



To: Los Osos Sustainability Group  
From: Stephanie Shakofsky  
Date: May 30, 2021  
Re: Review of Basin Yield Metric & Chloride Metric (CONFIDENTIAL)

**Summary:** The Los Osos Groundwater Basin continues to degrade with seawater intrusion advancing. Given the continuing degradation, the BMC should consider, at a minimum, resetting the Maximum Sustainable Yield back to the originally agreed upon 2,400 AFY and resetting the Agricultural Water Usage back to 800 AFY. Using these original calculations, the BMC is not meeting its Basin Yield Metric goal of 80%.

Chloride levels are rising in key wells and overall salinity is increasing as evidenced not only by the Chloride readings but also by the increases in conductance and total dissolved solids. It is clear that established metrics are not being met and, under current conditions, may possibly never be met. Therefore, it would be prudent policy to minimize any new additional water usage in the basin until the BMC has adequately shown that agreed upon metrics and goals are being met.

### **I. Basin Yield Metric**

**RECOMMENDATION:** The BMC should strongly consider resetting the maximum sustainable yield back to 2,400 AFY as agreed upon in the Stipulated Judgement (2015). The basis for this recommendation is the continuing degradation of the basin, which includes but is not limited to, active wells exceeding or nearing 250 mg/l of chloride.

**RECOMMENDATION:** The BMC should strongly consider resetting the agricultural water usage back to 800 AFY as originally set in the Basin Plan (2015) which was based on historical surveys of agricultural use and aerial photography. The basis for this recommendation is that the 2017 calculated agricultural water use that applied an evapotranspiration and rainfall model (effectively lowering the agricultural water usage from 800 AFY to 670 AFY) is an idealized and unrealistic water usage calculation given typical agricultural practices in San Luis Obispo County and used an unrealistic irrigation efficiency factor of 92%.

## *Discussion*

As defined in the Basin Plan, the basin yield metric is calculated each year by:

$$\text{Annual GW Production} \div \text{Maximum Sustainable Yield}$$

Where Annual GW production is the total water removed by purveyors, and estimates of community users (parks), agriculture, and domestic wells. And, where Maximum Sustainable Yield was calculated using the basin Model (Modflow + SEAWAT) and then agreed upon in Stipulated Judgement (2015) to be set at 2,400 AFY for five years.

Specifically, Section 6.3.2 of the Basin Plan states “The Sustainable Yield<sub>x</sub> is determined for a given set of infrastructure in place by using the Model to determine the maximum amount of groundwater extractions that may occur with a stable seawater intrusion front, and no active well producing water with chloride concentrations above 250 mg/l.

This initial Maximum Sustainable Yield of 2,400 AFY was to be set for 5 years, as agreed upon in the Stipulated Judgement (2015). However, because certain infrastructure was completed or was anticipated to be completed, the Maximum Sustainable Yield was increased by 360 AFY in 2016 to 2,760 AFY which is where it remains to date for calculating the 2020 metric.

The recommendation to return to the 2,400 AFY Maximum Sustainable Yield is based on the fact that chloride readings for at least one well (LA10) has exceeded the 250 mg/l of Chloride goal set by the Model. It also appears that well LA11 will likely exceed the 250 mg/l of Chloride goal in the very near future. Moreover, water quality data is clearly showing a continuing degradation and increasing salinity of the basin which does not meet the criteria of maintaining a stable seawater intrusion front. This is discussed in more detail in the Chloride metric discussion.

An additional concern is that the DRAFT 2020 Annual Monitoring Report recommends an update and an increase to the Maximum Sustainable Yield now that the location of the second Program C expansion well is finalized. However, current water quality data do not support a increase in the Maximum Sustainable Yield as this memo discusses.

The Maximum Sustainable Yield in the basin is constrained primarily by the need to prevent Lower Aquifer seawater intrusion. The goal is to keep the Basin Yield Metric at or below 80% which is intended to represent a conservation of water usage and maintain a stable intrusion front, as well as compensate for a variety of uncertainty factors in the model. While this goal is articulated well in the Basin Plan (*source: Section 6.3.3 Seawater Intrusion Targets*) it is important to keep expectations for simulated model forecasts in line with actual chloride concentrations and other water quality and real time data.

Coastal aquifers are complex environments characterized by transient water levels, variable salinity and water density distributions, and heterogeneous hydraulic properties. Climate variations, groundwater pumping, and fluctuating sea levels create dynamic hydrologic

conditions, which are interrelated with the distribution of dissolved salts through water density-salinity relationships. Moreover, these processes are often important at different spatial and time scales. In short, these real life and dynamic systems are extremely difficult to model.

Saltwater intrusion is severely affecting the water quality in the Los Osos basin, which presently is the sole source of potable water in the basin. Intrusion requires years to decades to reverse and remediate. Therefore, any prudent water management plan must include margins of safety that consider the uncertainty in estimated basin yields from modeling, and must include adaptive management strategies with contingency actions that can be implemented quickly should the proposed plan not work.

