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Memorandum

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Subject	**Supplemental Alkalinity Modification**	**Project Name**	Spokane County Regional Water Reclamation Facility
Attention	Valerie Garcia	**Project No.**	D33616CP
From	William Leaf		
Date	April 2, 2021		

This memorandum documents the modification to the supplemental alkalinity system at the Spokane County Regional Water Reclamation Facility (SCWRF). The SCRWRF has been considering replacement of sodium hydroxide (NaOH) as the alkalinity source in the mixed liquor with either magnesium hydroxide $Mg(OH)_2$ or calcium carbonate ($CaCO_3$), (Jacobs, January 7, 2020). The full-scale chemical trials started in March 2020 and ran through September 2020. The results of the trials together with an evaluation of the respective chemicals is presented. The selection of the replacement chemical is based on the annual cost and operational benefits realized at the facility.

Full-scale Supplemental Alkalinity Test Results

Magnesium hydroxide and calcium carbonate both provided the supplemental alkalinity required at the SCRWRF, maintaining the high level of process performance. Supplemental alkalinity is required at the SCRWRF to account for the additional of ferric chloride ($FeCl_3$), which for every pound (lb) of $FeCl_3$ used 0.92-lb of alkalinity as $CaCO_3$ is consumed. SCRWRF is required to fully nitrify within the system annually to meet the National Pollutant Discharge Elimination System (NPDES) discharge permit (see Table 1) and to meet the requirements of the membrane manufacturer warranty (< 1.0 mg/L ammonia-nitrogen [NH_3-N] average).

Table 1 – Effluent Ammonia-Nitrogen Requirements (Seasonal Limits, adapted from NPDES permit load limits)

Season	Effluent Permit Criteria
April, May, October	1.0 mg/L
June – September	0.25 mg/L
November – March	16 mg/L

A combination of NaOH, $Mg(OH)_2$, and $CaCO_3$ was used throughout 2020 and the effluent criteria for NH_3-N removal was achieved. Figure 1 presents the effluent NH_3-N concentrations throughout the chemical trial period. While there was a relatively high effluent NH_3-N value in June 2020, the monthly average limit of 0.25 mg/L was still achieved. The influent flow at the SCRWRF is also shown on Figure 1, showing how the plant operates close to its rated capacity on a daily basis.

