FEATURE

A Clear Look at Reuse Systems

Setting up the most efficient process to capitalize on purifying and reusing water requires an in-depth review of the goals and costs

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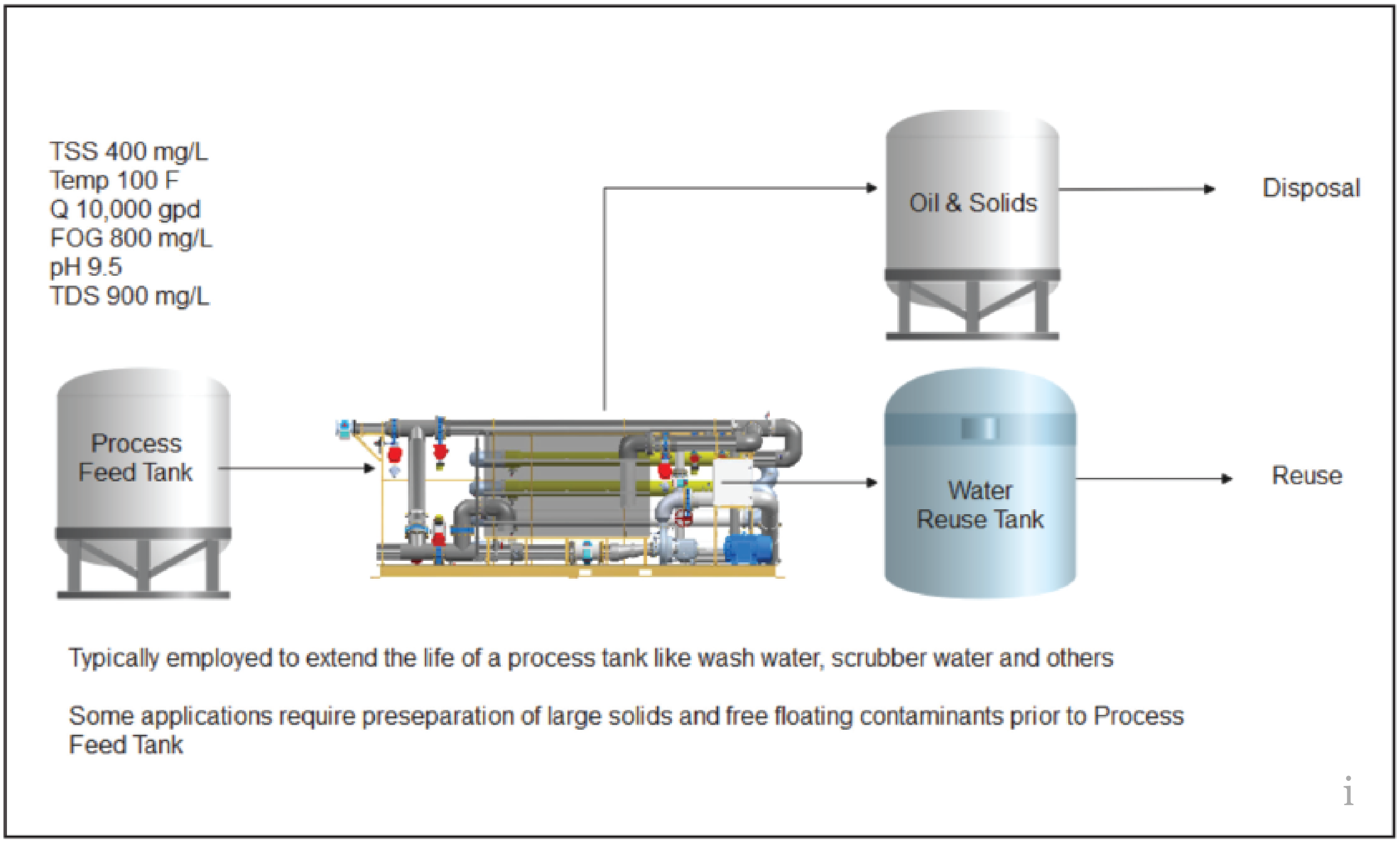
To begin designing wastewater purification and reuse systems for industry and sanitary waste, one needs a detailed characterization of the wastewater along with a detailed characterization of the requirements for reuse. The wastewater and reuse characteristics together will determine the treatment/purification requirements and, thereby, the capital expenditures and operational expenditures needed. This estimate of costs should be completed early in the process to determine if the reuse project has merit and is cost-effective. Treatability work typically is conducted to define the treatment system requirements and design parameters.