The BMC created metrics that allow the parties, regulatory agencies, and the public to evaluate the status of seawater intrusion in the Basin through objective, numerical criteria that can be tracked over time. However, single metrics are not designed for early detection, and decision-making must rely on current and best available data.

Therefore, because the water quality data clearly shows that the BMC is not meeting the goals set forth in the Basin Plan (specifically Section 6.3.2) and the Stipulated Judgement, it is recommended that the BMC consider resetting the Maximum Sustainable Yield back to the initially agreed upon 2,400 AFY.

It is also recommended that, at a minimum, the BMC consider resetting the Agricultural Groundwater Production estimate back to 800 AFY. The Basin currently encompasses approximately 1,090 acres of land that is zoned for agricultural uses. In 2015, estimated acreage of irrigated agricultural land was 375 acres. Over the past five years that number has been lowered to 283 acres based on the County's aerial photography updates. Although inaccuracies may exist in the estimation of irrigated lands from aerial photography, the most significant calculation errors and inaccurate assumptions exist in the parameters used to estimate agricultural water use based on soil moisture content, crop rooting depth, local rainfall and evaporation, and the efficiency of any given farmer's irrigation system (*source: Draft 2020 Annual Monitoring Report, Appendix G*).

In brief, the most significant potential errors in the method used by the BMC for calculating water usage for irrigated crops are as follows:

1. The BMC used an unreasonably high irrigation efficiency number of 92%. Although, an extremely efficient and properly maintained drip irrigation system might approach a 92% efficiency, typically drip irrigation systems have efficiencies ranging between 60% and 90% while sprinkler irrigation systems tend to have low efficiencies ranging between 50% to 70%.

In estimating water usage for unmetered irrigation systems the U.S. Department of Energy suggests the following efficiency coefficients (*source: US Dept of Energy, Guide for Estimating Unmetered Landscaping, 2010*):

- Low Efficiency: 50%: sprinkler type systems that are aging with poor maintenance and lack of proper scheduling
- Medium Efficiency: 65%: sprinkler type systems that have regular maintenance and proper scheduling
- High Efficiency: 85%: micro irrigation systems that have regular maintenance and proper scheduling.

2. The BMC calculation assumes that every farmer uses an evapotranspiration (ET) model in their irrigation decision process. This is an extremely idealized view of typical farming practices. While some farmers may use an ET model to assist in their irrigation schedule, most farmers irrigate on a fixed schedule which most likely uses significantly more water than typical ET model estimations.

3. The BMC calculation does not consider other onsite farm water usage including, but not limited to: plant wash down, production processing facilities, frost protection sprinkler systems, and pesticide and herbicide delivery systems. These farming processes can use significant amounts of water.

While it is understood that agricultural wells are privately owned, and often not metered, so that exact water usage is not available and educated guestimates must be calculated, it is also imperative that calculated estimates take a prudent and conservative approach to estimating water use.

For example, using a conservative efficiency coefficient of 50% (instead of the 92% currently being used by BMC) to compensate for the uncertainties and unknowns of the parameters used in the agricultural ET model, then agricultural water production for 2020 would equate to approximately 1,198 AFY compared to 650 AFY calculated by the BMC (*source: Table G-5, Draft 2020 Annual Monitoring Report*).

It is also interesting to note, that by applying the more conservative irrigation efficiency coefficient of 50%, the approximated agricultural water use is closer to the historical estimates published by others for the Los Osos Basin:

<b>Estimates of Agricultural Water Use in Los Osos Basin</b>	
Dept of Water Resources (1973)*	<b>1,100 AFY</b>
Brown & Caldwell (1983)*	<b>1,070 AFY</b>
this paper (2021) @ 50% irrigation efficiency	<b>1,198 AFY</b>
CHG (2020 Annual Report) @ 92% irrigation efficiency	<b>650 AFY</b>

\*source: Basin Plan (2015), Sec. 4.5 Production by Agricultural Water Users, p. 42-46.

The Basin Plan (p.110-114) describes the range of uncertainties for the model calculations noting that the two most significant factors contributing to uncertainty are: (1) the physical

characteristics of and hydrogeologic relationships with the Basin, and (2) the assumptions regarding the estimated levels of pumping by private domestic and agricultural water users.

The Basin Plan (p.113) goes on to state that, “depending on the severity of any inaccuracies regarding the underlying assumptions or unexpected conditions, the impact on future Basin management could range from minimal to significant.”

It would appear that non-purveyor pumping rates may be significantly underestimated, and the impacts on the Basin management are likely significant.

Therefore, the BMC should consider, at a minimum, resetting the agricultural use back to 800 AFY, until such time that actual water usage can be obtained from the agricultural community.

