Primary Clarifier Decision Matrix

Primary Clarifier						
Raw Value						
Alternatives	Lifecycle Costs ($)	M&O ($/yr)	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Best Value	750,000	103,500	2.00	2.00	3.00	3.00
Rectangular	750,000	206,880	3.00	2.00	3.00	3.00
Circular	864,600	103,500	2.00	2.00	1.00	2.00
Normalized Score						
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Rectangular	1.00	0.50	0.67	1.00	1.00	1.00
Circular	0.87	1.00	1.00	1.00	0.33	0.67

There were six criteria used to determine the best technology for the primary clarifier and were weighted based on the clients' needs. These criteria were lifecycle cost, O&M, social and environmental factors, staffing levels, process efficiency improvements, and feasibility and constructability.

Lifecycle costs and O&M costs were estimated using a WTP cost estimation formula, social and environmental factors were judged based on engineering judgment, staffing levels were based on available literature, process efficiency improvements were based on typical TOC removal rates, and feasibility and constructability were based on engineering judgement.

Alternative 1-Rectangular Tank Clarifier: Rectangular clarifiers take less area than other clarifier designs. They provide an extensive pathway for the treated water and suspended solids, and will not lead to short circuiting and increased sludge settling associated with circular clarifiers.

Alternative 2-Circular Tank Clarifier: Circular clarifiers function differently than the other clarifiers. Circular clarifiers function by having an inlet at the bottom of the tank. Circular tanks are easy to maintain. However, circular tanks require more land compared to the other designs

Weighted Score							
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability	Total Weighted Score
Weight	2	2	1	1	3	3	
Rectangular	2.00	1.00	0.67	1.00	3.00	3.00	7.67
Circular	1.73	2.00	1.00	1.00	1.00	2.00	6.73

Table above shows the final weighted scores for the alternatives from highest scoring to lowest scoring. The rectangular clarifier was found to be the best alternative. The reason this alternative is preferred is because it had the greatest process efficiency improvements.

Secondary Clarifier Decision Matrix

Secondary Clarifier						
Raw Value						
Alternatives	Lifecycle Costs ($)	M&O ($/yr)	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Best Value	336,854	5,053	3	10	6	10
Circular	2,419,055	27,665	6.00	10.00	6.00	9.00
Rectangular	6,080,664	219,597	7.00	8.00	10.00	10.00
Floc Blanket	336,854	5,053	14.00	2.00	10.00	5.00
Lamella/Plate	109,433,114	1,549,923	3.00	2.00	6.00	7.00
Normalized Score						
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Circular	0.139	0.183	0.500	1.000	1.000	0.900
Rectangular	0.056	0.023	0.429	0.800	0.600	1.000
Floc Blanket	1.000	1.000	0.214	0.200	0.600	0.500
Lamella/Plate	0.003	0.003	1.000	0.200	1.000	0.700

There were six criteria used to determine the best technology for the primary clarifier and were weighted based on the client's needs. These criteria were lifecycle cost, O&M, social and environmental factors, staffing levels, process efficiency improvements, and feasibility and constructability.

The lifecycle cost was written in a dollar amount with a higher value being less desirable than a lower value and determined using a WTP cost estimation formula. The same is true for the M&O cost. Social and environmental impacts were scored based on the expected TOC removal and shock load tolerance of the system found in available literature with a lower value being less desirable than a higher value. Staffing levels were based on available literature and engineering judgement with a higher value being less desirable than a lower value. Process efficiency improvements were estimated on average retention times found in available literature with a higher value being less desirable than a lower value. Lastly, feasibility/constructability was scored based on evidence from available literature, and engineering judgement with a higher value being less desirable than a lower value.

Alternative 1: Rectangular clarifiers work by allowing the particles to collect together and fall out of the water by the time they reach the end of the basin. These clarifiers balance between conserving space and price at the cost of being less efficient than some the other designs

Alternative 2: Circular clarifiers work by allowing the particles to float to the bottom where they are picked up by a scraper while the treated water floats along the top and leaves the basin. These basins are famously easy to design, and maintain, and infamously take up a larger footprint, require more parts, and additional considerations for flow splitting and short circuiting

Alternative 3: Lamella/Plate clarifiers fill a typical rectangular basin with several pipes to increase the effective surface area particles can settle onto. This makes this basin the best in terms of capacity per unit area and removal of particles, but require more design effort, are more expensive, and more maintenance intensive than other clarifiers.

