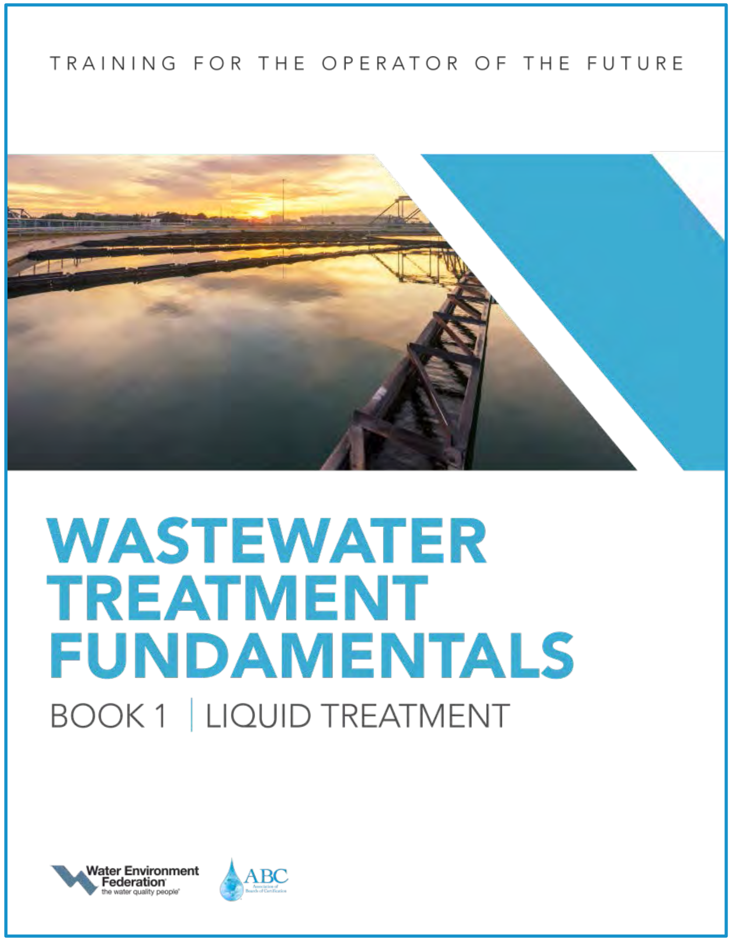
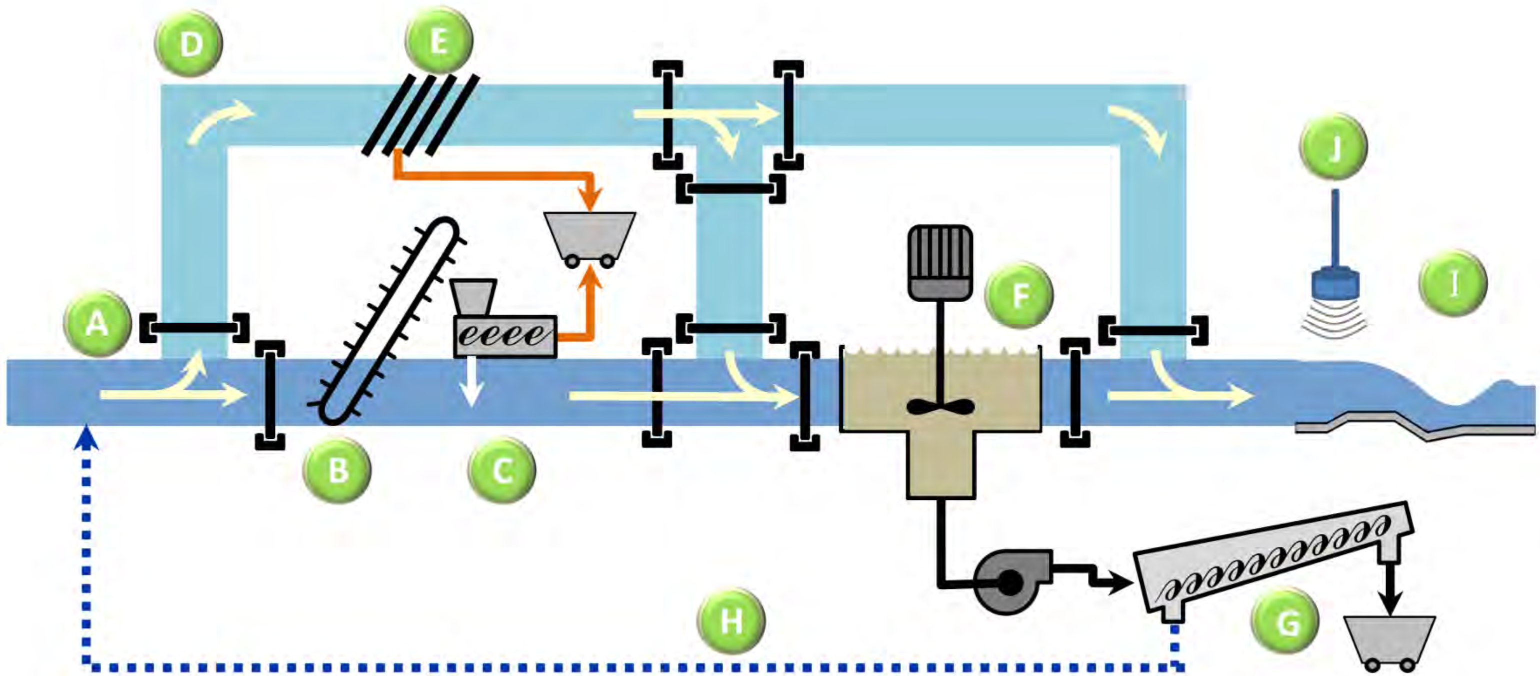
Game Changing Education