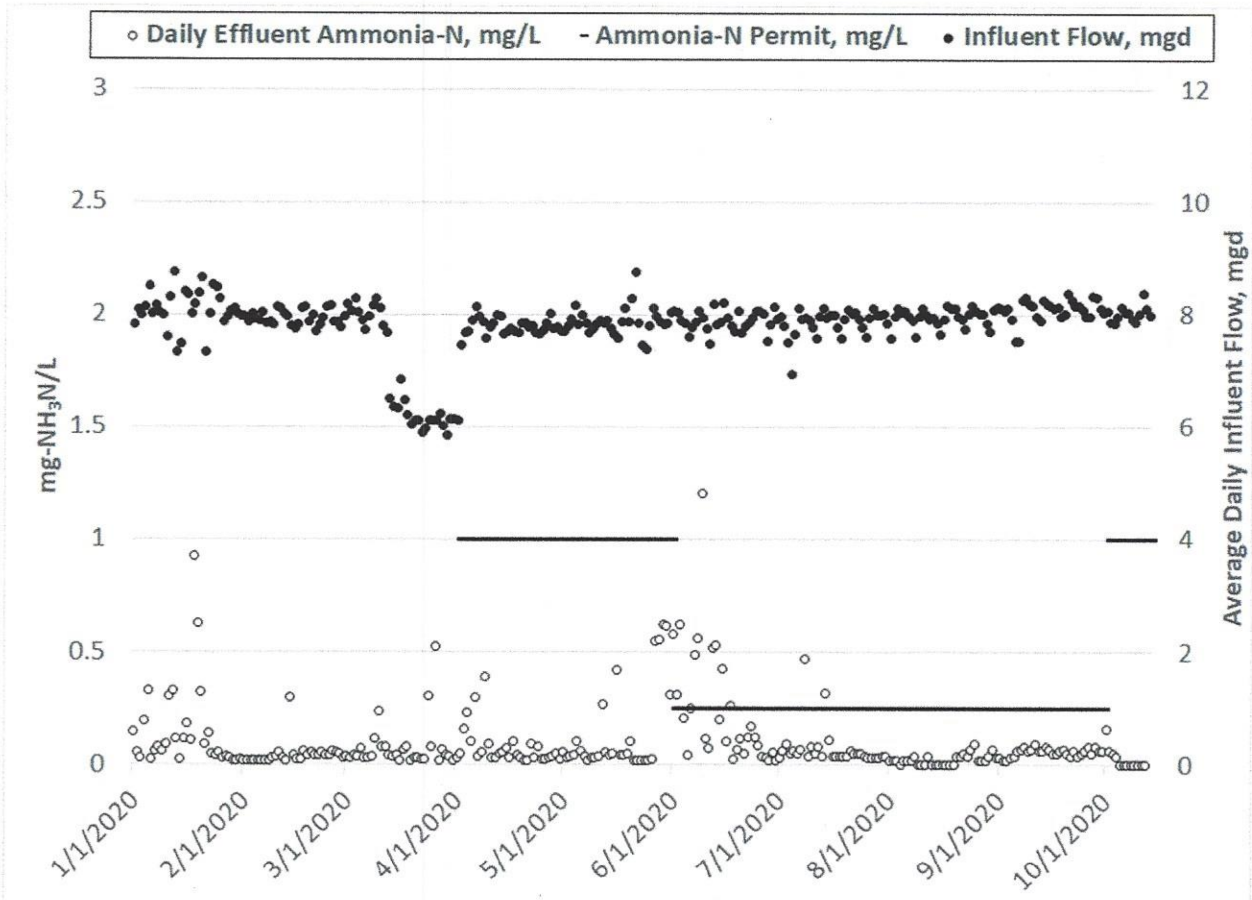

Figure 1 – Effluent Ammonia-Nitrogen Daily Average Concentrations and Daily Average Influent Flow

The full-scale trial for each chemical was completed throughout 2020. Each chemical was introduced into the return activated sludge (RAS) stream, which returns mixed-liquor (ML) from the membrane tanks back to the bioreactor. Figure 2 presents the time period for each chemical throughout the trial period.

