CITY OF MODESTO
JENNINGS ROAD FACILITY
TECHNICAL MEMORANDUM
CANNERY SEGREGATION PUMP STATION
OPERATIONAL EVALUATION

FINAL
MAY 2013
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1.0 PURPOSE

The purpose of this technical memorandum (TM) is to evaluate the Cannery Segregation ("Can Seg") pump station for the City of Modesto, California, located at the Jennings Rd. Secondary Treatment Facilities site. The TM identifies possible causes for operational problems and recommendation for improvements to the pump station.

2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The key findings and recommendations are summarized below:

- The Can Seg pump station consists of three equally sized pumps to achieve a firm capacity of 28 million gallons per day (mgd). Three equally sized pumps with a capacity each of 14 mgd were installed. Two pumps are designed for duty operation with one pump serving as a standby. One additional deck space is available for a future pump. The current average daily flows range between 13 to 18 mgd. As such, the installed pumps are oversized and running off their curve, causing vibrations and rough running conditions.

- The Can Seg flows have declined over recent years and have only exceed 20.3 mgd in two occasions over the last five canning seasons. As such, the firm capacity of the pump station should be reduced to from 28 mgd to 20.3 mgd. The standby pump should be programmed to switch on for additional capacity in the rare event that flows exceed 20.3 mgd.

- Many parameters in the wet well design at the Can Seg pump station differ from Hydraulic Institute (HI) standards for pump intake design. The approach flow characteristics at the pump bowls causes pump cavitation and pre-swirling of fine sand and grit at the pump intake.

- The pump bowl and impeller have been damaged both from cavitation and from abrasion and erosion caused by a high volume of fine sand and grit material present in the cannery waste.

- Long-term contact with low pH cannery waste leads to aggressive corrosion on the cast iron and steel components of the pump. The corrosion and pitting on these components is accelerated by the deterioration of the lining.

- The plant staff has been pulling the pumps out of the wet well annually to repair the pumps and to recoat the bowls and the pump columns. Pump impellers wear rings
and line shafts have been replaced and restored several times since installation in 1997.

- We recommend replacing the three existing pumps with three new vertical turbine solids handling pumps that have better flow characteristics for the current operating conditions. In addition, we recommend that the pumps be installed with open top confined inlet barrels to improve the hydraulic conditions at the pump intake. The estimated cost for the new pumps and inlets is $2.32 million.

3.0 BACKGROUND

The Can Seg pump station at Jennings Road was placed in service in 1999. It is usually operated for about four months every year during the canning season (July through October). The pump station receives food process byproducts from the pump station located at the Sutter Avenue Primary Treatment Facility, and pumps to the irrigation mixing box at the Jennings Rd. site, where the food processing water is mixed with flow from the irrigation reservoir and sent to the ranchland at the Jennings Road site. The pump station currently has three 20-inch Vertical Turbine Solids Handling (VTSH) pumps model 20QMN-A manufactured by Ingersoll-Dresser Pumps (IDP). The pumps are each rated for 14 mgd (9,722 gallons per minute [gpm]) at 55 feet of total dynamic head (TDH) at 1,190 RPM. The pumps are equipped with 200 HP motors which are speed controlled using VFDs manufactured by Allan Bradley, Model 1336 Plus.

The Can Seg pump station at Jennings Road was designed in June 1998 as part of the Ranch Cannery Pump Station and Force Main Project. At the time of design, numerous food process facilities and two major canneries fed into the Can Seg system. The original design accommodated for a future capacity of 42 mgd, which was envisioned to be achieved by increasing the size of the pump impellers and motor, and adding an additional pump.

Since the time of design, the number of food processing plants in Modesto has decreased. One of the two major canneries that fed into the system during design is not longer in operation. As such, Can Seg flows have decreased significantly from the design firm capacity of 28 mgd to 15.2 mgd on average. Figure 1 shows the plot of daily average flow rates from the 2008 to the 2012 cannery seasons. In this time frame, the Can Seg flow rates is below 20 mgd for 98 percent of the time and have only exceeded 20.3 mgd on two days.

In recent years, the City has encountered operational challenges with the Can Seg Pump Station at Jennings Road. Plant maintenance operators have noted that the pumps are experiencing vibration and require frequent costly annual maintenance. After the cannery season each year, the pumps are the lifted out of the wet well for repairs and maintenance work. When the pumps were taken out of service and disassembled, severe damages incurred by cavitation and corrosion were observed in the inlet bell, impeller, retaining bolt,
discharge head, and other pump components. According to staff, the pumps have been rebuilt three times within 10,000 hours. The plant maintenance operators have remediated problems with the shaft and flush bearing; however, damage from cavitation and corrosion has not been addressed. In addition, the pumps were observed by the plant staff to have harmonic problems where excess vibration occurs between 31-35 Hz.
Figure 1  2008 - 2012 Cannery Segregation Daily Average Flow Rates
4.0 EVALUATION OF PUMP STATION AND OPERATIONAL CHALLENGES

This section reviews the operational challenges for the Can Seg pump station and determines possible causes for the rough running conditions at the pump station based on site visit observations, existing data, and hydraulic analyses.

4.1 Can Seg System Study

Carollo conducted a computer desk top hydraulic study of the Can Seg Pump Station. The construction drawings from Camp Dresser & McKee - CDM (Ranch Cannery Pump Station and Force Main Project – June 1998) were used as a basis to calculate the system head curves. The published pump curve data from the IDP shop drawings (Appendix A) were then superimposed on chart. The system TDH curves were based on cement mortar lined steel pipe, and three TDH curves were developed using three different assumptions for the friction factor “C” (Hazen-Williams equation; C=130 “smooth new pipe”; C=120 “slightly rougher pipe lining”; and C=110 “rougher pipe lining”). In addition, we simulated highest lift conditions (low wetwell and high mixing box water surface elevation) and lowest lift to create a range of operating condition requirements that a pump or combination of pumps will need to meet (See Appendix B for detailed system curve calculations).

Results are used to create the TDH curves for Figures 3 through 6. The hydraulic analysis on the existing pump station show that the existing pumps are not operating on their pump curves. A single pump operating at full speed is oversized for current conditions when the flow is between 8 and 14 mgd. When two pumps are operating in parallel, the pumps are better suited for the design firm capacity of 28 mgd at 55 feet.

