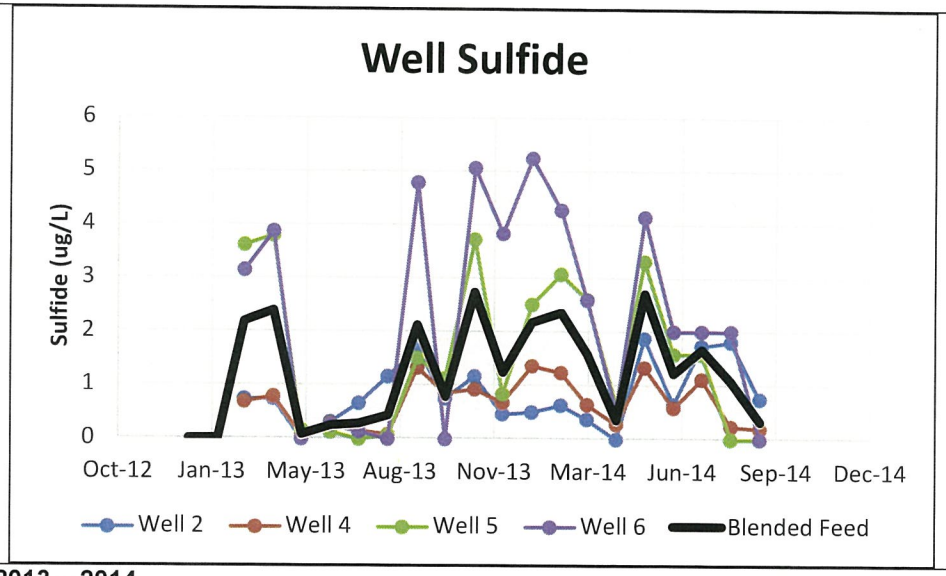
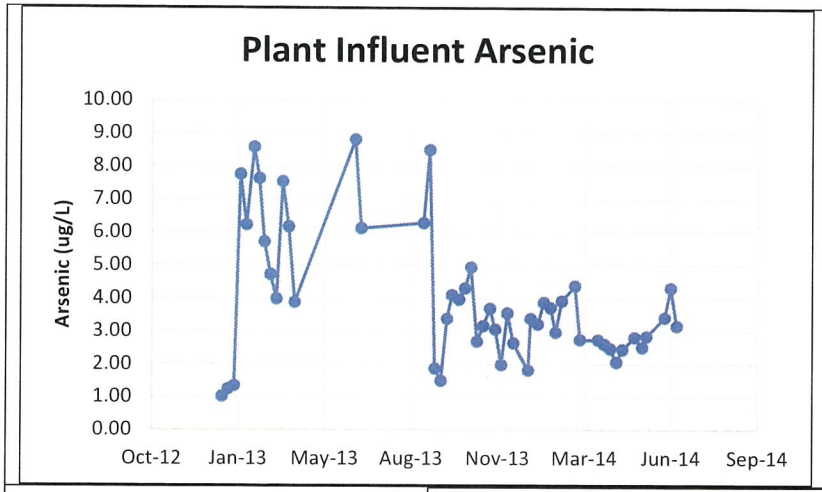


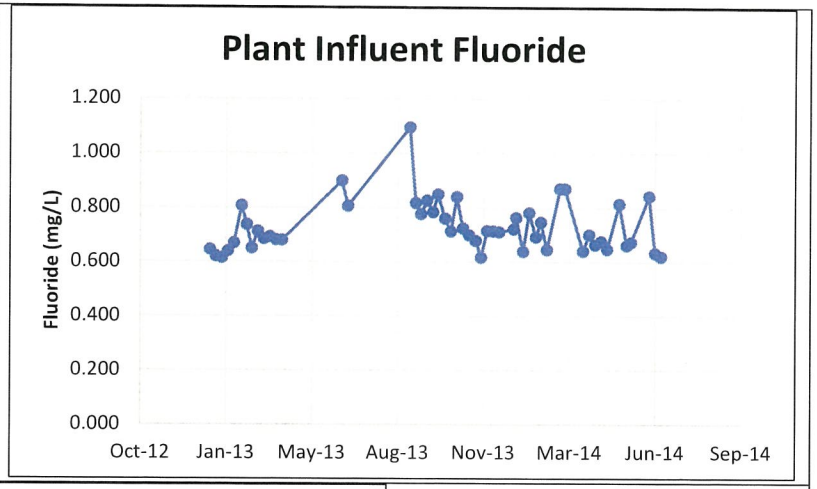
Figure 19 Well Water Quality 2013 – 2014