For any treatment and reuse systems employing membrane filtration, properly selecting the membranes provides the best method of ensuring the qualitative result desired.



Best Membrane Fit

Membrane selection is based on wastewater characteristics and the desired recovered water quality requirements in the process in which the membranes are utilized.

Typical wastewater treatment or purification systems for reuse include the following:

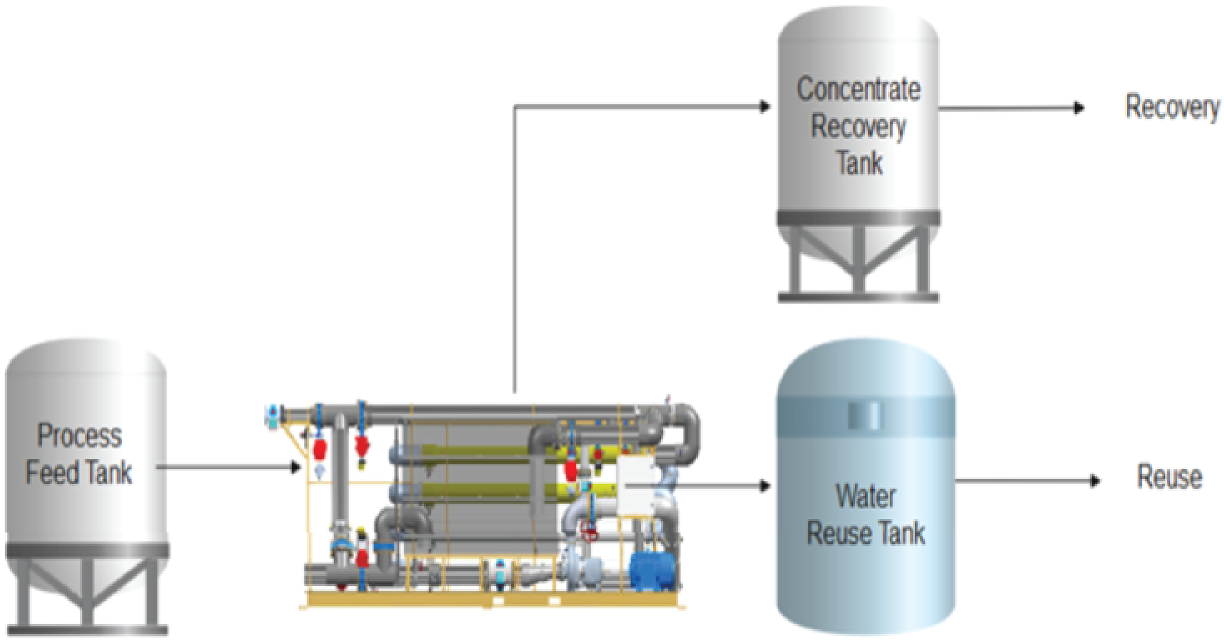
- Purifying process baths or tanks typically using ultrafiltration (UF) for contaminant removal — for cleaning tanks, scrubbers, vibratory metal finishing, and any other systems to produce higher quality water for reuse. See Figure 1 (below).
- Recovering specific components found in the wastewater, such as precious metals, latex paint, textile size separation, pigments, oil, and anything else with high enough concentrations to make separation and recovery cost-effective. See Figure 2 (p. 36).

- Membrane bioreactors (MBR) biological treatment for reuse in cooling towers, scrubbers, and like-type water users that do not require potable water or high-purity water, such as food processing facilities, metal working facilities, and general manufacturing; and all types of manufacturing and food processing facilities. See Figure 3 (p. 37).
- When higher MBR permeate water quality is required, reverse osmosis (RO) can be employed to produce higher quality water for reuse. See Figure 4 (p. 39).

Figure 5 (p. 41) employs pretreatment and an MBR prior to reuse and creates three different recovered water streams for reuse.

