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City of Grants Pass

TECHNICAL MEMORANDUM NO. 7

Water Restoration Plant Facility Plan

Liquid Treatment Upgrade Alternatives

FINAL

April 2014

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City of Grants Pass

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LIQUID TREATMENT UPGRADE ALTERNATIVES

1.0 BACKGROUND

Technical Memorandum No. 5 developed an analysis of the capacity of major unit processes in the liquid stream of the Grants Pass Water Restoration Plant (WRP). Table 1 presents a summary of capacity evaluations for each unit process in the liquid stream. For each unit process, the table shows a capacity criterion and values for that criterion under three different conditions: rated process capacity, current condition, and future (2035) condition. The last three columns indicate the adequacy of process capacity under current and future loading conditions and the estimated adequacy based on unit process condition.

The capacity analysis indicated that the headworks, primary clarifiers, and secondary treatment system have insufficient capacity at PHF for hydraulic criteria, process criteria, or both at this time. The primary sedimentation tanks are also out of capacity for max month wet weather (MMWWF) overflow rates. The activated sludge aeration tanks (AT) are currently out of capacity for average dry weather flow (ADWF) conditions with one aeration tank out of service (OOS) and for max month dry weather flows (MMDWF) in full nitrification operation. In Table 1, the third to last column indicates the adequacy of each unit process under loading conditions predicted for the year 2035. This shows that the headworks, primary sedimentation tanks, activated sludge system, and secondary clarifiers have capacity deficiencies under 2035 loading conditions. The second to last column indicates the estimated year when a capacity deficiency would take place. The last column shows estimated 2035 condition and indicates that several additional facilities may require upgrades due to condition issues that impact reliability.

Based on either capacity or condition deficiencies, the following unit processes require some kind of upgrade:

- Screenings compaction system.
- Primary sedimentation tanks.
- Grit removal system.
- Activated sludge system.
- UV disinfection system.

Alternatives for upgrading these unit processes are evaluated in this memorandum.

Table 1 Liquid Stream Capacity Summary
City of Grants Pass – Liquid Treatment Upgrade Alternatives

Unit Process	Capacity Criterion	Unit	Rated Capacity	Current Flow	2035 Flow	Adequate Current Capacity?	Adequate 2035 Capacity?	Estimated Year Capacity Exceeded	Adequate Current Condition	Adequate 2035 Condition?
Raw Sewage Pumps	PHF (Firm)	mgd	44.0	27.2	33.9	Yes	Yes	After 2035	Yes	Yes
Screening System	PHF (Firm)	mgd	34.0	27.2	33.9	Yes	Yes	After 2035	Yes	Yes
Screenings Compaction	PHF	cf/hr	25	14	17	Yes	Yes	After 2035	No	No
Screening Effluent Channel	PHF	mgd	18.5	27.2	33.9	No	No	Exceeded Now	No	No
Primary Sedimentation Tanks	MMWWF Overflow Rate	gpd/sf	2,000	2,218	3,338	No	No	Exceeded Now	Yes	Yes
Primary Sedimentation Tanks	PHF Overflow Rate	gpd/sf	4,000	5,860	7,300	No	No	Exceeded Now	Yes	Yes
Primary Sedimentation Tanks	PHF Hydraulic Capacity	mgd	18.5	27.2	33.9	No	No	Exceeded Now	No	No
Grit Removal System	Flow Capacity	gpm	220	143	178	Yes	Yes	After 2035	No	No
Activated Sludge System	ADWF One AT OOS	mgd	5.0	5.2	8.0	No	No	Exceeded Now	No	No
Activated Sludge System	ADWF One SC OOS	mgd	6.2	5.2	8	Yes	No	Approximately 2020	No	No
Activated Sludge System	MMDWF Partial Nitrification	mgd	7.0	6.3	9.7	Yes	No	2017	No	No
Activated Sludge System	MMWWF Secondary Treatment	mgd	11.0	10.3	15.5	Yes	No	2018	No	No
Activated Sludge System	PHF Contact Stabilization, Overflow Rate	gpd/sf	1,250	1,631	2,032	No	No	Exceeded Now	No	No
Activated Sludge System	MMDWF Full Nitrification	mgd	3.5	6.3	9.7	No	No	Exceeded Now	No	No
Activated Sludge Blowers	MMDWF Demand (Partial Nitrification)	cfm	8000	4,800	7,000	Yes	Yes	After 2035	Yes	No
Activated Sludge Blowers	MMDWF Demand (Full Nitrification)	cfm	8000	4,000	5,800	Yes	Yes	After 2035	Yes	No
Secondary Clarification	PHF Hydraulic Capacity	mgd	20.8	27.2	33.9	No	No	Exceeded Now	Yes	No
Ultraviolet Disinfection System	PHF (Firm)	mgd	35	27.2	33.9	Yes	Yes	After 2035	No	No

2.0 UPGRADE ALTERNATIVES

Upgrade alternatives were discussed in a workshop conducted in March 2013. The following analysis and conclusions were presented.

2.1 Screening Facilities

During peak hour flows, there is inadequate hydraulic capacity in the screenings effluent channel to pass all of the influent raw sewage (RS) to the primary sedimentation tanks. Once flow passes through the screens, it must pass through the two openings in the wall separating the primary clarifier influent channel from the screenings effluent channel. The openings create a sudden contraction in the channel, with a downstream width of only 12-inches per opening, which limits flow to 18.5 mgd. In order to meet PHF for 2035, hydraulic improvements including widening the existing openings and removing the knockouts for the future expansion will be required. The estimated construction cost for this project, including engineering, legal, and administration (ELA) costs, is $112,000.

While the capacity of the screenings compaction system appears to be adequate for anticipated 2035 loadings, the existing unit has failed on multiple occasions and the fact that there is only one unit places stress on operations staff during an equipment outage. As a result, it is recommended that replacement alternatives be considered. Table 2 presents the estimated cost for replacement of a single washer/compactor and the estimated cost with purchase of an uninstalled spare. The table shows the estimated equipment replacement cost, the estimated cost for construction by a contractor, and the total estimated project cost including an allowance of 20 percent for engineering, legal, and administration (ELA) costs.

Table 2 Cost Comparison for Screenings Compactor Replacement Alternatives
City of Grants Pass – Liquid Treatment Upgrade Alternatives

Cost Element	Single Washer/Compactor	Washer/Compactor with Uninstalled Spare
Equipment Cost	$88,000	$176,400
Estimated Construction Cost	$188,000	$333,400
Project Cost with ELA	$226,000	$400,300

The City purchased a new screenings compactor in 2013.

2.2 Primary Sedimentation Tanks

Technical Memorandum No. 5 presented the analysis of the primary sedimentation system, which concluded that short-term improvements are required to upgrade the capacity of the system. Under current PHF conditions up to 9 mgd of RS, some of which may be unscreened, must bypass the primary clarifiers. Alternatives considered for upgrade included:

- Construction of additional rectangular primary tanks.
- Construction of alternative sludge storage and rehabilitation of the existing circular sedimentation tank.
- Construction of a parallel high rate sedimentation system.

2.2.1 New Rectangular Sedimentation Tanks

Figure 1 illustrates a potential location for construction of additional primary sedimentation tanks. Construction of one new rectangular tank of the same dimensions as one of the existing tanks would increase PHF hydraulic capacity to approximately 28 mgd, which is sufficient for current peak hourly flows.

A second rectangular clarifier provides capacity to treat 2035 PHF flows at 3650 gpd/sf and well exceeds the capacity requirement for MMWWF. With all four tanks in service, the mean removal rates for total suspended solids (TSS) are greater than 45% for MMWWF and greater than 25% for PHF. Capacity analysis for the activated sludge process in Technical Memorandum (TM) No. 5 was based on construction of two new primary tanks.

2.2.2 New Sludge Storage Tanks

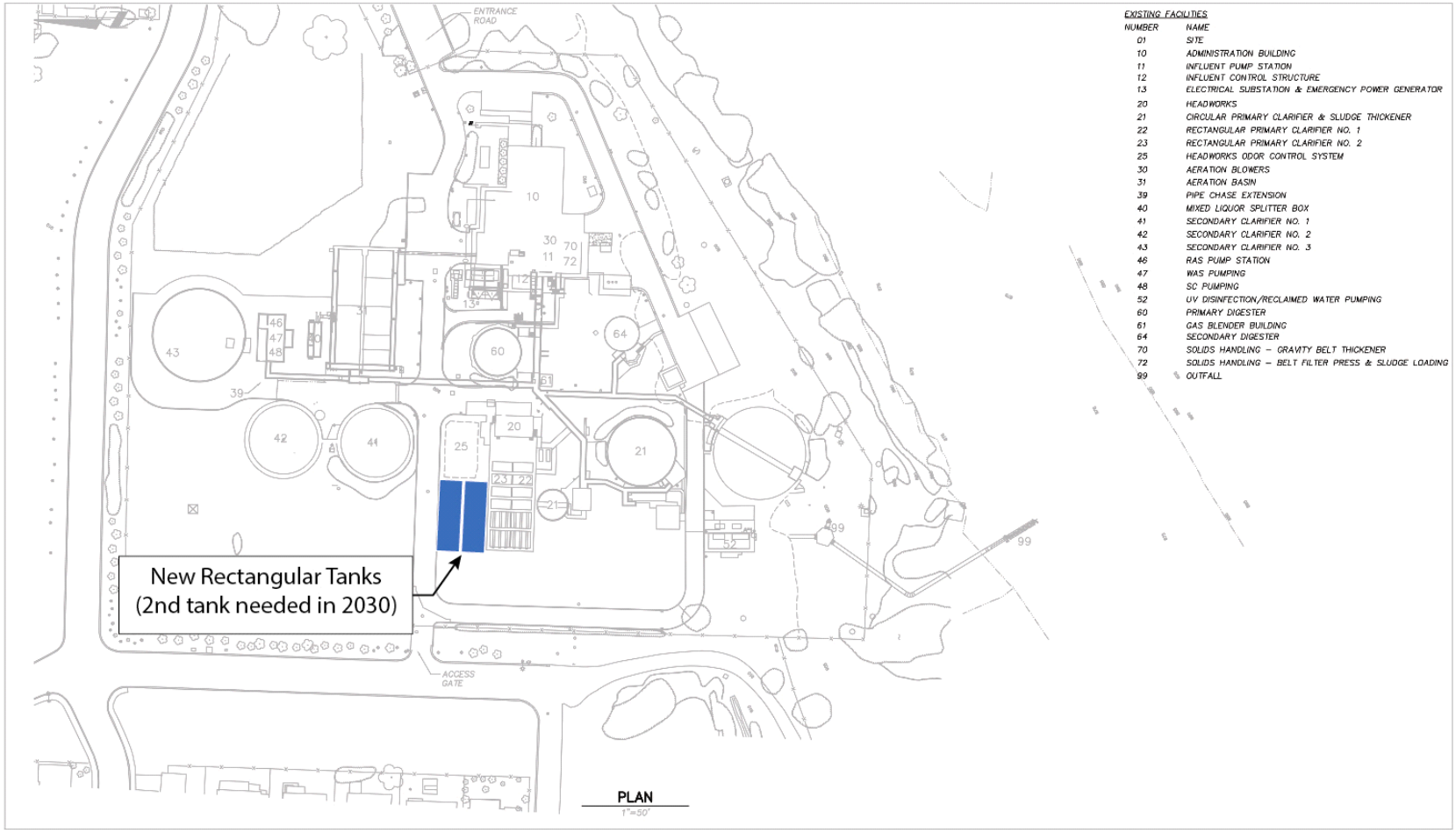
The existing circular sedimentation tank is currently being used for sludge storage. While this tank dates from the 1950's and would require significant refurbishment, returning this tank to sedimentation service is a potentially viable alternative for correction of current capacity deficiencies in primary sedimentation. One additional barrier to returning this tank to service is that during high flows water overflows into the basin from the secondary treatment system. In this case, a new tank would be constructed for sludge storage. Figure 2 presents a possible location for a new sludge storage tank. It was assumed that a new 50-ft diameter, 25-ft depth storage tank would be constructed with approximately the same storage time as the existing 75-ft diameter, 12.5-ft depth clarifier tank.

