MWMC Eugene-Springfield WPCF Facility Plan – Secondary Clarifier Enhancement Alternatives

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Project File – Task 4.1

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Executive Summary

It is anticipated that the Eugene-Springfield Water Pollution Control Facility (E-S WPCF) will have to increase its secondary treatment peak capacity to address the projected increase in wastewater flows and the ever-changing and more restrictive National Pollutant Discharge Elimination System (NPDES) effluent limitations. The current secondary treatment capacity is estimated at 103 mgd to 111 mgd. Above 103 mgd the existing secondary effluent quality begins to degrade rapidly, limited by the capacity of the existing secondary clarifiers. The result is a secondary effluent having a higher effluent total suspended solids (TSS) than is acceptable.

Based on existing plant flow data and secondary effluent TSS data collected in past years, an analysis of the capacity of the existing secondary clarifiers was performed. Analysis shows that the existing secondary clarifiers can produce an acceptable and reliable effluent quality up to an average daily surface overflow rate (SOR) and sustained peak SOR of 750 gpd/sf and 1050 gpd/sf, respectively. This translates to an average daily and sustained peak secondary clarifier capacity of 80 mgd and 111 mgd, respectively, if all eight existing secondary clarifiers are on line.

In order to increase the existing secondary treatment capacity, the secondary clarifier capacity will have to be expanded. Increases in secondary clarifier capacity can be achieved by optimizing the performance of the existing secondary clarifiers through a series of structural baffling techniques and mechanical equipment modifications. Optimizing the performance of the existing secondary clarifiers also improves the reliability of performance and minimizes the construction of new secondary clarifiers, thus maximizing the Metropolitan Wastewater Management Commission's (MWMC's) existing investment. Three alternatives were considered for expanding the capacity and enhancing the operation of the existing eight secondary clarifiers. It was assumed that all alternatives considered would result in the same level of operational performance and effluent TSS reliability;

therefore, a non-monetary analysis was not necessary. Furthermore, the primary differences between the alternatives are the structural approach to achieving the desired performance, and the level of structural and mechanical retrofit needed to address other problematic issues associated with the existing units. The three alternatives and their associated costs are summarized in Table 1.

TABLE 1
Summary of Secondary Clarifier Baffling and Mechanism Improvements – Alternatives Comparison
MWMC Facility Plan, Eugene-Springfield

Alternative	**Capital Cost (millions of dollars)**
1 – Partial Retrofit – Baffling and Mechanism Retrofit	$2.9 million
2 – Partial Retrofit – Baffling with Mechanism Retrofit and New Effluent Launder	$5.5 million
2 – Complete Retrofit – Baffling with Complete Mechanism Replacement and New Effluent Launders	$7.0 million

The baffling and associated miscellaneous improvements for each alternative are anticipated to result in an increased secondary clarifier capacity of 20 to 30 percent. A capacity increase of 40 percent has been observed in some installations; however, in the absence of stress testing data for a E-S WPCF secondary clarifier, it has been assumed conservatively that the clarifier capacity will be increased by a minimum of 20 percent. This translates to a sustained peak SOR for each secondary clarifier to 1260 gpd/sf and a total sustained peak flow capacity of 134 mgd with all eight secondary clarifiers on line.

During an October 2003 workshop with MWMC staff and CH2M HILL staff, the three alternatives and their costs were presented. MWMC staff unanimously chose to proceed with Alternative 2 as the preferred alternative. Stress testing of the retrofitted secondary clarifiers can be conducted to determine the actual estimated capacity increase resulting from the modifications.

Introduction

This technical memorandum has been prepared as part of the Metropolitan Wastewater Management Commission (MWMC) Eugene-Springfield Water Pollution Control Facility (E-S WPCF) Facility Plan Update and Pre-Design (Project No. 80010) and consists of an evaluation of alternatives for providing additional secondary clarifier capacity and reliability at the E-S WPCF. This memorandum focuses on enhancing the operation of the existing secondary clarifiers through a series of structural baffling and mechanical equipment improvements. The alternatives presented in this memorandum arise from MWMC's desire to enhance their existing secondary treatment facilities in order to optimize their existing investment. This memorandum focuses on a three-tier approach addressing enhancements and assessing capacity as follows:

1. Analysis of the existing secondary clarifier performance data.
2. Assessment of the most appropriate baffling technologies and their implementation.