4.2 Site Visit and Field Evaluations

Plant O&M staff and Carollo conducted a field visit on September 27, 2012 to collect information during cannery season operating conditions, compare field dimensions with available record and shop drawings for the pump station and IDP pumps. A field meeting was held on the same day to review operational challenges and maintenance history with the City’s O&M staff. The O&M staff confirmed that the pumps have several difficulties including corrosion, cavitation, adverse inlet hydraulics, shaft misalignment, flush water quality, and vibrations.

4.2.1 Field Pump Test

A field test to confirm the results from the desk top hydraulic study was conducted during the September 27, 2012 site visit. The butterfly valve (BRV101) immediately downstream of the magnetic flow meter was incrementally closed to create an artificial resistance pressure
head and raise the system head requirement. At each interval, readings for pressure head, pump speed, wet well water level, and flow rate was recorded. Severe vibrations were observed when the valve is fully or mostly open. The vibrations diminished as the valve is incrementally closed. This test confirmed the findings of the desk top study which indicated that system head is significantly below the pump operating head and that the current pumps are oversized for current flow conditions.

4.3 Review of Existing Data

4.3.1 Review of Drawing/Layout

Design drawings for the Can Seg P.S. were reviewed for consistency and some pertinent dimensions were compared with field measurements. The drawings appear to conform to field measurements and observations with the exception of the circular concrete openings on the Can Seg pump station deck, which are shown to be 42 inches on the drawings, but were measured to be about 33-inches in the field.

4.3.2 Review of Shop Drawing

The submittal for the existing IDP pumps was reviewed to determine the material specification of the components, the coating specification, and the performance test curve. Submittal shows the components susceptible to cavitation and corrosion damage such as the impeller, diffuser bowl, and suction bell to be made of ASTM A48 cast iron. The original submitted coating is Polyamidoamine Epoxy that contains 69 percent volume solids. This solids content is less than the High Solids Epoxy that Carollo specifies for submerged pump components under similar conditions.

Performance test curves for the IDP pumps show that all three pumps deliver more than 55 ft of total dynamic head (TDH) at 10,000 GPM (14.4 mgd) at full speed. However, discussions with the plant staff and hydraulic analysis indicates that only 20-32 ft of total discharge head is needed at normal operating flow rates, suggesting that the pumps are not suitably sized for current flows.

4.3.3 Review of Training Workshop Document

The Training Workshop Document contains information about the different operating modes and the design criteria of Can Seg system. The document shows an initial station capacity of 28 mgd, which will later be expanded to an ultimate capacity of 42 mgd. However, according to staff, these predicted high flows are not seen in the recent cannery seasons and is not expected any time soon.

4.3.4 Summary of Data and Photos

The Training Workshop Document and the performance pump test in the submittal both reveal that the TDH for the IDP pumps are much higher than the actual operating pressure head needed. This discrepancy results in operation that is outside of the pump curve, which
creates adverse flow conditions that may cause cavitation. Photos (Figure 2) taken in the field when the pumps are taken out of service confirm that intake bell, impellers, discharge head, and other components of the pump been significantly impaired by corrosion and cavitation.

Figure 2 Cavitation and Corrosion Damage on Pump Components

a) Intake bell corrosion and abrasion, note spiraling pattern from pre-swirling; b) Impeller edge eroded by cavitation and corrosion; c) Discharge head corrosion; d) Disintegration of pipe lining between discharge and check valve.
4.4 Hydraulic Evaluation

4.4.1 Wet well design as compared to Hydraulic Institute standards

Hydraulic Institute Standards for pump intake (HI 9.8) contains a series of geometrical guidelines aimed to minimize adverse hydraulic phenomena such as vortices, excessive pre-swirl at intake bell, and non-uniform flow at the impeller eye. The observed vibrations, cavitation, and abrasion damage may be caused or exacerbated by these adverse hydraulic phenomena at the intake. Comparisons of dimensions shown on design drawings and HI recommended dimensions reveal salient differences in many hydraulically sensitive parameters. These comparisons are summarized in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HI Standard (1)</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach velocity entering wet well</td>
<td>≤2.0 ft/s</td>
<td>Not measured, but calculated at 0.9 ft/s at 14 mgd.</td>
</tr>
<tr>
<td>Velocity in channel</td>
<td>≤1.0 ft/s</td>
<td>Not measured, but calculated at 1.1 ft/s at 14 mgd.</td>
</tr>
<tr>
<td>Suction bell intake velocity</td>
<td>3.0-8.0 ft/s</td>
<td>2.2 ft/s at 8 mgd 3.9 ft/s at 14 mgd</td>
</tr>
<tr>
<td>End wall clearance</td>
<td>24”</td>
<td>72”</td>
</tr>
<tr>
<td>Floor clearance</td>
<td>9.6” – 16”</td>
<td>18”</td>
</tr>
<tr>
<td>Influent Pipe</td>
<td>Coaxial wetwell and free of flow disruption for eight pipe diameters</td>
<td>Perpendicular to wetwell</td>
</tr>
<tr>
<td>Anti-rotation baffle</td>
<td>at the last pump</td>
<td>none</td>
</tr>
</tbody>
</table>

Note:
HI recommended dimension calculations are based on inlet bell outside diameter of 32”

The wet well geometry differs significantly from the recommended trench-type geometry in the HI standards. The HI trench-type wet well features an inlet above the suction bell and a wider section above the narrow trench, where the pump intake is situated. This layout reduces turbulence by slowing the velocity in the channel above the trench and directing flow downward into the trench. In comparison, in the existing pump station, the inlet is at the channel bottom and there is no trench to uniformly direct flow toward the suction bell. In addition, suction bell intake velocity ranges on the low side of the HI acceptable range for flows under 14 mgd, causing grit to swirl excessively at the pump intake. Furthermore, the
flow enters the wet well perpendicularly from the upstream 66-inch line and this may create additional turbulence in the wet well channel. These adverse hydraulic phenomena may be an exacerbating factor in causing cavitation and excessive vibrations.