Alternative 4: Floc Blanket clarifiers fill a hopper bottomed tank with a layer of floc that acts as a filter for the water pumped up through this floc layer. It is extremely cost effective, and low maintenance. However, it is susceptible to system shocks, and has a much longer retention time.

Weighted Score

Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability	Total Weighted Score
Weight	1.5	1.5	1	1	3	2	
Circular	0.209	0.274	0.500	1.000	3.000	1.800	6.783
Rectangular	0.084	0.035	0.429	0.800	1.800	2.000	5.147
Floc Blanket	1.500	1.500	0.214	0.200	1.800	1.000	6.214
Lamella/Plate	0.005	0.005	1.000	0.200	3.000	1.400	5.610

Table shows the final weighted scoring for all the secondary clarifier alternatives in order of highest scoring to lowest scoring. The circular clarifier was found to be the best alternative. The reason this alternative is preferred is because it is the most cost effective when land is not highly weighted, and land is not highly weighted.

Filtration Decision Matrix

Filtration

Raw Value

Alternatives	Lifecycle Costs ($)	M&O ($/yr)	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Best Value	8,854,154	200,000	1.00	1.00	5.00	3.00
Rapid Sand Filter (Anthracite/Sand)	8,854,154	554,889	1.00	2.00	4.00	3.00
Cloth Media Filter	10,000,000	200,000	1.00	1.00	1.00	3.00
Slow Bio-Sand Filter	14,412,231	720,611	1.00	3.00	4.50	2.00
Ultrafiltration	98,139,691	8,247,032	2.00	2.00	4.50	2.00
Reverse Osmosis w/ Pre-Treatment	196,279,382	17,729,152	3.00	3.00	5.00	1.00

Normalized Score

Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Rapid Sand Filter (Anthracite/Sand)	1.00	0.36	1.00	0.50	0.80	1.00
Cloth Media Filter	0.89	1.00	1.00	1.00	0.20	1.00
Slow Bio-Sand Filter	0.61	0.28	1.00	0.33	0.90	0.67
Ultrafiltration	0.50	0.01	0.33	0.33	1.00	0.33
Reverse Osmosis w/ Pre-Treatment	0.09	0.02	0.50	0.50	0.90	0.67

Alternative 1-Rapid Sand Filtration: In this type of filtration system, particles will get absorbed into the filtration material. Sand filtration is generally effective in reducing pollutants at a reasonable cost. It is also relatively easy to maintain through backwashing. Dual sand filtration systems have a high filtration rate, and require a small area.

Alternative 2-Ultrafiltration (UF): Ultrafiltration is a low-pressure membrane filter. The UF membrane has a nominal pore size of 0.01 micrometers making it an effective technology for the removal of viruses, bacteria, protozoans, suspended solids, and turbidity. Chemicals will be needed to clean the membranes regularly. There are no DBP and a smaller construction footprint with this design. Unfortunately, UF membranes will not remove dissolved organic matter which may cause poor color, taste, and odor the technology is also expensive.

Alternative 3-Reverse Osmosis (RO) with Pre-Treatment: Reverse osmosis is a high-pressure process where water gets pushed towards a semipermeable membrane to separate contaminants from a filtered stream of water, leaving a waste stream behind. If the water being treated has a high salt content, this can cause undesirable environmental effects. Nearly all RO systems will need pre-treatment before being used because RO membranes foul easily. A good choice of pre-treatment is microfiltration or ultrafiltration. While RO systems treat water without chemical dosing, bacteria will still get trapped in the membranes. This means the RO will need to be cleaned from with biocides; however, the system should work more efficiently with a pre-treatment. The cost for a RO system is high and generally not feasible for large treatment plants.

Alternative 4-Slow Bio-Sand Filter: Slow bio-sand filters works best when the water coming in is ozonated which increases its biodegradable organic matter. One advantage is that bio-sand filters do not have chlorine coming in with the filter influent. Biofilters remove organic matter, various minerals, and improve taste and odor. The filter media in the biofilter will need to be changed out or regenerated periodically to keep the system working, so there is some maintenance involved. Slow filters take up a large amount of area to work properly.

Alternative 5-Cloth Media Filtration: Cloth Media Filtration has water going through a series of discs with cloth over them. This is an inexpensive treatment technology as well as one that has few harmful impacts and does not take up much space. Cloth media filtration devices are low maintenance, but they are not as effective in removing TOC as other alternatives.