3. Stress testing of the enhanced clarifiers to assess their capacity.

Existing Secondary Clarifiers

There are currently eight secondary clarifiers at the E-S WPCF. Each secondary clarifier has the following general characteristics:

- 130 feet in diameter
- 14-foot side water depth
- Sloped floor (1 in 20)
- Inboard launders supported off of concrete beams (approximately 12 feet inboard)
- Rapid sludge removal (RSR) mechanisms with polyvinyl chloride (PVC) suction tubes
- 44-inch influent column

Operations personnel observed and noted the following deficiencies with respect to the condition and operation of these clarifiers:

- Significant pluming of suspended solids directly behind the rotating mechanism, resulting in inadequate settling of solids and deterioration of effluent quality
- Significant quantities of suspended solids exiting the clarifier and entering the effluent launder between the side wall and the inside weir of the inboard launder
- The inability to adjust the sludge withdrawal rate from individual suction tubes with the adjustable orifices while the clarifier is in operation
- The inability to observe the withdrawal rate and characteristics of the sludge from a suction tube while the clarifier is in operation
- The suction tubes drag on the delaminated floor coating, which may hinder sludge removal at various locations within the clarifier and result in sludge piling
- Excessive horizontal density currents aided by the vertical stacking of the suction tubes along the radius of the mechanism
- Deterioration of the weir, baffle, and launder steel as a result of inadequate coating systems

These issues are illustrated in Figures 1 through 3.

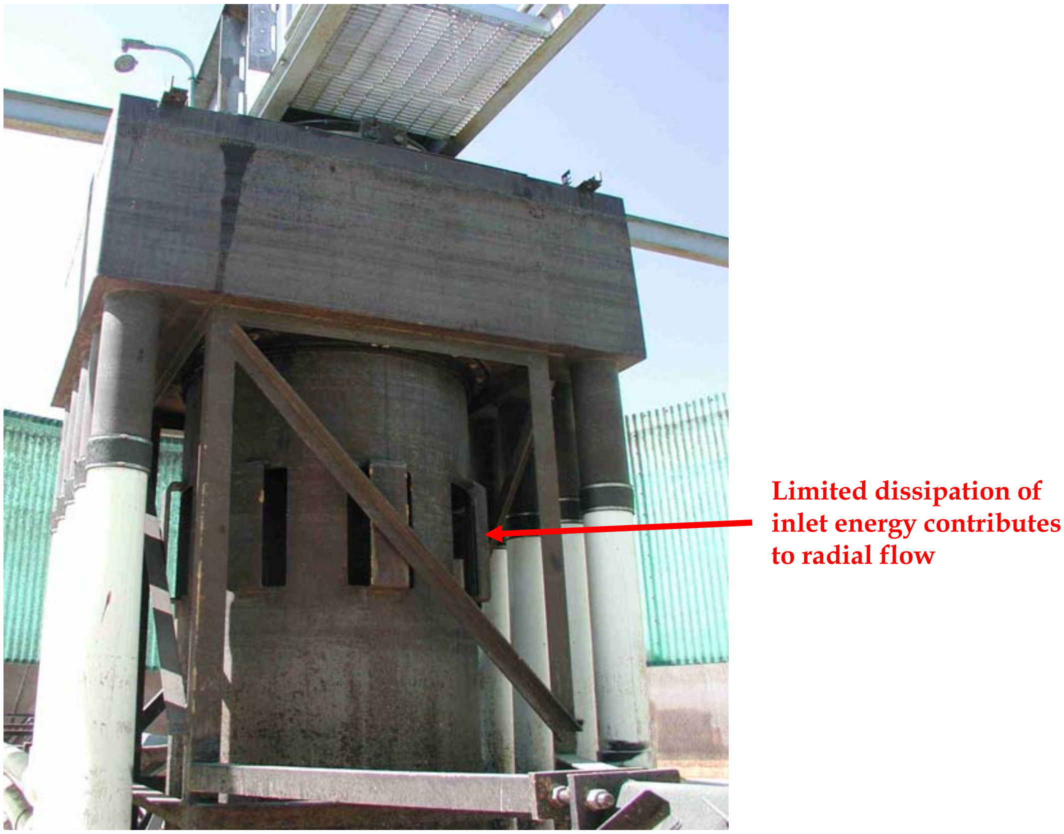

FIGURE 1
Existing Secondary Clarifier Center Column
MWMC Facility Plan, Eugene-Springfield