4.4.2  **Hydraulic Calculations**

In the desk top study, calculations were performed to evaluate a range of total dynamic head for different pipe friction factors and generate system curves. Dimensions and material specification listed in drawings were used for the friction calculations, while current alarm settings and daily average water levels in the pump station and irrigation mixing box were used to evaluate the actual static head. The performance test curves for the existing pumps are fitted on available data. The resulting analysis illustrating system and existing pump curves are shown on Figure 3. To verify the calculated system curves, additional field-testing was conducted based on two pumps operating in parallel on November 16, 2012. After calibrating for field elevations, the seven data points were then plotted against the calibrated system curves. The calibrated field data points fits closely with the average system curve (depicted by the green TDH graph on Figures 3 through 6).

Figure 3 shows that two current pumps running in parallel is capable of producing 21,000 gpm (30.2 mgd) at 52 feet, which is more than the specified designed firm capacity of 28 gpm at 55 feet TDH. This discharge head requirement in the original design appears to be based on the high friction scenario. However, available data and profile recording show that average flow rate and pressure head requirement have been much lower in the recent cannery seasons, as confirmed by the 2008 through 2012 cannery segregation flow data. Over the average range of operation, the pump curve at full speed is far above the system curve. Significant speed reduction using VFDs are required before the pump curve intersects the system curve. Furthermore, with a single pump in operation at full speed, the pump curves intersect the system curve at the tail end (right side of the curve), where NPSHr rises sharply. This creates cavitation when NPSHr exceed NPSHa.

From these hydraulic calculations, it appears that existing pumps are not well sized for operation in the 8- to 14-mgd flow range, as the flow/head characteristics for the pumps is much larger than the system requirement. The field pump test conducted on September 27, 2012 confirmed the gap between the pump curve and the TDH system curves. The pump was observed to run smoother as the butterfly valve on the discharge line was incrementally closed to provide resistance head and raise the system curve.
(1) Low Wet Well Level, High Mix Box Level, Hazen-Williams C = 110.
(2) Normal Operating Head, Wet Well Level and Mix Box Level from Daily Average Readings from 1-Aug-12 to 30-Sep-12, C = 120.
(3) High Wet Well Level, Low Mix Box Level, C = 130.
5.0 RECOMMENDATIONS

5.1 Alternative A - Replacement of Existing Pumps with new Vertical Turbine Solids Handling pumps

Due to poor condition of the existing pumps and the salient decrease of cannery segregation flow rates in the recent years, we recommend replacing the existing Can Seg pumps with new Vertical Turbine Solids Handling pumps (VTSH) with open top confined barrel inlet that are suitably sized for current and future cannery waste flows. The pumps should be selected such that the following parameters are met:

- Pump dimensions are compatible with existing wet well dimensions.
- Pump curve intersects systems curve for current daily average flows between 13 to 18 mgd.
- Pump is operating on or near the best efficiency point for daily average flows
- Pump impeller, line shaft, suction bell, fasteners, and other components susceptible to corrosion are made of corrosion-resistant material.

A quote for new 20-inch VTSH pumps with standard corrosion upgrade provided by JM Squared is included in Appendix C. The corrosion-resisting upgrade consists of nitronic 50 line shaft with ceramic coating on bearings, and epoxy coating and lining on pump components. In addition to these standard upgrades, we recommend that the impeller to be constructed of 316L stainless steel.

The quoted pumps operate with 100 HP high efficiency motors as opposed to the current pumps that require 200 HP motors. These proposed new pumps are sized such that a single pump is sufficient to handle flow rates up to 10 mgd and that two pumps in operation will meet the new firm capacity of 20.3 mgd. The new pump curves are plotted with the existing system curves in Figure 4, which shows that the quoted pumps are smaller and have a steeper curve than the existing IDP pumps, making them more compatible with flows between 8 to 14 mgd. Two pumps are required to meet the new firm capacity of 20.3 MGD and an additional standby pump should be provided for redundancy.

5.1.1 Open Top Confined Barrel Inlets

Carollo recommends that open top confined barrel inlets be installed around the intake of each pump to mitigate the effects of adverse hydraulic conditions such as vortices, grit-swirling, turbulence, flow rotation, and uneven flow distribution. The open top confined inlet is a hollow cylinder with flow guiding vanes that is installed around the pump intake. The confined inlets will reduce or eliminate the turbulence generated from the abrupt flow direction change at the wet well entrance. The confined inlets will also eliminate vortices,
pre-swirl at intake bell, and non-uniform flow at the impeller eye by directing flow from the
top of the barrel uniformly downwards toward the suction bell of the pump.
Figure 4  Alternative A: Fairbank Morse VTSH Pump Curves

(1) Low Wet Well Level, High Mix Box Level, Hazen-Williams C = 110.
(2) Normal Operating Head, Wet Well Level and Mix Box Level from Daily Average Readings from 1-Aug-12 to 30-Sep-12, C = 120.
(3) High Wet Well Level, Low Mix Box Level, C = 130.
5.2 Alternative B - Replacement of Existing Pumps with Axial Flow Propeller Pumps from Fairbanks Morse

Axial flow propeller pumps with stainless steel propeller and bowl liner may be a suitable substitute for the existing VTSH pumps if both parameters outlined in section 5.1 for VTSH pump and the following conditions are met:

- The passing sphere size of the pump is larger than the size of the solids in the cannery and food processing water.
- There are no stringy solids in the cannery and food processing water that may clog and impair the impeller.

Single stage axial flow propeller pumps tend have lower head capacities and stricter reliable operating ranges than VTSH pumps. If this alternative is chosen, care should be given to the selection of the pump such that the pump operates at or near the max speed under normal operating conditions. One model of Fairbanks Morse axial flow pump is plotted with the existing system curves in Figure 5. However, without adjustments, this particular model does not appear to be well suited for the system. Three pumps are required to meet the new firm capacity of 20.3 MGD and additional standby pump should be provided for redundancy. Open top confined inlet barrels are also recommended on the pump intake to mitigate adverse hydraulic conditions.

5.3 Alternative C - Replacement of Existing Pumps with Axial Flow Propeller Pumps of Alternate Manufacturer

Axial flow propeller pumps from an alternate manufacturer with standard materials of construction, stainless steel propeller, and stainless steel bowl liner can be considered as a lower cost alternative than options A and B. Axial flow pumps from Prime Pump Co. is plotted with the existing system curve in Figure 6. Three pumps are required to meet the new firm capacity of 20.3 MGD and additional standby pump should be provided for redundancy. Open top confined inlet barrel is also recommended for this alternative to eliminate cavitation and abrasive erosion.