2.2.3 New High Rate Sedimentation Tanks

An alternative primary sedimentation system to conventional gravity sedimentation uses "ballast" to increase settling rates with resulting decrease in required sedimentation area. The 2001 *Facilities Plan Update* (Parametrix 2001) recommended upgrade of the Grants Pass WRP by construction of new high rate sedimentation tanks to reduce loadings on the activated sludge system. High rate sedimentation could also provide hydraulic relief of existing rectangular primary sedimentation

tanks, which with withdrawal of the older circular tank from service, are near to overloaded under currently experienced flows.

There are several kinds of high rate sedimentation products on sale in the current marketplace. The two common kinds include the Actiflo™ process manufactured by Veolia in France and marketed by Krüger in the United States and the Densadeg™ process manufactured by Degremont. The Actiflo™ process uses sand as ballast, which is recovered in cyclone separators. The process uses chemical treatment with iron or aluminum salts and organic polymers to stabilize sludge particles and entrain finer particles into the sludge floc. A schematic diagram of the Actiflo™ process provided by Veolia is shown in Figure 3. The Densadeg™ process recirculates primary sludge to provide the ballast to increase sedimentation rates. The Densadeg™ process typically operates at up to five times lower overflow rate than the Actiflo™ process. Therefore, for this project, we received a proposal from Krüger for an Actiflo™ process to operate in place of new gravity sedimentation tanks. A potential location for the new high rate sedimentation (HRS) process on the Grants Pass WRP site is illustrated in Figure 4.



POTENTIAL LOCATION FOR NEW PRIMARY SEDIMENTATION TANKS

FIGURE 1

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

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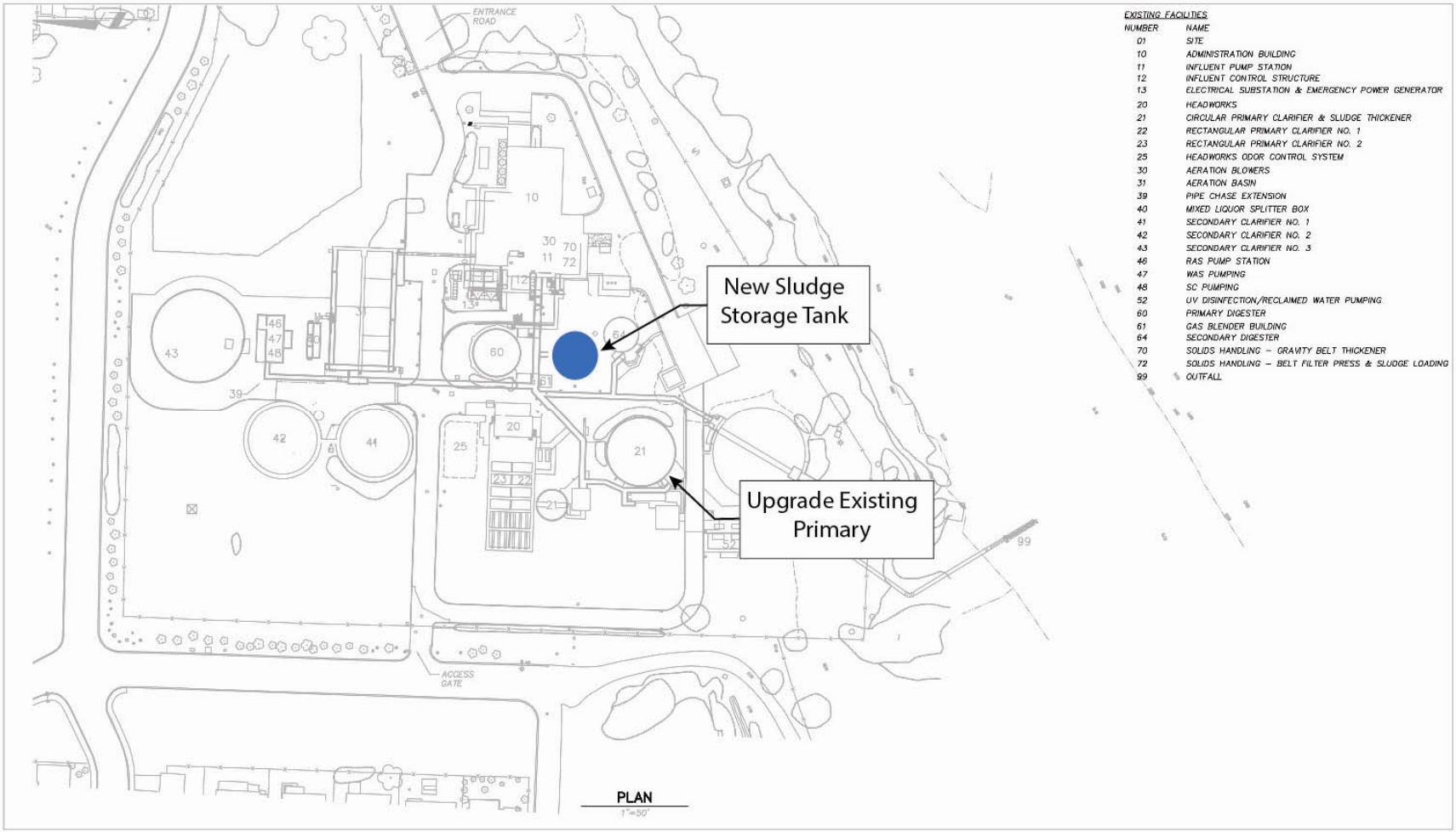

POTENTIAL LOCATION FOR NEW SLUDGE STORAGE TANK

FIGURE 2

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

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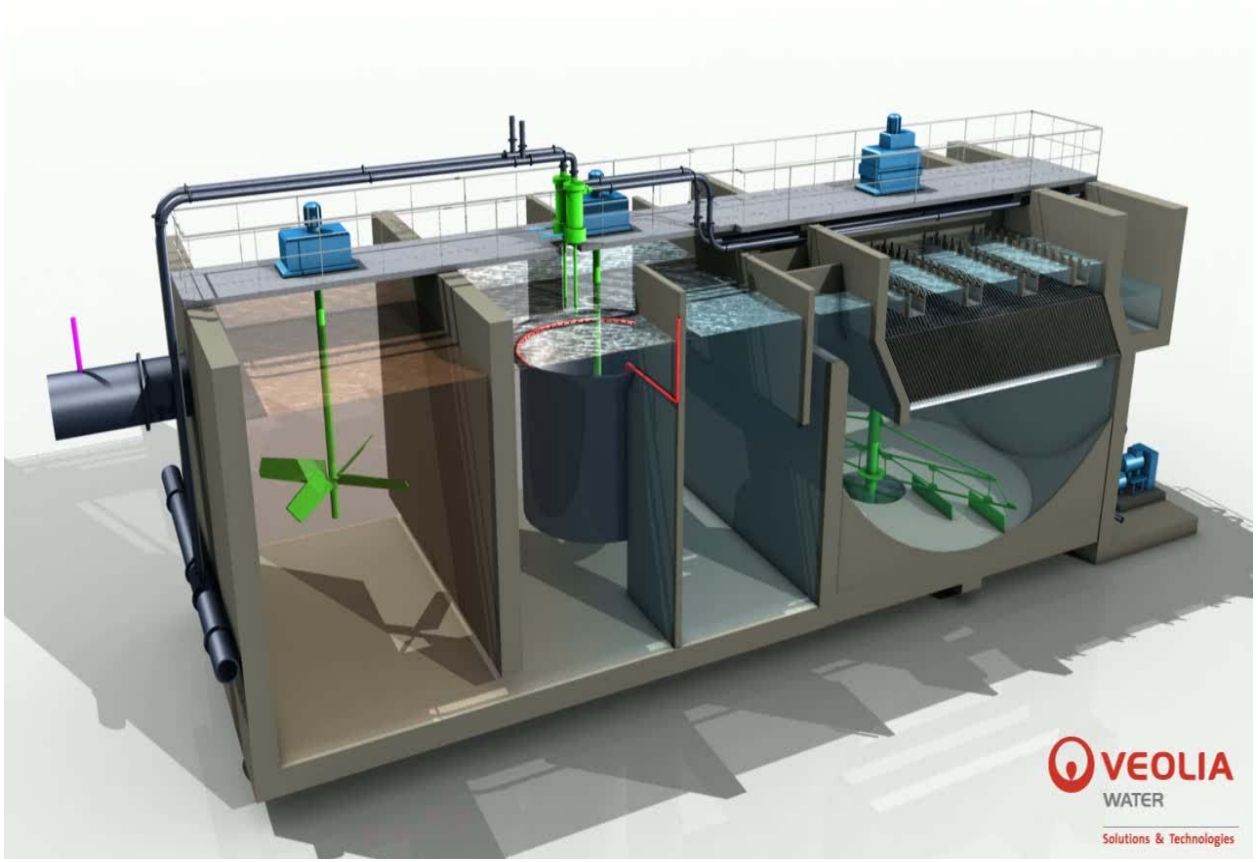

SCHEMATIC DIAGRAM OF THE ACTIFLO™ PROCESS

FIGURE 3

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

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POTENTIAL LOCATION FOR NEW ACTIFLO™ PROCESS

FIGURE 4

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

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2.2.4 Primary Sedimentation Alternatives Comparison

Table 3 presents a comparison of costs for the alternative primary sedimentation alternatives. Installation of two new rectangular primary sedimentation tanks would have a lower capital, operating, and present worth cost than the alternatives. This comparison does not capture the reduction in solids and BOD loading to the secondary treatment process for an Actiflo™. This will be considered further when we evaluate activated sludge system upgrade alternatives.

