11 June 2009

# Draft Technical Memorandum

To: Mr. Tom Trott
San Luis Obispo County Public Works

From: Todd Reynolds, PE
Aileen Kondo, PE

Subject: Carbon Dioxide System and pH Control Improvements
Lopez Water Treatment Plant
K/J 0968002

## Introduction

The San Luis Obispo County (SLOC) Public Works' Lopez Water Treatment Plant (WTP) is a 6 million gallon per day (MGD) treatment plant treating surface water from Lopez Reservoir. The Lopez WTP was recently upgraded, and the new treatment process consists of pre-oxidation with potassium permanganate, coagulation, flocculation, dissolved air floatation (DAF), chlorine dioxide disinfection, low-pressure membrane filtration with PALL microfiltration (MF) membranes, followed by additional free chlorine disinfection. The new Lopez WTP facilities began operations in June 2007.

The surface water from Lopez Reservoir has naturally high pH, hardness and alkalinity and a strong tendency to scale. This has led to the deposition of calcium carbonate scale on plant components including piping, valves, feed strainers and the MF membrane filter elements. The excessive scale formation has required increased maintenance labor effort and costs, and has impacted the operations of the Lopez WTP.

Kennedy/Jenks Consultants (Kennedy/Jenks) described the potential for a carbon dioxide ($CO_2$) storage and feed system for the Lopez WTP as part of an evaluation of the Lopez WTP, dated July 2008. Adding $CO_2$ to the water will produce carbonic acid ($H_2CO_3$) and the carbonic acid will reduce the pH of the water. Lowering the pH will reduce the tendency for calcium carbonate ($CaCO_3$) to precipitate and form scale on the wetted plant components, strainers and MF membranes.

This Technical Memorandum provides the following information on the feed water scaling issues and recommendations for a $CO_2$ system:

- The cause of the scale formation at the Lopez WTP
- The impact of the scale formation
- The benefits of the proposed $CO_2$ system and pH control improvements for Lopez WTP plant operations
- Conceptual design criteria and location for the new $CO_2$ storage and feed system
- Conceptual level opinion of probable project capital and operating costs.

## Scaling at the Lopez WTP

The surface water from Lopez Reservoir has naturally occurring high hardness, alkalinity and pH. The relatively high source water pH is due, in part, to algal activity in the shallow source water reservoir. The algae, by the sunlight photosynthesis process, consume available $CO_2$ in the water during the day resulting in a significant diurnal increase in pH. The increased pH raises the $CaCO_3$ saturation Langelier Saturation Index (LSI) and creates scale-forming conditions.

Based on water quality data from June 2007 to Dec 2008, the Lopez WTP average source water characteristics are summarized in Table 1 below. The variation of LSI scale formation over the 18-month period is shown on Figure 1 on page 5.

Table 1: Lopez WTP Average Source Water Characteristics

| Water Characteristic | Source Water | Typical Scale/Corrosion Control Objectives |
|---|---|---|
| Typical pH Range | 7.9 to 8.6 | 7.5 to 7.8 |
| Calcium, mg/l as CaCO3 | 182 | ~50 – 60 or less |
| Alkalinity, mg/l as CaCO3 | 262 | ~100 – 120 or less |
| Temp, degrees C | 18.7 | -- |
| Langlier Saturation Index, | +1.0 | -0.5 to +0.5 |
| Calcium Carbonate Precipitation Potential, mg/l | 60 | 10 to 30 |
| Ryznar Index | 5 | 6 to 8 |
| Aggressive Index | 13 | > 12 |

There are a number of indices and characteristics that relate to the probable scaling and corrosion potential of various minerals in water including the Langelier Saturation Index, Calcium Carbonate Precipitation Potential, Ryznar Index, and Aggressive Index. A brief explanation of these indices is described below.

**Langelier Saturation Index (LSI)** – This is an index of calcium carbonate saturation developed nearly 70 years ago by Dr. Wilfred Langelier, Professor of Sanitary Chemistry at the University of California, Berkeley.

The Langelier Index is calculated as LSI = pH - $pH_S$. The $pH_S$ of calcium carbonate saturation is calculated from total dissolved solids (TDS), temperature, calcium, and bicarbonate concentrations:

$$pH_S = \text{Temperature} + \text{TDS} – \text{Calcium} – \text{Alkalinity Factors}$$

Temperature, calcium, and alkalinity have major effects, while TDS has a minor effect on $pH_S$. As pH, hardness and alkalinity increase, there is a tendency for calcium carbonate scale to form. Also, if TDS, calcium, and alkalinity are constant, as temperature rises, calcium carbonate will precipitate at lower pH. This condition is observed with high hardness and hot water in dishwashers, glasses, etc. (Singley, 1985).

Cement and concrete are largely composed of calcium carbonate. At negative Langelier Indices, there is a tendency for the calcium and carbonate to leach out from the cement, leaving a weak matrix of aluminum and silicate as well as roughened surfaces, which increases friction and low flow capacity in pipelines (Holtschulte, 1985). While at positive Langelier Indices, there is a tendency to form calcium carbonate scales, which provides some protection of metals from corrosion. If the LSI is too high then excessive and roughed films will form, pipe diameter will be reduced and this will also result in flow loss (Ryder, 1985).

The most desirable range of LSI is between –0.5 and +0.5, where neither scale deposition nor calcium leaching is excessive (Vik, 1996). A slightly positive LSI of approximately +0.2 to +0.5 is desirable to form a thin protective scale on distribution pipes to minimize corrosion.

The Lopez WTP source water has an average LSI of 1.0 which tends to precipitate excessive scale. However as shown on Figure 1, below, the Lopez WTP source water LSI can be as high as +1.6.

**Calcium Carbonate Precipitation Potential (CCPP)**

The term Calcium Carbonate Precipitation Potential (CCPP) was developed by D.T. Merrill and R.L. Schultz at the University of Colorado in 1977, to denote the quantity of $CaCO_3$ that can theoretically be precipitated from over-saturated waters or dissolved into under-saturated waters.

$$CCPP = 50{,}000\ (AIk_i - Alk_{eq})$$

$AIk_i$ = Initial Alkalinity

$AIk_{eq}$ = Calcium and Alkalinity after precipitation.