Reuse Opportunities

The simplest purification and reuse opportunity is cleaning process baths. The example used is an alkaline cleaner bath for removal of oil and suspended solids. The ultrafilter removes all the oil and suspended solids without altering the pH. It maintains the surfactant that is present and not bound to oil or solids. Additional cleaning chemicals will be added at the alkaline cleaning tank to maintain effectiveness of the solution. As the fluid is purified for reuse, the total dissolved solids (TDS) gradually will increase. Typically, permeate that is acceptable for sewer discharge is bled from the system to prevent TDS growing to a level that interferes with the cleaning process. Another benefit achieved beyond reusing water and chemicals is that the temperature is maintained through the recovery process. This same functional process can be applied to other process tanks where the ultrafilter effectively removes the contaminants. The process tank is monitored for pH, chemical composition, and TDS. See Figure 1 (p. 35)



Some applications require preseparation of large solids and free floating contaminants prior to Process Feed Tank

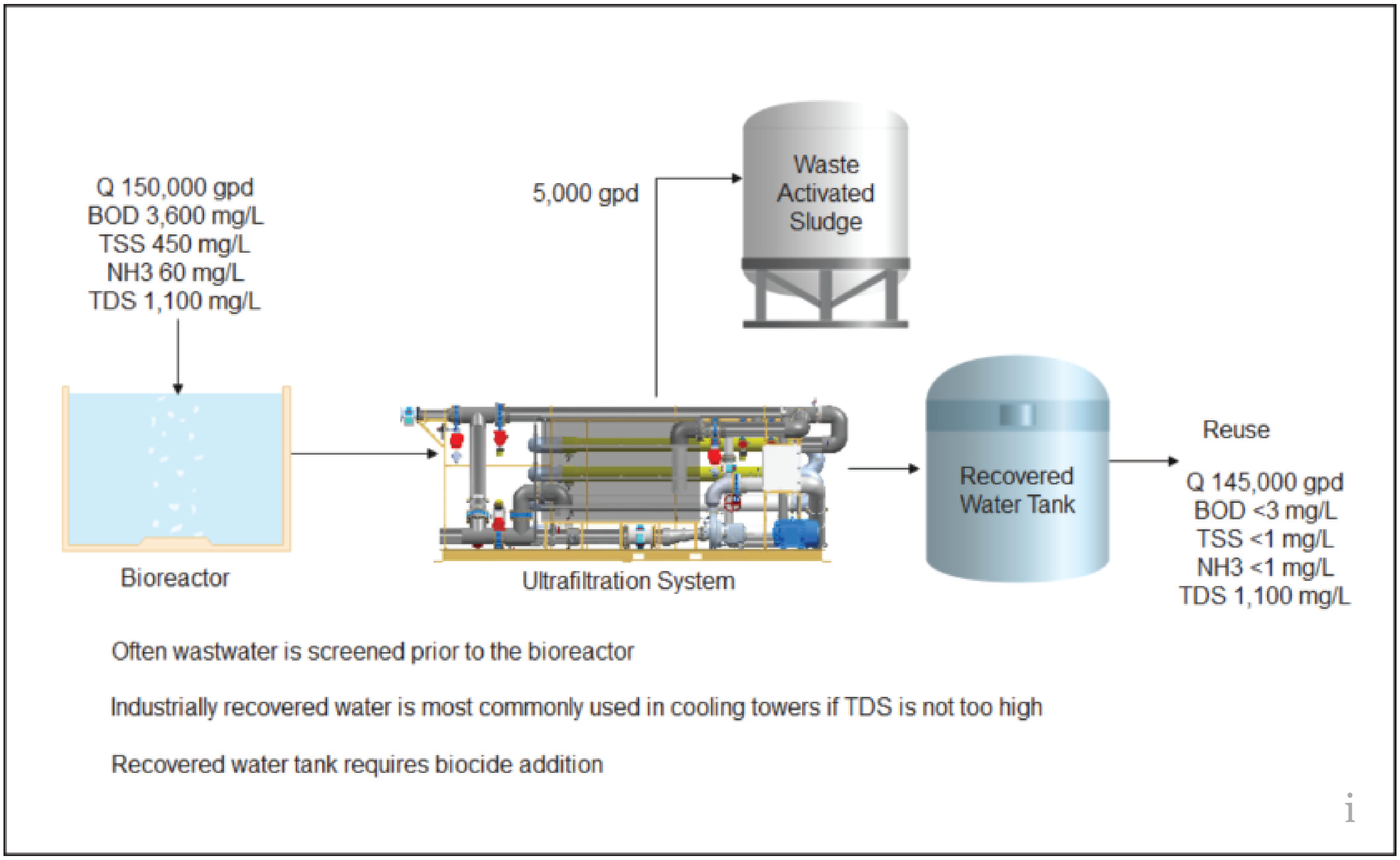
Others may require chemical pretreatment like metals recovery