Table 3 Cost Comparison for Primary Treatment Upgrade Alternatives
City of Grants Pass – Liquid Treatment Upgrade Alternatives

Cost Element	New Primary Tanks	Sludge Holding Tank	New Actiflo™
Capital Cost ($ Million)	$4.52	$5.10	$9.97
Chemical Cost ($/year)	N/A	N/A	$82,000
Total Present Worth Cost ($ Million)	$4.72	$5.30	$11.19

As a way to consider factors in addition to cost in selection of process alternatives, we have prepared a selection criteria-ranking system. The basis for this system is illustrated in Figure 5.

A total of 10 ranking criteria were identified, including 8 criteria not based on cost. For criteria where a quantitative value can be assigned to the alternative, a ranking of 3 was given to the best alternative, a ranking of 2 for the alternative that had a quantitative value less than 1.5 times the lowest alternative, and a value of 1 for alternatives greater than 1.5 times the value of the lowest alternative. The ranking of qualitative criteria is explained in the table. For example, the process that produced the best effluent quality is given a ranking of 3, the process that would be expected to produce the worst effluent quality is given a ranking of 1, and a process with an intermediate effluent quality is given a ranking of 2.

Figure 6 presents the resulting un-weighted scoring for the primary treatment alternatives. The highest ranked alternative is to provide new rectangular primary sedimentation tanks.

Criterion	Criterion Ranking Explanation		
	Worst	**Intermediate**	**Best**
Capital Cost	>1.5 * Lowest = 1	< 1.5 * Lowest = 2	Lowest = 3
O&M Cost, PW	> 1.5 * Lowest = 1	<1.5 * Lowest = 2	Lowest = 3
Risk	Few worldwide installation; New technology = 1	Intermediate level of success.	Several local and large number of successful worldwide installations = 3
Future Flexibility	No room for future	Intermediate	Ample room for future
Footprint, sf	> 1.5 * Lowest = 1	< 1.5 * Lowest = 2	Lowest = 3
Energy, kWh/year	> 1.5 * Lowest = 1	< 1.5 * Lowest = 2	Lowest = 3
Odor	Most odor prone	Intermediate	Least odor prone
Compatibility with existing processes	Most stranded assets = 1	Intermediate = 2	Least stranded assets = 3
Biosolids Quality/Quantity	Least suitable for composting	Intermediate = 2	Most suitable for composting = 3
Effluent Quality	Worst Effluent Quality = 1	Intermediate = 2	Best Effluent Quality = 3

Figure 5 Alternatives Ranking Criteria

Criterion	Weight	Weighted Ranking		
		New Primary Tanks	Sludge Holding Tank	New Actiflo
Capital Cost	1	3	1	1
O&M Cost	1	3	3	1
Risk	1	3	3	1
Future Flexibility	1	2	2	2
Footprint	1	1	1	3
Energy	1	3	3	2
Odor	1	2	2	2
Compatibility with existing processes	1	3	3	2
Biosolids Quality / Quantity	1	2	2	1
Effluent Quality	1	2	2	3
Total		**24**	**22**	**18**

Legend:	Score
Highest Ranking	3
Intermediate Ranking	2
Lowest Ranking	1

Figure 6 Alternatives Ranking for Primary Treatment Alternatives

2.3 Grit Removal System

The grit removal system for the Grants Pass WRP uses cyclones and grit washers to remove grit particles from primary sludge flows. This system has been in place since 1996 and will require replacement due to deficient condition at some time during the planning period. The alternative to primary sludge de-gritting would require construction of a de-gritting tank for the entire liquid stream process flow. Whatever system that could be used for grit removal of the entire flow stream, head losses would be in excess of 3 feet, which would probably require intermediate pumping or significant modification of the influent pumping system. For this reason, this kind of upgrade was not considered further. The least-cost alternative is replacement of existing primary sludge pumps, grit cyclone and grit washer with new equipment. A cost estimate for these replacement projects is presented in Table 4. They are shown as separate projects for grit pump replacement and grit cyclone and washer replacement because Grants Pass may wish to implement them separately.

Table 4	Cost Comparison for Grit Removal Equipment Replacement Alternatives *City of Grants Pass – Liquid Treatment Upgrade Alternatives*	
Cost Element	**3 Grit Pumps**	**Cyclone and Washer**
Equipment Cost	$113,000	$119,000
Construction Cost	$241,000	$255,000
Project Cost with ELA	$289,000	$306,000

2.4 Activated Sludge System

As discussed in TM No. 5, the activated sludge system must be evaluated as a complete system, including both aeration and sedimentation (clarifier) tanks. This capacity analysis in TM No. 5 concluded that the activated sludge system is near to full capacity under current loadings. The Department of Environmental Quality (DEQ) imposed new effluent quality requirements for ammonia at Grants Pass in 2009. To increase removal of ammonia (nitrification) the activated sludge system has been operated with a higher solids residence time (SRT). This increase in SRT results in a decrease in activated sludge capacity, since it must be implemented by increasing mixed liquor suspended solids (MLSS) concentrations, which in turn reduces the flow that can be accommodated by the secondary clarifiers.

A series of potential upgrade alternatives were identified in a workshop with Grants Pass staff in January 2013. These included:

- Improved settleability.
- Chemically enhanced primary treatment (CEPT) or Actiflo™.
- Increase aeration tank volume.
- Increase clarifier area.
- BioMag™.
- Integrated fixed film activated sludge (IFAS).
- Parallel membrane bioreactors (MBR).

Analysis of each of these potential upgrade strategies is provided below.

2.4.1 Improved Settleability

TM No. 5 showed that settleability of the activated sludge system at the Grants Pass WRP has been variable. Sludge volume index (SVI) is a commonly used operational test for sludge settleability. This test is an indicator of how well activated sludge settles in the secondary clarifiers. The SVI test measures the volume of settled activated sludge in a 1,000-milliliter (mL) container after a 30 minute settling time. This value is then divided by the MLSS concentration and multiplied by 1,000 to calculate the SVI value. A high value for SVI indicates relatively poorly settling sludge.

A low value for SVI indicates a relatively well settling sludge. SVI values for the Grants Pass WRP over the last five years have varied from under 100 mL/g to over 400 mL/g. The average SVI in the summer season has been approximately 150 mL/g, and the average SVI in the wet weather season has been approximately 170 mL/g. Activated sludge systems with anaerobic selector zones, like the system at the Grants Pass WRP, often experience SVI values under 120 mL/g. Thus, there is potential for improvement of WRP capacity by optimizing sludge settleability.

To identify potential capacity improvements from settleability improvement, we considered what improvement in capacity would result if the SVI could be lowered to 120 mL/g from the current average of 150 mL/g during the partial nitrification season. This result is shown in Figure 7. Reduction in SVI increases the partial nitrification capacity only modestly, from estimated MMDWF capacity of approximately 7 mgd with an SVI of 150 mL/g to approximately 8 mgd with an SVI of 120 mL/g. This degree of capacity improvement would be insufficient to accommodate the 2035 MMDWF 9.4 mgd. As a result, this alternative is rejected as a long-term capacity solution, although settleability improvement could improve the ability of the operators of the WRP to take one aeration tank out of service for membrane diffuser inspection and cleaning during the partial nitrification season.

2.4.2 Chemically Enhanced Primary Treatment (CEPT) or Actiflo™

Actiflo™ was considered as an alternative primary sedimentation upgrade strategy above, but the influence of improved primary sedimentation performance on activated sludge system capacity was not considered there. By improving primary sedimentation capture of suspended solids, chemically enhanced primary treatment (CEPT) increases the relative capacity of the activated sludge system. Either conventional CEPT or Actiflo™ operates on the same principle of chemically coagulating sludge particles and enhancing separation. Carollo used its steady state process model Biotran to estimate the degree of enhancement that would take place with CEPT. The model indicated a modest reduction in influent BOD concentration during MMDWF from approximately 140 mg/l with conventional sedimentation compared to 123 mg/l with CEPT. Concentrations for TSS removal were respectively 104 mg/L for conventional versus 90 mg/L for CEPT. This represents a removal rate increase from 30 percent to 39 percent for BOD and from 46 percent to 53 percent for TSS. As shown in Figure 8, this produces a modest increase in activated sludge capacity to approximately 8 mgd from the capacity of 7 mgd with conventional sedimentation. For MMWWF conditions, the predicted improvement in primary effluent concentration for BOD was from 72 mg/L to 67 mg/L for BOD and from 67 mg/l to 63 mg/l for TSS. This corresponds to a removal rate increase from 22 percent to 28 percent for BOD and from 33 percent to 38 percent for TSS. As shown in Figure 9, this produces a modest increase in activated sludge system capacity to no more than 12 mgd compared to 11 mgd for conventional primary sedimentation. As shown in Figure 10, CEPT plus addition of one aeration tank would increase capacity of the WRP to approximately 14 mgd during MMWWF. We used a proposal received from Krüger to estimate capital and operating costs for a CEPT / Actiflo™ alternative assuming only one new aeration tank would be required.

