Wastewater Treatment Fundamentals I

Chapter Summary and Time Allotments

Chapter Title	Learning Objectives	Average completion time
Chapter 1 Introduction to Wastewater Treatment	• Understand the need for wastewater treatment. • List some of the components of domestic wastewater. • Identify major unit processes of domestic WRRFs. • Understand the linkages between the liquid stream and solids handling sides of a WRRF. • Label appropriately. • Draw an example WRRF, clearly label the main unit processes, and give the function of each. • Draw a typical natural treatment system and a typical mechanical treatment system. • Describe the permitting requirements of the Clean Water Act (CWA) and the biosolids 503 regulations.	3 Hours
Chapter 2 Characterization and Sampling of Wastewater	• List the significant sources of wastewater for a domestic WRRF. • Evaluate the effect of activities in the service area on flow patterns at the WRRF. • Explain how the size of the collection system and population served affect diurnal flow patterns. • List and define additional components of domestic wastewater. • Estimate flows and loads to a WRRF from population data. Calculate per capita generation rates. • Convert nitrogen and phosphorus compounds to expressions as N and P, respectively.	3 hours
Chapter 3 Preliminary Treatment of Wastewater	• Describe the purpose of trash racks, bar screens, comminutors and grinders, and grit basins; • Compare and contrast different screen types; • Select a screen category given downstream equipment requirements; • Place a screen or grit basin into service or remove one out of service; • Compare and contrast different types of grit basins; • Calculate flow velocity for an open channel or full pipe; • Determine the optimum number of grit basins to place into service to maintain a desired • flow velocity; • Troubleshoot common screening and grit removal process control and mechanical • problems; and • Describe potential effects of septage receiving on facility operations.	5 hours
Chapter 4 Primary Treatment of Wastewater	• Describe the purpose of primary clarification; • Categorize influent parameters according to whether they can be removed by primary clarification;	6 hours

	• Label all components of circular and rectangular primary clarifiers and describe the function of each; • Inspect and maintain clarifier equipment; • Place a primary clarifier into service or remove one from service; • Calculate hydraulic detention time and surface overflow rate; • Determine the optimum number of clarifiers to place into service to maintain a desired surface overflow rate and detention time; • Estimate the quantity of sludge produced given primary influent and effluent TSS concentrations; • Calculate sludge pumping time required for a given sludge thickness and volume; • Collect process control samples, conduct settleable solids analysis, and evaluate results; • Anticipate seasonal changes and make appropriate process control changes; and • Troubleshoot common mechanical and process control problems.	
Chapter 5 Fundamentals of Biological Treatment	• Describe how dissolved and particulate organic matter are removed by biological treatment processes; • Predict the fate of dissolved organic material based on its characteristics; • Categorize the main groups of microorganisms and their functions in secondary treatment processes; • Compare and contrast carbon and energy sources for heterotrophic and autotrophic bacteria; • Compare growth rates of heterotrophic and autotrophic bacteria; • Define and explain the purpose of aerobic, anoxic, and anaerobic conditions in biological treatment processes; • Predict the behavior of heterotrophic bacteria, nitrifying autotrophic bacteria, and phosphate accumulating bacteria under aerobic, anoxic, and anaerobic conditions; • Understand the terms yield, decay, maximum growth rate, half-saturation coefficient, and substrate; • Compare bacterial growth rates at different wastewater temperatures and explain how growth rates affect treatment process capacity; and • Explain the effect of substrate concentrations on bacterial growth rates.	4 hours
Chapter 6 Wastewater Treatment Ponds	• List and describe the three types of wastewater ponds; • Describe the interrelationships between bacteria, algae, and predator organisms; • Explain the three mechanisms for nitrogen removal in ponds; • Evaluate the effects of water temperature, sunlight, nutrient availability, and other operational parameters on population dynamics; • Discuss the causes of fall and spring turnover in facultative ponds;	4 hours

	• Inspect and maintain pond components; • Determine when to use series versus parallel operation; • Calculate hydraulic detention time and organic loading rate; • Place a pond into service or remove a pond from service; • Collect process control samples and evaluate results; and • Troubleshoot common process control problems.	
Chapter 7 Fixed-Film Treatment	• Understand biofilm growth and decay; • Explain the principles underlying mass transport through a biofilm; • Label all components of trickling filters and RBCs and describe the function of each; • Determine the direction of airflow through a trickling filter; • Place a trickling filter or RBC into service or remove one from service; • Inspect and maintain trickling filter and RBC equipment; • Calculate organic and hydraulic loading rates (HLRs) for trickling filters and RBCs; • Make process adjustments to maintain a desired biofilm thickness or weight in trickling filters and RBCs; • Determine the recycle ratio required to maintain a desired Spülkraft (SK) value for a trickling filter; • Interpret influent biochemical oxygen demand (BOD) data and adjust the size of stage 1 treatment for an RBC in response; • Collect process control samples and evaluate results; • Implement corrective actions to minimize the effects of biofilm predators; and • Troubleshoot common mechanical and process control problems.	5 hours
Chapter 8 Activated Sludge	• Describe the components of an activated sludge process and the functions of each. • Describe the relationship between activated sludge microbiology and sludge settleability. • Explain the importance of balancing the growth of floc formers and filament formers. • Identify microorganisms common to activated sludge processes including filamentous bacteria, protozoa, metazoa. • List at least three groups of microorganisms present in activated sludge and describe the conditions that promote their growth. • Evaluate information on types of microorganisms present to determine underlying operating conditions. • Compare and contrast complete-mix, plug-flow, and batch operation. • Inspect and maintain equipment associated with the activated sludge process. • Compare and contrast gould sludge age, mean cell residence time (MCRT), solids retention time (SRT), and solids retention time aerobic ($SRT_{aerobic}$).	12 hours