Recovered concentrate often requires further processing

Water Reuse tank requires biocide addition

Another reuse opportunity exists by separating water from product. In this case, water is removed through the UF system thereby concentrating the product that is contained in the tank. The concentrate of product/solids is the UF concentrate. The water phase can be reused with the same constraints as outlined above. This has been applied for recovery of latex, pigments, textile size, and others. The concentrated recovered product often needs further treatment to be reused. See Figure 2 (p. 36).

Figure 3 (below) shows a typical process for producing water for reuse through an MBR system for reduction of organic content and total suspended solids (TSS). The system can be provided originally as an MBR or an existing biological system can be retrofitted to create an MBR. Prior to the wastewater being introduced to the bioreactor, the waste is normally screened. In some cases, UF or dissolved air flotation (DAF) is used for pre-separation of solids, fats, oils, and grease (FOG). Industrially the most common use for the UF permeate is cooling tower makeup. The MBR almost always will reduce the organic to a level that is acceptable, but the cycles of the cooling tower may be increased due to the TDS often being higher in the MBR permeate than in the incoming water supply.

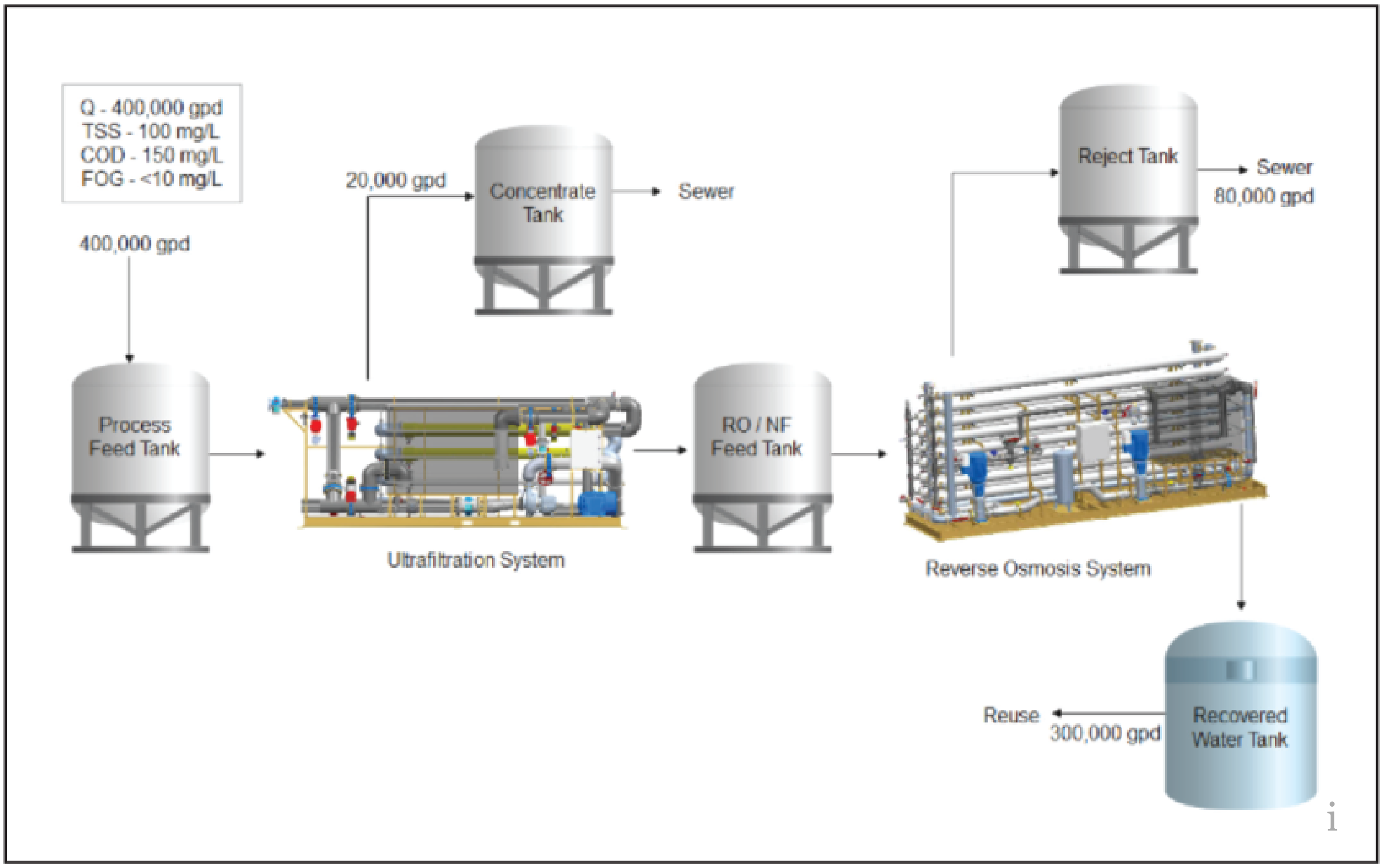


When the application calls for a high level of purification to reuse water, RO is typically used to purify UF permeate or MBR UF permeate. The RO system will reduce soluble organic and inorganic components remaining in the UF permeate. The concentrated solids removed by the ultrafilter can sometimes be discharged to sewer and occasionally must be hauled, and the UF permeate is the feed to the RO system.