5.4 Additional Recommendations:

In addition, we recommend the following improvements to the pump station:

1. Add an open top confined inlet barrel for each pump (whether new or refurbished pumps).
2. Install concrete support below the check valve on each pump discharge, which is currently unsupported.
3. Coat the inside of the wet well with Enduraflex elastomeric coating to protect the concrete from corrosion.

4. Flush out wet well and replacing volume with freshwater or tertiary effluent at the end of the cannery season. Prolonged stagnant conditions with cannery waste rich in organic matter and low in pH cause corrosion.
Figure 5  Alternative B: Fairbanks Morse Axial Flow Pump Curves

(1) Low Wet Well Level, High Mix Box Level, Hazen-Williams C = 110.
(2) Normal Operating Head, Wet Well Level and Mix Box Level from Daily Average Readings from 1-Aug-12 to 30-Sep-12, $C = 120$.
(3) High Wet Well Level, Low Mix Box Level, $C = 130$. 
Figure 6  Alternative C: Prime Pump Co. Axial Flow Pump Curves

(1) Low Wet Well Level, High Mix Box Level, Hazen-Williams C = 110.
(2) Normal Operating Head, Wet Well Level and Mix Box Level from Daily Average Readings from 1-Aug-12 to 30-Sep-12, C = 120.
(3) High Wet Well Level, Low Mix Box Level, C = 130.
5.5 Cost Estimate

A preliminary cost estimate based on provided quotes for the different alternative are summarized in Table 2. Two options, installation by contractor and installation by owner, are provided for each alternative. Detailed cost breakdown for each alternative and option is tabulated in Table 3 through Table 8. The cost estimates assume that the project is scheduled to be completed by mid-2014.

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<th>Alternative</th>
<th>Installation By Contractor</th>
<th>Installation By Owner</th>
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<tr>
<td>A – Fairbanks Morse VTSH (3 pumps)</td>
<td>$2,325,000</td>
<td>$1,399,000</td>
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<tr>
<td>B – Fairbanks Morse Axial Flow Pumps (4 pumps)</td>
<td>$1,324,000</td>
<td>$797,000</td>
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<tr>
<td>C – Prime Pump Co. Axial Flow Pumps (4 pumps)</td>
<td>$1,208,000</td>
<td>$727,000</td>
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Table 3  Cost Estimate for Alternative A - VTSH Replacement and Upgrades
Cannery Segregation Pump Station Evaluation
City of Modesto

<table>
<thead>
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<th>NO.</th>
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<th>Qty</th>
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<td>3</td>
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<td>02</td>
<td>Open Top Confined Inlets (316 SST)</td>
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<td>03</td>
<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
<td>$62,000.00</td>
<td>3</td>
<td>$186,000</td>
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<tr>
<td>04</td>
<td>100-HP VFD Replacement Allowance</td>
<td>$36,250.00</td>
<td>3</td>
<td>$108,750</td>
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<tr>
<td>05</td>
<td>Check Valve</td>
<td>$39,000.00</td>
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<td>06</td>
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**TOTAL DIRECT COST**  
$1,165,750

<table>
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<th>%</th>
<th>Description</th>
<th>Subtotal</th>
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<tr>
<td>30.0%</td>
<td>Contingency</td>
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<td>18.0%</td>
<td>General Contractor Overhead, Profit &amp; Risk</td>
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**TOTAL ESTIMATED CONSTRUCTION COST**  
$2,003,996

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<td>12.0%</td>
<td>Engineering, Legal &amp; Administration Fees</td>
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<td>4.0%</td>
<td>Owner's Reserve for Change Orders</td>
<td>$80,160</td>
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**TOTAL ESTIMATED PROJECT COST**  
$2,324,636

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.
# Table 4
**Cost Estimate for Alternative A2 - VTSH Replacement and Upgrades**
---
### City of Modesto

<table>
<thead>
<tr>
<th>NO.</th>
<th>DESCRIPTION</th>
<th>Unit Cost</th>
<th>Qty</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>01</td>
<td>Fairbanks Morse VTSH Pump &amp; Motor (typ. Of 3 Pumps)</td>
<td>$250,000.00</td>
<td>3</td>
<td>$750,000</td>
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<td>02</td>
<td>Open Top Confined Inlets (316 SST)</td>
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<td>3</td>
<td>$75,000</td>
</tr>
<tr>
<td>03</td>
<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
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<td>3</td>
<td>$186,000</td>
</tr>
<tr>
<td>04</td>
<td>100 HP VFD Replacement Allowance</td>
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<tr>
<td>05</td>
<td>Check Valve</td>
<td>$39,000.00</td>
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</tr>
<tr>
<td>06</td>
<td>Check Valve Support</td>
<td>$2,000.00</td>
<td>3</td>
<td>$6,000</td>
</tr>
<tr>
<td>07</td>
<td>Wet Well Enduraflex Lining Allowance</td>
<td>$40,000.00</td>
<td>1</td>
<td>$40,000</td>
</tr>
</tbody>
</table>

**TOTAL DIRECT COST**

$1,165,750

Owner's Engineering, Legal, and Adminstration Fees, and Reserve 20.0% $233,150

**TOTAL ESTIMATED PROJECT COST**

$1,398,900

*OWNER INSTALL OPTION*

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.
# Table 5: Cost Estimate for Alternative B – Fairbanks Morse Axial Flow Pumps Replacement
## Cannery Segregation Pump Station Evaluation
### City of Modesto