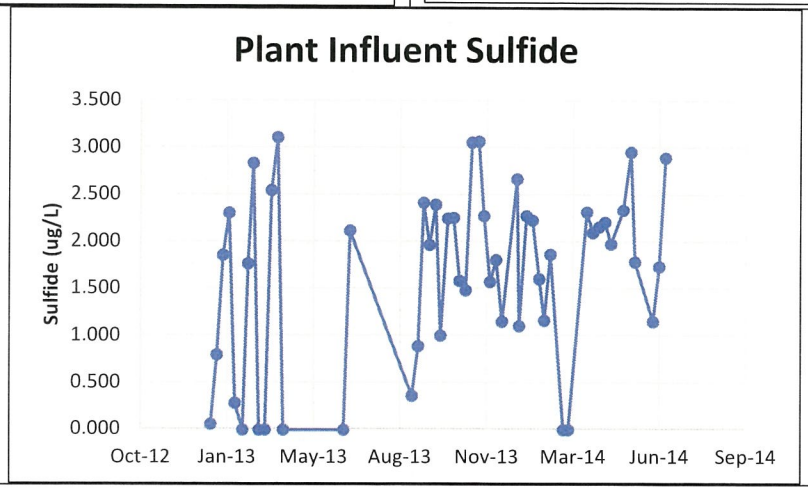
Plant Influent Quality

Plant influent quality is also measured weekly for arsenic, fluoride and sulfide. We additionally recommend that these data are regularly trended also to provide an indication of water quality into the plant. Trends for 2013 to 2014 are shown below.