	Weighted Score						
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability	Total Weighted Score
Weight	2	2	1	1	3	1	
Rapid Sand Filter (Anthradite/Sand)	2.00	0.72	1.00	0.50	2.40	1.00	7.62
Cloth Media Filter	1.77	2.00	1.00	1.00	0.60	1.00	7.37
Slow Bio-Sand Filter	1.23	0.56	1.00	0.33	2.70	0.67	6.48
Ultrafiltration	1.00	0.02	0.33	0.33	3.00	0.33	5.02
Reverse Osmosis w/ Pre-Treatment	0.18	0.05	0.50	0.50	2.70	0.67	4.60

Table above shows the final weighted scoring for all the filtration alternatives in order of highest scoring to lowest scoring. The rapid sand filter was found to be the best alternative. The reason this alternative is preferred is because it has a reasonable capital/operating cost, it has little to no negative environmental impacts, it does not require a high amount of maintenance, and it does a good job in removing unwanted pollutants from the water. As rapid sand filters are fairly common and have a relatively small footprint, it scored well in the feasibility/constructability category.

Disinfection Decision Matrix

Disinfection						
Raw Value						
Alternatives	Lifecycle Costs ($)	M&O ($/yr)	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Best Value	1,769,525	77,407	1	1	5	5
Pre-Ozonation (LOX) and UV (Trojan UV Signa)	24,255,528	2,641,729	1.00	2.00	5.00	4.00
UV (Trojan UV Signa)	3,294,000	138,000	1.00	1.00	2.00	5.00
Chlorination (Sodium Hypochlorite)	1,769,525	77,407	3.00	2.00	2.00	2.00
Ozonation (LOX)	20,961,528	2,503,729	1.00	2.00	4.00	4.50
Pre-Ozonation (LOX) and Chlorination (Sodium Hypochlorite)	22,731,053	2,581,135	3.00	3.00	5.00	1.00
Normalized Score						
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability
Pre-Ozonation (LOX) and UV (Trojan UV Signa)	0.07	0.03	1.00	0.50	1.00	0.80
UV (Trojan UV Signa)	0.54	0.56	1.00	1.00	0.40	1.00
Chlorination (Sodium Hypochlorite)	1.00	1.00	0.33	0.50	0.40	0.40
Ozonation (LOX)	0.08	0.03	1.00	0.50	0.80	0.90
Pre-Ozonation (LOX) and Chlorination (Sodium Hypochlorite)	0.08	0.03	0.33	0.33	1.00	0.20

Alternative 1-Ozonation with liquid oxygen (LOX) and Chlorination (Sodium Hypochlorite): The existing disinfection technologies at the NWTP include pre-ozonation before the final sedimentation basins followed by chlorine dosing after the filtration. The use of ozone as a disinfectant is relatively expensive, but it does an effective job in eliminating organics, taste and odor, bacteria, and viruses. A LOX storage tank, ozone generator, and contact chamber are all needed for this process. The use of LOX rather than natural air is used to reduce maintenance in large treatment plants. If the source water has Bromide, there will be a reaction with the ozone causing Bromate. Ozone does not cause the other DBPs that chlorine does Sodium Hypochlorite can be very useful in reducing some pathogenic organisms in water; however, chlorine does react with some natural organics causing the formation of DBPs. Compared to chlorine gas, it is safer to store and handle. It can also cause taste and odor problems. Chlorine acts as an effective residual for the water leaving the plant, and it is relatively inexpensive and does not require a lot of maintenance.

Alternative 2-Ozonation with LOX: The use of ozone as a disinfectant is relatively expensive, but it does an effective job in eliminating organics, taste and odor, bacteria, and viruses. A LOX storage tank, ozone generator, and contact chamber are all needed for this process. The use of LOX rather than natural air is used to reduce maintenance in large treatment plants. If the source water has Bromide, there will be a reaction with the ozone causing Bromate. Ozone does not cause the other DBPs that chlorine does

Alternative 3-Pre-Ozonation with LOX and Ultraviolet Radiation: The ozone system will be the same as above with the storage tank, ozone generators as well as the contact chamber After the filtration, a series of UV lights would be added. UV has the advantages of having short treatment time, having no odor/taste problems, no chemical dosing needed as well as not forming any DBPs. Unfortunately, UV does not provide any residual downstream of treatment, and does require electricity.

Alternative 4-Ultraviolet Radiation: The UV system would be the same as mentioned above. If used alone, it is slightly less effective than with pre-ozonated water. It is relatively inexpensive considering how UV systems have been growing in popularity.