Recalculating the Basin Yield Metric by using the originally agreed upon Maximum Sustainable Yield of 2,400 AFY and the original calculated agricultural water use of 800 AFY, **then the BMC has never met the 80% goal for the Basin Yield Metric as the table below illustrates:**

Year	Reported Water Use/SY	Reported Basin Yield Metric (Goal = 80%)	Recalculated Water Use/SY	Recalculated Basin Yield Metric (Goal = 80%)
2015	$\frac{2,170 \text{ AFY}}{2,450 \text{ AFY}}$	89%	$\frac{2,170 \text{ AFY}}{2,400 \text{ AFY}}$	90%
2016	$\frac{2,160 \text{ AFY}}{2,760 \text{ AFY}}$	78%	$\frac{2,160 \text{ AFY}}{2,400 \text{ AFY}}$	90%
2017	$\frac{2,070 \text{ AFY}}{2,760 \text{ AFY}}$	75%	$\frac{2,200 \text{ AFY}}{2,400 \text{ AFY}}$	92%
2018	$\frac{2,030 \text{ AFY}}{2,760 \text{ AFY}}$	74%	$\frac{2,160 \text{ AFY}}{2,400 \text{ AFY}}$	90%
2019	$\frac{1,900 \text{ AFY}}{2,760 \text{ AFY}}$	69%	$\frac{2,070 \text{ AFY}}{2,400 \text{ AFY}}$	86%
2020	$\frac{2,010 \text{ AFY}}{2,760 \text{ AFY}}$	73%	$\frac{2,160 \text{ AFY}}{2,400 \text{ AFY}}$	90%

## II. Chloride Metric

**Recommendation: Chloride readings should be combined with existing Conductance and Total Dissolved Solids (TDS) readings to create a clearer understanding of the overall salinity and degradation of the basin.**

### *Discussion*

The BMC has defined the Chloride Metric as the weighted average concentration of chlorides in four key wells (LA8, LA10, LA11, and LA12), where the concentration of well LA10 is given twice the weight of the other three wells in order to increase the sensitivity of the metric to various management actions (*source: Basin Plan, p.108*).

Chloride is the major anion of seawater, and it moves through aquifers at nearly the same rate as the intruding water. Thus, it is recognized that increasing chloride concentrations are typically the first indication of the approach of a seawater contamination front. In an area where no other source of saline contamination exists, high chloride concentrations can be considered definitive proof of seawater contamination and an appropriate measurement.

Yet, other water quality measurements can provide indications of increasing salinity and should also be used in describing conditions in the Basin. Specifically, electrical conductivity (measured as Conductance in umhos/cm) is a strong indicator of salinity, and total dissolved solids (TDS, mg/l) is also a common salinity parameter, particularly for groundwater quality measurements (*source: Chloride, Salinity and Dissolved Solids, USGS Science Center, 2020*).

The BMC acknowledges that the Chloride Metric is a simplification of basin conditions that will vary significantly from year to year due to localized chloride fluctuations (*source: Draft Annual Monitoring Report, 2020, p.69*).

However, the BMC has not considered the continuing increase in Conductance and TDS over time in the four key wells. The current and historic water quality data show a steady increase in salinity in all four key wells, as show in the table:

Well #	Conductance (umhos/cm) <sup>1</sup>		Total Dissolved Solids (TDS) (mg/l) <sup>2</sup>	
	2004	2020	2004	2020
LA8	390 →	464	200 →	300
LA10 <sup>3</sup>	1,200 →	1,310	410 →	970
LA11	1,300 →	1,650	840 →	1,040
LA12	790 →	891	410 →	510

<sup>1</sup>Typical Conductance Readings (umhos/cm):

Deionized Water: 0.5  
 Drinking Water: 200-1,000  
 Brackish Water: 1,000-35,000  
 Seawater: >35,000  
 (Source: USGS, Saline Water & Salinity, 2020)

<sup>2</sup>Typical Total Dissolved Solids (mg/l)

Freshwater: <1,000  
 Brackish Water: 1,000-10,000  
 Seawater: >10,000  
 (Source: CA State Water Resources Control Board, Fact Sheet 3.1.3.0, 2004)

<sup>3</sup>No data for fall 2020

Again, a cautious level of concern should be adopted by the BMC with a reasoned approach to decision-making that is based on the quantitative water quality data available to date in order to avoid a threat that is serious and plausible.

**Conclusions:**

1. The Los Osos Groundwater Basin continues to degrade with seawater intrusion advancing.
2. Given the continuing degradation, the BMC should consider, at a minimum, resetting the Maximum Sustainable Yield back to the originally agreed upon 2,400 AFY and resetting the Agricultural Water Usage back to 800 AFY. Using these original calculations, the BMC is not meeting its Basin Yield Metric goal of 80%.
3. The BMC is not meeting its Chloride Metric. Chloride levels are rising in key wells and overall salinity is increasing as evidenced by the increases in conductance and total dissolved solids.
4. It is clear that established metrics are not being met and, under current conditions, may possibly never be met. Therefore, it would be prudent policy to minimize any new additional water usage in the basin until the BMC has adequately shown that agreed upon metrics and goals are being met.