	• Calculate process control variables, including MCRT, SRT, $SRT_{aerobic}$, and food-to-microorganism ratio (F/M). • Determine whether MCRT, SRT, or $SRT_{aerobic}$ is the most appropriate control variable given facility data. • Select a target sludge age to meet treatment objectives at a particular water temperature. • Calculate theoretical maximum return activated sludge/waste activated sludge (RAS/WAS) concentrations from settleometer test results. • Calculate actual RAS/WAS concentrations using influent flow and RAS flow. Compare against theoretical maximum thickness to optimize RAS flowrate. • Predict the effect of increasing or decreasing sludge age on other process control variables including mixed liquor suspended solids (MLSS) concentration, mixed liquor volatile suspended solids (MLVSS) concentration, F/M, and wasting rate. • Select a target dissolved oxygen (DO) concentration to prevent filamentous bulking and/or maximize ammonia removal rates. • Describe how hydraulic and solids loading parameters are calculated for secondary clarifiers and the relative importance of each. • Explain how the maximum solids loading rate to a secondary clarifier depends on sludge settling characteristics. • Collect process control samples, conduct testing, and evaluate results. • Start up a new activated sludge process, place a basin into service, or take one out of service. • Troubleshoot common activated sludge and secondary clarifier process control and mechanical problems. • Discuss differences between different types of activated sludge processes (complete mix, step feed, oxidation ditch, pureox, etc.). Understand that they are all based on the same underlying biological principles	
Chapter 9 Nutrient Removal	• Predict the fate of different nitrogen and phosphorus species during biological and chemical treatment. • Interpret chemical equations, predict the composition of ionic compounds, convert moles to milligrams per liter (mg/L), and calculate chemical dosages from balanced chemical equations. • Explain the steps involved in nitrification, denitrification, and enhanced biological phosphorus removal (EBPR) and identify the microorganisms responsible for each transformation. • List the stoichiometric requirements for and products of nitrification, denitrification, EBPR, and chemical phosphorus removal. • Identify the most important process control parameters for nitrification, denitrification, chemical phosphorus removal, and EBPR. • Describe the effects of environmental variables (pH, dissolved oxygen [DO], etc.) on each biological process.	8 hours

	• Evaluate process control data to determine whether nitrification, denitrification, or EBPR will be inhibited. • Demonstrate how to manipulate process variables to maximize nitrification and denitrification rates. • Determine best time of day and flowrate for adding recycle stream flows from solids-handling processes to minimize effluent nitrogen and phosphorus concentrations. • Calculate alkalinity requirements for nitrification and chemical phosphorus removal. • Calculate stoichiometric doses of metal salts required for phosphorus removal and estimate actual dose based on treatment objectives. • Select a metal salt and addition point based on treatment objectives	
Chapter 10 Disinfection	• Compare and contrast the goal of disinfection versus sterilization; • Explain the concept of indicator organisms and list six characteristics that make an ideal indicator organism; • Compare and contrast testing methodologies for indicator organisms; • Discuss the effect of temperature and pH on chlorine chemistry; • Predict the effect of various chemical components, for example, nitrite and ammonia, on chlorine residual; • Understand the difference between combined, free, and total chlorine residual (TCR); • Explain why understanding the breakpoint curve is important for facilities that nitrify; • Manipulate contact time (CT) or residual to achieve a desired level of inactivation of indicator organisms; • Adjust chlorine dose to meet discharge permit limits for indicator organisms; • Label all components of different types of disinfection equipment and describe the functions of each; • Inspect, operate, and maintain chlorination, dechlorination, and UV disinfection equipment; • Place disinfection equipment into service and remove it from service safely; • Calculate chemical feed rate, dose, or flow given two of the three variables; • Determine required chemical feed pump settings in milliliters per minute (mL/min); • Discuss the mechanism behind UV inactivation of genetic material; • Explain how effluent quality can affect UV disinfection efficiency; and • Troubleshoot common mechanical and process control problems.	8 hours
Final Exam	• Randomized 100 question final exam cover questions from each chapter. Must achieve a passing score of 80%.	4 hours