<table>
<thead>
<tr>
<th>NO.</th>
<th>DESCRIPTION</th>
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<th>TOTAL</th>
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<tbody>
<tr>
<td>01</td>
<td>Fairbanks Morse Axial Flow Pump &amp; Motor</td>
<td>$83,000.00</td>
<td>4</td>
<td>$332,000</td>
</tr>
<tr>
<td>02</td>
<td>Open Top Confined Inlets (316 SST)</td>
<td>$25,000.00</td>
<td>4</td>
<td>$100,000</td>
</tr>
<tr>
<td>03</td>
<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
<td>-$</td>
<td>4</td>
<td>$-</td>
</tr>
<tr>
<td>04</td>
<td>100 HP -VFD Replacement Allowance</td>
<td>$36,250.00</td>
<td>4</td>
<td>$145,000</td>
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<tr>
<td>05</td>
<td>Check Valve</td>
<td>$39,000.00</td>
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<td>$39,000</td>
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<tr>
<td>06</td>
<td>Check Valve Support</td>
<td>$2,000.00</td>
<td>4</td>
<td>$8,000</td>
</tr>
<tr>
<td>07</td>
<td>Wet Well Enduraflex Lining Allowance</td>
<td>$40,000.00</td>
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**TOTAL DIRECT COST** $664,000

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<td>Subtotal</td>
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**TOTAL ESTIMATED CONSTRUCTION COST** $1,141,457

<table>
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<tr>
<th>Engineering, Legal &amp; Administration Fees</th>
<th>12.0%</th>
<th>$136,975</th>
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<tr>
<td>Owner’s Reserve for Change Orders</td>
<td>4.0%</td>
<td>$45,658</td>
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**TOTAL ESTIMATED PROJECT COST** $1,324,090

---

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment, nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.
# Cost Estimate for Alternative B2 – Fairbanks Morse Axial Flow Pumps Replacement – Owner Install Option

Cannery Segregation Pump Station Evaluation
City of Modesto

## PROJECT SUMMARY

<table>
<thead>
<tr>
<th>NO.</th>
<th>DESCRIPTION</th>
<th>Unit Cost</th>
<th>Qty</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Fairbanks Morse Axial Flow Pump &amp; Motor</td>
<td>$83,000.00</td>
<td>4</td>
<td>$332,000</td>
</tr>
<tr>
<td>02</td>
<td>Open Top Confined Inlets (316 SST)</td>
<td>$25,000.00</td>
<td>4</td>
<td>$100,000</td>
</tr>
<tr>
<td>03</td>
<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
<td>$</td>
<td>4</td>
<td>$</td>
</tr>
<tr>
<td>04</td>
<td>100 HP VFD Replacement Allowance</td>
<td>$36,250.00</td>
<td>4</td>
<td>$145,000</td>
</tr>
<tr>
<td>05</td>
<td>Check Valve</td>
<td>$39,000.00</td>
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<td>$39,000</td>
</tr>
<tr>
<td>06</td>
<td>Check Valve Support</td>
<td>$2,000.00</td>
<td>4</td>
<td>$8,000</td>
</tr>
<tr>
<td>07</td>
<td>Wet Well Enduraflex Lining Allowance</td>
<td>$40,000.00</td>
<td>1</td>
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**TOTAL DIRECT COST** $664,000

Owner's Engineering, Legal, and Administration Fees, and Reserve 20.0% $132,800

**TOTAL ESTIMATED PROJECT COST** $796,800

*OWNER INSTALL OPTION*

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment, nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.
### Table 7: Cost Estimate for Alternative C – Axial Flow Propeller Pumps and Upgrades – Alternative Manufacturer (Prime Pump Co.)

#### Cannery Segregation Pump Station Evaluation

#### City of Modesto

<table>
<thead>
<tr>
<th>NO.</th>
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<th>Qty</th>
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</tr>
<tr>
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<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
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<tr>
<td>04</td>
<td>100 HP -VFD Replacement Allowance</td>
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<td>Check Valve</td>
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<td>Wet Well Enduraflex Lining Allowance</td>
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**TOTAL DIRECT COST** $606,000

Contingency 30.0% $181,800

General Contractor Overhead, Profit & Risk 18.0% $141,804

Escalation to Mid-Point 3.0% $27,888

Sales Tax 8.8% $84,259

**Subtotal** $1,041,751

**TOTAL ESTIMATED CONSTRUCTION COST** $1,041,751

Engineering, Legal & Administration Fees 12.0% $125,010

Owner's Reserve for Change Orders 4.0% $41,670

**TOTAL ESTIMATED PROJECT COST** $1,208,432

---

*The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.*
Table 8  Cost Estimate for Alternative C2 – Axial Flow Propeller Pumps and Upgrades – Alternative Manufacturer (Prime Pump Co.) – Owner Install Option  
Cannery Segregation Pump Station Evaluation  
City of Modesto

<table>
<thead>
<tr>
<th>NO.</th>
<th>DESCRIPTION</th>
<th>Unit Cost</th>
<th>Qty</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Prime Pump Co. Axial Flow Pump &amp; Motor</td>
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<td>4</td>
<td>$ 274,000</td>
</tr>
<tr>
<td>02</td>
<td>Open Top Confined Inlets (316 SST)</td>
<td>$ 25,000.00</td>
<td>4</td>
<td>$ 100,000</td>
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<td>316L SST Impeller and Corrosion Resistance Upgrades</td>
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<td>-</td>
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<tr>
<td>04</td>
<td>100 HP VFD Replacement Allowance</td>
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<td>Check Valve</td>
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<td>$ 39,000</td>
</tr>
<tr>
<td>06</td>
<td>Check Valve Support</td>
<td>$ 2,000.00</td>
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<td>$ 8,000</td>
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<td>Wet Well Enduraflex Lining Allowance</td>
<td>$ 40,000.00</td>
<td>1</td>
<td>$ 40,000</td>
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</table>

**TOTAL DIRECT COST**  
$ 606,000

Owner's Engineering, Legal, and Administration Fees, and Reserve  
20.0%  
$ 121,200

**TOTAL ESTIMATED PROJECT COST**  
$ 727,200

*Owner Install Option

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.
APPENDIX A - EXISTING INGERSOLL-DRESSER PUMP CURVES
INGERSOLL-DRESSER PUMP COMPANY
PUMP TEST DATA