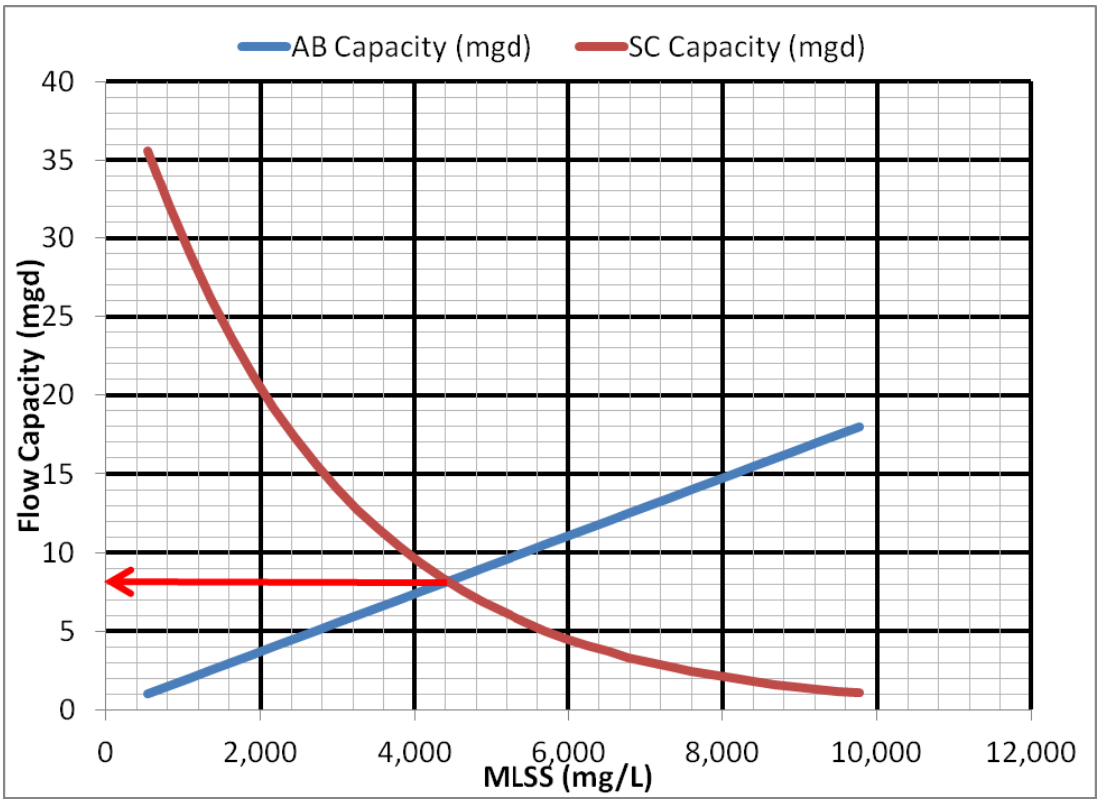

Figure 7 MMDWF Capacity by Reduction of SVI to 120 mL/g

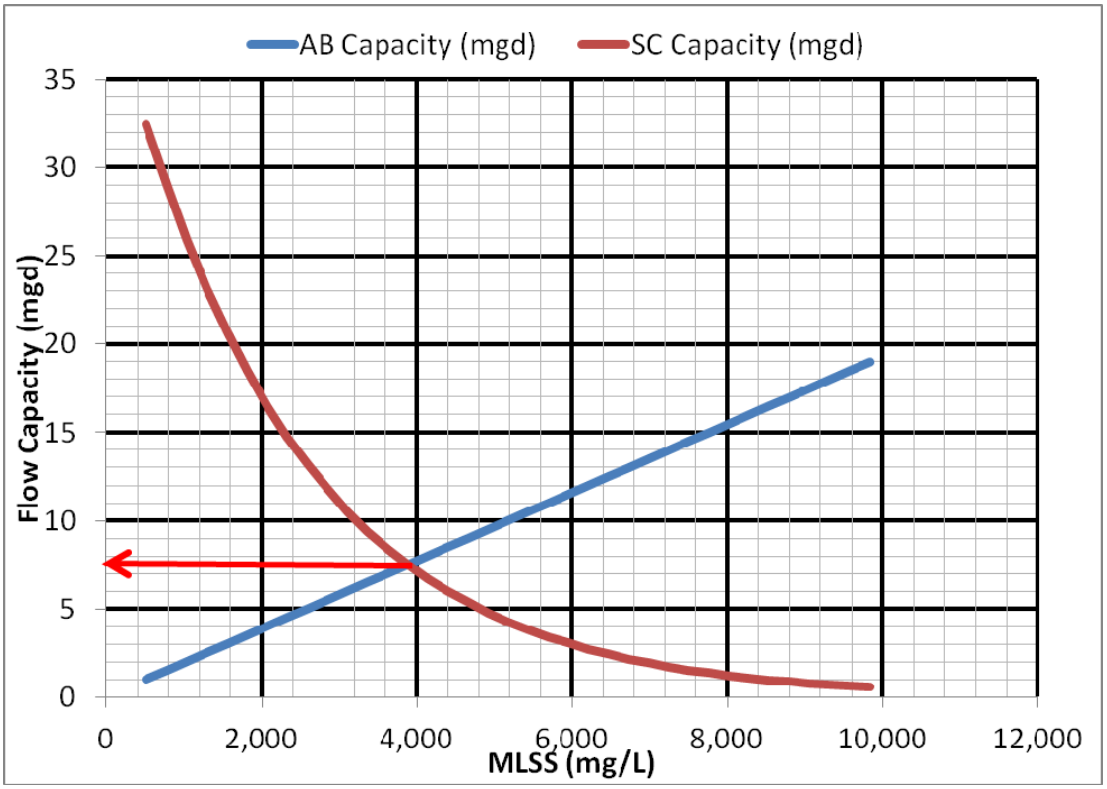

Figure 8 MMDWF Capacity of CEPT

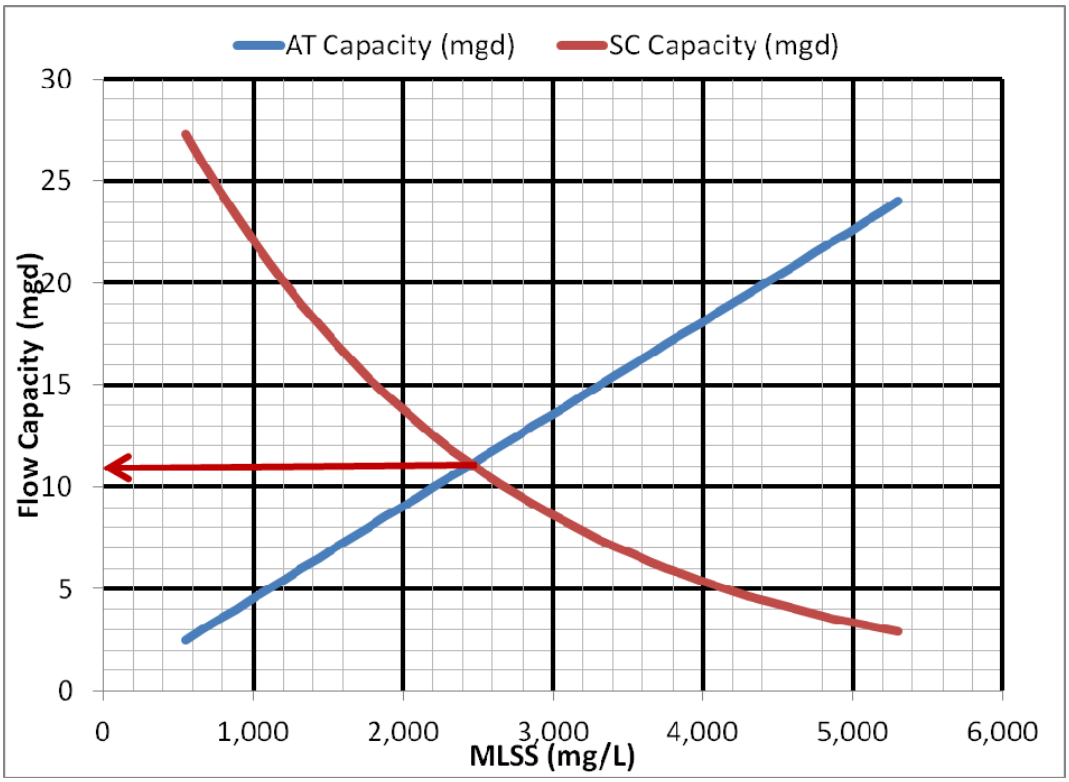

Figure 9 MMWWF Capacity of CEPT

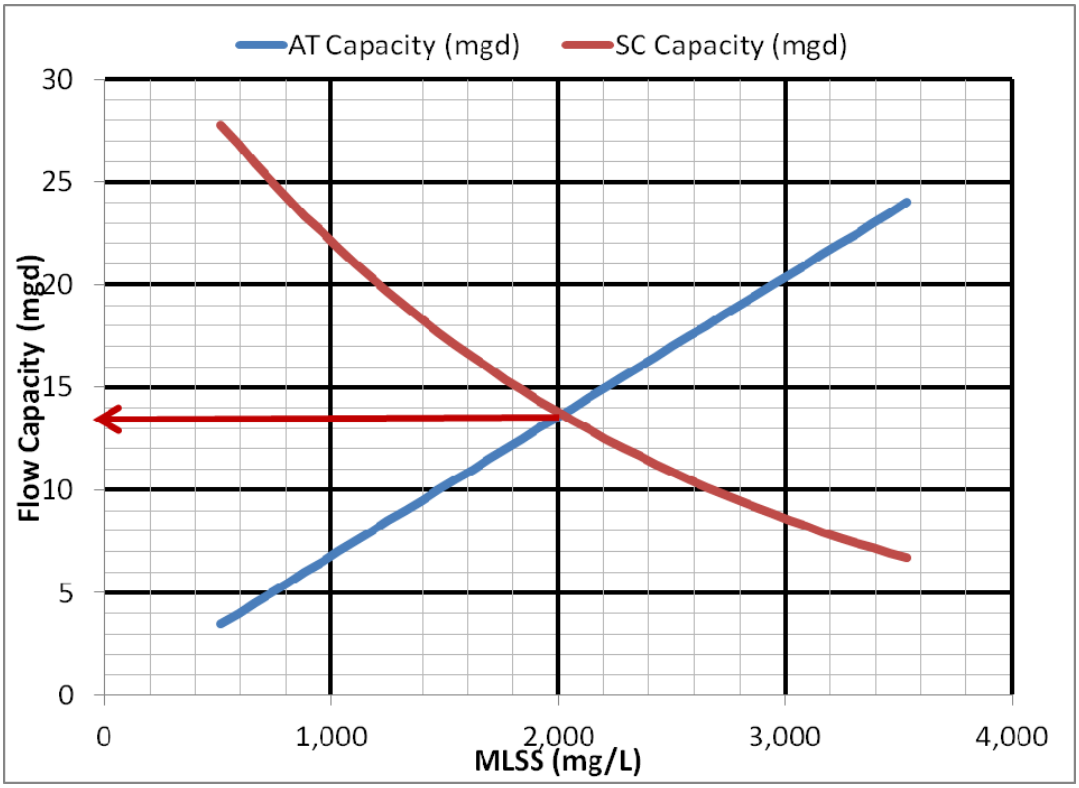

Figure 10 MMWWF Capacity of CEPT with Addition of One Aeration Tank

2.4.3 Increase Aeration Tank Volume

A conventional strategy for upgrade of the WRP for Grants Pass would be to add additional aeration tank volume. Figures 11 and 12 indicate that by doubling the current aeration tank volume without increasing sedimentation tank area, the MMDWF capacity would be increased from 7 mgd to approximately 10 mgd and the MMWWF capacity would be increased from approximately 11 mgd currently to approximately 15 mgd. This would approximately satisfy capacity needs for 2035. Figure 13 presents a potential site location for two new aeration tanks.

2.4.4 Increase Clarifier Area

An alternative strategy for increasing the capacity of the activated sludge process would be to increase the secondary clarifier area. Figure 14 shows the impact on WRP capacity of doubling the secondary clarifier area, instead of doubling the aeration tank volume. The figure shows the impact on capacity for the partial nitrification season at MMDWF. The figure shows that increasing secondary clarifier tank area would increase capacity from approximately 7 mgd to approximately 9 mgd, but to do so would require operation with a MLSS concentration of almost 5,000 mg/L. Such a high MLSS concentration would be well outside the normal range of 2,000 to 4,000 mg/L. Additional clarifier area alone will not significantly increase the capacity of the activated sludge system. Upgrades to aeration tank volume and clarifier area should be considered in tandem because capacity of the two processes is inherently related.

