Technical Memorandum

SMCSD Headworks, Primary and Secondary Treatment Pre-Design

Subject: **TM 4: Grit Removal**

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The purpose of this technical memorandum (TM) is to present the evaluation and design development of grit removal facilities to be implemented at the Sausalito-Marin County Sanitary District (SMCSD) Wastewater Treatment Plant (WWTP). This TM is intended to be included as an appendix to the Recommended Project Summary, which includes a summary of major recommendations. All drawings referenced in this TM are bound together as a separate attachment. The TM is organized in the following sections:

1 Summary Findings and Conclusions

The SMCSD WWTP currently does not have grit removal facilities. Removal of grit from the wastewater flow helps to minimize grit accumulation in other process tanks (particularly the digester) and minimize wear on equipment. Grit facilities consist of the following basic components:

- A grit chamber to remove material from the raw wastewater flow stream
- Pumping/conveyance of the separated grit slurry
- Grit reduction/classification equipment
- Storage of dewatered/classified grit

There are several grit equipment and arrangement options that can be used as part of a headworks facility. An evaluation of a range of options was prepared based on the specific requirements of the SMCSD facility and RMC's experience with similar facilities.

The key criteria considered to determine the grit system that provides the best combination of reliability and cost effectiveness were:

- Flow capacity and redundancy
- Grit chamber and classifier technology

To accommodate the full range of anticipated influent flows, it is recommend that two separate automated grit chambers be installed each with a process capacity of 3 to 4 MGD and a hydraulic capacity of 7 MGD. This would provide redundancy because one grit chamber would need to be in service for normal flow conditions, and both chambers would need to be in service only during the infrequent high flow events (above 4 MGD).

Recommended Grit Removal Option

There are several grit removal technologies that could be used for the SMCSD facility. In this TM the following grit removal options are considered:

- Mechanical Vortex Grit Basins
- Aerated Grit
- Eutek HeadCell System

The Table 1 below summarizes the comparison of the systems and their qualitative rankings based on the identified evaluation criteria.

Table 1: Grit Removal Option Comparison

Ranking Category	Mechanical Vortex Basin	Aerated Grit	Headcell
Capital Cost	●	○	◉
Annual O&M Cost	●	○	◉
Process Efficiency	◉	◉	●
Reliability	◉	◉	◉
Proven Operation	●	●	○
Minimization of Odors	●	○	●

● Excellent ◉ Very Good / Good ○ Fair / Acceptable

Due the lower relative capital and O&M cost and proven reliable performance, it is recommended that a mechanical vortex system be used. The mechanical vortex grit system provides the best combination of small footprint, good removal efficiency, low power consumption and low odor generation.

Recommended Grit Handling Option

Grit removed by the grit removal system will be pumped to a grit reduction/classification system to remove organic material and reduce the total volume of grit requiring disposal. It is recommended that a recessed impeller pump be used to pump the grit to the grit reduction/classification system. In this TM the following grit reduction/classification options were considered:

- Cyclone Classifier
- Huber Coanda Grit Washer
- Eutek Slurrycup

The findings from this evaluation are:

1. The cyclone/classifier system has the lowest capital cost but has a relatively high life cycle cost due to the high water and organic content of the final grit, which results in higher disposal costs and higher odor generating potential.
2. The Huber Coanda grit washer (or similar units by other manufacturer) has a medium capital cost but has the lowest estimated life cycle cost due to the low water content and organic content of the final grit, which results in low disposal costs and lower odor generating potential.
3. The Eutek Slurry Cup has a high capital cost and medium life cycle cost. The main advantage of this equipment is that it removes a higher percentage of the fine grit particles compared to the cyclone and Huber system. If SMCSD experiences high downstream maintenance cost due to sludge pump wear, this system may provide the lowest overall life cycle cost.

Based on the evaluation, the Huber Coanda grit washer (or similar) is recommended for the SMCSD facility. The Huber Coanda is recommended because it produces a relatively cleaner grit than a cyclone/classifier and has lower capital and O&M costs compared to the Eutek Slurry Cup.

2 Design Criteria

Design criteria for flow capacity and redundancy for the grit removal system are presented in the following sections.