Table 3 - Plant Influent Water Quality 2013 - 2014





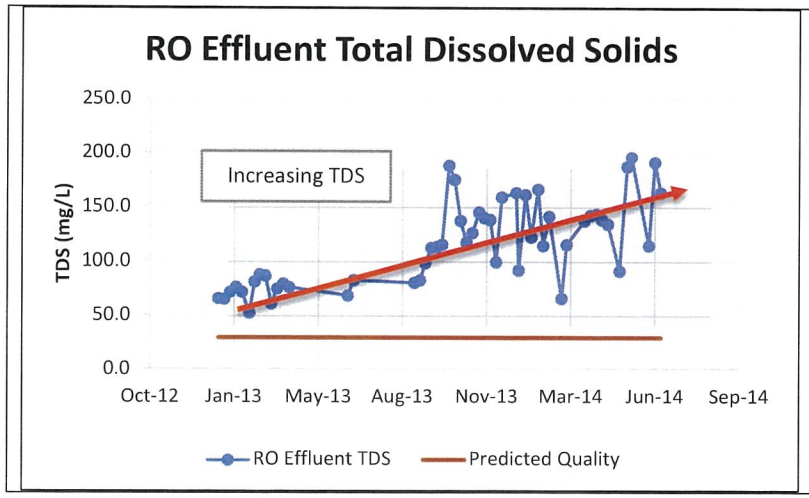


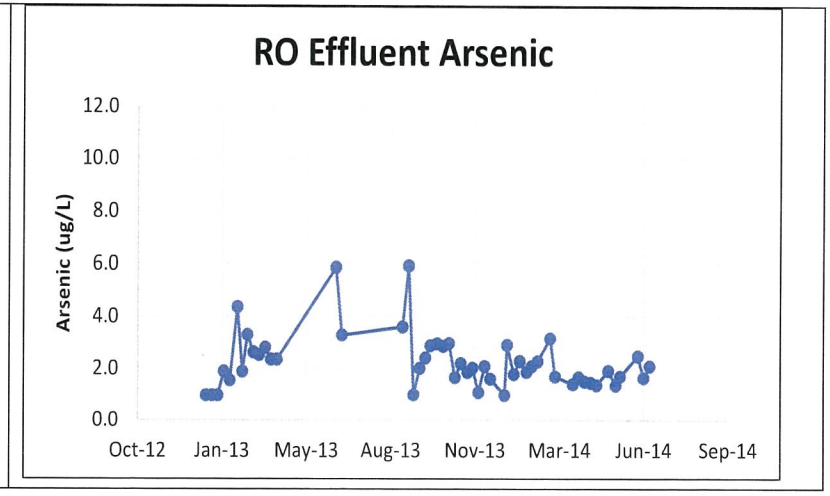
RO Effluent Quality

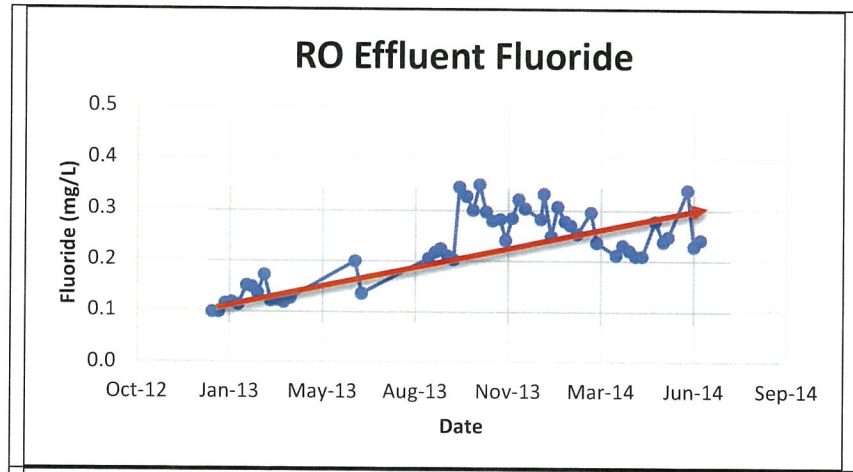
RO effluent quality is also monitored weekly for a number of parameters as described earlier. As for plant influent and plant final effluent, we strongly recommend the trending of these parameters. They show quite clearly a substantial increase in RO permeate TDS, a result of worsening of performance of the RO membranes over the course of 2013 – 2014.

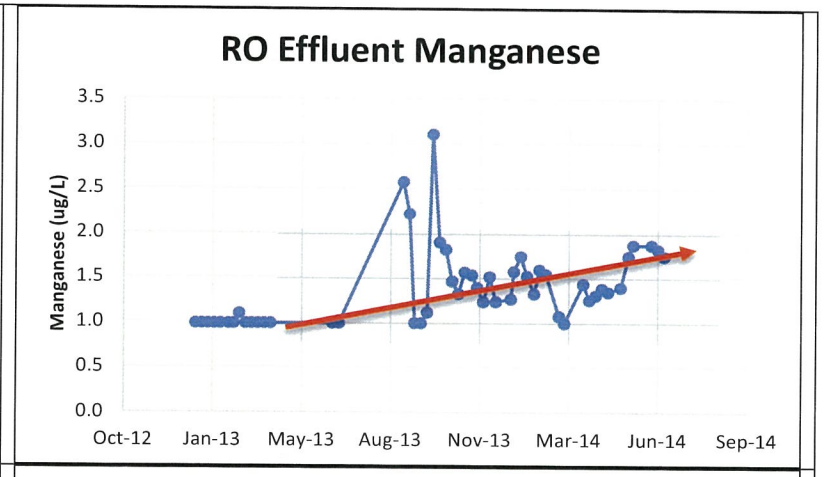
We have compared the RO Effluent total dissolved solids (TDS) actual results against the result anticipated from RO system projection software. The measured TDS has been measured up to 3-4 times higher than anticipated. This is a very poor result for membrane performance, and may be a result of significant membrane damage. We understand that some membranes are currently being autopsied which may provide some indication of what may have occurred.

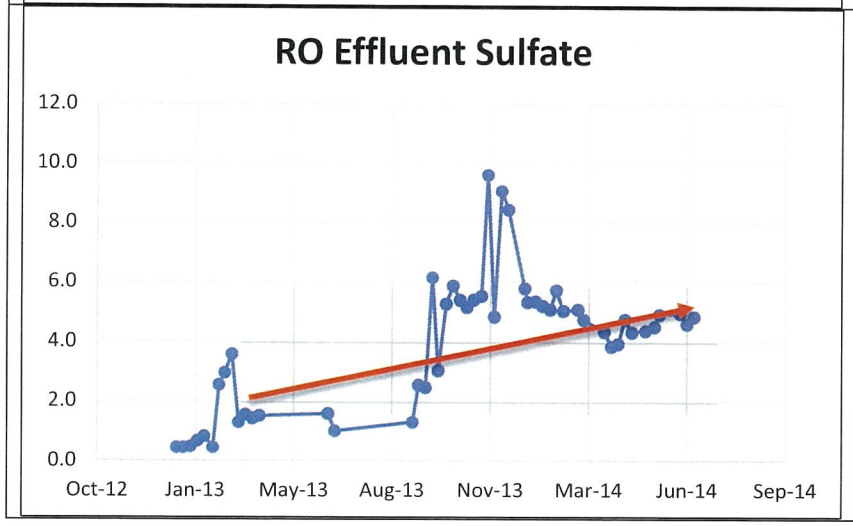
Similar trends in performance for other parameters, which is increasing the likelihood of a failure of overall treated water quality.