Ideally, the rejected RO system product should be able to discharge to the sewer and in arid areas the reject could be used for irrigation by controlling the degree of concentration through the RO system. To make sewer discharge or irrigation work, the pretreatment completed at the ultrafilter must remove the contaminant that may be present in excess of the sewer discharge requirements or the irrigation standards.

Financial Breakdown

CAPITAL EXPENSE	MBR Conversion	New MBR + RO	Sanitary MBR
Equipment & Installation	$300,000	$3,500,000	$$1,600,000
Building	$15,000	$250,000	$20,000
Purified water distribution	$75,000	$200,000	$65,000
1st Year Cost per 1,000 gal	$8.90/1,000 gal	$21.64/1,000 gal	$46.16/1,000 gal
OPERATIONAL EXPENSE			
Power @ $0.08/KWH	$0.30/1,000 gal	$0.63/1,000 gal	$0.67/1,000 gal
Chemical w/o RO	$0.06/1,000 gal	$0.05/1,000 gal	$0.05/1,000 gal
Chemical w/RO	N/A	$0.20/1,000 gal	$0.19/1,000 gal
Labor @ $20/H	-0-	$0.40/1,000 gal	$0.80/1,000 gal
Disposal	-0-	$0.002/1,000 gal	-0-
Maintenance 10-year average	$0.12/1,000 gal	$0.55/1,000 gal	$0.45/1,000 gal
TOTAL	$0.48/1,000 gal	$1.83/1,000 gal	$2.16/1,000 gal
SAVINGS			
Water & Sewer	-0-	$0.03/1,000 gal	$0.04/1,000 gal
Surcharge	-0-	$2.10/1,000 gal	-0-
Disposal	-0-	-0-	-0-



Reuse opportunities must be identified and the qualitative requirements for reuse in those applications must also be identified.

In most cases, the organics present in the reject and the higher concentration of dissolved solids are not typically a problem for sewer discharge. When the TDS exceeds the concentration acceptable for irrigation, the volume of produced water (recovery) can be decreased, thereby lowering the TDS in the reject that is used for irrigation.