2.1 Flow Capacity

The recommended design flows for the new headworks facility are discussed and presented in the TM 1: Design Criteria. A summary of the key design flows for the grit removal process at current influent flows are presented in Table 2.

Table 2: Design Flow Criteria

Flow Parameter	Flow
Average Dry Weather Flow (ADWF)	1.5 MGD
Minimum Diurnal Flow	0.25 MGD
Peak Day Dry Weather Flow (PDWF)	3.2 MGD
10-Year Event Instantaneous Peak Wet Weather Flow (PWWF)	13 MGD

The new headworks will need to accommodate peak flows without equalization. On-site equalization would be located downstream of the headworks processes.

2.2 Reliability

To provide reliability for the new grit system the following are recommended to provide redundancy:

- For normal flow conditions, including modest wet weather events, provide a completely redundant grit channel system (isolation gate, grit chamber, grit conveyance).
- For peak wet weather flow events, both grit chambers would be used with total a hydraulic capacity of 13 MGD and a total process treatment capacity of 8 MGD
- Provide one grit pump for each grit channel, plus one standby grit pump for the entire grit channel system.
- Provide one grit reducer/classifier for each grit channel with no additional standby units.

3 Grit Removal Equipment Selection

Grit removal is critical to the protection of wastewater treatment equipment as the heavier particles present in wastewater, such as sand and gravel, can cause unnecessary abrasion and wear on mechanical equipment, grit deposits in pipelines and channels, and an accumulation of grit in process structures. Grit is typically defined as particles larger than 0.008 inches (65 mesh) and with a specific gravity greater than 2.65.

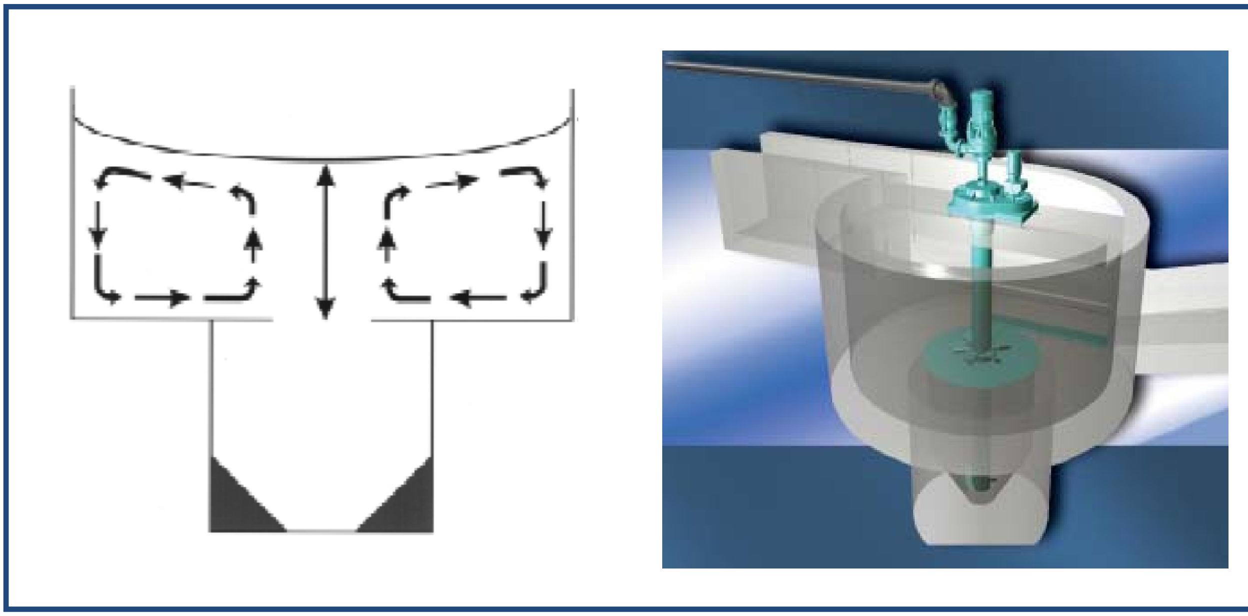
The three alternatives considered for grit removal for the SMCSD headworks project are:

- Mechanical Vortex Grit Basins
- Aerated Grit
- Eutek Headcell System

3.1 Mechanical Vortex Grit Removal

The mechanical vortex grit removal system utilizes a circular basin with a grit hopper on the bottom and tangential inlets and outlets. The wastewater moves in a circular pattern within the basin, while baffles impart a helical flow pattern that forces grit into the center and to the bottom of the tank where it enters the grit hopper. A motor driven rotating paddle is used to assist in maintaining the vortex flows and provides hydraulic currents to assist in separating the lighter organic material from the grit. The grit is removed from the hopper using a grit pump and conveyed to the grit handling facilities. Figure 1 shows a cross-sectional representation of the fluid flow path in a mechanical vortex grit chamber. There are multiple manufacturers of mechanical vortex grit systems, such as Smith & Loveless, Eimco and WesTech.

Figure 1: Flow Path in Mechanical Vortex Grit Chamber



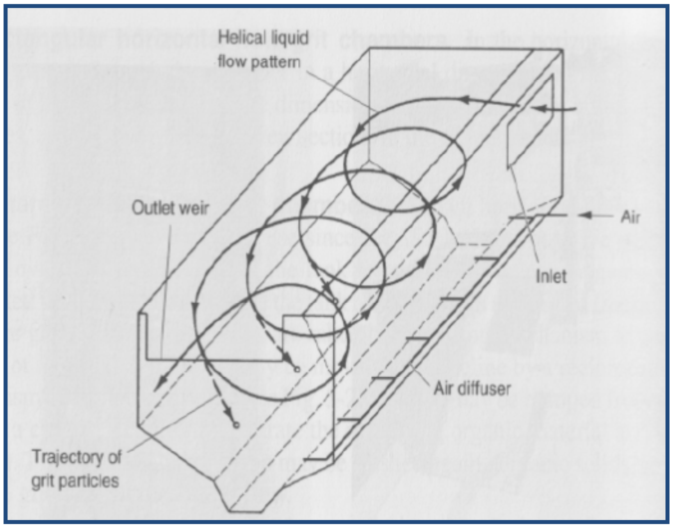
The major advantages of a mechanical vortex grit removal system include low energy consumption, small process footprint, and low odor potential (as compared to aerated grit removal). The major construction costs for the mechanical vortex grit system are the equipment package and the concrete basin. The major components of the equipment package include the paddle motor, the grit pump and the rotating paddles.

The vortex grit basin would be covered with metal covers and the foul air extracted from the headspace would be sent to the existing odor control system. Locations where a mechanical vortex grit removal system is in operation for similar applications are Novato Sanitation District (NSD) and American Canyon. SMCSD staff conducted a field visit to the NSD mechanical vortex grit installation in August 2009 and spoke with the NSD operations staff about their experience with the unit. The feedback received from the NSD operations staff was positive and indicated that the technology functions well.

3.2 Aerated Grit

Aerated grit removal utilizes a rectangular chamber with aeration headers and a sloped bottom to remove the grit from the influent wastewater. The grit, which is heavier than the liquid and the organic material in the wastewater, settles to the bottom of the tank by an induced spiral liquid flow pattern. This spiral flow pattern is shown in Figure 2 and is created through a combination of the momentum from the influent wastewater and the air introduced to the tank by the submerged aeration header. The grit particles are too heavy to continually rise to the top and eventually settle into the grit hopper for removal.

Figure 2: Aerated Grit Removal Basin



The design criteria for an aerated grit process are presented in Table 3.

Table 3: Typical Aerated Grit Design Standards

Criteria	Typical Design	Comments
Length to Width ratio	2.5:1 to 5:1	A longer tank would promote a better helical flow pattern
Depth	6 to 16 feet	
Floor slope	Min 5%	
Detention time	2-5 minutes at peak flow, may be longer if used for pre-aeration	
Overflow rate	35,000 gpd/sf	
Aeration type	Coarse bubble	
Aeration rate	3 to 8 cfm/ft of length	8 cfm/ft used for design
Aeration control	Sparger system capacity	