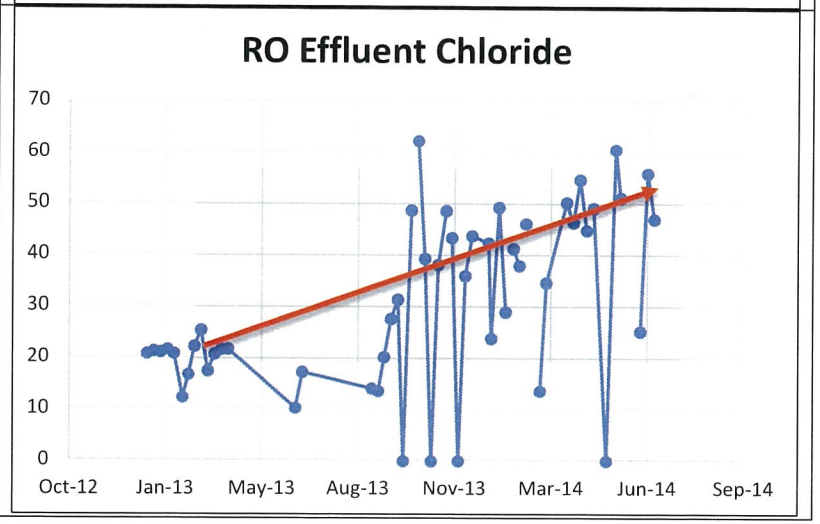












Final Effluent Quality

Details of final effluent quality have been provided in the Plant Performance Targets section above.

Water Quality Management Documentation

Water quality management documentation consists of the Sampling Manual (being developed by the water quality specialist), several specific sampling and analysis standard procedures, a sampling schedule, and the regulatory reports themselves (described above).

Additionally, the OMMP provides details of both internal and regulatory sampling and analysis (discussed previously), however some of these are out of date and don't reflect current practice.

Sampling Schedule

A sampling schedule is included in the overall Water Distribution/System Team schedule (see below). This notifies what sampling is to be conducted for each shift, and acts as a checklist for regulatory sampling.