UF followed by RO is typically employed when the organic content in the UF permeate is relatively low. The feed tank to the RO system will require the addition of a nonoxidizing biocide. As the concentration of contaminants increases beyond the value shown in Figure 4 (above), several system components change. The pretreatment often is more involved; selection of membrane often changes; the ability to discharge UF concentrate to sewer may not be possible; and the ability to reuse RO reject may compromised. Figure 5 (p. 41) shows an industrial application where the water was reused in three different applications. The wastewater was first pretreated through a DAF for removal of gross FOG and TSS. The wastewater was then processed through the MBR. The solids from the DAF and the waste activated sludge were dewatered in a filter press with the filtrate returning to the equalization tank. A portion of the UF permeate was sent directly to cooling towers and a portion was sent to the feed tank of the RO system. The volume of RO permeate required for high-purity uses was small, and this allowed the RO system to operate with a relatively high reject rate thereby limiting the degree of concentration of dissolved solids and making the reject acceptable for irrigation.

Water Treatment Costs

The economics of water treatment for purification and reuse can vary broadly.

One of the simplest recovery projects is the conversion of an existing biological facility to an MBR. For example, a recent project utilized a sequencing batch reactor (SBR) for treatment/reduction of biochemical oxygen demand (BOD) before conversion. The project consisted of providing a tubular UF system and interconnecting the ultrafilter with the SBR tank. The aeration system was adequately sized and did not need any work as part of the conversion. There also was a sheltered space located relatively close to the SBR that was large enough to house the UF system, with only minor costs associated with the shelter to make it ready for the installation of the ultrafilter. The capital and operational expenses are shown on the table on p. 38 under the heading of MBR Conversion.

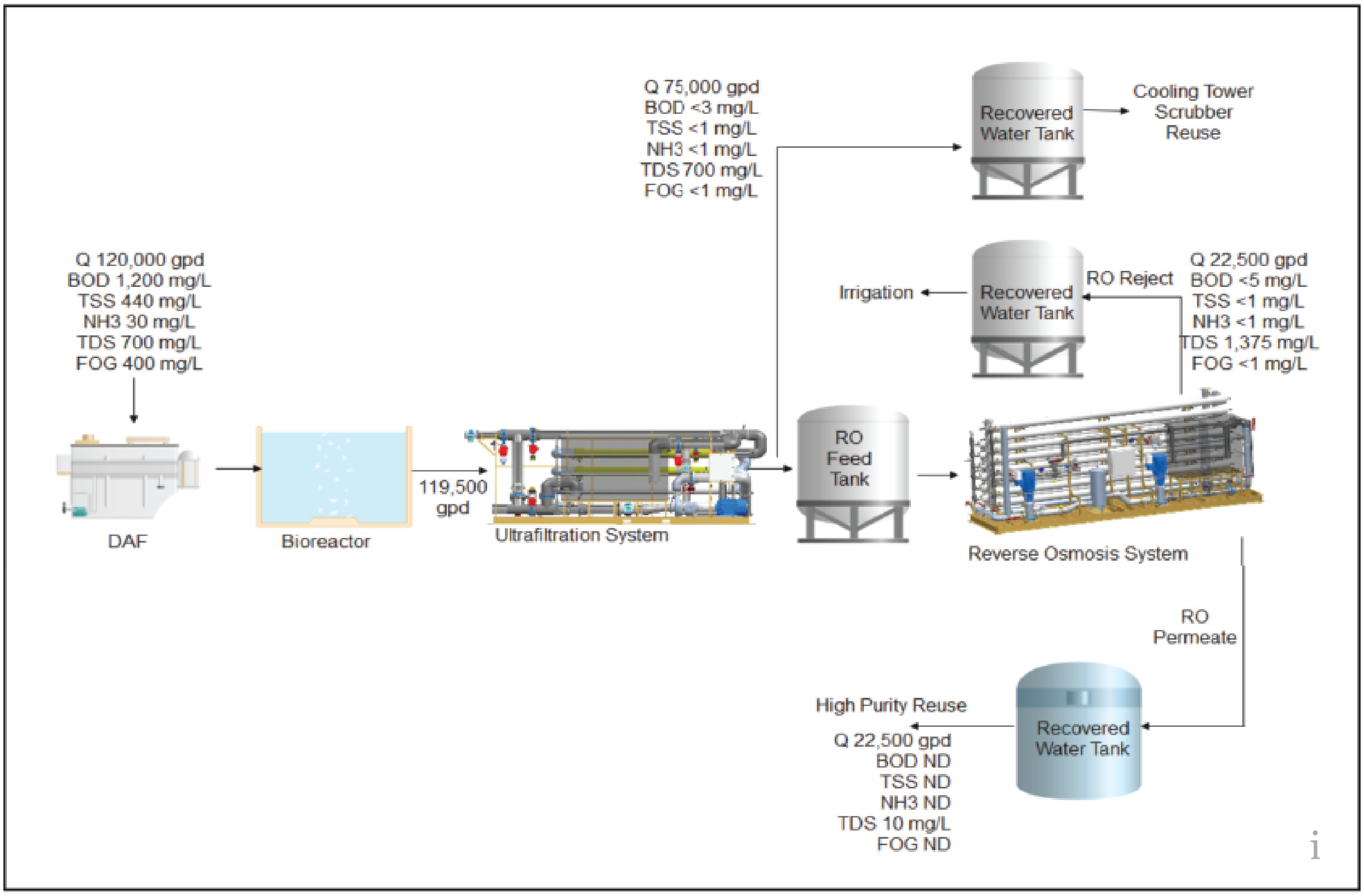
The next example includes the supply of a complete MBR system followed by reverse osmosis. The residual waste activated sludge was dewatered and landfilled and the reject from the RO system was discharged to sewer. The capital cost for the system was more per gallon of water recovered, and the operating cost also is higher per gallon of water recovered in that more equipment is employed for recovery than in the previous example. The recovery project was driven by the need to clean and reuse water because the location was in an arid area. It was necessary to provide a shelter for the equipment. The uses of the recovered water included cooling tower makeup, scrubber makeup, and boiler feed. The expenses are shown on the table on p. 38 under the heading of New MBR + RO. Another type of reuse is through capturing sanitary wastewater and purifying it for reuse. Typically, an MBR system will purify wastewater adequately for use as cooling tower makeup, toilet flushing, irrigation, and specific cleanup uses. In most cases, the initial screenings are separated for disposal while the waste-activated sludge was discharged to sewer.

