MEMO

To: Jeff Pelz (West Yost)  
    Kathryn Gies (West Yost) 

From: Susan Landon, BOS  
      Joe Husband, WHI 

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ARCADIS Project No.:  
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Subject: Special Design Study TM #1b - Fine Mesh Screening for Enhanced Primary Effluent Treatment 

BACKGROUND INFORMATION

Objective

This Enhanced Primary Treatment Evaluation involves an investigation of two technologies identified by the City of Davis that could reduce the loadings to the secondary treatment processes: chemically enhanced primary treatment (CEPT) and use of fine screens. This technical memorandum (TM) focuses on the application of fine screening at the Davis Wastewater Treatment Plant.

Fine Screening Technologies

Typically, screening at wastewater treatment plants (WWTPs) in the USA is utilized as a pretreatment step to remove wastewater solids to protect downstream equipment and processes. The type of screening, such as coarse or fine screening, generally reflects the size of the openings of the screen device. The WEF Manual of Practice No. 8 (MOP 8) categorizes fine screens as having >0.5 mm to 6 mm openings and microscreens as having 0.5 mm or less openings. Fine screening is typically used in the USA for raw influent and less frequently for primary effluent. Smaller opening screens in the 1 to 3 mm range have been used to protect membrane bioreactors, cloth filters or integrated activated sludge (IFAS) media from fibrous and other materials that would degrade operation. Fine screening has not been used to achieve specific organic or solids loadings reductions for biological treatment. Fine screening is also used in
Europe, however, the technology has developed into the use of equipment termed fine mesh sieves that have much smaller screen openings, typically <1 mm. Fine mesh sieves are considered equivalent to primary treatment and have widespread use in the Netherlands instead of primary sedimentation tanks to meet the European Union primary treatment requirements of >50% total suspended solids (TSS) removal and >20% 5-day biochemical demand (BOD5). Many Netherlands facilities are landlocked with little space for expansion.

Fine screen equipment is available in a variety of configurations that generally utilize perforated plates or band screens. Configurations include multiple rake, step or stair screens and drum type screens. Microscreens are based on a drum type configuration but use a fine mesh fabric. The majority of fine mesh sieves used in Europe are represented by the Salsnes™ Filter fine mesh sieve which uses an endless wire cloth with a mesh size from 0.1 to 1.0 mm.

Screening and sieve equipment have operation requirements which must be factored into any design. These factors include high headloss requirements, often there are many moving parts with difficult maintenance access and may require a large footprint. Washing and compacting of captured screenings is important. Washing removes organic material from the screenings for return to the wastewater and helps control odors. Compacting reduces the volume of screenings which reduces storage and disposal costs.

**Studies**

A literature search was performed to obtain information on the use of fine screens or fine mesh sieves for reducing solids and organic loads, particularly when used for primary effluent screening upstream of secondary biological treatment. All of the papers that were reviewed studied fine mesh sieves in the context of primary treatment and not as an additional treatment step for primary effluent. However, this information was still useful to determine the potential performance of fine mesh sieves to enhance primary treatment. Following is a summary of the key information noted from these studies.

A German study (Schier, 2005) described the increasing importance of fine sieves as additional pre-treatment to protect MBR systems. The paper compared removal efficiency of two types of fine sieves - a horizontal slit screen (gap size 0.75 mm) and a mesh sieve (gap size 0.75 mm). Both screens were constructed as drum filters. The results for the 10-day sampling and testing for TSS and COD removals for the two sieve types were:

- 15% TSS removal for slit screen vs. 25% for mesh sieve
- 9% COD removal for slit screen vs. 25% for mesh sieve

The paper did not clearly establish whether the testing was performed on raw influent wastewater or coarsely screened wastewater.
Nussbaum (2006) summarized the performance of the Salsnes Technology which is a fine mesh sieve based on a rotating belt technology. The technology uses a continuous wire cloth, or mesh screen, and an air-knife cleaning system. The wire mesh cloth is flushed with hot water two to six times a day to remove fat and grease. The paper summarized the results of the fine mesh sieve used for primary treatment at four municipal wastewater treatment plants in Norway and also used for primary treatment of brewery wastewater. The four municipal wastewater treatment plants in Norway used 0.35 mm fine mesh openings that operated with a filter mat. The results for the four plants are averaged and presented in Table 1 along with the range of performance.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent, mg/L Average (range)</th>
<th>Effluent, mg/L Average (range)</th>
<th>Removal, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD5</td>
<td>247 (176 – 308)</td>
<td>125 (36 – 187)</td>
<td>52 (39 – 80)</td>
</tr>
<tr>
<td>TSS</td>
<td>351 (284 – 413)</td>
<td>75 (34 – 95)</td>
<td>79 (72 – 75)</td>
</tr>
</tbody>
</table>