The CCPP predicts the theoretical maximum amount of calcium carbonate that may be precipitated, based upon temperature, pressure, pH, TDS, and solids, and kinetic equilibrium concentrations. However, it is not an accurate predictor of calcite scale that forms and adheres to the surface. It is likely that some of the calcium carbonate precipitates are the minerals valerite or aragonite that form tiny colloidal precipitates in the water, but are not as adherent as calcite.

The rate of precipitation is a function of the square of the CCPP concentration. Thus a reduction of the CCPP by half will lower the precipitation rate to one quarter, and a reduction of CCPP to ten percent will reduce the precipitation rate to one percent. The Lopez WTP source water has an average CCPP of approximately 60 mg/l which tends to precipitate scale.

The recommendation of a CCPP in the 4 to 10 mg/l range is a useful parameter for corrosion protection, but often is too low for calcite scale control. A CCPP in the rage of 10 to 30 mg/l should be acceptable to reduce scale precipitation and also provide for a thin protective scale for corrosion control.

**Ryznar Index (RI)** - This index is derived from the formula RI = 2 $pH_S$ – pH, and was developed from the Langelier Index by Dr. Ryznar, a chemist with Nalco Water Conditioning Company of Illinois, empirically from observations of steel pipe corrosion (EES-K/J 1989). A relatively benign condition occurs in the RI range of 6 to 8. Above an RI of 8, corrosion of steel or cast/ductile iron occurs more rapidly and increased metal leaching and aggravated corrosion occurs, while below 6 – scale formation is prevalent (Singley 1985). The Lopez WTP source water has an average RI of 5 which tends to precipitate scale.

**Aggressive Index (AI)** - This index was originally developed by the American Water Works Association (AWWA) Standards Committee for Asbestos Cement Pipe as a simplified calcium carbonate saturation degree measurement, considering only the water pH, calcium and alkalinity concentration, while neglecting the relatively minor effects of TDS and the relatively low temperature range of water distribution piping. It is computed as:

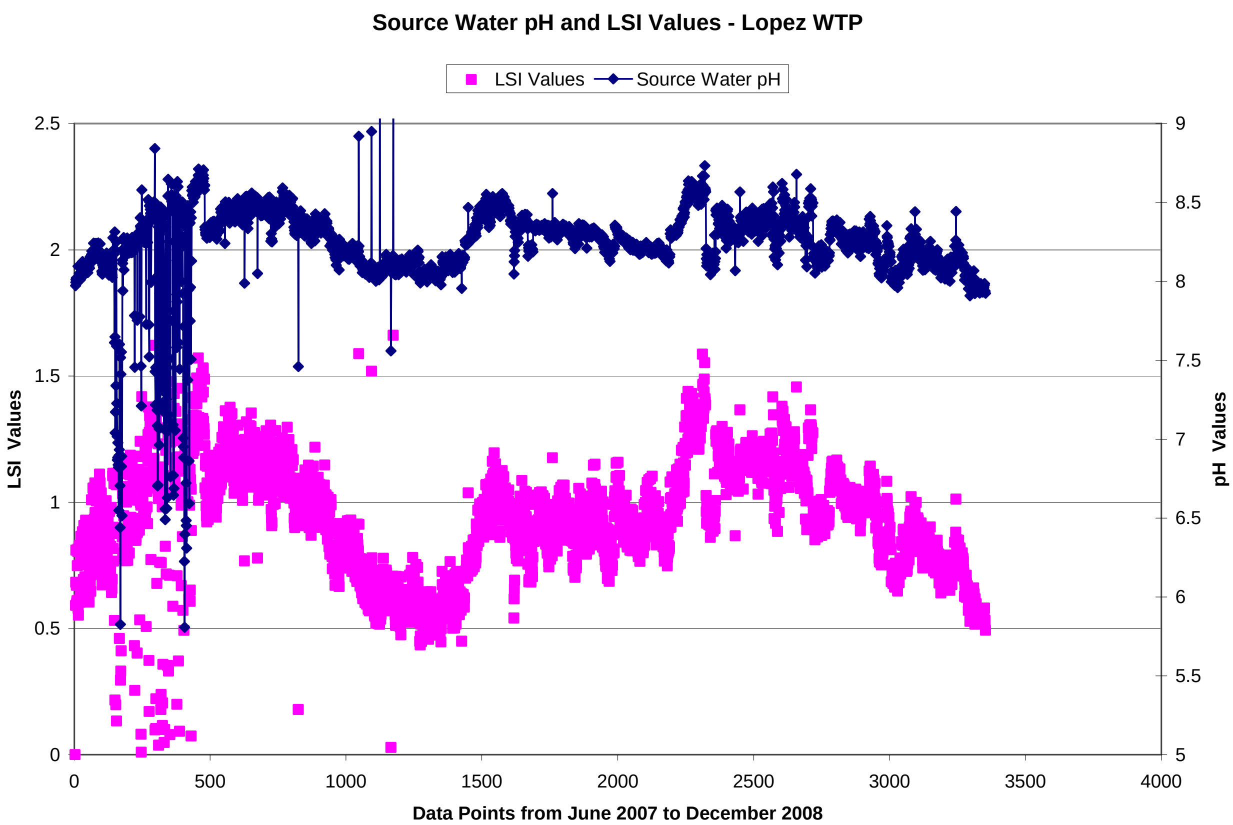
$$A.I. = pH + \log (Ca \times Alk) \text{ (expressed as } CaCO_3)$$

Above an AI of 12, no cement deterioration is expected, while unprotected cement is not recommended when AI is less than 10. AI ranges between 12 and 10 are increasingly more aggressive, approaching 10 (Singley, 1985). The Lopez WTP source water has an average AI of 13 which is protective of concrete pipe lining and structures.