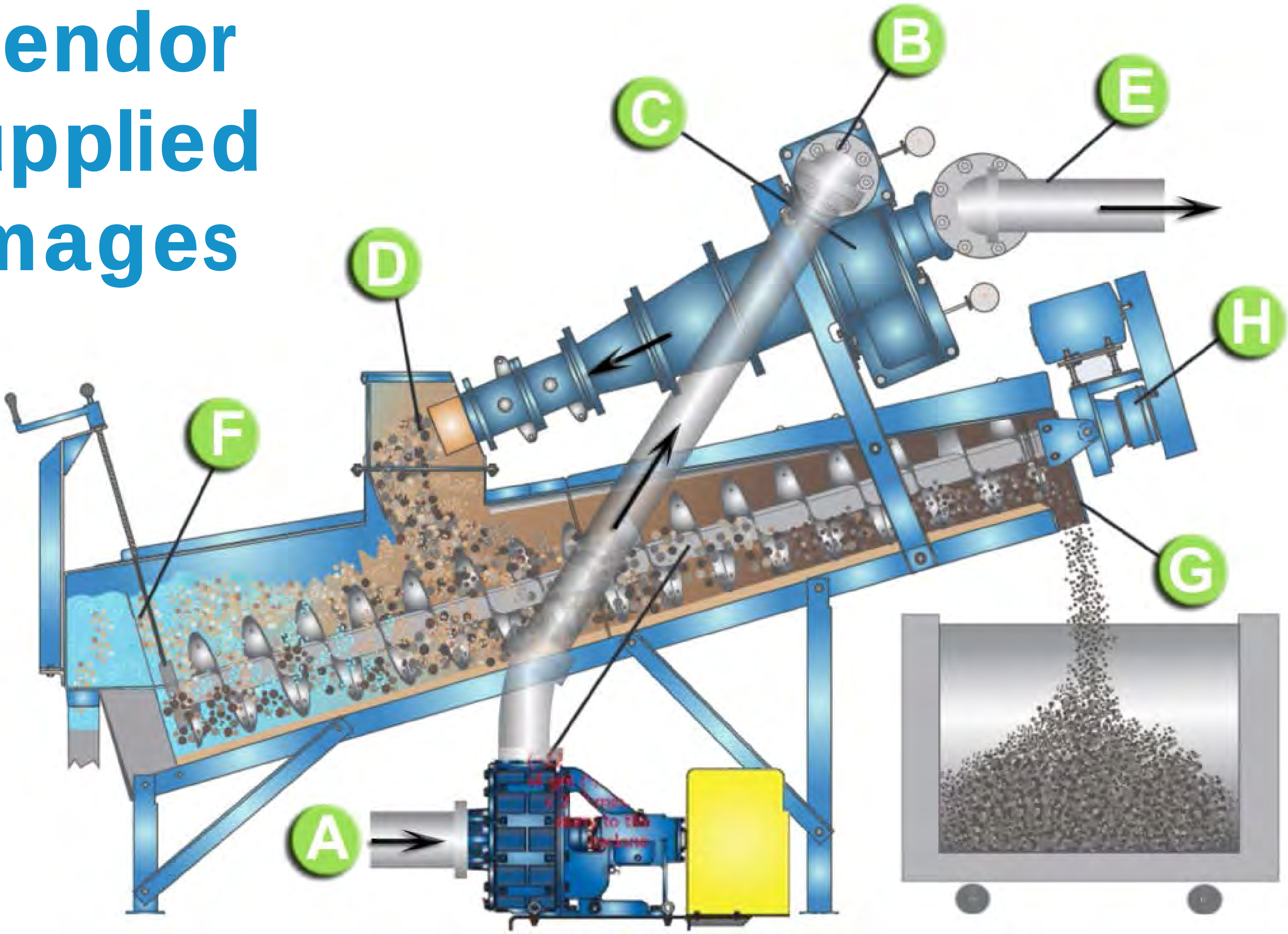
- Based on ABC's Need-to-Know criteria
- Utilizes WEF publications
- Reflects current knowledge
- Peer-reviewed
- Represents the expertise of hundreds of water quality professionals.