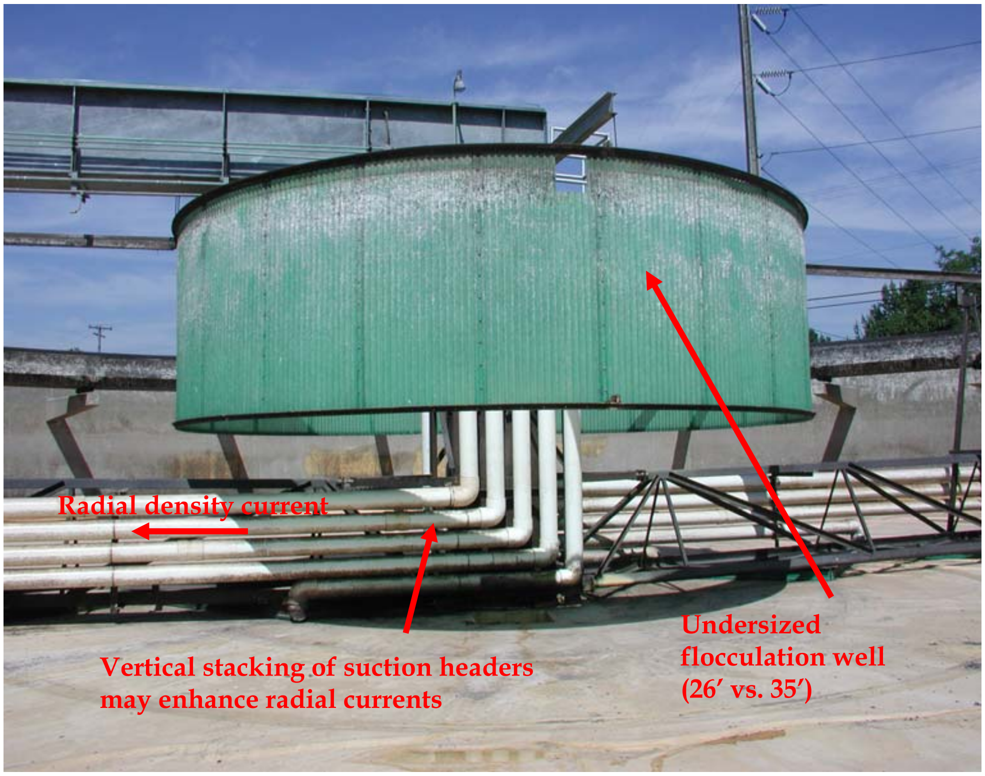

FIGURE 2
Existing Secondary Clarifier Mechanism
MWMC Facility Plan, Eugene-Springfield

FIGURE 3
Existing Secondary Clarifier Suction Headers
MWMC Facility Plan, Eugene-Springfield

Existing Secondary Clarifier Data Analysis

Figure 4 shows a plot of effluent total suspended solids (TSS) from the existing secondary clarifiers versus surface overflow rates (SOR). The surface overflow rates in this figure represent the average day SOR, so that daily peak diurnal SORs are inherent in the numbers. This figure illustrates the historical performance of the existing secondary clarifiers and shows consistent clarifier performance up to approximately 750 gpd/sf. Beyond 750 gpd/sf the effluent quality begins to deteriorate quickly. These data are significant in that they show that the existing clarifiers in their current mode of operation can produce an effluent quality with relatively good reliability below 10 mg/L TSS provided that the SORs remain below an average of 750 gpd/sf. These data will provide the basis for estimating the increased capacity of the secondary clarifiers after enhancements are made.