## Variation in LSI and Scaling Potential at the Lopez WTP

The photosynthesis process in Lopez Reservior and the natural variation of water quality through the year create both daily and monthly variation in the LSI scale forming potential of the water. The variation in pH and the temperature have the greatest impact. Figure 1 presents the LSI of the source water to the Lopez WTP based on measured pH, temperature, hardness and alkalinity over a period from June 2007 to December 2008.

**Figure 1: Lopez WTP Source Water pH and LSI Values**




The LSI of the Lopez WTP source water varies from approximately +0.5 to +1.6 over the year. From the above data, the LSI is typically above +1 from June through October when there is increased photosynthesis and increased temperatures in Lopez Reservoir. The high pH and resulting LSI of greater than +1 of the water is creating scale on the Lopez WTP facilities.

## Impacts of Scale Formation on the Lopez WTP

The high pH and LSI values of the source water cause a calcium carbonate scale to form on the insides of pipes, valves and other surfaces that the water comes in contact with. At LSI values of -0.5 to +0.5 the scale tends to be relatively thin and helps to protect the pipe surfaces from corrosion. As the LSI value increases, the scale deposition rate increases and excessive scale can form on wetted surfaces.

The facilities at the Lopez WTP that have been or could be impacted by excessive source water scaling include:

- **Process Piping** – excessive scale can develop on the inside of the plant process piping and increase friction headloss and energy use, and reduce pipe capacity over time.
- **Source Water Instrumentation** – excessive scale may impact operation of flow meters and sensors, and can plug sample lines to analyzers. The Lopez WTP Operations Staff perform acid cleaning of sample lines to WTP analyzers annually to prevent clogging of these systems.
- **Flocculation Mixers** – excessive scale buildup on the mixer blades can cause increased or unbalanced motor loads, accelerated bearing and gear wear, and reduced mixing efficiency.
- **DAF System Aeration Diffuser Nozzles** – excessive scale buildup can plug the DAF System aeration diffuser nozzles. See Photo 1 below. The Lopez Operations Staff perform acid cleaning of diffuser nozzles every 6 months to prevent clogging of these systems.
- **Particle Strainers** - excessive scale buildup has occurred on the particle strainers located ahead of the membrane units. The scale increases the pressure drop across the unit and causes the system to backwash frequently, wasting energy and water.
- **Membrane Filters** – excessive scale can form on the piping, valves and membrane elements of the membrane filter system. See Photo 2 below. This increases maintenance and requires more frequent acid cleanings of the system to maintain the system performance.

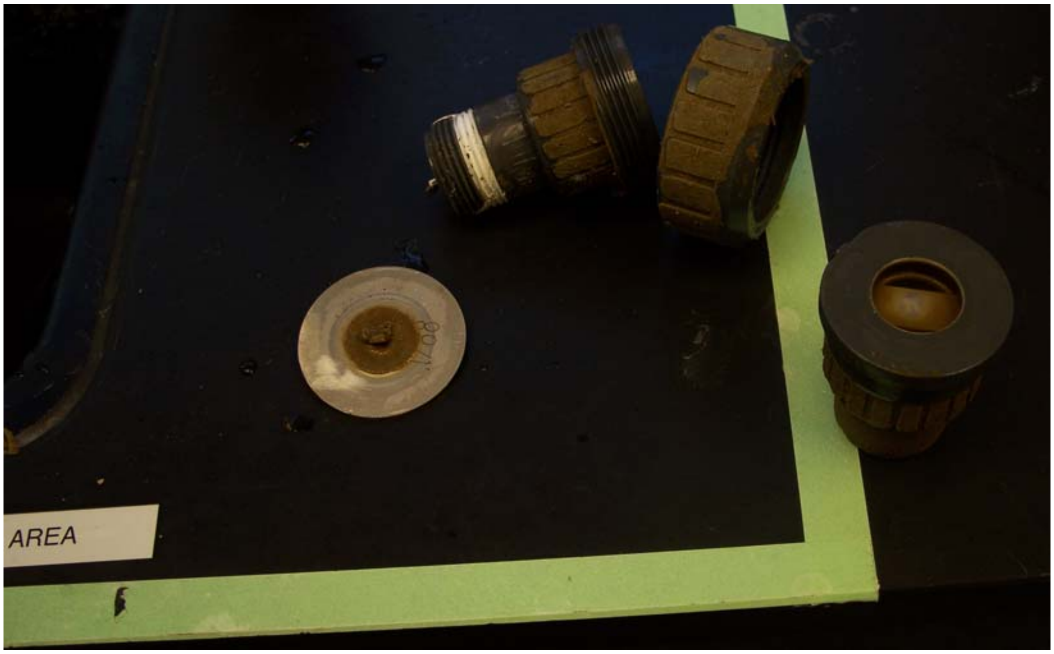



Photo 1: Scale formation plugging the DAF diffuser nozzles

Photo 2: Excessively thick scale layer on the metal surface of a butterfly valve.

The overall impacts of a high LSI value and excessive calcium carbonate scale formation include:

- increased labor and maintenance costs to periodically remove the accumulated scale with acid cleaning,
- increased energy costs to pump the water through clogged strainers and pipelines,
- reduced plant production from the equipment down-time during periodic acid cleanings
- potential increased scale buildup in the drinking water distribution system

## Changes at the Lopez WTP that Likely Contributed to Additional Scale Formation

Changes to the Lopez WTP process during the recent facility upgrade project in 2006 and 2007 may have contributed to the excessive scale formation that is now occurring at the facility. The previous treatment process used alum as a coagulant and gas chlorine as the disinfectant. Both these chemicals are acids and can tend to lower the pH of the source water. The previous treatment process chemical addition may have helped to lower the source water pH and thus lower the LSI values and the associated tendency for scale to precipitate.

The new treatment process uses a polyaluminum chlorohydrate (PACl) chemical as a coagulant. While this coagulant has benefits for the membrane treatment process and is not as sensitive to pH variations in the source water, the chemical is neutral with respect to pH. It does not tend to lower the source water pH. Therefore, by switching from alum (acidic) to PACl (neutral) the source water LSI is no longer reduced and more scaling could occur.