Graphics Intensive

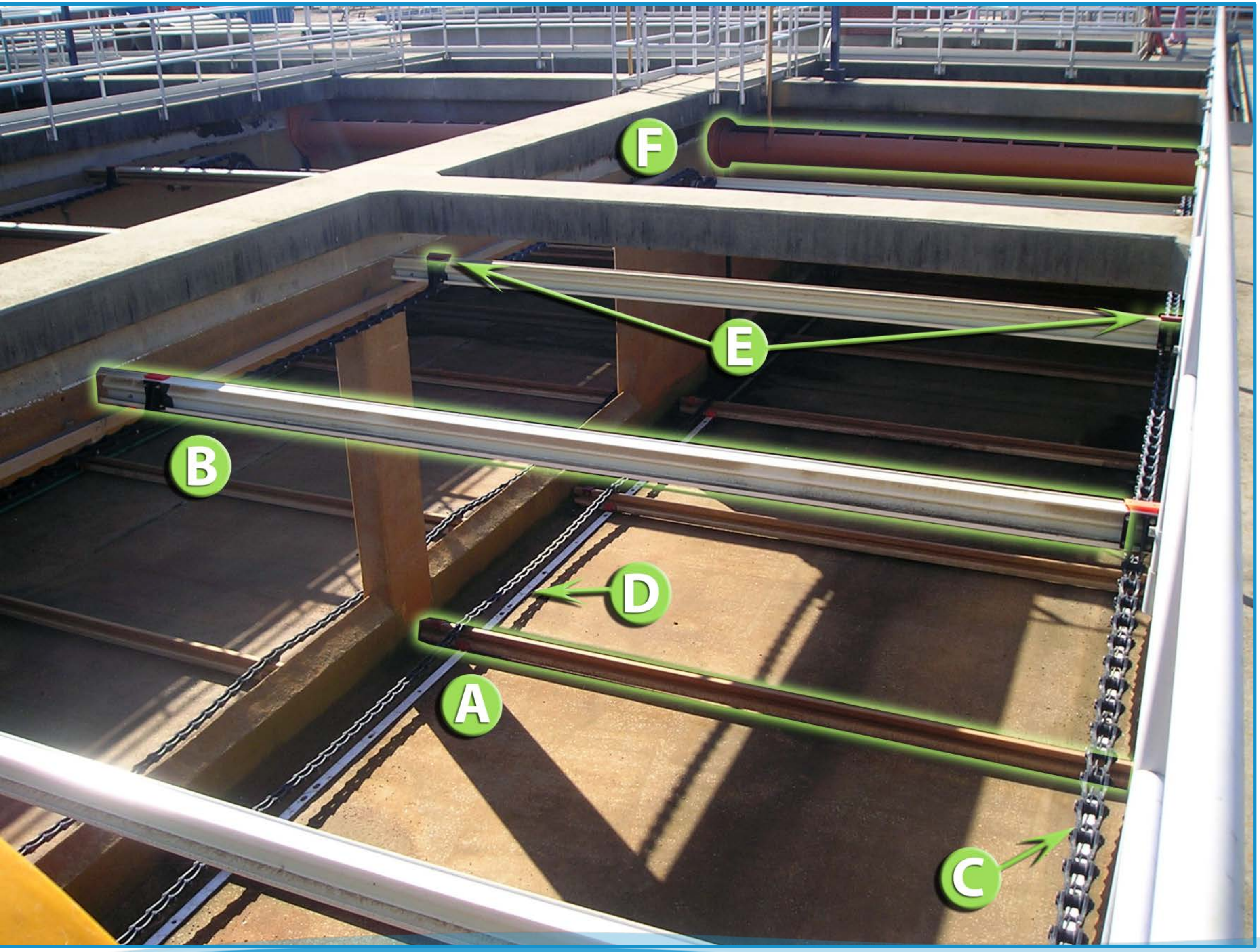


A – Slide Gate
B – Mechanical Bar Screen
C – Screenings Wash Press
D – Bypass Channel
E – Manual Bar Screen
F – Vortex Grit Basin
G – Grit Classifier
H – Water Recycle
I – Flume
J – Flow Measurement