By way of comparison, as reported in West Yost Draft TM entitled “Basis of Design for the City of Davis Wastewater Treatment Plant Secondary and Tertiary Improvements” dated 31 October 2012 (Draft Basis of Design Memo), the primary clarifiers are removing approximately 63% TSS and 31% BOD at an average surface overflow rate of approximately 700 gpd/sf. This was for an influent TSS of 337 mg/l, thus fine screen may be able to remove additional TSS than the existing primary clarifiers. However, BOD removal is dependent on the TSS being removed and raw wastewater characteristics. Based on our review of the City of Davis raw wastewater and primary effluent, there is a higher fraction of soluble BOD in Davis, than the facilities in Norway.

The rotating belt sieve was also used to test the removal of TSS and COD for a brewery wastewater that contained small particles of grain, yeasts, straws, paper and glass. Influent TSS concentrations ranged from 258 mg/L to 1227 mg/L with an average of 750 mg/L. The initial testing of a 0.35 mm mesh size resulted in 32% TSS removal and 16% COD removal but the study found that the wastewater particles were too small to build a good filter mat and a subsequent study used a 0.25 mm mesh size which allowed a filter mat to develop. The average TSS and COD removals increased to 55% and 25%, respectively, with the smaller mesh size.

Several papers were prepared by the Norwegian Water Technology Centre A/S on the feasibility of using the Salsnes Filter™ fine mesh sieve technology for primary treatment. The first paper (Rusten, 2000) compared primary settling to 0.3 mm fine mesh sieve treatment. The expected treatment performance for TSS, COD and total BOD5 removals were 60%, 40% and 30%, respectively, for the fine mesh sieves and 50%, 35% and 25%, respectively, for primary sedimentation. The paper also found that the Salsnes Filter™ fine mesh required significantly less area than comparable primary sedimentation tanks and had a
much lower investment cost. The second paper (Rusten, 2002) compared the size requirements and cost for a theoretical secondary treatment plant with and without fine mesh sieves for primary treatment based on the same fine screening performance described above. While the study did not consider using primary sedimentation tanks, the study found that the size of the activated sludge basins was more than 60% higher with no fine mesh primary treatment compared to using fine mesh primary treatment. This can be true of facilities with and without primary sedimentation. Energy and maintenance costs were higher for the scenarios with fine mesh screening but were not quantified.

Another paper (Ruiken) looked at the theoretical energy savings by using a fine mesh sieve (0.35 mm) instead of primary settling for three secondary wastewater treatment plants. The paper focused on the removal of toilet paper, or cellulose fibers, stating that this material constitutes a significant fraction of the wastewater. The cellulose was found to comprise 80% of the sieved material. The fine mesh sieve requires more energy to operate than a primary setting tank but the separated materials can be dewatered more effectively to 25% to 50% with related cost for reduced hauling. The paper appeared to use 50% TSS and 35% COD removals along with 100% cellulose removal for fine mesh sieves but did not give the performance values used for primary settling. The evaluation assumed that the sieved material has a high energy value due to the cellulose material and is disposed of by incineration. The paper stated the fine mesh sieving may result in less aeration requirements but did not quantify this. The study indicated that the overall energy consumption and production comparisons factored in the activated sludge process, digestion, biogas production and sludge transport, dewatering and incineration. The study generally concluded that overall WWTP energy consumption including sludge treatment is reduced by about 50% when a higher fraction of the influent was sieved and a major source of COD (the cellulose) was removed from biodegradation. The study did note that the effect of removing the paper fibers from the effluent and waste sludge was unknown.

The conclusions from the literature search are as follows:

- Fine screening of influent wastewater has been used to replace primary sedimentation but not specifically studied or used as primary effluent treatment to further reduce organic loadings to secondary treatment.

- The use of very small screen openings (<0.5 mm) is comparable to well performing primary sedimentation tanks in regard to TSS, COD and BOD removal.