It is anticipated that an aerated grit removal system would operate automatically with minimal operator intervention. Periodic maintenance requirements include pump lubrication, general pump maintenance, blower maintenance and aeration diffuser cleaning. Aeration and agitation of the influent wastewater can result in the release of volatile organic compounds (VOCs). These releases have both an odor and safety impact. The aeration can also begin the biological decomposition of the organic material in the wastewater, which can release gaseous by-products. Aerated grit basins would be covered with metal covers and the foul air extracted from the headspace, which would be sent to the existing odor control system. The foul air flow will be greater than the amount of aeration air flow to ensure that the headspace is under negative pressure to minimize the escape of fugitive odors. Consequentially, an aerated grit facility would require more odor control capacity than a similarly sized vortex grit or headcell system and would likely exceed the capacity of the existing odor control system at the treatment plant.

The main elements of an aerated grit removal system that have an impact on the process reliability are the grit pumps, aeration supply blowers and submerged diffusers. Table 4 summarizes the major advantages and disadvantages of a new aerated grit removal system.

Table 4: Aerated Grit Chamber Summary

Advantages	Disadvantages
Provides odor stripping upstream of primary tanks	Odor stripping will require larger odor control facility and large concrete installation requirements
Proven ability to remove grit	High energy use
No mechanical equipment submerged in tank	Large process footprint

Locations where an aerated grit removal system is in operation in similar applications are Central Marin Sanitation Agency (CMSA), Vallejo Sanitation and Flood Control District (VSFCD), Central Contra Costa Sanitary District (CCCSD), and Delta Diablo Sanitary District (DDSD).

3.3 Eutek Headcell Grit Removal

The Eutek Headcell is a hydraulic grit removal system. This system utilizes a boundary layer effect to separate grit from the influent wastewater. This separation is accomplished using a series of conical plates that are stacked to allow for a large amount of surface area in a small footprint. The wastewater is split between the conical plates through a distribution header that impacts a tangential flow pattern in the chamber. The grit is trapped in the boundary layer of the plates and swept towards the center where it falls into a collection bin and is pumped to grit handling facilities. Organic particles are generally too large to be contained in the boundary layer and are re-suspended into the wastewater flow. Figure 3 shows an illustration of the Headcell equipment.

Figure 3: Eutek Headcell Equipment

Table 5 summarizes the major advantages and disadvantages of a new Headcell grit removal system.

Table 5: Headcell System Summary

Advantages	Disadvantages
Low energy consumption	Efficiency dependent on tangential velocities
Small process footprint	Sensitive to plugging from screened materials
High removal efficiencies	Poor access to trays for maintenance

There are limited locations where a Headcell grit removal system is in operation for similar applications.

3.4 Recommendation: Grit Removal

Due to the lower relative capital and O&M cost and proven reliable performance, it is recommended that a mechanical vortex system be used. The vortex grit system provides the best combination of small footprint, good removal efficiency, low power consumption and low odor generation.

4 Grit Handling Equipment Selection

Grit handling equipment is used to reduce the amount of water and organics from the grit slurry after it is removed from the grit chamber. The following grit reduction/classification components and options were considered:

- Pumping and conveyance of the separated grit slurry to grit reduction/classification equipment
- Grit reduction and classification via one of the following options:
  - Cyclone Classifier
  - Huber Coanda Grit Washer
  - Eutek Slurrycup
- Storage of dewatered/classified grit

4.1 Grit Slurry Pumping and Conveyance

The grit slurry removed from the grit chamber needs to be conveyed to grit reduction and classification equipment. The basic options for these conveyances are:

- Recessed impeller pumps with a flooded suction
- Self priming pumps located on top of the grit chamber
- Air lift pumps
- Screw augers

It is recommended that consideration be given to the use of air lift pumps because of the short distance from the vortex grit chambers to the grit reduction and classification equipment. The air lift pumps could operate more frequently and at a lower flow rate than recessed impeller pumps. This selection will be further evaluated during detailed design to confirm air lift pumping. If air lift pumps are not used, recessed impeller pumps with a flooded suction are recommended as they provide the best combination of reliability and cost effectiveness.

4.2 Grit Reduction and Classification

4.2.1 Efficiency

A goal of this TM is to identify grit dewatering equipment and the associated handling facility with high reliability and low operational costs. The ideal technology will also allow maximum odor control and smooth integration with existing plant operations.

