*Lecture Contact Hours: 48-54; Homework Hours: 96-108; Total Student Learning Hours: 144-162*

**CUYAMACA COLLEGE**
COURSE OUTLINE OF RECORD

## CENTER FOR WATER STUDIES 216 – ADVANCED WATER TREATMENT II

3 hours lecture, 3 units

**Catalog Description**
This course is an advanced study of the principals involved in the theory, components, and operations of an Advanced Water Treatment Facility where reclaimed water is treated to augment potable water supplies and teach recycled water standards. Overview of treatment theory, design, operation, and monitoring, of components that complete an Advanced Water Treatment, multi barrier treatment facility.

**Prerequisite**
"C" grade or higher or "Pass" in CWS 116 or equivalent

**Entrance Skills**
Without the following skills, competencies and/or knowledge, students entering this course will be highly unlikely to succeed:
1) Describe Advanced Water Treatment system components.
2) Describe how Ozone disinfection is different than Chlorine disinfection.
3) Describe the Biological Activated Carbon filtration system and how it is different from conventional water treatment filtration.
4) Perform basic mathematical calculations related to ozone system disinfection
5) Describe basic safety procedures of the ozone destruct systems and why they are required by the regulatory agency.

**Course Content**
1) Introduction to Advanced Water Treatment Operations
   a. Review, Advanced Water Treatment Operations
   b. Review, Basics of Ozone Disinfection
   c. Review, Basics of Biological Activated Filtration, Granular Activated Filtration systems and pretreatment requirements of Membrane Filters
   d. Review, Basics of Micro Filtration, Ultra-Filtration, Nano Filtration systems and pretreatment requirements of the Reverse Osmosis system
   e. Review, Basics of Reverse Osmosis system and pretreatment requirements of the Ultraviolet Disinfection system
   f. Review, Basics of Ultraviolet light irradiation for disinfection
   g. Review, Basics of Advanced Oxidation Process for enhancement of cell photolysis and application for water disinfection
2) Advanced Ozone System Operations
   a. Ozone System Operations Safety
   b. Liquid Oxygen Gas and cryogenic system components
   c. Ozone System, electrical hazards
   d. Ozone System, Ozone gas Safety, sampling, contactor, and destruct
   e. Ozone System, CT and Log Removal Value, LRV
   f. Ozone System, Evaluating dose, tracer study, CSTR method
   g. Ozone System, T-10 method inactivation rates, Dissolved
   h. Ozone System, Continuous Stirred Tank Reactor, CSTR method
   i. Ozone System, Dissolved Ozone Plug Flow Reactor, DOPFR