Vendor Supplied Images

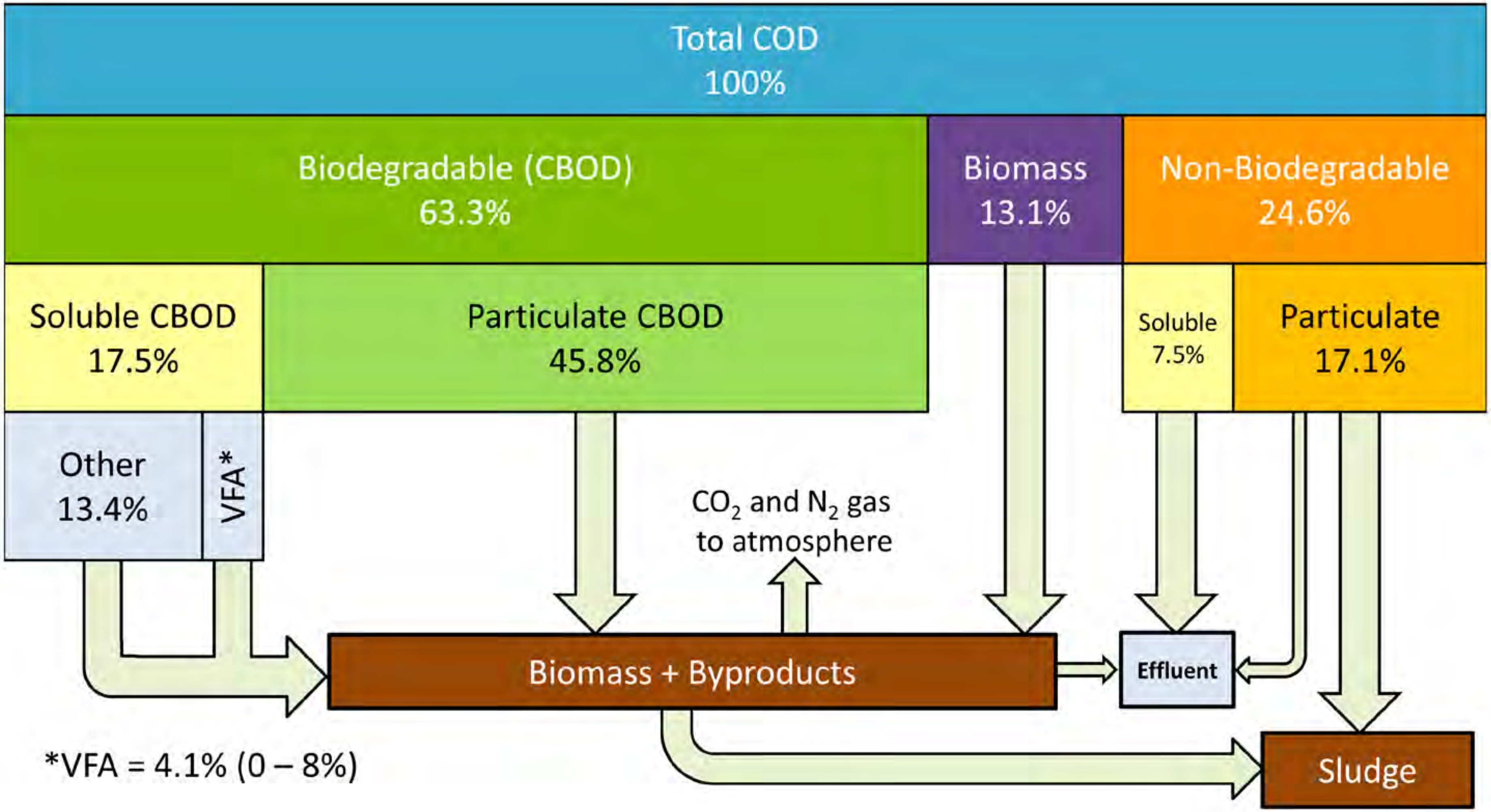


Water Environment Federation
the water quality people™



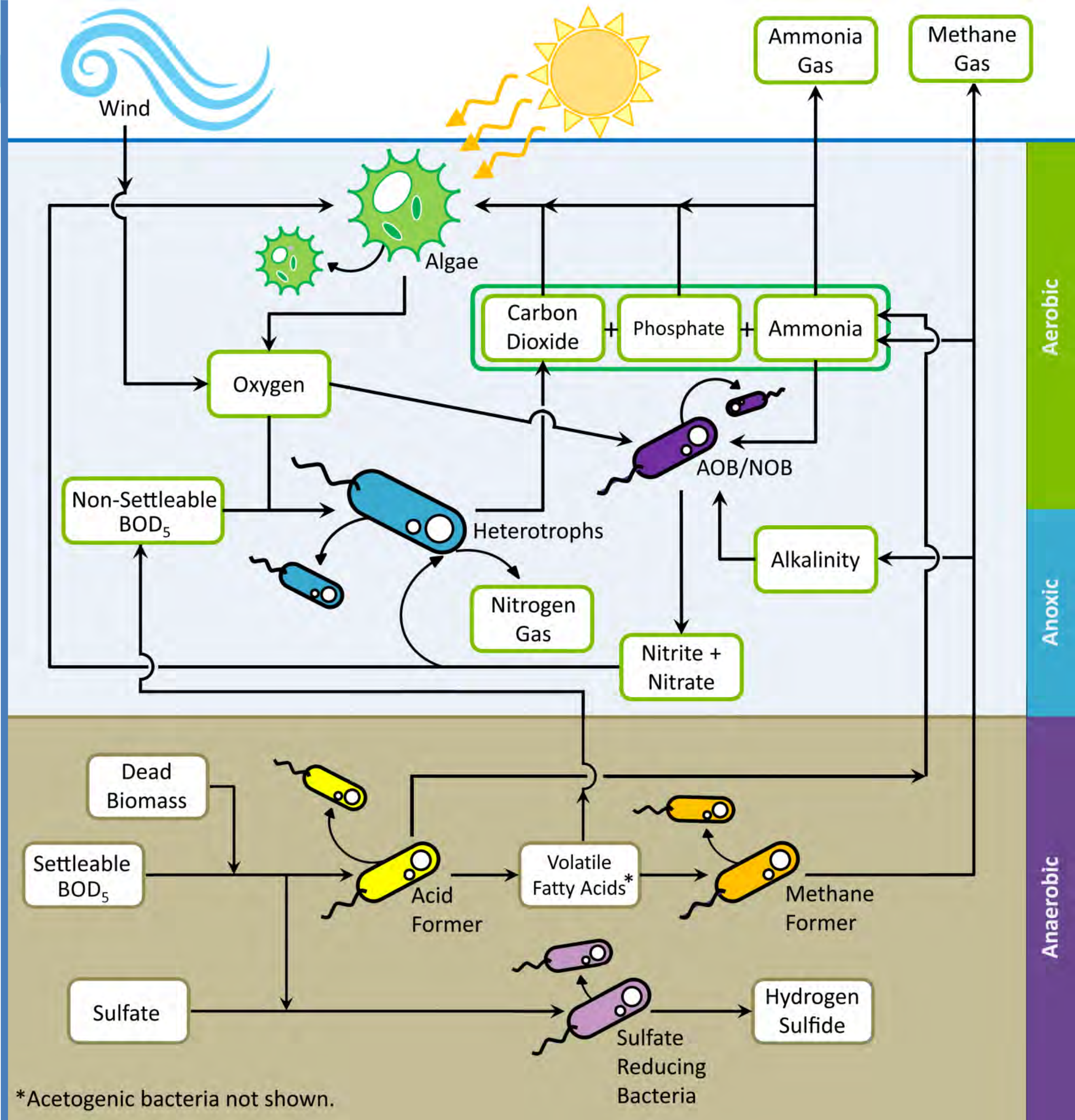