The grit dewatering systems under consideration were evaluated based on costs, reliability, safety, odor control, potential future benefits and the ability improve other plant operations. The removal of the inorganic solids and retention of water and organic solids is a major differentiator between the grit dewatering systems under consideration. Each system uses a different method to separate the inorganic solids from the grit slurry and does so with varying degrees of success. Grit that is not removed from the slurry is returned to the main treatment process and passes through pumping/piping systems as well as several intermediate processes, abrading and potentially damaging the process structures and mechanical equipment. If a larger portion of the inorganic solids are removed from the grit slurry by the grit handling facility, the quantity of grit returned to the wastewater flow is reduced, thereby minimizing subsequent downstream process impacts.

4.2.2 Equipment

Virtually all of the grit reduction and classification equipment currently on the market consists of some variation of a vortex chamber to concentrate grit followed by a stilling chamber. The grit discharged from the stilling chamber is moved via a conveyor to the disposal bins. The competitive systems on the market vary in the following performance features:

- Removal efficiency of fine grit particles
- Retention of organic particles in the grit matrix
- Separation efficiency of the water from the grit stream
- Removal efficiency of grit at varying flow rates

Three grit dewatering equipment options were considered as part of this evaluation:

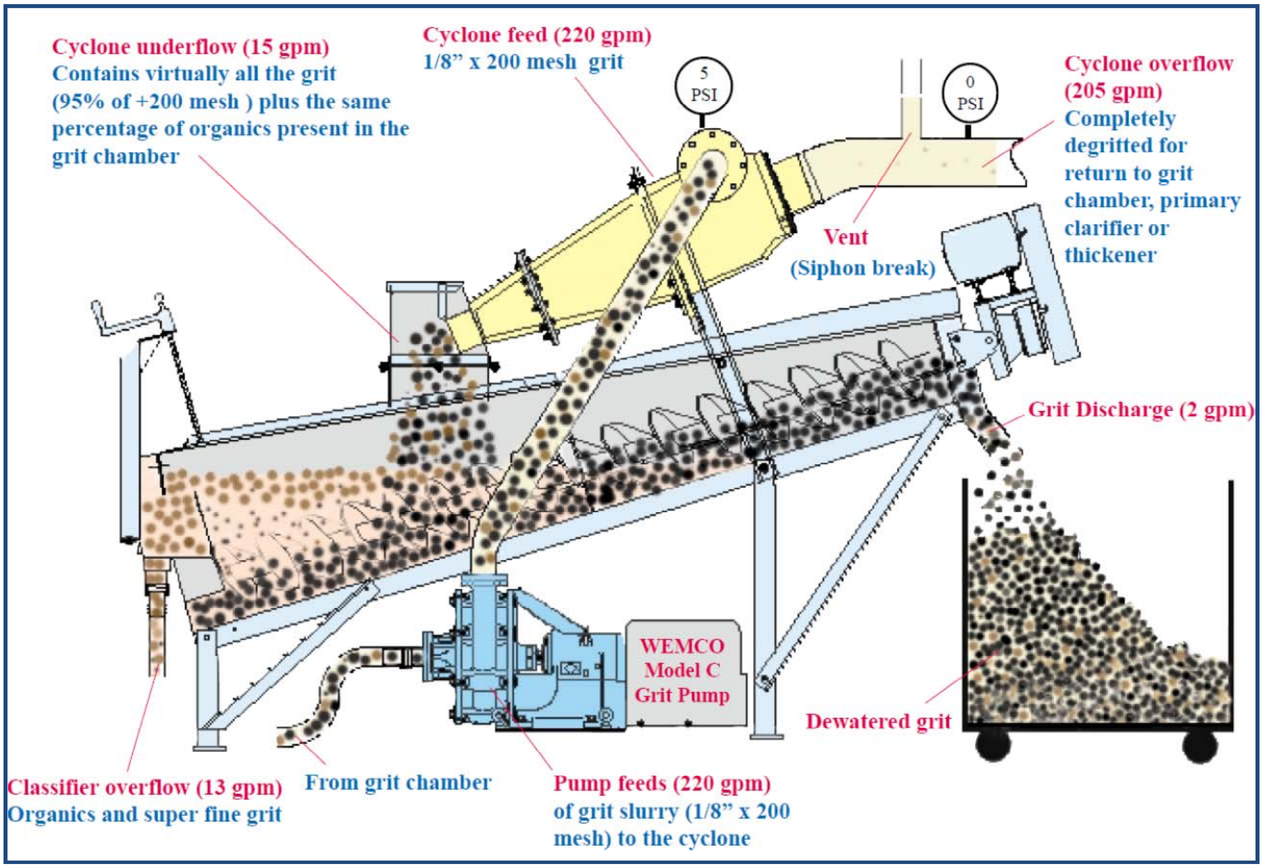
- Cyclone/Classifier
- Huber Grit Washer
- Eutek Slurry Cup