<table>
<thead>
<tr>
<th>RPM</th>
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<th>TDH</th>
<th>BHP</th>
<th>Eff</th>
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<td>57.2</td>
<td>166.5</td>
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<tr>
<td>1187</td>
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<td>166.5</td>
<td>84.0</td>
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<td>14.3</td>
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<tr>
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<td>8819.9</td>
<td>63.0</td>
<td>168.1</td>
<td>83.4</td>
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<tr>
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<td>7561.8</td>
<td>68.5</td>
<td>166.5</td>
<td>79.7</td>
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<tr>
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<td>5025.8</td>
<td>79.3</td>
<td>161.5</td>
<td>62.2</td>
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<td>174.3</td>
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<tr>
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<td>0.0</td>
<td>108.4</td>
<td>168.1</td>
<td>0.0</td>
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</table>

I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 20QMN PUMP 9903MS000841-3

David A. Hane

SP.GR.: 1.000

0.033" RING GAP

Casing Data

<table>
<thead>
<tr>
<th>A48 CL35</th>
<th>SIS-3</th>
<th>-</th>
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<tbody>
<tr>
<td>MATERIAL</td>
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<td>TONGUE</td>
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Impeller Data

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<th>A48 CL35</th>
<th>1A</th>
<th>.62Lx3.0B</th>
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</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>FINISH</td>
<td>DISC. TIPS</td>
</tr>
</tbody>
</table>

UB5899

PATT. NO. COMB. NO. DIA

20QMN 1 S-000841 9903MS000841-3 7MAY99 SPH QA 200H/1200R.#53 20x14.#31 1190 T-S000841-3B
This pump is designed to deliver:

- **US GPM**: 9722
- **TDH**: 55 (FT)
- **RPM**: 1190
- **Efficiency**: 84%
- **BHP**: 162
- **NPSHR**: 29 (FT)

5" Diameter Solid
2 Vane Impeller
Driver: Electric Motor

This curve shows the expected heads and efficiencies at other capacities, but this additional data is only approximate and is not guaranteed.
Client: City of Modesto
Project: Can Seg Pump Station Evaluation
Job No: 9076A.00

General
1. Required Pumping Capacity
   Q (min) 4 mgd Basis: Conservative Assumption
   Q (startup) 8 mgd Basis: City Staff
   Q (design) 28 mgd Basis: CDM Training Workshop

2. Process Fluid
   Cannery Waste from Sutter Primary Plant

3. Operational Criteria
   VFD Driven - Maintain an operator selectable flow setpoint
   2 Duty / 1 Standby

4. System Background
   The pump station receives cannery waste (CW) from Sutter Ave. Can Seg Pump Station, and pumps CW to the mixing box at the Jennings Rd. site, where the CW can be mixed with flow from the irrigation reservoir and sent to ranches at the Jennings Road plant site. The pump station currently has three 20” Vertical Turbine Solids Handling (VTSH) pumps model 20QMN-A manufactured by Ingersoll-Dresser Pumps (IDP). The pumps are each rated for 14 MGD (9,722 gpm) at 55’ TDH at 1,190 RPM and are equipped with 200 HP motors

5. System Schematic
   66” CW (RCP) from Sutter
   36” Steel Cement Lined Pipe
   GAT 101
   GAT 102
   GAT 103
   Overflow weir at 4’ from top
   Irrigation Mixing Box
   HWL EL 64.50
   LWL EL 59.00
   LWL EL 39.50
   LWL EL 47.50
   HWL EL 47.50
   LWL EL 39.50
Modified Curves

System Curves

Suction Elevation at C5 Wet Well = 43.8

Discharge Mixing at B10

Flows from Can-Seg PS to Mixing Box

<table>
<thead>
<tr>
<th>Segment</th>
<th>A1</th>
<th>A2</th>
<th>B</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>D</th>
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<tbody>
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<td>Flow Rate (mgd)</td>
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<td>6.00</td>
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<td>12.00</td>
<td>12.00</td>
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<td>Flow Rate (gpm)</td>
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<td>8333.33</td>
<td>8333.33</td>
<td>8333.33</td>
<td>8333.33</td>
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<td>18.56</td>
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<tr>
<td>Pipe Diameter (inches)</td>
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<td>36.00</td>
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<td>36.00</td>
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<td>36.00</td>
</tr>
<tr>
<td>Pipe Area (ft²)</td>
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<tr>
<td>Haugen Williams (C)</td>
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Minor Losses

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<th>Value</th>
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<tr>
<td>Elbow, 90</td>
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<tr>
<td>Elbow, 45</td>
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<tr>
<td>Sudden Expansion 20&quot; to 36&quot;</td>
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<tr>
<td>Tee, line flow</td>
<td>0.30</td>
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<td>Tee, branch flow</td>
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<tr>
<td>Deacreaser</td>
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<td>Andir (Whit Straight)</td>
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<td>Magnifier</td>
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<td>Butterfly Valve (Open)</td>
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<td>Total</td>
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System Head Loss, water (ft)

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<tr>
<td>34000</td>
<td>48.96</td>
<td>48.96</td>
<td>48.96</td>
</tr>
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</table>

Total System Head Loss (ft) = 6.57

Discharge Elevation

Suction Elevation

System Head

73% Percent Static

System Head Loss (ft) = 17.90

Total Head (ft) = 24.47

Simulations Under Different Friction C

<table>
<thead>
<tr>
<th>Flow Rate (gpm)</th>
<th>C = 110.00</th>
<th>C = 120.00</th>
<th>C = 130.00</th>
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<td>34000</td>
<td>48.96</td>
<td>48.96</td>
<td>48.96</td>
</tr>
</tbody>
</table>

27% Percent Friction

10.7' mixing box water level reading from Scada
Optimal Point: \( \frac{102,000 \text{ gal}}{1440 \text{ min}} \) = 14.7 MGD per pump

\( \frac{78,000 \text{ gal}}{1440 \text{ min}} \) = 11.3 MGD per pump

20ft column diameter?
Need testing schematic
Pump Column Material

(Est.) 8ft Discharge head to 36" Cannery Waste Force Main

Hazen-Williams (C) = 110, 120, 130

Steel cement lined: C = 130, 110, 120

Check Valve (Swing) \( K = 2.5 \)

Wye (thru. straight): 0.45

Sudden Expansion: \( K_e = \left(1 - \frac{A_1}{A_2}\right)^2 = \left(1 - \frac{\pi (20)^2}{\pi (36)^2}\right)^2 = \left(1 - \frac{10^2}{18^2}\right)^2 = 0.47\)