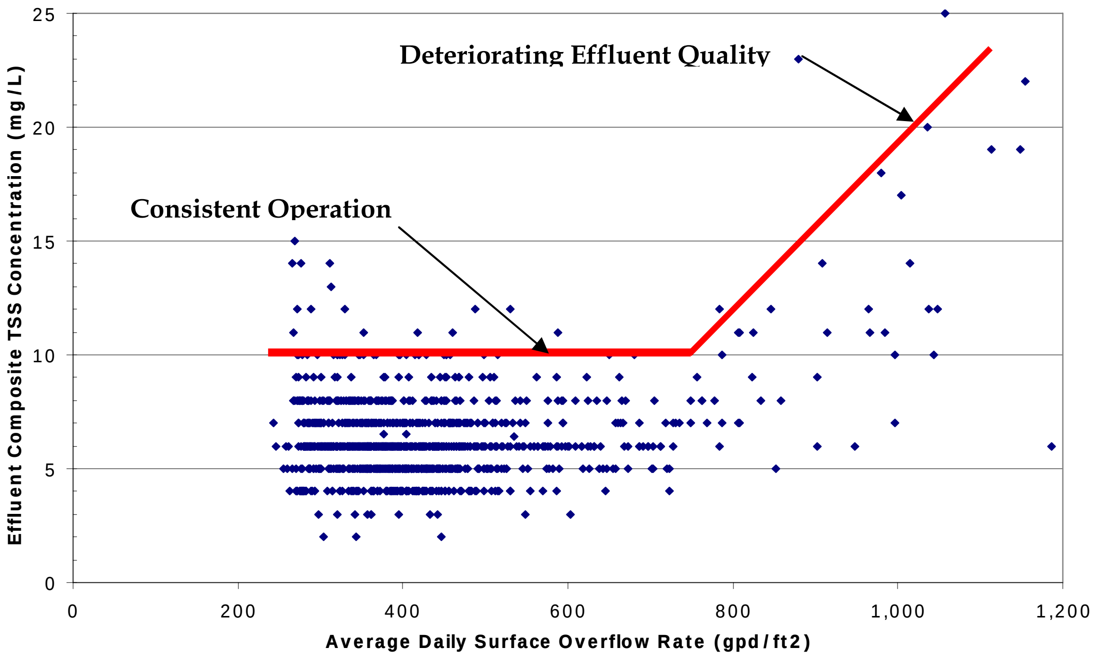

FIGURE 4
Effluent TSS vs. Surface Overflow Rate
MWMC Facility Plan, Eugene-Springfield

Description of Clarifier Baffling Techniques

There are essentially four concepts that baffling techniques attempt to address:

1. The dissipation of energy at the inlet to the clarifier. This is accomplished by redirecting the radial velocity currents to tangential velocities, and may also include a variety of momentum cancellation techniques. This is typically accomplished with an energy dissipating inlet (EDI), which is placed around the center column of a new or existing clarifier inlet. The EDI typically contains a number of gates or pipes used to redirect the velocity currents.

2. The elimination of radial surface currents, which can carry suspended solids directly over the effluent weir and adversely impact effluent quality. This is typically accomplished with an appropriately sized flocculation well. The flocculation well is essentially a surface baffle with an open bottom to redirect suspended solids downward and enhance zone settling.

3. The dissipation or redirection of density currents. Density currents are a result of the zone settling characteristics of secondary sludge. As the sludge settles and forms a distinct sludge blanket/clarified effluent interface, the difference in density at the interface induces a radial velocity current directed outward to the perimeter wall. Experience has shown that 95 percent of the radial velocity currents occur at this interface. When the radial density current hits the perimeter wall of the clarifier the current is directed upward and carries suspended solids with it directly to the surface of

the clarifier. This is typically the location of the effluent weir and may result in a deterioration of effluent quality. There are typically two methods that are used reduce the density currents or redirect their velocities:

– The ring baffle is a vertical baffle extending from mid-depth to close to the floor. It is typically placed at approximately midway between the center of the clarifier and the exterior radius. This baffle is typically continuous around the diameter at which it is placed and is supported off of the mechanism of a new or existing clarifier. The baffle is placed so that it interrupts the radial flow at the sludge blanket interface and may provide enhanced flocculation of the suspended solids within the baffle. This type of baffle is suited for shallow clarifiers but has had overall mixed results in its implementation.

– The density current baffle (sometimes called a Stamford baffle) is a horizontal or angled baffle placed on the perimeter of the clarifier wall or launder trough. It intercepts the upward velocity at the perimeter wall of the clarifier resulting from the radial density currents. The upward flow is redirected back to the center of the clarifier where the velocity is then dissipated. This baffle arrangement is better - suited for secondary clarifiers having exterior launders.

Extrapolation of Data with Baffling Improvements

Experience has shown that baffling enhancements to secondary clarifiers can provide an increase in capacity and will improve the overall reliability of performance. When baffling technologies are properly applied most retrofits resulted in an increase of capacity from 20 to 30 percent, with some retrofits resulting in an increase of capacity up to 40 percent. In the absence of stress testing data for a Eugene-Springfield retrofitted secondary clarifier, it has been assumed conservatively that the clarifier capacity can be increased by a minimum of 20 percent. Subsequent stress testing may prove to yield a substantially higher increase in capacity as a result of baffling modifications and is therefore recommended as a final step in evaluating secondary clarifier capacity. Table 2 uses the data from Figure 4 to estimate the capacity and SORs resulting from enhancements made to the Eugene-Springfield secondary clarifiers. An important result from Table 2 is the recommended maximum sustained SOR, which will clearly dictate the wet season capacity of the secondary clarifiers and thus the wet season capacity of the secondary treatment facilities.