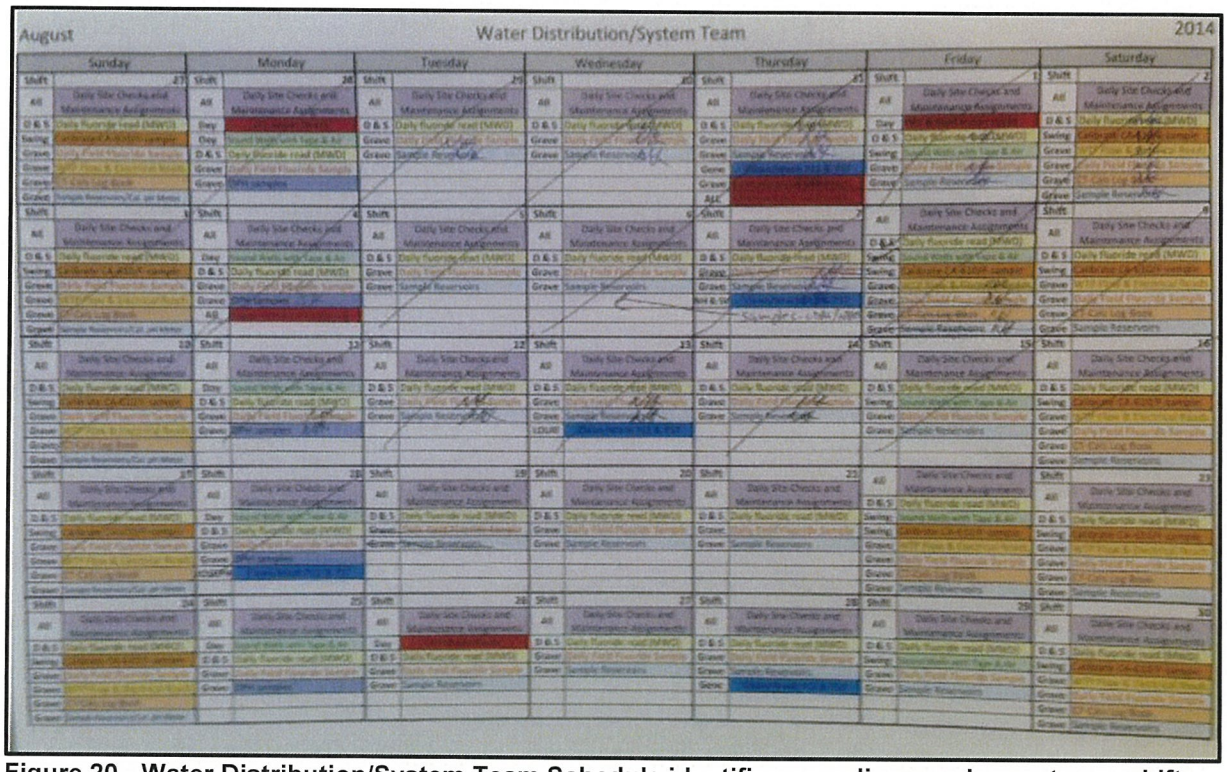


Figure 20 - Water Distribution/System Team Schedule identifies sampling requirements per shift.

This document is a helpful guide for operations staff. This advises what is required for operators on their particular shift. A further recommendation is to provide a "handshake" system whereby there is a confirmation provided of the sampling event having occurred. This can be in the form of a daily or weekly check list with a confirmation provided by the operator

when the sample has been taken and correctly stored or analyzed. Once the sample is taken, the chain of custody documentation will follow the sample through to completion.

Chains of Custody

The City has implemented chain of custody documentation for all external sampling and analysis requirements. This appears to work well and is used effectively in handling samples from site to the external laboratories. Several of these were sighted during the plant review and appear to be working well.

Recommendation: To provide greater surety that samples have been taken when required on a specific shift, we recommend that a "handshake" system be adopted to ensure sampling has occurred when required. This could take the form of a sampling check or shift log checklist which is completed by operators and communicated to the plant supervisor and/or water quality specialist.

Recommendations on Water Quality Management

The work that has been done in developing the Sample Manual, sample schedules and Chains of Custody documentation has been helpful in ensuring that samples are taken correctly, handled correctly, taken at the correct time.

The next step in ensuring effective water quality management is to bring all of this information together into one overall plan.

Recommendation: We recommend that the City develop a Water Quality Management Plan (WQMP) to incorporate all of the requirements of water quality management in the one document. This could be a stand-alone document, or it could be incorporated into the OMMP. It may be useful to develop a stand-alone document initially to enable the staff to "road-test" it, prior to incorporation into a regulatory reviewed document.

Items that would be included in the WQMP should be:

- Clear definition of water quality targets including both regulatory and plant performance targets.
- Important water quality targets within the process.
- Current Chains of custody documentation.
- Sampling procedures for all sample points including details of sample bottles, labelling, preservation, storage and any duplicate testing.
- Types of Samples. e.g. Grab, composite
- Proper sampling technique
- Labeling requirements
- Chain-of-Custody requirements/procedures

- Sample locations
- Sample frequency
- Sample schedules.
- Reporting templates.
- Operator knowledge requirements.
- Roles and responsibilities for sampling and analysis.
- Correct type of sample for each constituent of interest
- Process vs Regulatory sampling/testing

An important aspect of managing this document will be the introduction of effective version control, to ensure that any old documents are effectively superseded and updates to operation, sampling and reporting are effectively communicated.

Recommendation: We recommend that water quality reports be developed for effective internal communication of performance to operations staff and management. This should be for both regulatory requirements, but also importantly plant operational performance requirements. This is often effectively communicated in a dashboard type report, with simple indication of water quality acceptance or non-conformance, and provides an indication to operations staff if requirements are on target and being met.

Plant Performance Monitoring and Reporting

Overall, a great deal of data is monitored and recorded at the plant, both at the HMI system, but also via operator log sheets, water quality sampling and analysis, flow logs, energy logs and operator log books.