These costs will vary by location and the project scope. The recovery project is typically driven by the scarcity of water and/or the high cost of water and sewer. In some cases, there is an existing shelter for the equipment, and in others it is necessary to provide a shelter for the equipment. The availability of an existing space to house the equipment has obvious effect on the capital cost of the project. Expenses are broken down on the table on p. 38 under the heading of Sanitary MBR.

Calculating Expenses

To start a water recovery project, there is essential information to identify that will affect both the capital and operational expenses.

The existing facilities and location of those facilities will affect on the capital and operating cost for the water purification and reuse system. For those that have existing wastewater assets that can be converted, the capital cost is much less and often the operating costs are reduced. The same industrial facilities must consider the cost of delivering the purified water to those applications that will use the water. In some cases, the locations are relatively close to the water purification system and others are not. If the location is not close and/or the required infrastructure is not in place, it will increase the capital cost and possibly increase the operating cost. The ideal location is one where the wastewater source, treatment, and purification system and water users and infrastructure for either treatment and/or reuse exist and are located relatively close to each other.



The characteristics of the water source will have an obvious effect on the capital and operating cost for a water purification and reuse system. Reuse opportunities must be identified, and the qualitative requirements for reuse in those applications must also be identified. There are many contaminants that may be present in wastewater that may not be removed in the MBR process alone. Those contaminants that pass through the MBR process may make MBR permeate unsatisfactory for reuse in some applications and thereby require further purification using RO. An example is high TDS and high hardness, which will pass through the MBR process and can make reuse in cooling towers and others unacceptable. This may happen at an industrial facility. However, where sanitary wastewater is intercepted and used as the source of recovered water, it is rarely an issue. In any case, there needs to be a clear identification of the requirements for reuse and identification of the complete characteristics of the source of water that will be used for purification and reuse in order to identify the system requirements and thereby establish the capital and operating costs.

Operating costs can be significantly affected by labor costs. Facilities similar to the first example above, where there is an existing treatment system that is modified/upgraded and already employs an operator that can care for the system, normally see little effect to operating costs due to labor and sometimes require less operator attention than before the conversion. There is usually an increase in power resulting from the retrofit of a system to provide reuse. Attention must be given to implementing the water recovery system in a power effective way. Obviously, the cost of power also will affect the operating costs. The cost for chemicals is normally very small and maintenance costs are low during the first 3 to 5 years.

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