Each of the systems would require approximately the same structural and mechanical facilities and would discharge into disposal bins for removal and landfilling. The following sections provide a description of the systems being considered and their respective advantages and disadvantages.

Cyclone and Classifier System

There are several manufacturers of cyclone/classifier types of systems including Wemco, US Filter-Siemens, Thomas Conveyor Company and WesTech. Figure 4 shows a typical cyclone classifier unit.

Figure 4: Typical Cyclone/Classifier System



Source: Wemco Hydrogritter Brochure

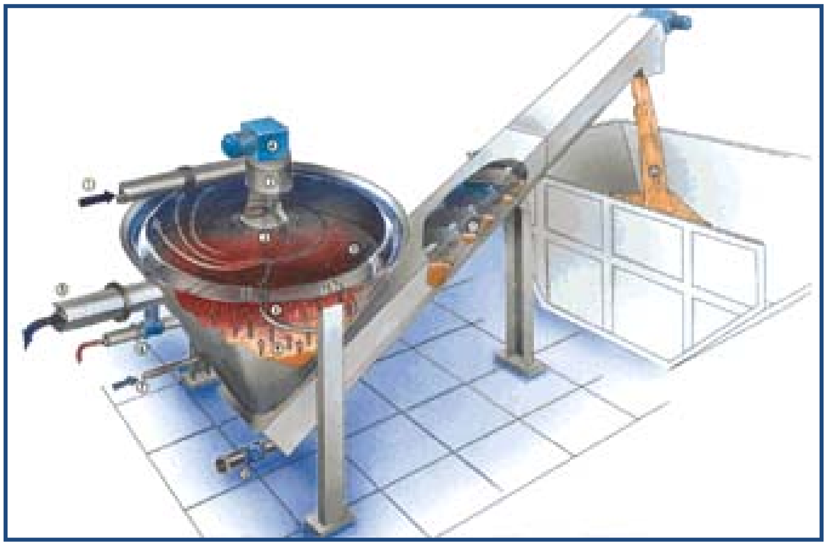
The main advantages of these systems are the low capital cost and long installation history. The disadvantages of these systems are the limited efficiency of removing fine grit, modest efficiency in washing organic materials, and potentially high water contents in the waste grit product. The dewatered grit from a typical cyclone/classifier has a moisture content of 70-75 percent and a high organic content, causing odors from the storage bins. This high water content results in higher weight of grit disposal.

SMCSD staff conducted a field visit to the NSD cyclone/classifier system installation in August 2009 and spoke with the NSD operations staff about their experience with the unit. The feedback received from the NSD operations staff was positive and indicated that the technology meets its intended design criteria. However, it was observed that the final grit is relatively moist and does contain significant amounts of organic material causing odors, and is therefore not recommended for the SMCSD installation because of the concerns about minimizing odor generation and material disposal volumes.

Huber Coanda Grit Washer

The Huber Coanda grit washer is a system that classifies and washes grit in a single compact unit. During the process, the mixture of grit, organics and water is fed into a vortex chamber which generates fast rotational motion. Figure 5 shows an illustration of the Huber Coanda unit.

Figure 5: Huber Coanda Grit Washer System



Grit and denser organic particles settle out as a result of the combined effects of gravity and inertia. These particles sink down to the lower section of the tank while the light organic matter is transported with the water over a discharge weir and returned to the wastewater flow. The separated grit is washed in the fluidized bed where organic matter is further removed. The washed grit is then transported by the screw conveyor, where gravity drainage provides additional dewatering, to the disposal bins.