While a great deal of data is available, there do not appear to be many reviews of performance trends in the medium to longer term. Without a method of reviewing operational information in this way, the operations team can become data rich, but knowledge poor. Data is useful when it can be communicated for effective decision making. One of the overall recommendations on review of the plant operations, is that plant monitoring be greatly developed to ensure that operations are able to notice trends of performance, identify potential issues and importantly identify options for optimization.

Plant Dashboard Reports

An effective way at providing useful important data at a glance is the development of dashboard reports. The intent of these reports is to provide information "at a glance" to quickly highlight key areas of operational importance, identify problem areas that need to be addressed, and review plant overall compliance.

An example dashboard, developed for a recycled water plant, is shown below. At a glance, it can provide monthly production, plant (or RO) recovery, energy consumption and water quality

compliance. These can be relatively easily configured, and will use data that is already gathered at the site.

Providing information in this way is also very empowering for operations staff, to allow them to see the targets they are aiming for, and to see improved performance demonstrated when it is achieved.

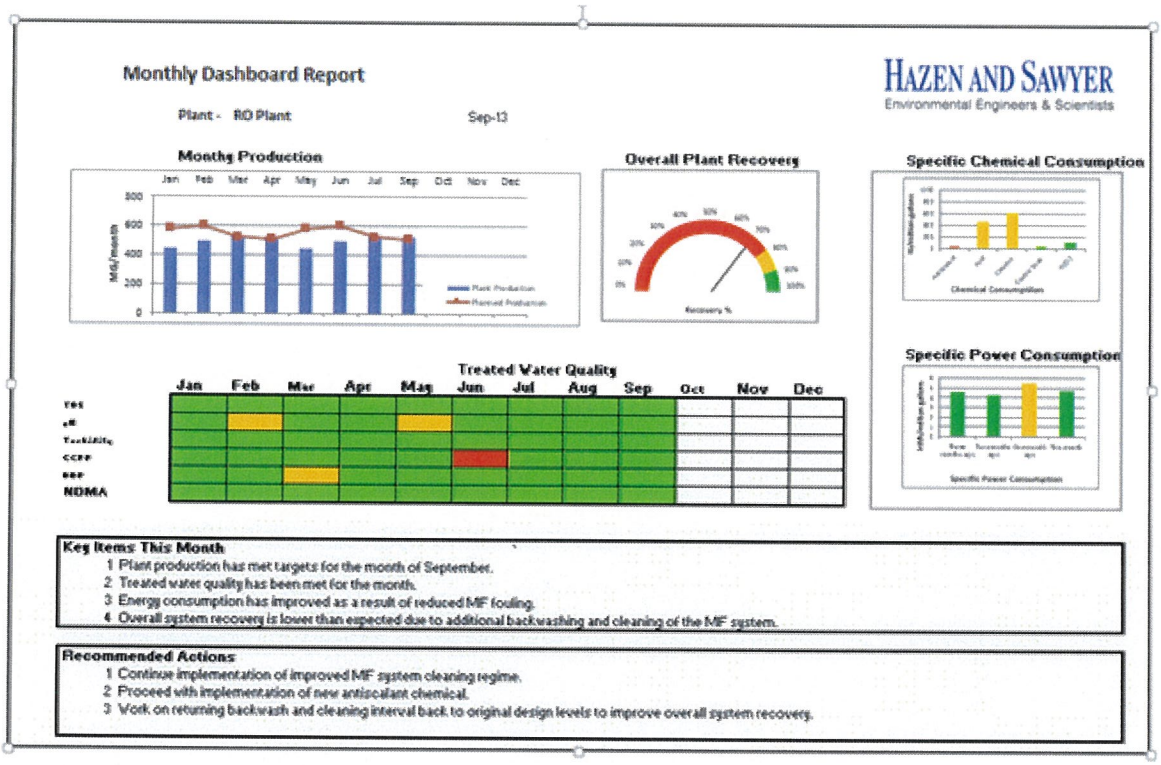


Figure 21 - Example Performance Dashboard Report

Recommendation: A series of dashboard reports be configured to allow "at a glance" review of plant performance.

Reverse Osmosis System Normalization

In order to accurately review the performance of the RO system, the operating data must be normalized, to take into account effects such as temperature, flow variation and TDS variation so that actual membrane condition is not masked by normal membrane operating phenomena.

Normalization provides a "correction" of operating data, filtering out these affects, and comparing performance to an original baseline condition to provide a more accurate picture of how the membranes are performing. It is very important that this data is logged and normalized, and provides the basis for the decision to clean membranes, and ultimately to replace them.