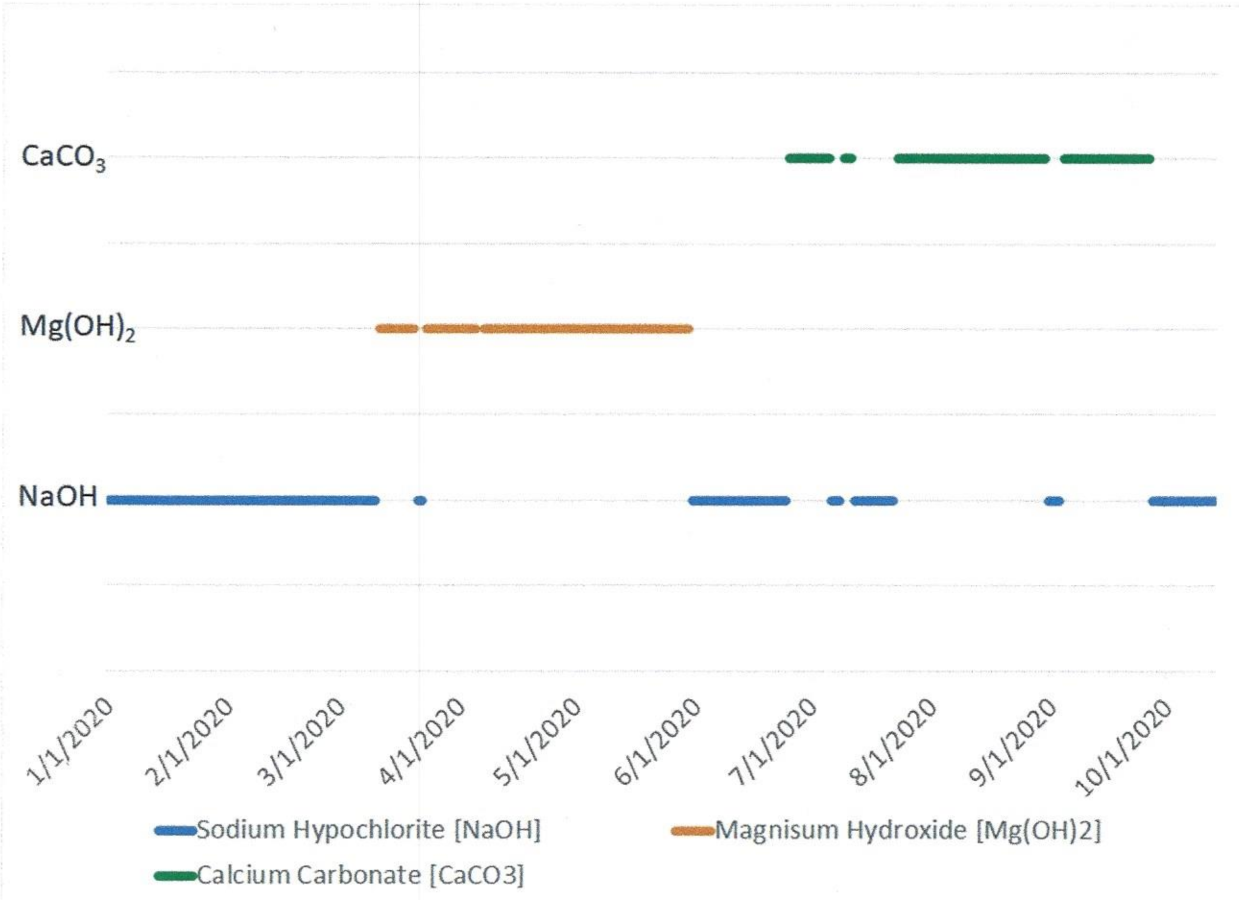

Figure 2 – Full-scale Supplemental Alkalinity Chemical Trial Duration

The dewatering performance during the full-scale supplemental alkalinity trials is presented in Figure 3. The total solids (TS) from the dewatering process is shown throughout the trial period. The average TS from the use of NaOH is 25.9 percent, with $Mg(OH)_2$ the concentration average increases to 28.4-percent TS, and the use of $CaCO_3$ results in an average of 27.4-percent TS.

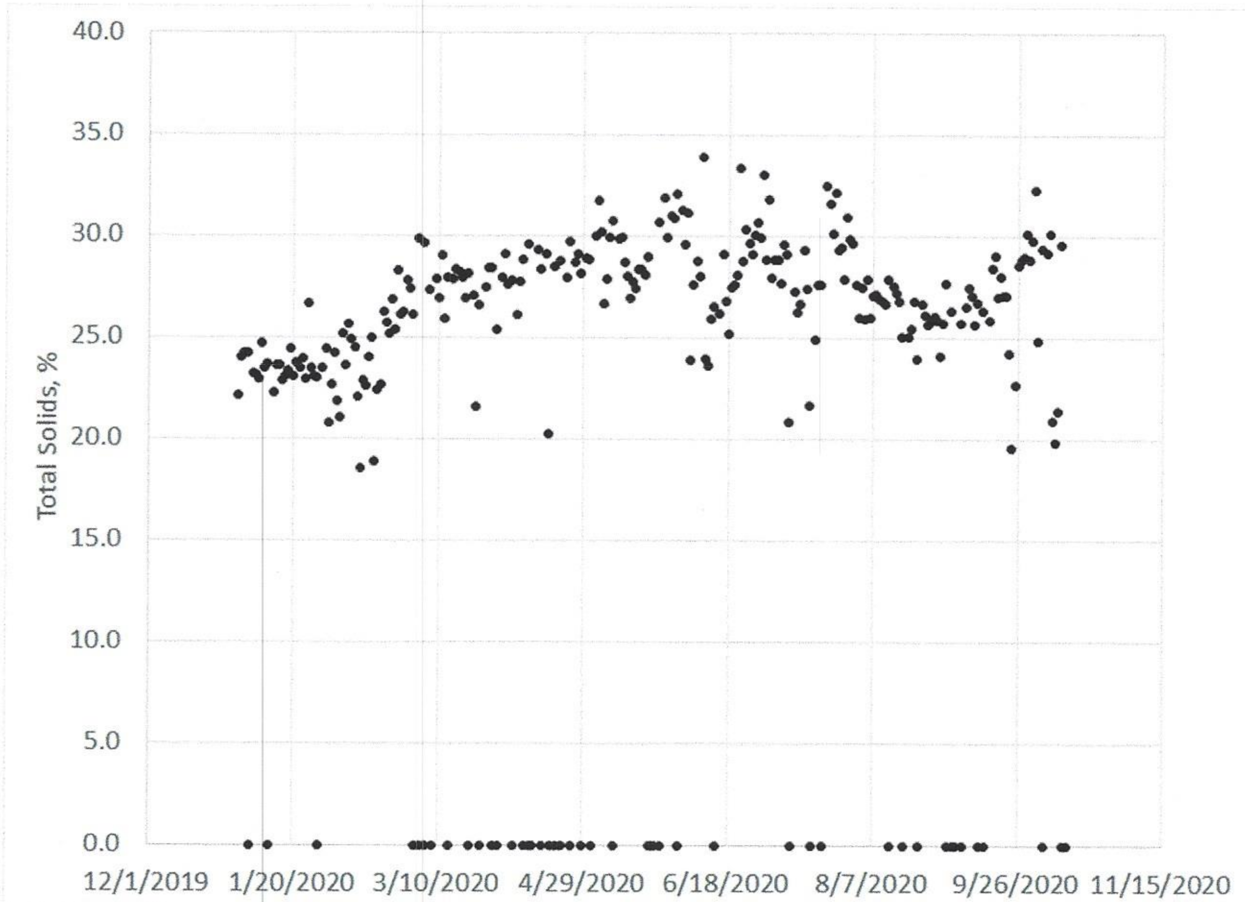

Figure 3 – Full-scale Supplemental Alkalinity Chemical Trial Dewatering Performance

Full-scale Supplemental Alkalinity Test Chemical Comparison

The supplemental alkalinity chemicals all provided good performance at the SCRWRF. The nitrification process remained robust throughout the duration of the chemical trial, indicating the required background alkalinity was available. The dewatering performance, based on percent TS in the biosolids, does improve with both $Mg(OH)_2$ and $CaCO_3$. The increase in percent TS in the dewatering biosolids is a benefit with either $Mg(OH)_2$ and $CaCO_3$.