Real World Photos

All in full color!



Infographics

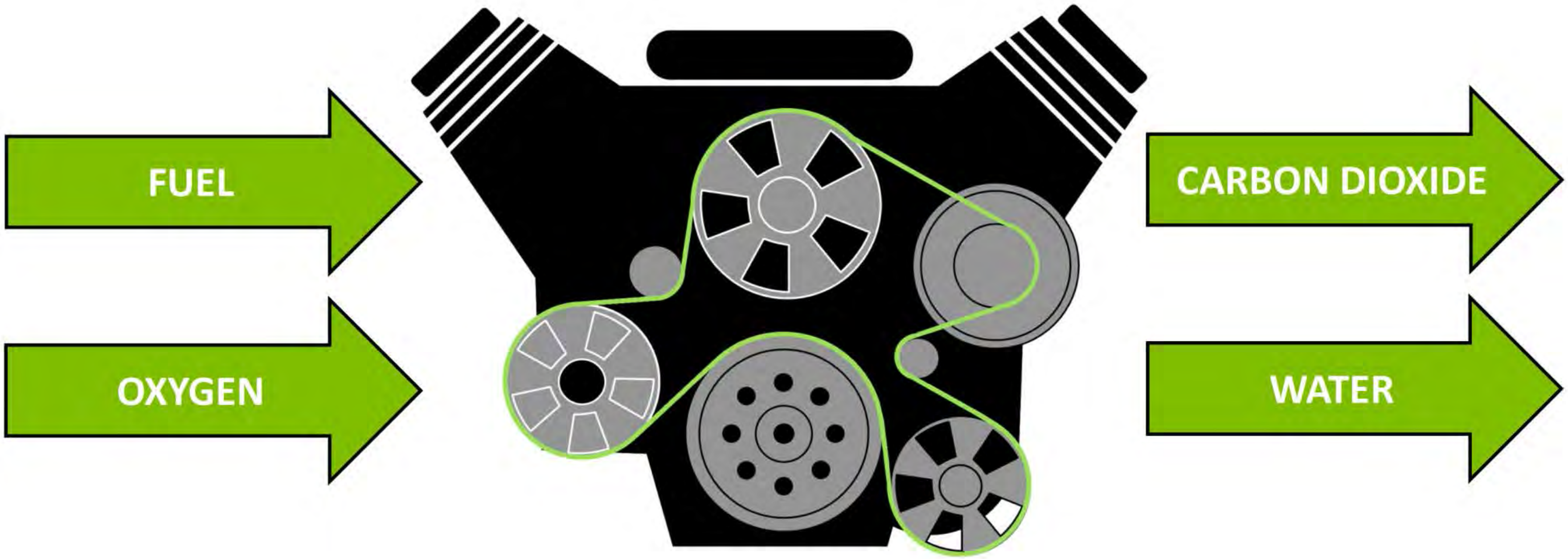
Pond Biology showing links between organisms