   j. Ozone System, Long Term 2 Enhanced Surface Water Treatment Rule, LT2ESWTR
   k. Ozone System, Daily CT ozone monitoring & Indigo method residual verification
3) Advanced Study of Biological Activated Filtration, BAC, Granular Activated Filtration systems and pretreatment requirements of Membrane Filters
   a. BAC process, Components
   b. BAC process, Gravity-Fed Filters
   c. BAC process, Pressurized Filters
   d. BAC process, Flow Meters, Level Indicators, Filtrate Valves
   e. BAC process, Differential Pressure Indicator
   f. BAC process, Backwash Pump, Blower, Underdrain System
   g. BAC process, Operation & Performance processes
   h. BAC process, Operating Modes
   i. BAC process, Backwash system
   j. BAC process, Operational Issues & Biological upsets
   k. BAC process, Performance indicators
   l. BAC process, Water Quality monitors
4) Advanced Study of Micro Filtration, Ultra-Filtration, Nano Filtration systems
   a. Membrane Filtration, constant filtrate produced by membrane system & Filtrate Storage
   b. Membrane Filtration, backwashing sequence
   c. Membrane Filtration, Pressure decay test for membrane integrity
   d. Membrane Filtration, Clean in Place, CIP
   e. Membrane Filtration, Enhanced Flux Maintenance, EFM
   f. Membrane Filtration, Process Performance Indicators
   g. Membrane Filtration, Transmembrane Pressure, TMP
   h. Membrane Filtration, Flux and Fouling, Total membrane square footage
   i. Membrane Filtration, Recovery and Waste Streams
   j. Membrane Filtration, Temperature Corrected Specific Flux, TCSF, Permeability
   k. Membrane Filtration, Pressure Decay Testing & correlation of pressure drop to Log Removal Value, LRV
   l. Membrane Filtration, Monitoring Water Quality and Oxidation Reduction Potential, ORP.
   m. Membrane Filtration, Turbidity using Nephelometric Turbidity Units, NTU and coalition for pathogen removal credits for log removal
   n. Membrane Filtration, Total Chlorine Residual, and effects on biofouling control
   o. Membrane Filtration, Combine Chlorine in the form of chloramines and Reverse Osmosis, R/O pre-treatment to avoid irreversible fouling of R/O membranes
   p. Membrane Filtration, pH control and speciation of chloramines and other related processes
5) Advanced Study of Reverse Osmosis, R/O, system Reverse Osmosis introduction
   a. RO Systems, Safety with Electrical system, Mechanical System, & Chemicals
   b. RO Systems, Advanced Flux and recovery with precipitate forming ions
   c. RO Systems, Advanced Chemical Dosing to balance fouling and specific flux
   d. RO Systems, Advanced evaluation of long-term trends
   e. RO Systems, Effects of Specific Flux changes and fouling thresholds
   f. RO Systems, Advanced evaluation of salt rejection of Sodium Chloride
   g. RO Systems, Advanced diagnosing of Membrane Breaches
   h. RO Systems, Advanced evaluation of pathogen compliance through Electrical Conductivity, EC or Total Organic Carbon, TOC monitoring
   i. RO Systems, Advanced TOC compliance and Recycled water stipulated limits
6) Advanced Ultraviolet, UV, and Advanced Oxidation Process, AOP
   a. UV/ AOP equipment
   b. Reactors, open channel & enclosed UV reactor
   c. UV lamps, lamp sleeves, wipers, power ballast
   d. UV Programmable Logic Controller, PLC
   e. Chemical oxidant system for AOP
   f. UV/ AOP system instrumentation and water quality meters

g. UV/ AOP System operating modes
h. Oxidant dosing and verification of dosing
i. UV/ AOP overall performance indicators

**Course Objectives**
Students will be able to:
1) Define the ozone treatment train pertaining to advanced water treatment operations system components and design.
2) Identify what the CT value is in the ozone system and explain how it satisfies the Log Removal Value of the advanced water treatment requirements.
3) State the 2 types of BAC filters and how they differ in the pretreatment of MF & UF multi-barrier systems.
4) Describe what transmembrane pressure is and how it affects the quality of advanced water treatment operations system
5) Explain how turbidity and total organic carbon differ in monitoring the quality of the advanced water treatment operations system

**Method of Evaluation**
A grading system will be established by the instructor and implemented uniformly. Grades will be based on demonstrated proficiency in subject matter determined by multiple measurements for evaluation, one of which must be essay exams, skills demonstration or, where appropriate, the symbol system.
1) Participation in classroom discussions
2) Homework assignments
3) Quizzes and exams
4) Projects and assignments utilizing the Field Operations Skills Yard

**Special Materials Required of Student**
None

**Minimum Instructional Facilities**
Smart classroom

**Method of Instruction**
1) Lecture and discussion
2) Multimedia presentations
3) Field trips
4) Demonstrations utilizing the Field Operations Skills Yard

**Out-of-Class Assignments**
1) Reading assignments
2) Writing assignments

**Texts and References**
1) Required (representative example): *Membrane Processes for Water Reuse; Anthony M. Wachinski McGraw Hill, 2013. ISBN-13: 978-0071748957, ISBN-10: 0071748954*
2) Supplemental: None

**Student Learning Outcomes**
Upon successful completion of this course, students will be able to:
1) Describe what ozone system CT is and how it satisfies the log removal value for treatment regulations
2) Describe what specific flux and fouling thresholds are and explain their advantage/ detriment to a reverse osmosis system

3) Explain what a single pass and multiple pass reverse osmosis system accomplishes
4) List the types of Ultraviolet reactors and explain why the Advanced Oxidation Process completes the disinfection of Advanced Water Treatment