The daily cost comparison with the supplemental alkalinity chemicals is based on the cost per alkalinity required. The alkalinity required is:

- Alkalinity Required = [Alkalinity Consumed] – [Influent Alkalinity] – [Effluent Alkalinity]

The facility does not regularly measure the influent alkalinity, so this was based on the historical value of 123 mg/L as $CaCO_3$. For this comparison it is assumed that this influent alkalinity is consistent throughout the trial period. The alkalinity consumed is based on the requirements for both nitrification and the use of ferric chloride. For each pound of ferric chloride used, 0.92-pound of alkalinity is consumed. The nitrification process consumes 7.1 pounds of alkalinity for each pound of ammonia-nitrogen removed. Throughout the entire trial period SCRWRF does introduce caustic into the plant effluent. This was not included in the evaluation, rather just the use of the supplemental alkalinity introduced into the mixed-liquor. Table 2 presents the comparison of supplemental alkalinity chemicals.

Table 2 – Supplemental Alkalinity Required

Chemical	Influent Alkalinity (lb/d)	Effluent Alkalinity (lb/d)	Alkalinity Consumed (lb/d)	Required Alkalinity (lb/d)	Caustic Usage (gpd)
NaOH	8,033	4,964	19,401	6,404	1,342
$Mg(OH)_2$	8,033	4,300	17,469	5,136	-
$CaCO_3$	8,033	5,448	20,684	7,203	-

lb/d = pounds per day

gpd = gallons per day

The estimated costs per day of required alkalinity is presented in Table 3.

Table 3 – Supplemental Alkalinity Cost Comparison

Chemical	Required Alkalinity	Total Trial Chemical Cost	2020 Average Daily Cost	Daily Cost per lb/d of $CaCO_3$
NaOH	6,404 lb/d (1,342 gpd)	-	$1,140	$ 0.18/lb $CaCO_3$
$Mg(OH)_2$	5,136 lb/d	$ 59,006	$ 756	$ 0.15/lb $CaCO_3$
$CaCO_3$	7,203 lb/d	$ 69,255	$ 911	$ 0.13/lb $CaCO_3$

NaOH Cost = $0.85/gallon

$Mg(OH)_2$ Cost, Regular Pricing = $2.375/gallon

$CaCO_3$ Cost, Regular Pricing = $1.71/gallon

There is a savings in annual dewatering costs with either $Mg(OH)_2$ and $CaCO_3$ when compared to NaOH. The increase in biosolids cake percent TS can result up to a 5.5 to 9 percent increase over the biosolids cake TS percentage with NaOH in use. The average monthly dewatering cost from the equivalent time period is 2019 was $39,984. The monthly savings with either $Mg(OH)_2$ and $CaCO_3$ would be approximately $2,199 to $3,599. The variability with other factors (e.g. – MLSS concentration, temperature, ferric chloride use) during the trial of $Mg(OH)_2$ and $CaCO_3$ does not warrant a direct comparison between these two alternative chemicals.

Recommendation

The use of either $Mg(OH)_2$ or $CaCO_3$ would be viable alternatives for use as supplemental alkalinity. Both of these chemicals prove to have additional annual savings at the SCRWRF when compared to the use of

NaOH. While $Mg(OH)_2$ is used more frequently at treatment facilities throughout North America, the use of $CaCO_3$ is used at a number of facilities throughout Europe. The use of $Mg(OH)_2$ and $CaCO_3$ did not have an adverse impact the performance of the membrane system during the trial period. The facility had high levels of permeability throughout the use of $Mg(OH)_2$ and $CaCO_3$.

The annual costs between $Mg(OH)_2$ and $CaCO_3$ appear to be comparable, with $CaCO_3$ having a slightly lower cost per alkalinity required. The chemical supplier for $CaCO_3$, Columbia River Carbonates (CRC), has proposed providing a new chemical storage and feed system if the SCRWRF switches to $CaCO_3$. Given this additional capital investment by CRC, together with the annual savings provided by $CaCO_3$, appears to make this to more cost-effective approach for SCRWRF. It is recommended that the SCRWRF proceed with the procurement, design, and installation of the $CaCO_3$ supplemental alkalinity system.

Reference

Jacobs. (2020). *Supplemental Alkalinity Modification – Update.* January 7, 2020.