The new primary disinfectant chemicals for the Lopez WTP are chlorine dioxide and sodium hypochlorite. While these chemicals offer advantages over gas chlorine, they have different impacts on the pH of the water to which they are added. Chlorine dioxide could be acidic or neutral depending on how it is produced. Sodium hypochlorite is basic and tends to increase the pH of the water to which it is added. By using sodium hypochlorite as a pre-oxidant and as a disinfectant after the membranes, the source water LSI is no longer reduced (and is possibly increased) and more scaling could occur.

## Benefits of a Proposed $CO_2$ and pH Control System

Kennedy/Jenks described the potential for a $CO_2$ system and pH control improvements for the Lopez WTP as part of an evaluation of the Lopez WTP, dated July 2008. Adding $CO_2$ to the water will produce carbonic acid ($H_2CO_3$) and the carbonic acid will reduce the pH of the water. Lowering the pH will reduce the tendency for $CaCO_3$ to precipitate and form scale on the plant components, strainers and MF membranes. The Lopez WTP Evaluation Report also discussed the advantages of a $CO_2$ system over that of a mineral acid addition such as sulfuric acid.

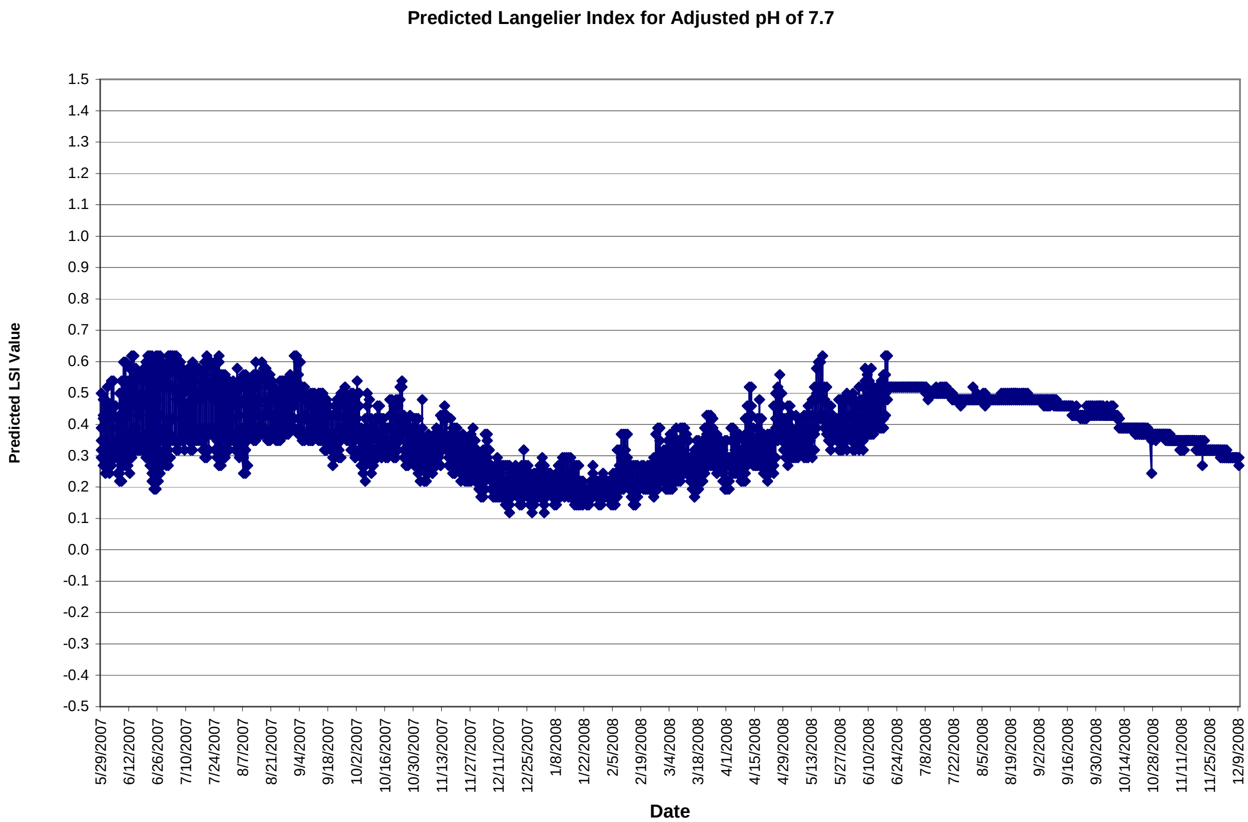
The proposed $CO_2$ system will permit Lopez WTP staff to replace the $CO_2$ removed from the source water by algae and to lower the pH and LSI of the source water to minimize scaling at the Lopez WTP. The $CO_2$ system would be automatically controlled to adjust or stop $CO_2$ addition if the pH in the source water drops, such as can happen at night when algae photosynthesis stops or during parts of the year when natural LSI values drop due to temperature and pH variation.

Table 2 presents the pH and LSI scaling potential reductions that an automated $CO_2$ and pH control system would provide. The system would dose $CO_2$ as needed to maintain a source water pH of approximately 7.7. This would provide for an average LSI value of approximately +0.4 and less LSI variation and scale formation. Figure 2 shows the LSI value based on adjusting the pH to 7.7 based on the source water data from June 2007 through December 2008.