The main advantages of this system are the production of a nearly dry and odorless grit and the low capital cost. The disadvantages of this system include the limited efficiency of removing extra fine grit. Examples of the Huber Coanda installations in California are at the Ukiah, Truckee Meadows and Bakersfield Wastewater Treatment Plants.

SMCSD staff conducted a field visit to the Ukiah installation in August 2009 and spoke with their operations staff about the performance of the Coanda unit. The Ukiah Coanda unit was installed in November 2008 and the washed grit was reported to be consistently dry and low in odors; this was verified in the field. A picture of the Ukiah Coanda unit is shown in Figure 6.

Figure 6: Huber Coanda Grit Washer System at Ukiah WWTP

Other companies that make a grit washer unit similar to the Huber Coanda include Westech and Lakeside.

Eutek SlurrycupTM/SnailTM System

The Eutek Slurrycup/Snail system consists of two components; the Slurrycup for grit washing and the Grit Snail for dewatering. Figure 7 shows a Eutek grit handling system installation.

Figure 7: Eutek Slurrycup and Grit Snail System

The Slurrycup uses a combination of an open free vortex and the boundary layer effect to capture, classify and remove fine grit and high density fixed solids from grit slurries. The grit underflow from the Slurrycup passes through the Hydraulic Valve which provides secondary washing. The washed grit is then dewatered by the Grit Snail which is an inclined step conveyor system.

This system provides high removal efficiency of abrasives of all sizes. The capital cost of this system is higher than alternatives discussed in previous sections. Other disadvantages of this system include the limited efficiency of dewatering and modest efficiency in washing organic materials from the grit. Examples of the installation of the Eutek Slurrycup/Snail system include the WWTP in Pinole, California, and dilute primary sludge degritting at the San Mateo WWTP.

4.2.3 Comparison of Treatment Efficiency and Performance

Each grit handling system has different grit settling, water recovery and organic solids separation capabilities as well as differences in cost and process features. Table 6 summarizes the comparison of the grit handling system options.

Table 6: Grit Handling Comparison Summary

Criteria	Cyclone/ Classifier	Huber Coanda Grit Washer	Eutek Slurrycup
Cost Analysis			
Supply Cost (2 units)	$150,000	$200,000	$250,000
Process Analysis			
70 Mesh Grit Removal Percentage	NA	96.5%	99.8%
140 or 150 Mesh Grit Removal	NA	NA	99.5% (140 mesh)
200 Mesh Grit Removal	NA	NA	99.0%
Grit Washing Included	No	Yes	Yes
Final Grit Characteristics			
Average Water (% of weight)	49.8%	4.2%	39.2%
Average Inorganic Solids (% of weight)	24.6%	94%	54.8%
Average Organic Solids (% of weight)	25.7%	1.8%	6.0%
Bulk Density (lbs/cf)	87.8	130	118.9

NA = Not Available

The findings from this evaluation are:

- The cyclone/classifier system has the lowest capital cost, but has a relatively high life cycle cost due to the high water and high organic content of the grit, which result in higher disposal costs and higher odor potential.
- The Huber Coanda grit washer has a medium capital cost, but has the lowest estimated life cycle cost due to the low water and low organic content of the grit, which result in low disposal costs and lower odor potential. It is estimated that the number of grit disposal loads could be reduced to once per week compared to twice per week for the cyclone/classifier. This reduction in hauling frequency could save approximately $10,000 per year in disposal costs. The Huber system is recommended for further consideration.
- The Eutek Slurrycup has a high capital cost and medium life cycle cost. The main advantage of this equipment is that it removes a higher percentage of the fine grit particles compared to the cyclone/classifier and Huber system. This system does not wash organics from the grit to the same level as the Huber Coanda system, however it will have some disposal cost savings compared to the cyclone/classifier. This system will provide some savings in downstream

maintenance costs due to reduced sludge pump wear compared to both the cyclone/classifier and Huber system.

4.2.4 Recommendation: Grit Reduction and Classification

The Huber Coanda unit is recommended because it offers the lowest life cycle cost, while providing a washed grit low in organic content and low in odor potential.