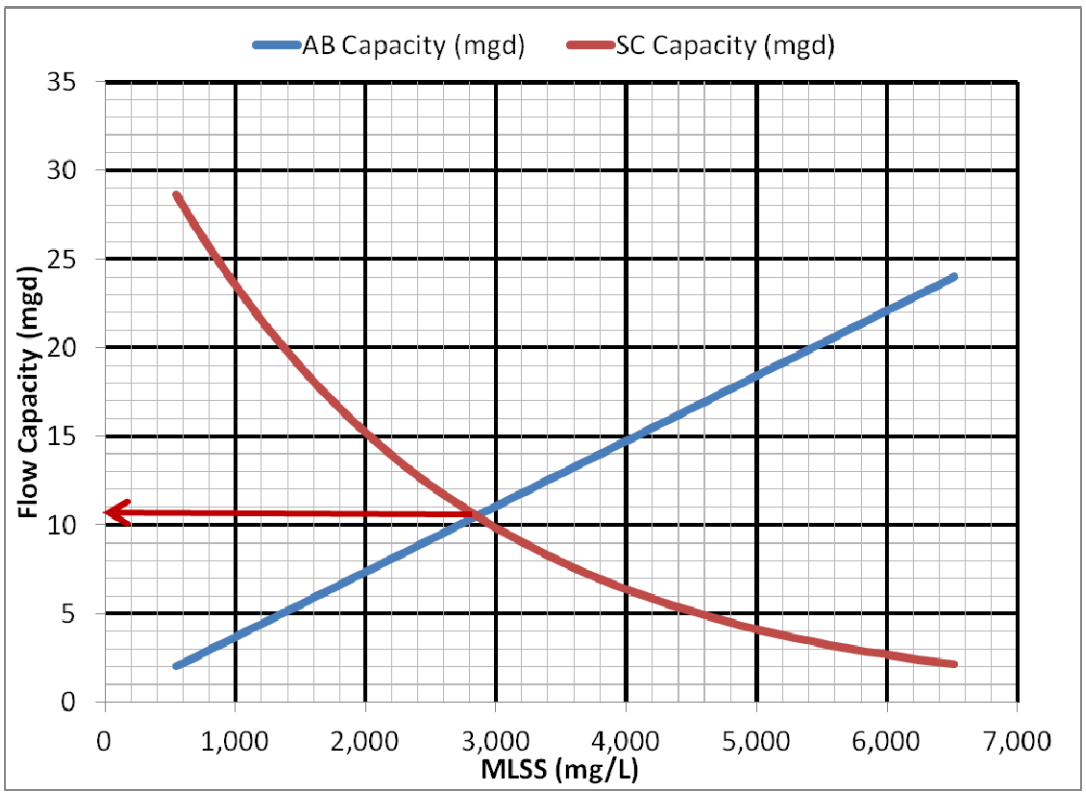

Figure 11 MMDWF Capacity of Addition of Two Aeration Tanks

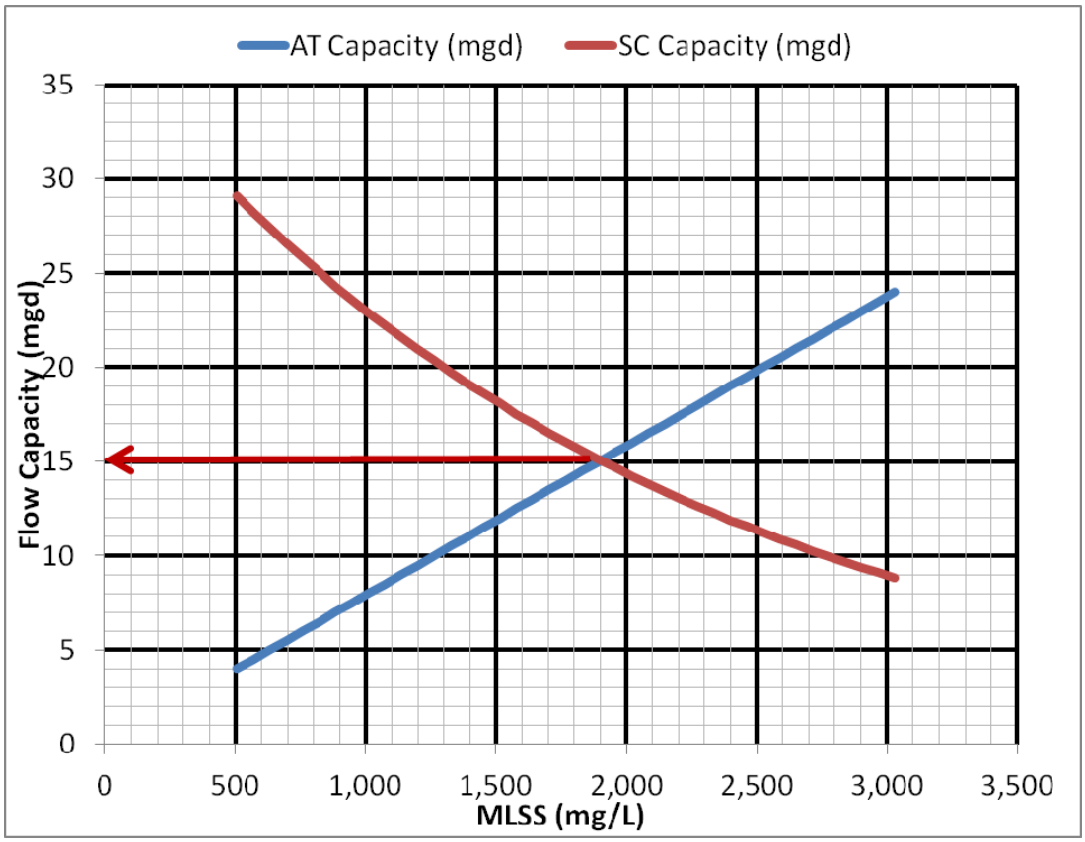

Figure 12 MMWWF Capacity of Addition of Two Aeration Tanks

POTENTIAL LOCATION FOR TWO NEW AERATION TANKS

FIGURE 13

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

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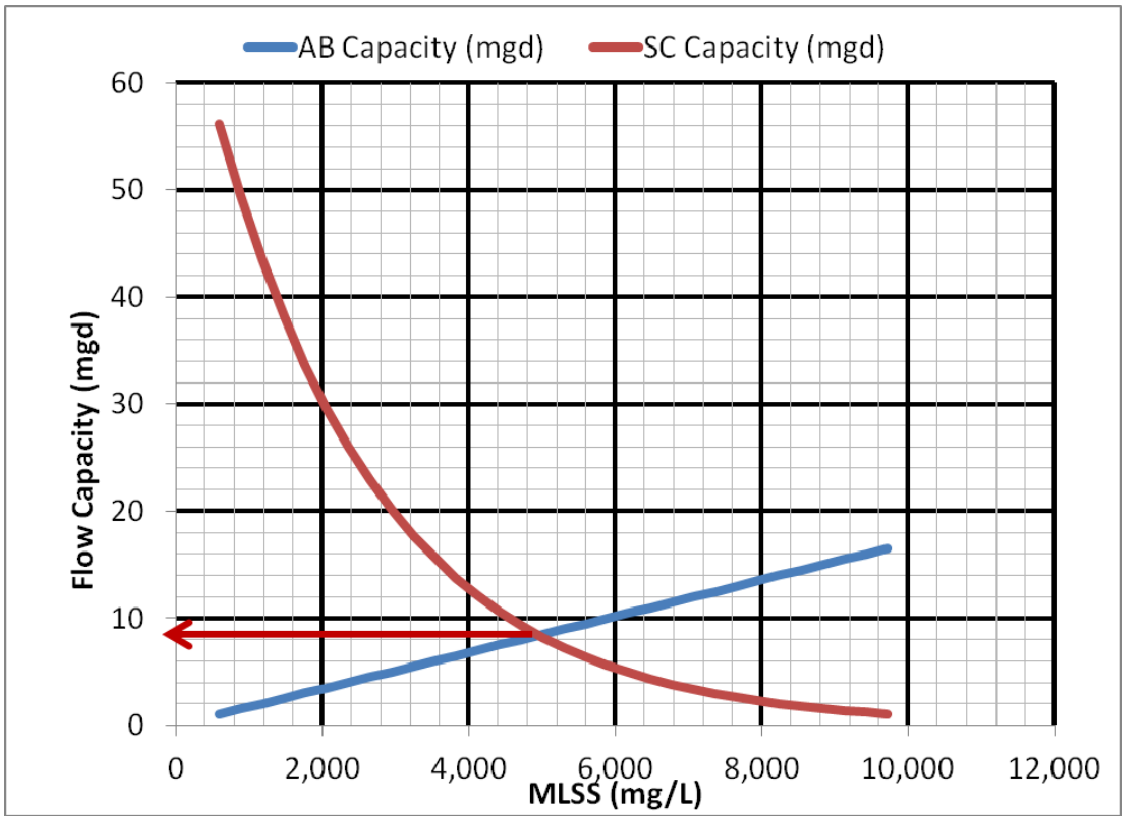
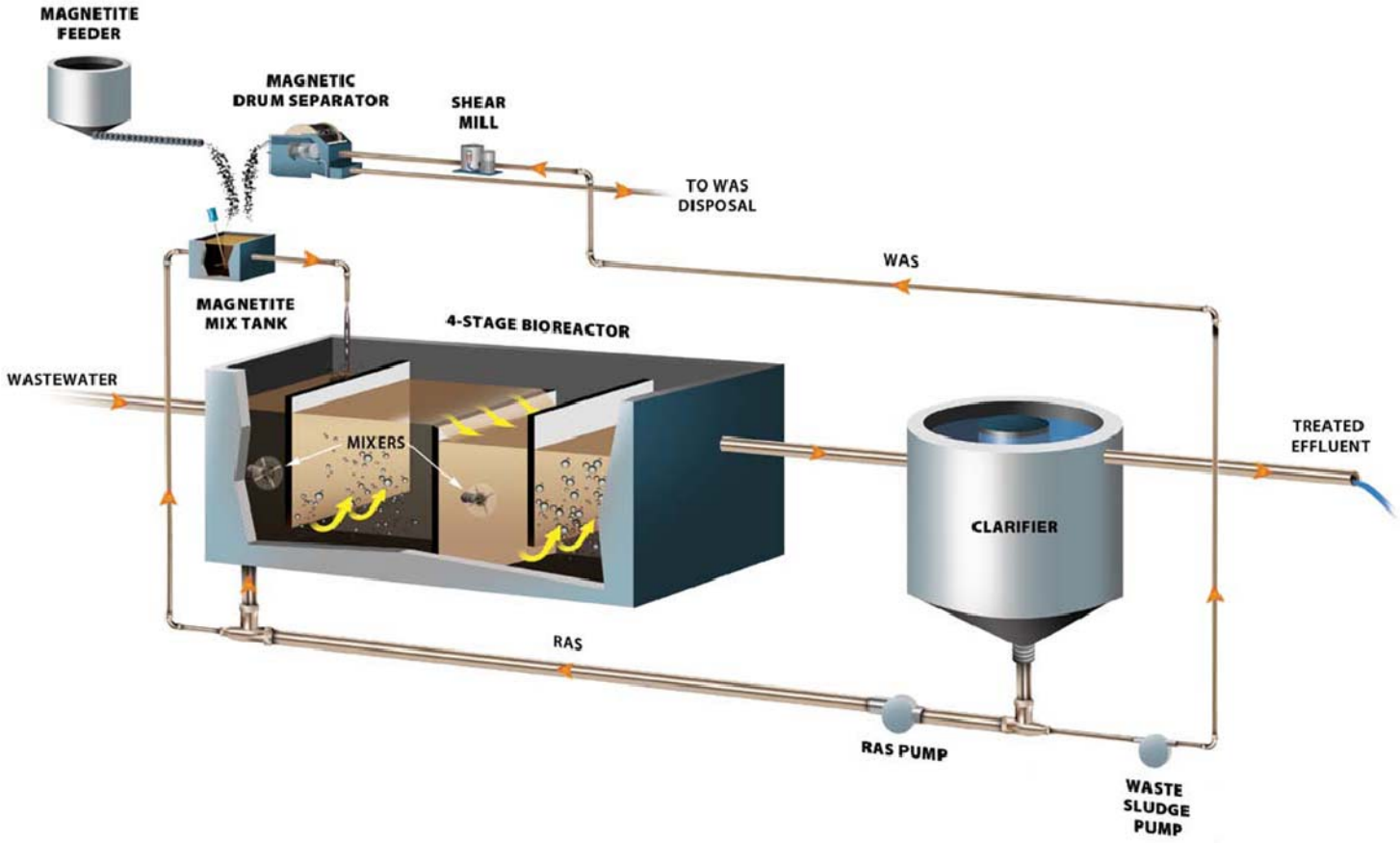


Figure 14 Impact on Capacity of Doubling Secondary Clarifier Area

2.4.5 BioMag™

BioMag™ is a trademarked process to increase the capacity of an activated sludge process by adding a magnetized ballast to the MLSS to produce dramatically higher settling rates. The process was developed by an American company, Cambridge Water Technologies, and recently sold to the large German industrial firm, Siemens. In this process, magnetite is added to the MLSS and removed from the waste activated sludge (WAS) by a magnetic drum separator after passage through a grinder mill to disturb adhesion of sludge particles to the magnetite. After separation, magnetite is returned to the MLSS. A continuous make-up of magnetite is required. This process is illustrated schematically in Figure 15.

We received a proposal from Siemens for this project. Siemens proposed maintaining the same aeration tank volume, but construction of two new 100-foot diameter secondary clarifiers in addition to BioMag equipment. The proposal included supply of ballast storage and feed system, a ballast recovery system, a chemical feed system and control hardware. The quoted price for equipment only was $2,100,000. This did not include installation, buildings to house the new equipment, nor any piping or electrical appurtenances. Since the BioMag™ process increases the capacity of the secondary clarifiers by increasing settling rates, we have assumed that the Siemens proposal to add new secondary clarifiers was a misunderstanding of details about the existing plant, and have ignored this in our cost and other impact comparisons.



SCHEMATIC DIAGRAM FOR THE BIOMAG™ PROCESS
(COURTESY SIEMENS INDUSTRY INC.)

FIGURE 15

2.4.6 Integrated Fixed Film Activated Sludge (IFAS)