Table 2: Water Characteristics with $CO_2$ Addition

| **Water Characteristic** | **Average Source Water** | **pH Reduction with CO2 addition to LSI ~+0.5** | **Typical Scale/ Corrosion Control Objectives** |
|---|---|---|---|
| $CO_2$ dose, mg/l | -- | Up to 25 | |
| pH range | 7.9 to 8.6 | 7.7 | 7.2 to 7.8 |
| Calcium, mg/l as CaCO3 | 182 | 182 | ~120 – 150 or less |
| Alkalinity, mg/l as CaCO3 | 262 | 262 | ~100 – 120 or less |
| Temp, degrees C | 18.7 | 18.7 | -- |
| Langlier Saturation Index, | +1.0 | +0.4 | - 0.5 to +0.5 |
| Calcium Carbonate Precipitation Potential, mg/l | 60 | 37 | 10 to 30 |
| Ryznar Index | 5 | 6.5 | 6 to 8 |
| Aggressive Index | 13 | 12.4 | > 12 |

**Figure 2: Predicted Lopez WTP Adjusted Source Water LSI Values**




The addition of $CO_2$ can provide the following benefits:

- Lower pH and LSI to reduce scale formation in the Lopez WTP.
- Reduced labor, maintenance cleanings and energy costs associated with excessive scale.
- Provide for more stable coagulation and pretreatment performance due to a more constant source water pH.
- Potentially increase the disinfection CT achieved with free chlorine following the membranes. Free chlorine is more effective at lower pH. Chlorine dioxide disinfection is not impacted by pH variation between pH of 6 to 9.
- Help reduce potential excessive scale formation in the distribution system piping.

## $CO_2$ Preliminary Design Criteria and Layout

### Carbon Dioxide System Design Criteria

The carbon dioxide system would consist of a liquid $CO_2$ storage tank, vaporizer, injector and diffuser. The liquid $CO_2$ from the tank would be vaporized into a gas and then injected into a carrier water solution under high pressure to create a carbonic acid feed solution. The carbonic acid would be conveyed to the injection point through PVC pipe and diffused into the process water. Converting the $CO_2$ gas to carbonic acid improves the efficiency of the system. The $CO_2$ as carbonic acid is rapidly mixed into solution and can be injected into a pipeline rather than requiring a large baffled tank.

Preliminary design criteria for the carbon dioxide storage and feed system are summarized in Table 3 below.

Table 3: Carbon Dioxide System Preliminary Design Criteria

| Parameter | Unit | Design Value |
|---|---|---|
| Process Flow (Avg / Max) | MGD | 4.5 / 6.7 |
| Design Finished Water pH | pH | 7.7 |
| Design $CO_2$ Dose (Min / Avg / Max) | mg/l | 3.13 / 15 / 25 |
| Design $CO_2$ Addition Rate (Min / Avg / Max) | ppd | 117 / 563 / 1400 |
| Feeder Unit | number | 2 |
| Feeder Capacity, Min | lb/hr | 3 |
| Feeder Capacity, Max | lb/hr | 60 |
| $CO_2$ Storage Unit | number | 1 |
| $CO_2$ Storage Capacity (each) | pounds | 100,000 |
| Supply at (Min / Avg / Max) Usage Rates | days | 850 / 175 / 70 |
| Bulk Delivery Volume | tons | 20 |

### Carbon Dioxide Storage and Feed System Layout

The carbonic acid solution would be introduced to the process water at the existing intake vault, ahead of the rapid mix and flocculation system to provide benefits to the pretreatment system. An alternate location for injection of carbonic acid solution would be ahead of the strainers at the feed pump wetwell. The $CO_2$ feed rate would be controlled through compound loop control by both the plant flow rate and pH feed back. Figure 1 shows the plant process schematic with the primary and alternate locations for $CO_2$ injection. Addition of carbonic acid at the primary injection point would permit use of the existing pH meter downstream of the flash mixer to control the $CO_2$ feed rate. Carbonic acid injection at the alternate location would require installation of a pH meter upstream of the membrane filters to control the $CO_2$ dose.

Liquid $CO_2$ would be stored on-site in 100,000 pound horizontal insulated storage unit, which would be periodically filled from a tanker truck. Horizontal storage systems provide for better aesthetics at the site and are better suited for seismic conditions. A 100,000 pound $CO_2$ storage unit would provide approximately 40 days of operation at maximum demand conditions and with enough room to permit delivery of full tanker loads (approximately 40,000 pounds) to the facility. The next standard size for the $CO_2$ storage unit is 60,000 pounds. This tank would also work and provide 14 days of operation at maximum demand (20,000 lbs) while permitting a full tanker delivery.

A 100,000 pound $CO_2$ storage tank would have a footprint of approximately 56-feet-6-inches by 7-feet-6-inches and would be approximately 8-feet-8-inches tall. The tank would be situated on a concrete equipment pad that extends 6 feet beyond the edge of the tank on all sides. Figure 2 shows plan and section views of the tank on a concrete pad.

Two pressure solution feed panels (one for redundancy) would be provided to combine the $CO_2$ vapor with the carrier solution to form the carbonic acid solution. The feed panels are each approximately 5-feet long by 2-feet wide by 5-feet tall. The feed panels would be located near the $CO_2$ storage tank to minimize $CO_2$ vapor piping.

Figure 3 shows a proposed location for the $CO_2$ storage and feed system at the Lopez WTP. The $CO_2$ system could be located along the existing access road on the west side of the existing clear water reservoir. Another potential location for the system would be the area below the Lopez Reservoir, near the drying beds.

## Opinion of Probable Costs and Savings

### Capital Construction Costs

The opinion of probable construction costs for the pH control system at the Lopez WTP is presented below. The estimate of probable construction costs was developed based on equipment supplier's budget prices and typical unit and construction costs. The estimate includes the materials and installation costs for the carbon dioxide storage and feed system, sales tax on materials, contractor's overhead and profit (OH&P) and a project estimate contingency of 20-percent based on conceptual level of design.

Table 4: $CO_2$ Storage and Feed System Conceptual Capital Cost

| Category | Cost |
|---|---|
| General Requirements, Mobilization, Etc. | $30,000 |
| Site Work, Excavation | $13,000 |
| Concrete Slab on Grade Bollards | $45,000 |
| $CO_2$ Storage and Feed System | $357,000 |
| Piping, Fittings and Accessories | $25,000 |
| Electrical and Instrumentation | $30,000 |
| **Subtotal** | **$500,000** |
| Taxes (7.75% on materials) | $30,000 |
| **Subtotal** | **$530,000** |
| Contractor OH&P (15%) | $80,000 |
| **Subtotal** | **$610,000** |
| Estimate Contingency (20%) | $120,000 |
| **Conceptual Project Cost** | **$730,000** |

### Operations and Maintenance Costs

Estimated operation and maintenance (O&M) costs for the $CO_2$ storage and feed system are summarized in Table 5 and described below. The O&M costs include chemical use, power use, maintenance materials and labor. The O&M costs are based on an average plant flow of 4.5 MGD and operation of the facility for 365 days per year.