Accessible Language

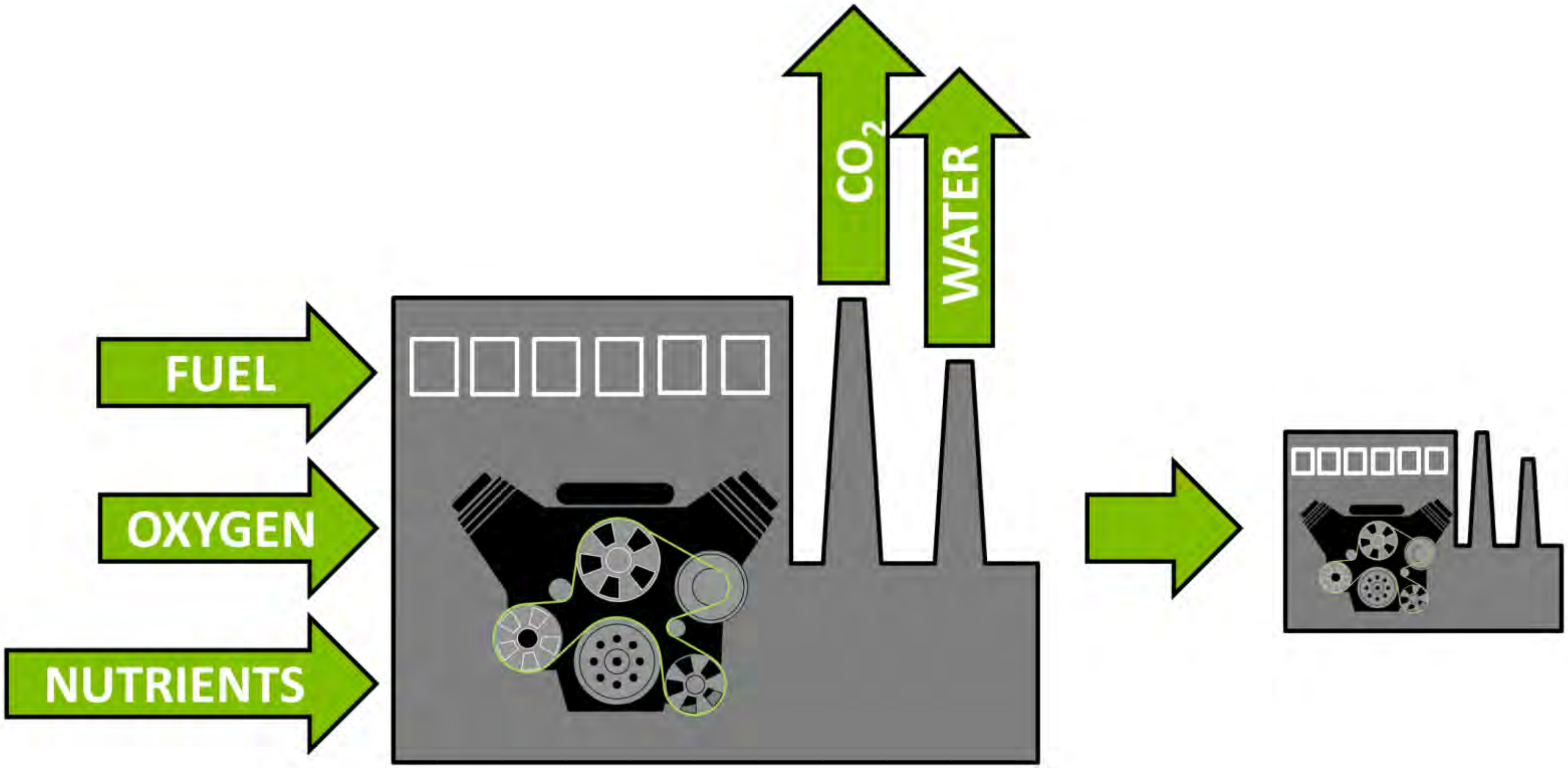
- Nitrification is the two-step biological oxidation of ammonia-nitrogen to nitrite and nitrate using oxygen as a terminal electron acceptor.
- Some bacteria obtain energy from ammonia (NH_3) or nitrite (NO_2). This process is called nitrification.