Another potential strategy for upgrade of the Grants Pass WRP would be to add fixed film media to the activated sludge system to increase the inventory of biological organisms without increasing the MLSS concentration loaded to the secondary clarifiers. These systems are called integrated fixed film activated sludge or IFAS systems. Various types of media are commercially available for these systems, including suspended media manufactured as sponges, hard plastic "wagon wheels," or plastic rope or web media fixed into trays that would be mounted on the aeration tank floor. The suspended media typically require relatively coarse bubble mixing, which increases the operating cost of these systems compared to conventional, fine-bubble aeration systems such as the one at the Grants Pass WRP. Fixed media installations have an apparent energy-efficiency advantage; however, there have been very few IFAS media installations in the United States of this type, and another agency's fixed IFAS media failed to meet the manufacturer's promises for improved nitrification. For these reasons, we have evaluated suspended media for Grants Pass, rather than fixed media.

Carollo received a proposal from Krüger for suspended media and equipment to upgrade the Grants Pass WRP. Krüger is owned by the international water technology company Veolia. The Krüger media was developed originally by a Norwegian company, AnoxKaldnes. Krüger proposed to place their K5 media with a unit surface area of 800 m^2/m^3 (243 ft^2/ft^3) in a fill density of 25 percent in one-half of the existing aeration tanks. Krüger calls this process configuration Hybas (for hybrid activated sludge).

Krüger proposed to modify the flow pattern through the tanks to reduce the forward velocity of the flow and reduce media migration. Figure 16 presents a sketch of the configuration that Krüger proposed. Carollo modeled this configuration using the fixed media module in the commercial biological process model BioWin™. We confirmed that this configuration should partially nitrify under 2035 MMDWF conditions. We also confirmed that part of the upstream portion of the aeration tanks could be anaerobic while partially nitrifying at 2035 MMDWF loadings.

The Krüger proposal included media, screens to contain the media in the Hybas reactor, and new "medium bubble (4.0 mm orifice)" stainless steel diffusers. Fine bubble panel diffusers would continue to be used in the upstream portion of the aeration tanks. The quoted price for media and equipment without installation or any other appurtenances was $801,000.