Table 5: $CO_2$ System Operating Cost

| Category | Cost ($/yr) |
|---|---|
| Chemical | $22,900 |
| Power | $18,000 |
| Maintenance Materials | $7,800 |
| **Total** | **$48,700** |

The average carbon dioxide cost is $22,900 per year at an average dosage rate of 15 mg/l and chemical cost of $210 per ton plus $250 per delivery for delivery and limited access fees (restriction to certain hours for delivery). A full load delivery is 20 tons.

The energy use for the $CO_2$ system would be from operating the storage tank refrigeration system, electric vaporizer and vapor heater. Assuming a power rate of $0.10 per kilowatt-hour, the probable annual power cost for operating the $CO_2$ system is $18,000.

The maintenance materials costs are estimated at 2.5% of the cost of the process equipment that requires routine maintenance including the $CO_2$ storage tank and feed equipment. The estimated maintenance materials costs are $7,800 per year.

The pH control system would be automated and should require very little additional operator labor. The labor involved in operating the $CO_2$ facilities would include receiving chemical deliveries and maintaining the $CO_2$ storage tank, feed equipment and instrumentation. The estimated additional labor effort includes up to six chemical deliveries per year and four hours for maintenance per month. It is assumed that current Operations and Maintenance staff would accomplish this work.

**Operations Savings**

The estimated savings from the project would be in reduced energy and maintenance (O&M) costs for acid cleanings of plant components and piping. The estimated savings are summarized in Table 6 and described below. The O&M costs include chemical use, power use, maintenance materials and labor. The O&M costs are based on an average plant flow of 4.5 MGD and operation of the facility for 365 days per year.

Table 6: Savings from Reduced Scale Formation

| Category | Cost ($/yr) |
|---|---|
| EFMC/CIP Chemical Savings | $3,000 |
| Energy Savings | $14,600 |
| Strainer, Diffuser and Instrumentation Acid Cleaning Savings | $8,000 |
| Plant Process Piping Acid Cleaning Savings | $20,000 |
| **Total** | **$45,600** |

The MF skid Enhanced Flux Maintenance Cleaning (EFMC) schedule has evolved to conducting an EFMC every 1.7 million gallons of treated water. This is approximately every 24 to 48 hours per skid depending on plant flow rates. The chlorine EFMC is performed for six (6) events and then the acid EFMC is performed on the seventh event. The cost of an acid cleaning for the MF systems is approximately $200 per event or $10,000 per year. Assuming the reduction of scale formation potential reduces the number of required acid CIP cleanings by one third, the estimated chemical savings would be $3,000 per year.

The energy savings from the $CO_2$ system would be primarily from reduced headloss through the feed strainers. However, overtime headloss in the main process pipes would also be reduced. The increased friction from the scale build up in the strainers is approximately 10 psi and requires additional pumping energy. Assuming average flow rates and a power rate of $0.10 per kilowatt-hour, the probable annual power cost for additional headloss is $14,600.

The Lopez Operations Staff expect to perform acid cleaning of strainers, DAF nozzles, and instrumentation sampling piping approximately every 6 months to prevent clogging of these systems. The estimated equipment rental and maintenance costs per cleaning event for the screens (three screens) is $3,500. The estimated maintenance costs for cleaning of the DAF nozzles and sample piping is $500 per cleaning.

**Cleaning of Scale from Plant Process Piping**

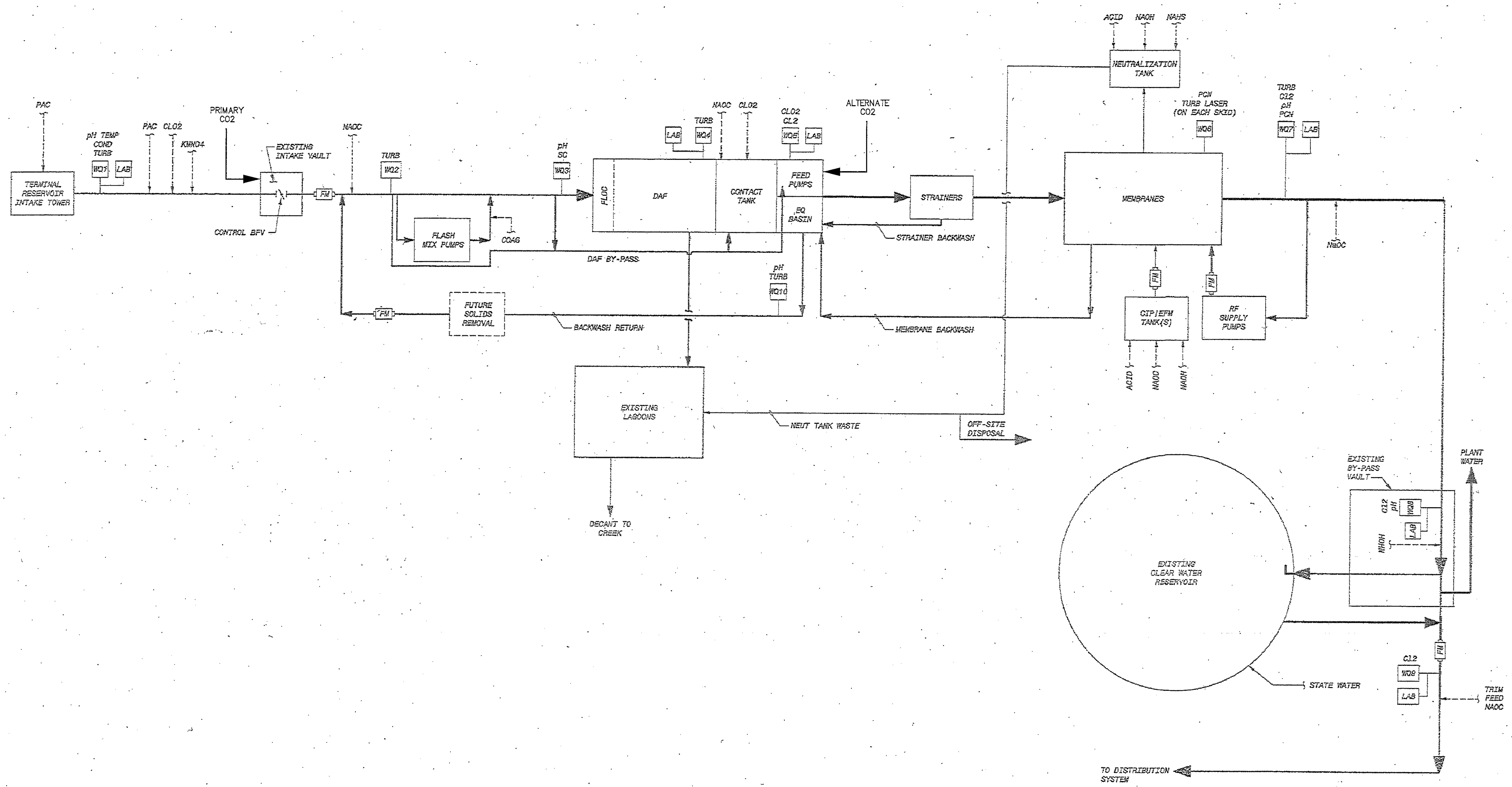
As described above, excessive scale can develop on the inside of the plant process piping and increase friction headloss and increase energy use, and reduce pipe capacity over time. While it is possible to perform acid cleanings of the large diameter plant process cleaning, this is not typically recommended for potable WTPs, and the costs are not easily quantified.