4.3 Storage Bin

There are several storage bin types and sizes under consideration for the grit handling facility. The material handling of bins is discussed in more detail in the TM 6: Materials and the TM 3: Screening. For grit disposal it is assumed that a nominal 6 cubic yard (CY) bin, which can be rear loaded to a short wheel base truck, will be utilized due to the limited truck access to the new headworks. A 6 CY bin will hold 3 to 7 days of screen and grit material.

5 Recommendations: Overall Grit System

The recommended process for grit removal at the SMCSD facility is a mechanical vortex grit removal system which provides the low life cycle cost. The recommended supporting equipment for the grit system are:

- Air lift grit pumps
- Huber Coanda (or equivalent) for grit washing and classification
- A 6 CY combined grit and screenings disposal bin

5.1 Design Criteria

The recommended design criteria for the grit process are presented in Table 7.

Table 7: Grit Process Recommended Design Criteria

Criteria	Value	Units
Grit Process		
Grit Chamber		
Type	Vortex	-
Number	2	-
Diameter	7 to 8	ft
Capacity	4(process), 7 (hydraulic)	MGD
Grit Pumps		
Type	Airlift	-
Number	2	-
Capacity	200	gpm
Grit Handling		
Type	Huber Coanda (or equivalent)	-
Number	2	-

5.2 Layout and Arrangement Options

The small footprint associated with a vortex grit system facility allows for a more compact headworks process area. Siting for the new grit handling facilities requires an optimum balance of the following factors:

- Good access for disposal bin loading and unloading by the outside hauler
- Minimized grit piping length between the grit pumps and the grit handing
- Minimized potential for odors to reach the property line
- Minimized impacts on current and planned plant operations

There are various options for the layout and arrangement of the grit system and overall headworks treatment train. Each option is discussed in the TM 6: Material Handling and TM 2: Siting. The recommended grit layout and arrangement are shown in Drawings M-11, M-12 and M-13.

5.3 Grit Facility Cost

The estimated construction cost for the grit facilities is approximately $1.11 million depending on the siting and equipment selections. See the project cost estimate for more details.

5.4 Operation and Maintenance (O&M)

The addition of grit process facilities will require increased operation and maintenance labor as well as power consumption to run the equipment. Operation and maintenance associated with the grit process and equipment is presented in the following sections.

5.4.1 O&M Labor

Some annual maintenance will be required for normal servicing and infrequent failures of the grit process facilities. However the additional labor is expected to be minor because the systems are automated and rugged. The addition of grit removal is also expected to reduce labor in other areas of the plant; primarily in the solids system because there will be less pump clogging, and digester cleaning required. Therefore, it is anticipated that the additional process facilities would improve overall plant performance, specifically for downstream processes. The estimated net impact on SMCSD labor is presented in Table 8.

Table 8: Estimated Required Process Labor

Labor Type	Process Labor (Hours/week)	Process Labor (Hours/Year)
Operation	4	208
Maintenance	2	104
Total	6	312

5.4.2 O&M Cost Estimate

Adding grit facilities to the SMCSD plant will have a small impact on the O&M costs relating to the following items:

- Operation and maintenance labor
- Grit disposal
- Energy
- Repair parts and service

The estimated O&M cost associated with the grit treatment process are presented in Table 9.

Table 9: Estimated O&M Costs

O&M Items	Quantity	Units	Unit Cost	Total Cost	Notes
Consumables					
Equipment Consumables	$520,000		1.0%	$5,200	% of Equipment Capital Cost
Mechanical Consumables	$20,000		1.0%	$200	% of Mechanical Capital Cost
Subtotal Consumables				$5,400	
Power					
Vortex Grit	12934	kwh	$0.15	$1,900	
Grit Pumps	32335	kwh	$0.15	$4,900	
Subtotal Power				$6,800	
Labor					
Operator	4	hr/week	$45	$9,400	
Maintenance	2	hr/week	$45	$4,700	
Subtotal Labor				$14,000	
Chemicals					
None				$-	
Subtotal Chemicals				$	
Total Annual O&M Cost				**$26,300**	

Drawings

Drawing M-11

Drawing M-12

Drawing M-13