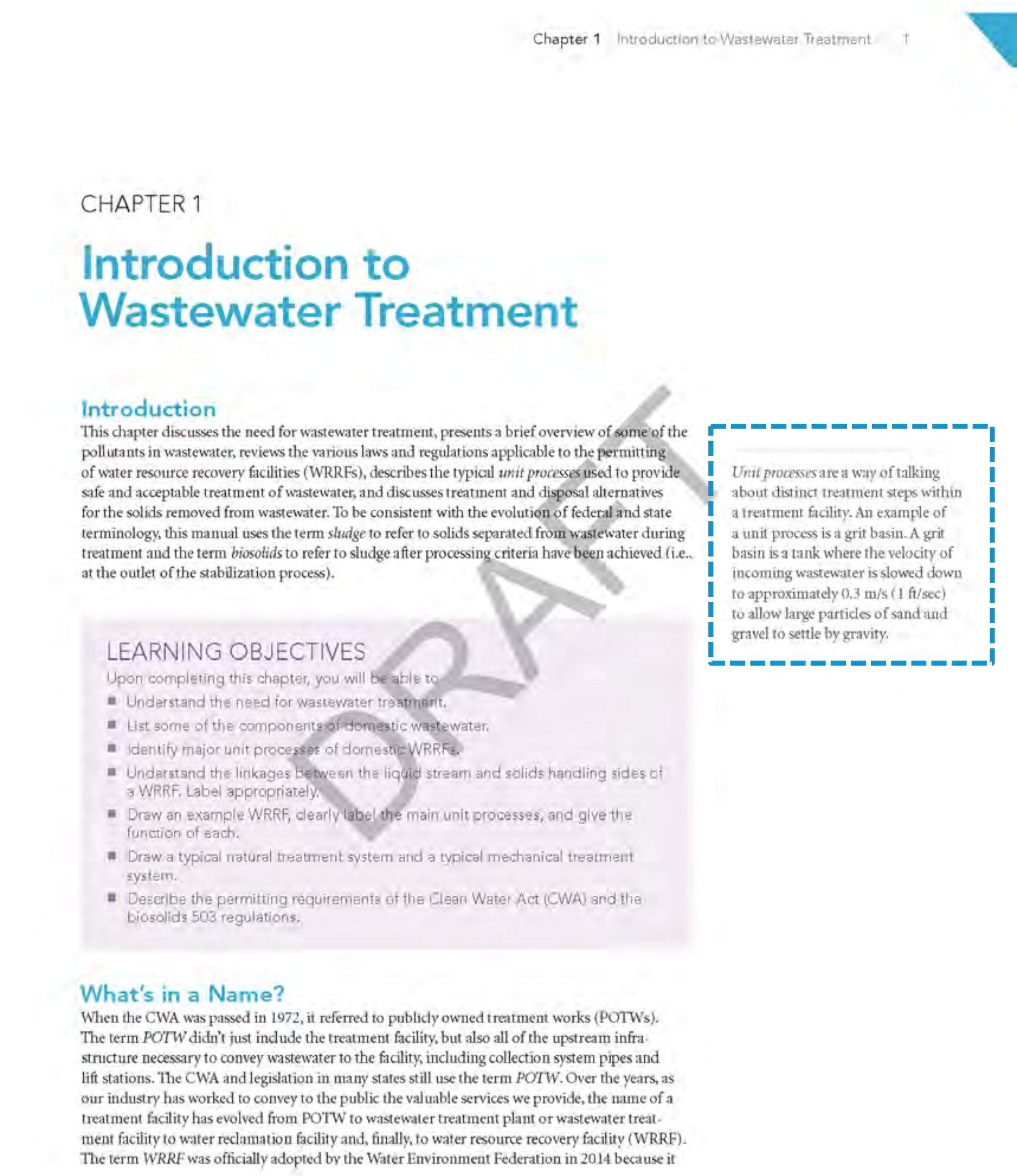
Relatable Analogies Explain Complex Topics