Food processing plants that have scale formation on plant process piping will typically shut down for several weeks and acid clean the pipes to remove the scale. Specialty contractors are brought in and heated citric acid solution is used to dissolved scale from the pipes. The acid solution is circulated through the piping for a period and then the system is drained and flushed (similar to a CIP on the MF system). The heated acid removes the scale but can also increase the general corrosion of the plant process piping.

This work is highly specialized and hazardous. It is usually performed at annual intervals by specialty contractors. The contractors have to circulate the acid for several days each year, while measuring scale removal and also possible corrosion of metal to prevent such occurrences. In addition, there is the disposal of spent acid and scale, flushing and bringing the system back into service. The estimated pipe cleaning cost is $20,000 per year. However, this approach of removing scale from the plant process piping may not be practical for the Lopez WTP. The recommended approach to address this issue is to minimize scale buildup through $CO_2$ addition and control of the pH and LSI.

## Summary

While the estimated operational savings for the CO2 system are approximately equal to the operating costs, Kennedy/Jenks recommends implementation of a $CO_2$ System and pH Control Improvements project for the Lopez WTP. The project will help to reduce the labor effort and plant down-time associated with scale control cleanings and help minimize long-term scale build-up issues in the plant and potentially the distribution system.

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LOPEZ WTP CO2 SYSTEM AND pH CONTROL

**PROCESS FLOW SCHEMATIC**

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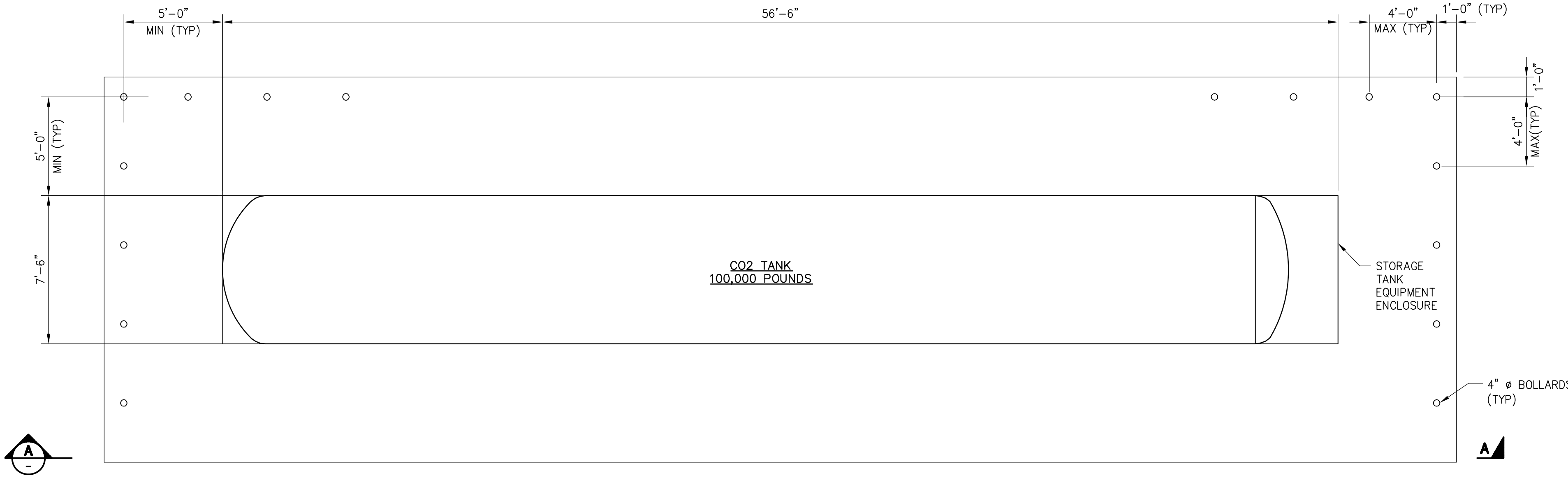
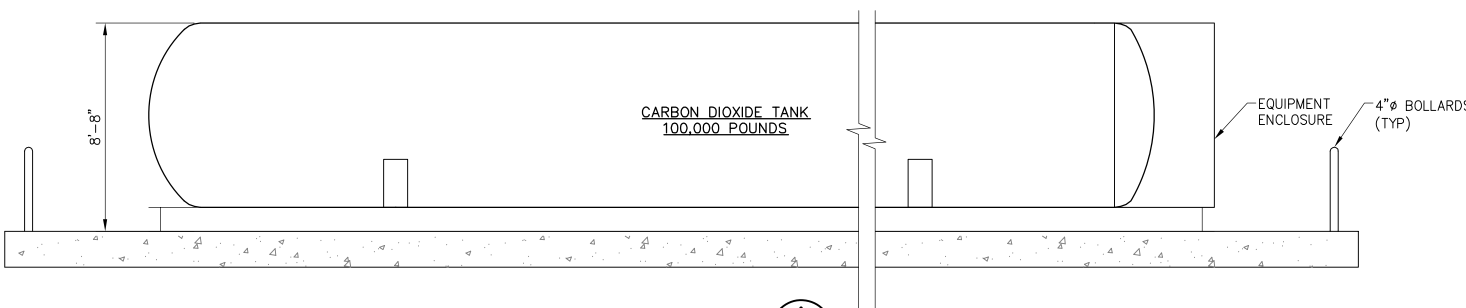
JUNE 2009