(Est.) 46' from P104 wye to ARV105

90° Elbow x 2

(Est.) 10' horizontal run
(Est.) 12' vertical run

Butterfly valve (open) \( K = 0.50 \)

Mag Meter: \( K = 0.20 \)
Sum Length: 880'  C = 130

Used 90° as conservative.
Max: 65.50
Segment A2

Steel Cement Lined.
NOTES:
1. FORCE MAIN STARTING STATION AT THE EAST END OF G-5. JOINT AT STATIONS FROM THIS STATION SHALL BE HELD.
Data Adjustment:

Elev. Between Gauge & wet well: +7.8ft
Pump column & discharge headloss: +1.0ft
Additional 3.5ft in Mix box: -3.5ft
+5.3ft

Gauge measures pressure head remaining in the system.
## City of Modesto
### Can-Seg Pump Test
#### 11/16/2012

<table>
<thead>
<tr>
<th># of Pumps</th>
<th>Hz</th>
<th>Wetwell Level (ft)</th>
<th>Flow (mgd)</th>
<th>Pressure (psi)</th>
<th>Mix Box Elevation (SCADA) (ft)</th>
<th>Mix Box Elevation (Measured from top) (ft)</th>
<th>Flow (GPM)</th>
<th>Pressure head (ft)</th>
<th>Adjusted Pressure Head (ft)</th>
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<td>14</td>
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<td>10</td>
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<td>2</td>
<td>10347</td>
<td>23.1</td>
<td>28.4 (+5.3 ft)</td>
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</tr>
<tr>
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<td>55</td>
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<td>17.1</td>
<td>11</td>
<td>14</td>
<td>1.8</td>
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<tr>
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<td>13</td>
<td>14</td>
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<td>35.33 (+5.3 ft)</td>
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<tr>
<td>2</td>
<td>50/50</td>
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<td>25.4</td>
<td>16/17</td>
<td>14</td>
<td>1.57</td>
<td>17639</td>
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<td>19/20</td>
<td>14</td>
<td>1.58</td>
<td>20000</td>
<td>45.045</td>
<td>50.345 (+5.3 ft)</td>
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</tbody>
</table>

hz of each pump (2 pumps running different pressures)
APPENDIX C – QUOTES AND MANUFACTURER CURVES
December 20, 2012

Jean Marc Petit
Carollo Engineers, Inc.
2700, Ygnacio Valley Rd., Suite 300
Walnut Creek, CA 945981

Reference: Modesto Cannery Segregation Pumps – VTSH Pump Estimate

Dear Jean Marc,

Per your request JM Squared is pleased to provide the following budget estimate price for complete replacement Fairbanks Morse VTSH pumps at the Modesto Cannery Segregation Pump Station.

**Complete Replacement Pumps**

Fairbanks Morse 20” LH Vertical Turbine Solids Handling (VTSH) pumps
Rated for 6,000 GPM @ approx. 51’ TDH running at 1180 RPM
Reduced speed: approx. 7,000 GPM @ 24’ TDH running at 1000 RPM
Cast Iron bowl, inlet bell & impeller, epoxy coated & lined
Steel column & discharge head, epoxy coated & lined
Nitronic 50 line shaft with ceramic coating on bearing surfaces
Stainless steel enclosing tube
Single mechanical seal
Non-witnessed performance testing included
100HP/1200RPM/3Phase/460Volt/TEFC motor
Approx. 15’ pump length

Est. Price: Approx. $206,000.00 each (sales tax, installation, VFD’s, accessories, etc. not included)
FOB: Kansas City, Kansas
Submittals: Approx. 6-8 weeks after acceptance of order
Delivery: Approx. 20-24 weeks for manufacture after approval

Please let me know if you need additional information.

Sincerely,

[Signature]

Martin Vesely
Name: Martin Vesely
Date: 12/20/2012

Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Modesto Cannery Segregation PS - VTSH at full speed

**Pump:**
- Size: 20"VTSH LH
- Type: VTSH
- Synch speed: 1200 rpm
- Curve: Impeller: V20D1A
- Specific Speeds:
  - Ns: 5526
  - Nss: 8131
- Dimensions:
  - Suction: ---
  - Discharge: 20 in

**Search Criteria:**
- Flow: 6000 US gpm
- Head: 51 ft

**Fluid:**
- Water
- Temperature: 60 °F
- Density: 62.37 lb/ft³
- Viscosity: 1.105 cP
- Vapor pressure: 0.2563 psi a
- Atm pressure: 14.7 psi a
- NPSHa: ---

**Motor:**
- Size: 100 hp
- Speed: 1200
- Frame: 444T
- Standard: NEMA
- Enclosure: TEFC

Sizing criteria: Max Power on Design Curve

--- Data Point ---
- Flow: 6000 US gpm
- Head: 51.1 ft
- Eff: 82%
- Power: 94.9 hp
- NPSHr: 23.1 ft

--- Design Curve ---
- Shutoff head: 95 ft
- Shutoff dP: 41.1 psi
- Min flow: 3600 US gpm
- BEP: 83% @ 6820 US gpm
- NOL power: 96.3 hp @ 6820 US gpm

-- Max Curve --
- Max power: 96.3 hp @ 6820 US gpm

**Performance Evaluation:**

<table>
<thead>
<tr>
<th>Flow US gpm</th>
<th>Speed rpm</th>
<th>Head ft</th>
<th>Efficiency %</th>
<th>Power hp</th>
<th>NPSHr ft</th>
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<td>---</td>
<td>---</td>
</tr>
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</table>

Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Selected from catalog: Fairbanks Morse Centrifugal.60 Vers: 3.3
Name: Martin Vesely  
Date: 12/20/2012

Modesto Cannery Segregation PS - VTSH at reduced speed

**Pump:**

- **Size:** 20"VTSH LH  
- **Type:** VTSH  
- **Synch speed:** 1200 rpm  
- **Curve:** Impeller: V20D1A  
- **Specific Speeds:**  
  - Ns: 5526  
  - Nss: 8131  
- **Dimensions:**  
  - Suction: ---  
  - Discharge: 20 in  