TABLE 2
Estimated Capacity and SOR's for Enhanced Secondary Clarifier Operation
MWMC Facility Plan, Eugene-Springfield

Condition	Maximum SOR (gpd/sf)	Capacity at 8 Clarifiers (mgd)	Capacity at 10 Clarifiers (mgd)	Capacity Increase with Modifications (% Increase)
Current Average (from Figure 4)	750	80	100	NA
Current Diurnal Peak* (from Figure 4)	1050	111	139	NA
Retrofitted Diurnal or Sustained Peak Range	1260-1365	134-145	167-181	20%-30%
Recommended Sustained Wet Season Peak	1260	134	167	20%

*****Typical diurnal peaks are approximately 1.4 times the average day flow.

Secondary Clarifier Baffling Improvement Alternatives

Table 3 summarizes three alternatives for enhancing the operation of the existing secondary clarifiers. It has been assumed that all the alternatives presented will result in the same level of operational performance with respect to capacity increase and effluent TSS reliability.

TABLE 3
Secondary Clarifier Enhancement Alternatives
MWMC Facility Plan, Eugene-Springfield

Alternative 1 - Partial Retrofit	Alternative 2 - Partial Retrofit with New Effluent Launder	Alternative 3 - Complete Retrofit
New Energy Dissipating Inlet	New Energy Dissipating Inlet	New Energy Dissipating Inlet
Block or Baffle Outboard Weir	New Outboard Launder and Weir	New Outboard Launder and Weir
New Flocculation Well	New Flocculation Well	New Flocculation Well
Convert Mechanism to Suction Header	Convert Existing Mechanism to Suction Header	Complete New Suction Header Manifold
	New Scum Baffle	New Scum Baffle
	New Skimmer Arms	New Skimmer Arms
	New Density Current Baffle	New Density Current Baffle
		New Drive Mechanism
		New Bridge

The primary differences between these alternatives are the structural approach to achieving the desired performance, and the level of structural and mechanical retrofit needed to address other problematic issues discussed earlier in this memorandum. A discussion of each alternative is presented below.

- **Alternative 1:** This alternative represents the minimum modifications required to achieve the operational performance results desired. It consists of installing a new EDI on the existing influent column to address the inlet velocity issues. A new flocculation well sized to accommodate the larger influent flows would redirect surface velocity currents. This alternative would retain the existing inboard launder. The outboard weir of this launder would need to be either blocked or baffled to prevent density currents from pushing suspended solids over this weir. Ring and density current baffles may redirect suspended solids toward an inboard launder, which is more than 12 feet off of the perimeter wall, and are therefore not recommended. Retrofitting the existing suction tubes to a single suction manifold with adjustable orifices would address the clearance issues of the mechanism off the floor, reduce the radial density currents, improve the sludge withdrawal distribution, and would increase the available head for sludge withdrawal.
- **Alternative 2:** This alternative would provide the same EDI, flocculation well, and mechanism retrofit as described in Alternative 1. In addition, this alternative proposes to remove the corroded inboard launder and relocate the launder at the exterior of the clarifier. The relocated launder would be fabricated steel, either painted or stainless. With the relocation of the launder a new scum baffle as well as new scum skimmer arms would be required. For outboard launders a density current baffle is recommended for density currents. This baffle could be either fiberglass reinforced plastic (FRP) or stainless steel.
- **Alternative 3:** This alternative would provide the same EDI, flocculation well, new outboard launder, skimmer arms, scum baffle, and density current baffle as described in Alternative 2. In addition, this alternative proposes to remove the entire existing influent column and drive mechanism and replace these with a new influent column and drive mechanism. This alternative also proposes to replace the existing clarifier bridges.

Launder Hydraulic Analysis

All of the alternatives presented propose the reduction and/or elimination of a significant portion of the effluent weirs. Table 4 summarizes the hydraulic impacts of the three alternatives and shows essentially very little hydraulic capacity reductions resulting from any of the alternative modifications. Submergence occurs when the water surface downstream of the weir rises above the invert of the v-notch weir, thus not allowing free fall over the weir plate. The submerged condition is a result of the combined head losses downstream of the clarifier weirs. A flooded weir occurs when the upstream water surface rises above the top of the V-notch weir. This condition results from the hydraulic overloading of the weir and is further adversely impacted by a submerged weir condition.