**FIGURE 1**




**CARBON DIOXIDE STORAGE TANK - PLAN**

SCALE: 1/8" = 1'-0"




**SECTION** A / -

SCALE: 1/8" = 1'-0"

**Kennedy/Jenks Consultants**

SAN LUIS OBISPO COUNTY PUBLIC WORKS
LOPEZ WTP CO2 SYSTEM AND pH CONTROL

**CO2 STORAGE EQUIPMENT**
**PLAN AND SECTION**

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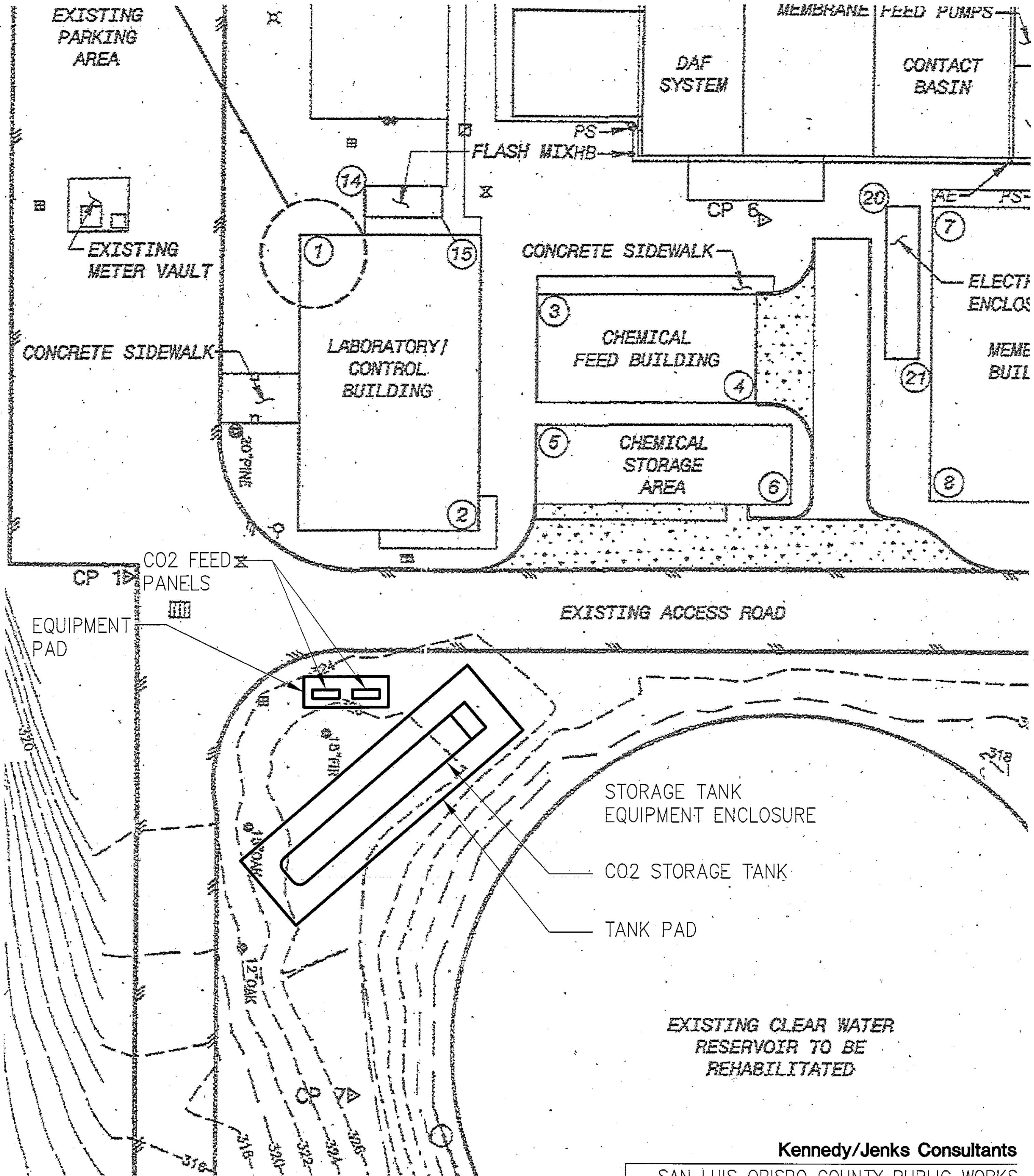
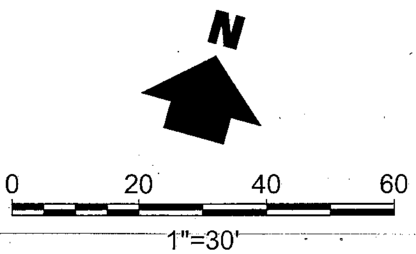
**FIGURE 2**




## SITE PLAN

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**CO2 SYSTEM PROPOSED LOCATION**

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**FIGURE 3**