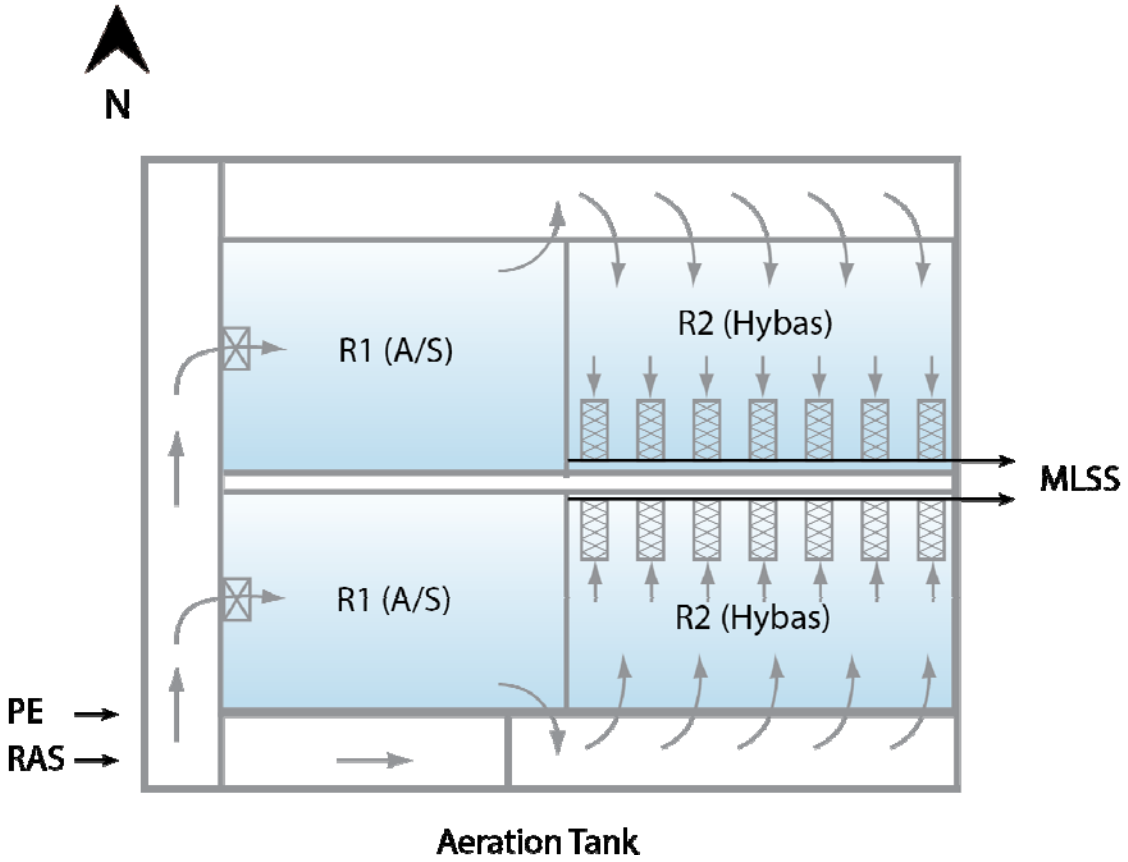
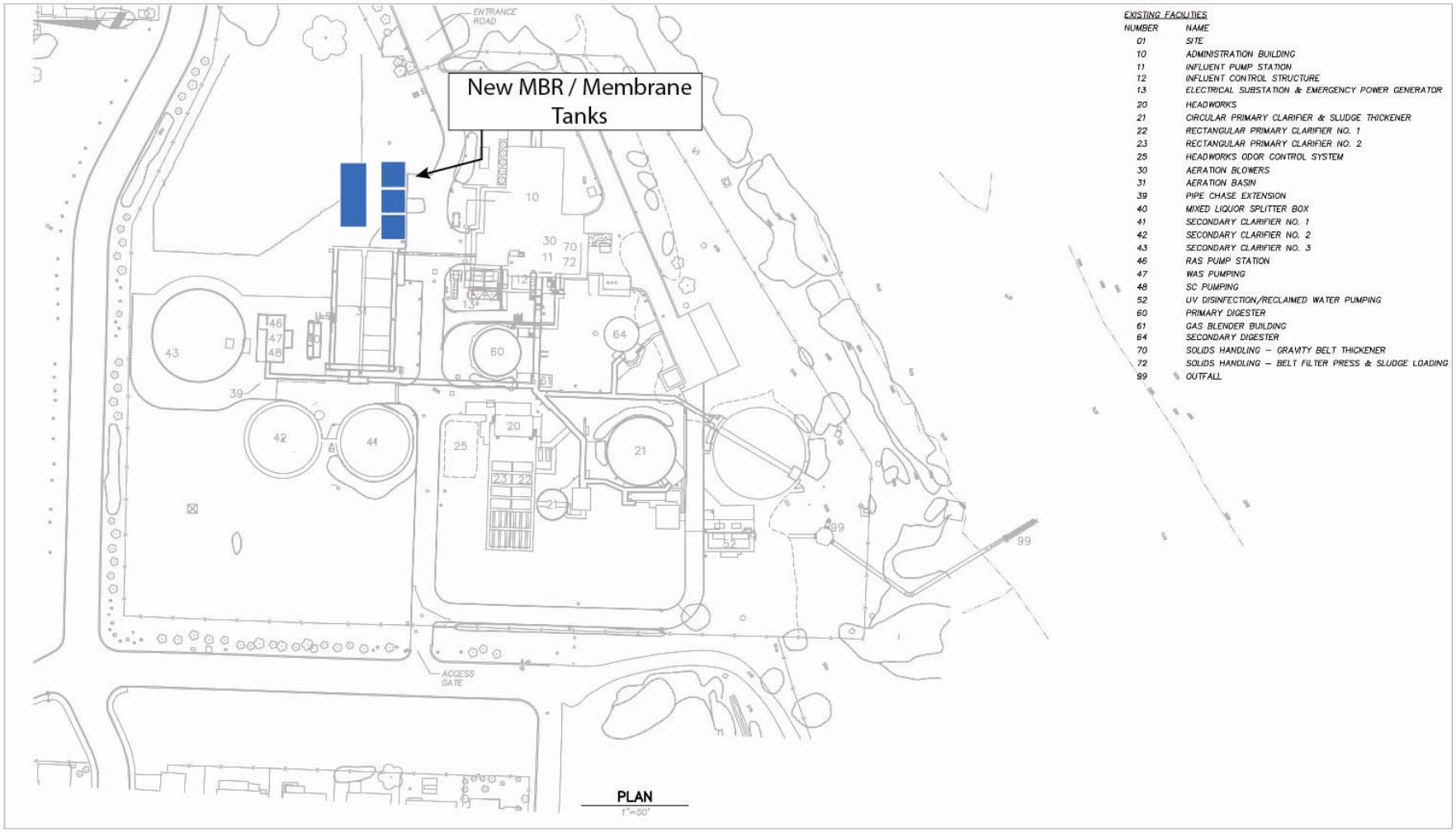


Figure 16 Sketch of Proposed IFAS Installation (Courtesy Krüger)

2.4.7 Parallel membrane bioreactors (MBR)

The last alternative considered for upgrade of the Grants Pass WRP was the membrane bioreactor (MBR) process. This process uses ultrafiltration or microfiltration sized membranes for separation of activated sludge from the MLSS, rather than gravity clarifiers. As a result, the MBR process can operate at relatively high concentrations of MLSS in the range of 6,000 to 10,000 mg/L. Higher concentrations than this result in excessively high aeration costs, because of reduced oxygen transfer efficiency. Membranes can be configured in either pressurized canisters or as hollow core fibers or flat plates suspended in the MBR aeration tank. The typical configuration for activated sludge applications is for hollow core fibers suspended in membrane tanks.

Because of the relatively small footprint of the membrane tanks compared to gravity clarifiers and the reduction in required aeration tank volume because of the higher MLSS concentration, a chief advantage of the MBR process is its relatively small footprint compared to the conventional activated sludge process. To retain the value of existing investment in activated sludge aeration tanks and clarifiers at Grants Pass, it was assumed that the MBR process would be operated as a base-loaded facility in parallel with existing aeration tanks and clarifiers, receiving one half of the flow up to a maximum flow of approximately one half of MMWWF (8 mgd). Figure 17 presents a potential location for new MBR and membrane tanks.



POTENTIAL LOCATION FOR TWO NEW MBR AND MEMBRANE TANKS

FIGURE 17

CITY OF GRANTS PASS
WATER RESTORATION PLANT FACILITY PLAN

carollo

2.4.8 Activated Sludge System Upgrade Comparisons

Cost estimates for activated sludge upgrade alternatives are shown in Table 5. The cost estimates indicate that the capital cost of an upgrade using IFAS equipment would be essentially the same as the cost for construction of two new aeration tanks. The operating costs for power would be greater for the IFAS system, however. The cost estimates indicate that both the BioMag™ and Parallel MBR alternatives would be significantly more expensive than construction of new aeration tanks. Figure 18 presents an un-weighted ranking of these four alternatives in terms of the criteria identified above. Construction of new aeration tanks has the highest ranking in five out of ten categories. IFAS has the highest ranking for future flexibility and footprint. Parallel MBR has the highest ranking for effluent quality. BioMag™ does not score a highest ranking in any category.

Table 5 Cost Comparison of Aeration Tank Upgrade Alternatives
City of Grants Pass – Liquid Treatment Upgrade Alternatives

Cost Element	New Aeration Tanks	New IFAS	New BioMag™	Parallel MBR
Capital Cost ($ Million)	$5.72	$5.75	$11.52	$30.16
Power and Chemical Cost ($/year)	$116,000	$146,000	$169,000	$618,000
Total Present Worth Cost ($ Million)	$7.42	$7.95	$14.02	$39.36

Notes:
1) MBR costs include membrane replacement cost.

Table 6 presents a cost estimate comparison for combined upgrade alternatives for primary and activated sludge process upgrade. This comparison captures the true impact of using CEPT or Actiflo™ as a primary sedimentation upgrade, since it gives credit to the impact of improved primary treatment performance on the secondary system. In this comparison, it is seen that the Actiflo™ alternative is more cost-effective than would be indicated by its ranking in Table 5 and Figure 6, where the impacts on secondary treatment are not included, but that it remains a higher cost alternative compared to construction of new primary and aeration tanks. Figure 19 shows the criteria ranking for these alternatives. The conventional alternative of constructing new primary and aeration tanks has the highest ranking overall and the highest ranking in 5 out of the ten criteria. The MBR has the highest ranking in three criteria: future flexibility, footprint, and effluent quality. The Actiflo™ has the lowest ranking overall and ranks highest in no individual criterion.

Table 6	Cost Comparison of Combined Primary Treatment and Aeration Tank Upgrade Alternatives *City of Grants Pass – Liquid Treatment Upgrade Alternatives*		
Cost Element	**New Primaries and Aeration Tanks**	**New Actiflo™/ CEPT + One New AT**	**MBR**
Capital Cost ($ Million)	$10.24	$14.59	$30.16
Power and Chemical Cost ($/year)	$136,000	$375,000	$618,000
Total Present Worth Cost ($ Million)	$12.24	$20.19	$39.36

Notes:
1) MBR operational costs include membrane replacement cost.