**Pump Limits:**

- **Temperature:** 160 °F  
- **Pressure:** ---  
- **Sphere size:** 5.25 in

**Search Criteria:**

- **Flow:** 6000 US gpm  
- **Head:** 51 ft

**Fluid:**

- **Water**  
  - **Density:** 62.37 lb/ft³  
  - **Vapor pressure:** 0.2563 psi a  
  - **Atm pressure:** 14.7 psi a  
  - **Viscosity:** 1.105 cP  
  - **NPSHa:** ---

**Motor:**

- **Size:** 60 hp  
- **Enclosure:** TEFC  
- **Frame:** 404T  
- **Standard:** NEMA  
- **Sizing criteria:** Max Power on Design Curve

--- Data Point ---

- **Flow:** 7000 US gpm  
- **Head:** 23.9 ft  
- **Eff:** 80%  
- **Power:** 53 hp  
- **NPSHr:** 24.5 ft

--- Design Curve ---

- **Shutoff head:** 68.2 ft  
- **Shutoff dP:** 29.6 psi  
- **Min flow:** 3600 US gpm  
- **BEP:** 83% @ 5780 US gpm  
- **NOL power:** 58.6 hp @ 5780 US gpm

-- Max Curve --

- **Max power:** 58.6 hp @ 5780 US gpm

**Performance Evaluation:**

<table>
<thead>
<tr>
<th>Flow (US gpm)</th>
<th>Speed (rpm)</th>
<th>Head (ft)</th>
<th>Efficiency (%)</th>
<th>Power (hp)</th>
<th>NPSHr (ft)</th>
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</table>

Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Selected from catalog: Fairbanks Morse Centrifugal.60 Vers: 3.3
Flow: 5800 US gpm
Head: 40 ft

Fluid:
- Water
- Temperature: 60 °F
- Density: 62.37 lb/ft³
- Vapor pressure: 0.2563 psi a
- Viscosity: 1.105 cp
- Atm pressure: 14.7 psi a
- NPSHa:

Motor:
- Standard: NEMA
- Size: 40 hp
- Enclosure: TEFC
- Speed: 1800
- Frame: 324T
- Sizing criteria: Max Power on Design Curve

--- Data Point ---
Flow: 4200 US gpm
Head: 19.7 ft
Eff.: 74.6%
Power: 28 hp
NPSHr: 28.2 ft

--- Design Curve ---
- Shutoff head: 56.4 ft
- Shutoff dP: 24.4 psi
- Min flow: ---
- BEP: 85% @ 3686 US gpm
- NOL power: 31.4 hp @ 2830 US gpm

--- Max Curve ---
Max power: 34.5 hp @ 2855 US gpm

Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.
Pump Data Sheet - Fairbanks Morse Pump, 60Hz

FAIRBANKS NIJHUIS*

Pump:
Size: 12"x512 (1 stage)
Type: Propeller/Mixed Flow
Synch speed: 1800 rpm
Curve: Impeller: 12LM7B
Specific Speeds: Ns: --
Dimensions: Suction: --
Diameter: 11.5 in
Vertical Turbine: Bowl size: ---
Max lateral: ---
Thrust K factor: 33.1 lb/ft

Pump Limits:
Temperature: ---
Pressure: ---
Sphere size: 0.9 in

--- Data Point ---
Flow: 4200 US gpm
Head: 23.9 ft
Eff: 79.2%
Power: 32 hp
NPSHr: 28.8 ft

--- Design Curve ---
Shutoff head: 61 ft
Shutoff dp: 26.4 psi
Min flow: ---
BEP: 85% @ 3832 US gpm
NOL power: 35.3 hp @ 2942 US gpm

--- Max Curve ---
Max power: 38.7 hp @ 2978 US gpm

Search Criteria:
Flow: 5800 US gpm
Head: 40 ft

Fluid:
Water
Density: 62.37 lb/ft³
Viscosity: 1.105 cp

Motor:
Standard: NEMA
Size: 40 hp
Speed: 1800 rpm
Enclosure: TEFC
Frame: 324T
NPSHr: ---

Performance Evaluation:

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<tr>
<th>Flow (US gpm)</th>
<th>Speed (rpm)</th>
<th>Head (ft)</th>
<th>Efficiency (%)</th>
<th>Power (hp)</th>
<th>NPSHr (ft)</th>
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Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.
Pump Data Sheet - Fairbanks Morse Pump, 60Hz

Name: Martin Vesely
Date: 12/8/2013

Pump:
Size: 12"-8512 (1 stage)
Type: Propeller/Mixed Flow
Synch speed: 1900 rpm
Curve: ---
Specific Speeds: ---
Dimensions: ---
Vertical Turbine: ---

Pump Limits:
Temperature: ---
Pressure: ---
Sphere size: 0.9 in

--- Data Point ---
Flow: 5800 US gpm
Head: 41 ft
Eff: 76.8%
Power: 78.3 hp
NPSHr: 47.7 ft

--- Design Curve ---
Shutoff head: 111 ft
Shutoff dP: 48.2 psi
Min flow: ---
BEP: 85% @ 5178 US gpm
NOL power: 87.2 hp @ 3976 US gpm

--- Max Curve ---
Max power: 95.6 hp @ 4024 US gpm

FAIRBANKS NIJHUIS™

Search Criteria:
Flow: 5800 US gpm
Head: 40 ft

Fluid:
Water
Density: 62.37 lb/ft³
Viscosity: 1.105 cP
Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:
Standard: NEMA
Size: 100 hp
Speed: 1800
Frame: 405T
Endosure: TEFC

Sizing criteria: Max Power on Design Curve

Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

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<th>NPSHr (ft)</th>
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Selected from catalog: Fairbanks Morse Propeller-MixedFlow.60 Vers: 1
PRIME PUMP COMPANY
M16A-8 deg
5600 GPM @ 40 ft., 1135 RPM
Min. Submergence Req’d.: 7 ft.
Imp. Dia.: 16"

MODEL M16A-8
PRIME PUMP COMPANY
M16A-8 deg
4200 GPM @ 24 ft., 880 RPM
Min. Submergence Req'd.: 7 ft.
Imp. Dia.: 16"
PRIME PUMP COMPANY
M16A-8 deg
4200 GPM @ 20 ft., 810 RPM
Min. Submergence Req'd.: 7 ft.
Imp. Dia.: 16"

MODEL M16A-8