TABLE 4
Hydraulic Impacts of Launder Modifications at the 25-Year River Stage Event
MWMC Facility Plan, Eugene-Springfield

Condition	Plant Capacity to Submerge Weirs (mgd)	Plant Capacity to Flood Weirs (mgd)
Existing Launder	160	166
Alternative 1 (Half Weir)	160	163
Alternative 2 & 3 (External Launder)	160	165

Alternative Cost Evaluation

Table 5 summarizes the total estimated project costs, including engineering and construction costs, for each alternative. The costs listed are for all eight secondary clarifiers to be retrofitted. Cost are expressed in 2003 dollars and should be adjusted as needed for the actual year of construction.

TABLE 5
Alternatives Cost Evaluation
MWMC Facility Plan, Eugene-Springfield

Option 1 Partial Retrofit	Option 2 Partial Retrofit With New Outboard Launders	Option 3 Compete Retrofit
$2,900,000	*$4,500,000	*6,000,000

*Add $1,000,000 for fabricated stainless steel launders, weirs, and scum baffles for 8 clarifiers.

Selected Alternative Enhancements, and Conclusions

During the October 7 workshop with MWMC staff and CH2M HILL staff, the three alternatives and their costs were presented. MWMC staff unanimously chose to proceed with Alternative 2 as the preferred alternative. The costs associated with Alternative 2 should be incorporated into the capital improvement plan (CIP). Table 6 summarizes the preferred alternative and Figure 5 shows a graphical representation of the modifications.

TABLE 6
Preferred Alternative for Secondary Clarifier Enhancements
MWMC Facility Plan, Eugene-Springfield

Alternative 2 - Partial Retrofit with New Effluent Launder
New Energy Dissipating Inlet
New Outboard Launder and Weir
New Flocculation Well
Convert Existing Mechanism to Suction Header
New Scum Baffle
New Skimmer Arms
New Density Current Baffle
Total Project Cost in 2003 Dollars = $4,500,000-$5,500,000

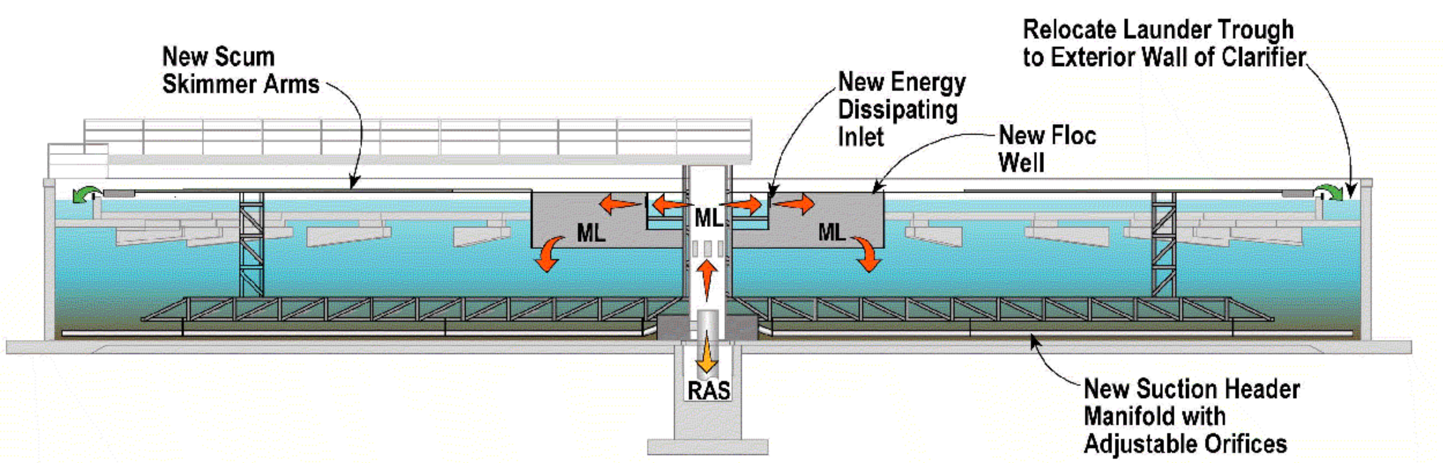

FIGURE 5
Preferred Alternative – Secondary Clarifier Enhancements
MWMC Facility Plan, Eugene-Springfield