Criterion	Weight	Weighted Ranking			
		New Aeration Tanks	New IFAS	New BioMag™	Parallel MBR
Capital Cost	1	3	2	1	1
O&M Cost	1	3	2	2	1
Risk	1	3	1	1	2
Future Flexibility	1	1	3	2	2
Footprint	1	1	3	2	2
Energy	1	3	2	2	1
Odor	1	2	2	2	2
Compatibility with existing processes	1	3	2	2	2
Biosolids Quality/Quantity	1	2	2	2	2
Effluent Quality	1	2	2	2	3
Total		**23**	**21**	**18**	**18**

Legend:	Score
Highest Ranking	3
Intermediate Ranking	2
Lowest Ranking	1

Figure 18 Comparison of Selection Criteria for Activated Sludge Upgrade Alternatives

Criterion	Weight	Weighted Ranking		
		New Primaries and Aeration Tanks	New Actiflo™ / CEPT + One New AT	MBR
Capital Cost	1	3	2	1
O&M Cost	1	3	1	1
Risk	1	3	1	2
Future Flexibility	1	1	2	3
Footprint	1	1	2	3
Energy	1	3	2	1
Odor	1	2	2	2
Compatibility with existing processes	1	3	2	2
Biosolids Quality / Quantity	1	2	1	2
Effluent Quality	1	2	2	3
Total		**23**	**17**	**20**

Legend:	Score
Highest Ranking	3
Intermediate Ranking	2
Lowest Ranking	1

Figure 19 Comparison of Selection Criteria for Combined Upgrade Alternatives

2.4.9 Full Nitrification Alternatives

Upgrade alternatives considered so far have been based on the assumption that the existing NPDES permit requirements for partial nitrification will remain in place in the future. The current NPDES permit requirement was based on toxicity analysis for ammonia in the Rogue River. This requires partial nitrification down to a level of 9.6 to 21 mg/L during the summer months. Partial nitrification has several disadvantages compared to full nitrification. Nitrite is not currently monitored at the Grants Pass WRP, but modeling of partial nitrification scenarios for Grants Pass by Carollo indicates the likely presence of nitrite in concentrations as high as 10 mg/L under some scenarios.

Nitrite has a significant chlorine demand. For plants that use chlorine for disinfection, nitrite has a demand of one pound of chlorine for each pound of nitrite. This does not affect the Grants Pass

WRP however, since UV disinfection is used rather than chlorine. Nitrite has some of the adverse effects of ammonia as a toxicant, however, and can also contribute to algal growth and potential nitrate contamination of downstream water resources. Based on these considerations, it is possible that nitrite could be regulated in the future.

Because of potential for a full nitrification requirement in the future, we developed alternatives to meet these possible permitting scenarios for Grants Pass. These were variations on the alternatives already discussed, including:

- New aeration tanks.
- IFAS.
- MBR.

Modeling indicated that four new aeration tanks would be required to allow operation with an aerobic SRT of 7.5 days to produce full nitrification. It was also assumed that alkalinity recovery using internal recycle to anoxic zones would be included in a full nitrification design. For the IFAS alternative, modeling indicated that addition of two new aeration tanks and IFAS media retrofit of existing tanks would produce a fully nitrified effluent. The MBR alternative developed in previous alternatives would not need modification since full nitrification is required for the MBR process.

Table 7 presents a comparison of estimated costs for these three alternatives. In this comparison, the conventional alternative of constructing new aeration tanks is more cost effective compared to IFAS alternative because of the need for tank expansion with IFAS for full nitrification. The MBR alternative is more cost competitive if full nitrification were to be required than it would be for partial nitrification, but it is still significantly more expensive than conventional upgrade. Figure 20 illustrates that building new aeration tanks is the preferred alternative with the highest total ranking overall and the highest ranking on five of the ten ranking criteria.

Table 7	Cost Comparison of Aeration Tank Upgrade Alternatives Full Nitrification *City of Grants Pass – Liquid Treatment Upgrade Alternatives*		
Cost Element	**New Aeration Tanks**	**New IFAS**	**Parallel MBR**
Capital Cost ($ Million)	$13.00	$22.08	$30.16
Operating Cost ($/year)	$119,000	$185,000	$618,000
Total Present Worth Cost ($ Million)	$14.80	$24.88	$39.36

Criterion	Weight	Weighted Ranking		
		4 New Aeration Tanks	New IFAS + 2 New AT	Parallel MBR
Capital Cost	1	3	1	1
O&M Cost	1	3	1	1
Risk	1	3	1	2
Future Flexibility	1	2	3	3
Footprint	1	1	3	2
Energy	1	3	1	1
Odor	1	2	2	2
Compatibility with existing processes	1	3	2	2
Biosolids Quality / Quantity	1	2	2	2
Effluent Quality	1	2	2	3
Total		**24**	**18**	**19**

Legend:	Score
Highest Ranking	3
Intermediate Ranking	2
Lowest Ranking	1

Figure 20 Comparison of Selection Criteria for Full Nitrification Upgrade Alternatives

2.4.10 Secondary Sedimentation Tank Addition

Additional secondary sedimentation tank area is recommended to maintain capacity of the Grants Pass WRP. The condition of the two, older sedimentation tanks is such that they will need replacement prior to 2035, but they may be left in service or evaluated for repairs at a later date. Under current PHF conditions, the secondary clarifiers are able to provide treatment for approximately 20 mgd, at a maximum overflow rate of 1250 gpd/sf, which requires over 7 mgd of PE to be bypassed directly to UV disinfection. By constructing a new 100-foot diameter clarifier the treatment capacity is increased to 30.6 mgd, which is nearly sufficient for 2035 PHF conditions. However, it should be noted that approximately 3 mgd of PE will still be bypassed around secondary treatment at peak flows. Table 8 presents a cost estimate for one new 100-foot diameter tank.

Table 8 Estimated Cost for New 100-Foot Diameter Clarifier
City of Grants Pass – Liquid Treatment Upgrade Alternatives

Cost Element	New 100-foot Diameter Tank
New Tank Structural Cost	$1,328,000
New Tank Equipment Cost	$300,000
Estimated Total Construction Cost	$4,170,000
Total Cost with ELA	$5,000,000

2.5 Ultraviolet Disinfection

The existing disinfection system at the Grants Pass WRP uses medium pressure ultraviolet (UV) disinfection. TM No. 5 discusses the potential cost-effectiveness of replacing the existing medium pressure UV lamp system with a more energy efficient low-pressure high intensity system. As part of the work for this memorandum, cost estimates were developed for replacement of the existing Trojan Model 4000 UV system with an open channel low-pressure high output (LPHO) system.

Table 9 presents comparisons of estimated costs for operation of the existing system compared to the present worth cost of replacement with a more efficient system. The estimated operating cost for electricity, lamp replacement, and maintenance for the existing system are estimated at approximately $128,000 per year. The present worth of this cost, assuming a discount rate of 3 percent over a 20-year period, is approximately $1.9 million. Compared to this, the operating and maintenance cost for the Calgon system is estimated at approximately $40,000 per year, with a present worth of approximately $600,000. This means that the City could spend up to $1.3 million in project cost for an equivalent present worth cost to the existing system. Replacement of one channel, which would accommodate WRP flow during average periods, is estimated to cost less than $800,000. Replacement of both existing channels is estimated to cost $1.2 million. Either of these projects would cost less in present worth than operation and maintenance of the existing system. Initial analysis indicates that the project may be eligible for an Energy Trust incentive of approximately $200,000. Furthermore, the existing “prototype” system is highly variable. On this basis, it would be justified to replace equipment in either one or two channels.

Table 9	**Cost Comparison for Upgrade of the Existing Trojan 4000 UV System** ***City of Grants Pass – Liquid Treatment Upgrade Alternatives***	
Cost Element	**Existing Trojan UV 4000**	**LPHO Replacement**
Capital Cost	$0	Both existing: $1.2 million One existing: $775,000 New channels: $2 million
Operating Cost ($/year) - Energy - O&M	 $60,000 $68,000	 $13,000 $27,000
Total Present Worth Cost ($ Million)	**$1.9**	**$1.4 to $2.8**

Notes:
1) Estimated Calgon equipment cost ($250 - $600K).
2) Does not include potential energy incentive of $200,000.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Recommended improvements for major liquid stream unit processes are summarized below:

- **Raw Sewage Pump Station**: The current pump station has sufficient capacity through 2035. No upgrades are needed.

- **Screening System**: The two existing screens and screenings handling system have adequate capacity for 2035 loadings however, structural modifications will be required to allow all flows to go through the headworks under PHF conditions.

- **Primary Sedimentation Tanks**: To operate effectively with 2035 flows, two additional primary sedimentation tanks of equivalent size to the two existing rectangular units will be needed. Construction of two new tanks was compared to rehabilitation of the existing circular sedimentation tank and construction of a new sludge storage tank, which would replace the current function of the circular sedimentation tank. Construction of new high rate sedimentation tanks using chemical treatment was also considered. The conventional alternative of constructing two new primary sedimentation tanks is the lower cost alternative and is preferred based on consideration of a series of ten selection criteria. The estimated project cost in current dollars for both tanks is approximately $4.5 million. To meet the MMWWF capacity criterion, one new tank is required immediately, while the second would be needed by 2030.

- **Grit Removal System**: The existing grit removal system has adequate capacity for 2035 loadings. Its condition, however, indicates that it should be replaced soon. The estimated cost for replacement is approximately $758,000. If needed, it may be possible to phase this upgrade deferring the pump replacement portion of the project.

- **Activated Sludge System**: The activated sludge system is nearing current capacity during both the partial nitrification and winter secondary treatment seasons. A series of alternatives were investigated for system upgrade. The most cost-effective and preferred system based on a series of ten selection criteria is construction of two new aeration tanks with associated appurtenances. The estimated cost for this project in current dollars is approximately $5.7 million. The capacity of the existing secondary clarifiers is inadequate for current PHF loadings at the desired loading rate of 1250 gpd/sf. The cost of a new 100-foot diameter unit is approximately $5 million in current dollars and will provide treatment capacity for the majority of the planning period.

- **UV Disinfection**: Alternatives for upgrade of the existing medium pressure UV system with a more energy efficient system with an estimated lower maintenance cost were investigated. It is concluded that replacement of the equipment in either one or two UV channels would be cost-effective without consideration of potential energy efficiency grants. These grants would make a replacement project even more attractive.

4.0 REFERENCES

Parametrix (June 2001) *Grants Pass Water Restoration Plant Wastewater Facilities Plan Update*.