- There may be some incremental removal of solids and organics by further treatment of primary effluent with a fine screening system but only if a very small screen opening (0.35 mm) is used. This is based on the results of the various European studies which showed TSS and BOD removals ranged from 10 to 30% higher than conventional primary settling performance for 0.35 mm or smaller screen openings.
• Fine screens must have ancillary equipment such as screen compactors, hot water for oil and grease removal and the expectation of higher maintenance attention than primary settling tanks.

• Disposal of the screening material will need to be explored further. If the screens are used in lieu of primary sedimentation, then the material captured on the screens will be highly organic and will require subsequent stabilization prior to disposal. If the screens are placed after the primary sedimentation basins, then the screening material, may or may not require any additional process (more than washing and compacting) prior to disposal. Site specific testing would be required.

Davis WWTP Performance

The application of fine screening to primary effluent for the Davis WWTP may have some limited benefit for the wastewater and solids handling processes depending on the performance of the existing primary sedimentation process and subsequent solids management system. The potential for some incremental reduction of solids and organic loadings to secondary treatment could reduce the capacity requirements for the aeration system and tankage. The organic load reduction will depend on the characteristics of the wastewater, particularly the soluble COD/BOD content, as well as that of the recycle stream generated from the screened material washing. Much of the solids that do not readily settle in primary treatment likely will be captured on fine screens and also translate into some incremental reduction in secondary biological sludge production. However, this will reduce the ratio of BOD to nitrogen which can negatively impact biological nitrogen removal. Accordingly, the use of a dynamic process model, such as BioWin or GPS-X will be required to access the impact of this additional carbon removal.

The combination of the existing primary sedimentation at the Davis WWTP with the addition of a primary effluent fine mesh sieve process could likely achieve a combined solids and organic loading reduction performance that would consistently be >60% TSS removal and >40% BOD5 removal. This combined treatment performance needs to be compared to the existing primary treatment performance to better define the additional solids capture that could be obtained with fine mesh sieve. However, the fine screen does come at a cost of additional headloss, and possibly pumping requirements.

If the primary effluent screening treatment could achieve an additional 10 to 20% reduction in loading, there would be a similar increase in existing secondary treatment capacity (or reduced additional treatment capacity requirements). There would also be expected similar reduction in waste secondary sludge production which translates to similar reductions in the downstream sludge processes (thickening, digestion and dewatering). Primary sludge production would not change.

The fine screening technologies and associated compaction treatment reduce the screenings to a high solids material typically 25 to 50% dryness. This material does not require further treatment and can be transported directly to disposal.
Conclusions

As noted earlier, with the good condition of the existing primary clarifiers, the replacement of the primary clarifiers with fine screens was not considered. The application of very fine screening treatment to primary effluent as additional treatment for the specific purpose of reducing loads to benefit downstream secondary treatment has not been widely used or studied. Only a very fine screening system (0.35 mm) should be considered as a larger screen opening is not likely to provide significant capture of primary effluent solids. There may be limited operational and cost benefit of using this new treatment step if the existing primary sedimentation currently performs well. An additional consideration is the introduction of a new type of mechanical equipment to the plant (and potentially new to the USA municipal market) brings with it new operation complexities and maintenance requirements.

Further evaluation of the existing wastewater characteristics and plant treatment performance should be performed to better determine the potential benefit of this technology. Bench scale or pilot testing should also be considered to better quantify the additional capture of primary effluent solids.

PROJECT CRITERIA

Minimum Requirements

Modifications to the preliminary and primary treatment systems necessary to implement required control system upgrades, implement power supply modifications, or accommodate new plant drain pipelines will be necessary.

Performance Criteria

Performance criteria, if any, are defined in the City of Davis Wastewater Treatment Plant Secondary and Tertiary Improvements Project Charrette implementation Plan by West Yost Associates, dated March 2013.

REFERENCE PROJECT

Reference project components, if any, are presented in the City of Davis Wastewater Treatment Plant Secondary and Tertiary Improvements Project Reference Project Report by West Yost Associates and ARCADIS, dated May 2013.

REFERENCES

WEF MOP 8, Design of Municipal Wastewater Treatment Plants, Volume 2: Liquid Treatment Processes, WEF, ASCE and EWRI, Fifth Edition (MOP 8).
Schier, W.; Frechen, F.; Wett, M.; Mechanical Pre-Treatment Stages of Municipal MBR Applications in Germany – Current Status and Treatment Efficiency, WEFTEC 2005.


Rusten, B., Feasibility study of Salsnes Filter™ fine mesh sieves used to increase primary treatment capacity at existing municipal wastewater treatment plants. Aquastream Report no: 02-055, August 2000.