Alternative 5-Chlorination (Sodium Hypochlorite): Chlorination can be useful in reducing pathogenic organisms in water, but it can easily form DBPs by reacting with natural organics in the water. It may also cause taste and odor problems. Chlorine acts as an effective residual for the water leaving the plant, and it is not expensive.

	Weighted Score						
Alternatives	Lifecycle Costs	M&O	Social & Environmental Factors	Staffing Levels	Process Efficiency Improvements	Feasibility/ Constructability	Total Weighted Score
Weight	2	1	1	1	4	1	10
Pre-Ozonation (LOX) and UV (Trojan UV Signa)	0.15	0.03	1.00	0.50	4.00	0.80	6.48
UV (Trojan UV Signa)	1.07	0.56	1.00	1.00	1.60	1.00	6.24
Chlorination (Sodium Hypochlorite)	2.00	1.00	0.33	0.50	1.60	0.40	5.83
Ozonation (LOX)	0.17	0.03	1.00	0.50	3.20	0.90	5.80
Pre-Ozonation (LOX) and Chlorination (Sodium Hypochlorite)	0.16	0.03	0.33	0.33	4.00	0.20	5.05

Table above shows the final weighted scoring for all the disinfection alternatives in order of highest scoring to lowest scoring. The preferred solution for a disinfection technology is Pre-Ozonation (LOX) and UV Radiation. While they have relatively high capital and operating costs, the negative environmental impacts are low as well as the maintenance needed. The combination of Pre-Ozonation and UV Radiation is effective in removing pollutants from the water as well as reducing poor taste and odor. The feasibility/constructability also scored reasonably.

Biosolids Management Decision Matrix

Biosolids			
Raw Value			
Alternatives	Initial Investment($)	Total Lifecycle Cost	Social & Environmental Factors
Best Value	120,000	10.00	9.00
Belt Filter Press	120,000	10.00	9.00
Heat Drying	300,000	8.00	6.00
Centrifuge Thickening	650,000	9.00	8.00
Gravity Thickening	3,200,000	8.00	7.00
Normalized Score			
Alternatives	Initial Investment	Total Lifecycle Cost	Social & Environmental Factors
Belt Filter Press	1.00	0.36	1.00
Heat Drying	0.61	0.28	1.00
Centrifuge Thickening	0.09	0.02	0.50
Gravity Thickening	0.50	0.01	0.33

Alternative 1-Belt Filter Press: A belt filter press is a machine that separates solids and liquids. It is a type of filter that dewaters sludge as it moves through the system. This system mainly runs sludge made of biosolids into a collection tank, and as the system is run, the solids are slowly pressed until all liquid is drained.

Alternative 2-Centrifugal thickening: Centrifugal thickening is the process of increasing the sludge concentration by migrating particles to the walls of a rapidly rotating cylindrical bowl through the usage of a centrifugal forces. This process includes the use of dewatering and produces non-liquid material that is also known as “cake”. Dewatering centrifuges requires high energy consumption per unit of solids to achieve higher solid concentrations.

Alternative 3-Gravity Thickening: Gravity Thickening is a system that increases the solid concentration by letting the particles settle to the base of a cylinder and producing a thickened solids stream at the base and a diluted stream at the surface. A gravity sludge thickener has the same design and mechanism as a primary clarifier. This technology is fitted with a stirrer to stir the basin and let the biosolids settle at the center of the tank and flow out to the periphery. As the water flows outward from the center of the tank, the suspended solids sink to the base of the cylindrical bowl and are scraped into a cone-shaped outlet with a rotating scraper and removed at the thickened sludge product stream. As the sludge is taken, the basin is left with a diluted stream.

Alternative 4-Heat Drying: Heat drying is the process of using heat to evaporate water from biosolids. The heat is utilized in direct and/or indirect dryers. A major advantage of using a heat drying process is that it produces Class A biosolids, which meet the highest standards in pathogen reduction requirement.

This is an effective biosolid management for facilities that are focused on the reduction of biosolid volume while producing reusable end products.

Weighted Score				
Alternatives	Initial Investment	Total Lifecycle Cost	Social & Environmental Factors	Total Weighted Score
Weight	5	3	2	10
Belt Filter Press	5.00	3.00	2.00	10.00
Heat Drying	2.00	2.40	1.33	5.73
Centrifuge Thickening	0.92	2.70	1.78	5.40
Gravity Thickening	0.19	2.40	1.56	4.14

Table above shows the final weighted scoring for all the biosolids management alternatives and design in order of highest scoring to lowest scoring. The belt filter press was found to be the best alternative.