Water Environment Federation
the water quality people™

Bacteria as Combustion Engines





CHAPTER 1

Introduction to Wastewater Treatment

Introduction

This chapter discusses the need for wastewater treatment, presents a brief overview of some of the pollutants in wastewater, reviews the various laws and regulations applicable to the permitting of water resource recovery facilities (WRRFs), describes the typical *unit processes* used to provide safe and acceptable treatment of wastewater, and discusses treatment and disposal alternatives for the solids removed from wastewater. To be consistent with the evolution of federal and state terminology, this manual uses the term *sludge* to refer to solids separated from wastewater during treatment and the term *biosolids* to refer to sludge after processing criteria have been achieved (i.e., at the outlet of the stabilization process).

Unit processes are a way of talking about distinct treatment steps within a treatment facility. An example of a unit process is a grit basin. A grit basin is a tank where the velocity of incoming wastewater is slowed down to approximately 0.3 m/s (1 ft/sec) to allow large particles of sand and gravel to settle by gravity.

LEARNING OBJECTIVES

Upon completing this chapter, you will be able to

- 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.

What's in a Name?

When the CWA was passed in 1972, it referred to publicly owned treatment works (POTWs). The term *POTW* didn't just include the treatment facility, but also all of the upstream infrastructure necessary to convey wastewater to the facility, including collection system pipes and lift stations. The CWA and legislation in many states still use the term *POTW*. Over the years, as our industry has worked to convey to the public the valuable services we provide, the name of a treatment facility has evolved from POTW to wastewater treatment plant or wastewater treatment facility to water reclamation facility and, finally, to water resource recovery facility (WRRF). The term *WRRF* was officially adopted by the Water Environment Federation in 2014 because it

Definitions within Main Text Increase Readability

pH is expressed in standard units (SU)... Discussed in more detail in Chapter 2.

and willfully falsifies, conceals, or covers up a permit violation or misrepresents a permit violation with fraudulent statements. The permitting system depends on accurate self-monitoring and reporting. In addition to federal penalties, individual states may levy their own civil, administrative, or criminal penalties. It is worth noting that federal and state agencies understand that WRRFs will have occasional process upsets and discharge permit violations. A discharge permit violation typically does not result in a fine or penalty unless the discharger is a repeat offender or willful violator. The important thing for an operator is to fully disclose any violation, why it occurred, and how it will be prevented from occurring again in the future.

Concentrations of pollutants are typically expressed in µg/L (parts per billion) or mg/L (parts per million). Mass loading is the total amount of pollutant in kilograms or pounds.

The NPDES or SPDES permits typically specify the discharge location, the allowable discharge flows, the allowable *concentrations (mass loads) of pollutants* in the discharge, the limits of the mixing zone (if any), and facility-specific sampling, monitoring, and reporting requirements. The permit will also list the treatment capacity of the WRRF in terms of flow and organic load. Most discharge permits will require a WRRF to be in the planning stages for the next expansion when either the monthly flow or load reaches 80% of the permitted capacity and to be under construction when either the monthly flow or load reaches 95% of the permitted capacity. Before it can be discharged to U.S. waters, municipal wastewater must have received secondary treatment—or more stringent treatment if necessary to meet water quality standards. The secondary treatment standards are shown in Table 1.3 (40 CFR § 133.102). The effluent *pH* must be maintained between 6.0 and 9.0 standard units (SU). When establishing permit requirements for a WRRF, regulators may consider the following issues in addition to the minimum regulatory requirements:

pH is expressed in standard units (SU) and is the negative log of the hydrogen ion concentration. pH is discussed in more detail in Chapter 2.

1. Preventing disease,
2. Preventing nuisances,
3. Protecting drinking water supplies,
4. Conserving water,
5. Maintaining navigable waters,
6. Protecting waters for swimming and recreational use,
7. Maintaining healthy habitats for fish and other aquatic life, and
8. Preserving pristine waters to protect ecosystems.

If a WRRF is not designed to remove a particular pollutant from an *indirect discharger* or if a large enough quantity of a particular pollutant enters the WRRF, it may "pass through" the treatment process partially or completely untreated. The pretreatment program helps prevent these pollutants from entering the WRRF.

Permit applications and required reports must be signed by an authority state-licensed individual of responsible charge, a principal executive officer, or ranking elected official. According to 40 CFR 122.22, all permits and reports submitted by a corporation must be signed by a responsible corporate officer; those submitted by a partnership or sole proprietorship must be signed by one of the general partners; and those submitted by a municipality, state, federal, or other public agency must be signed by a principal executive officer or ranking elected official.

Water resource recovery facilities designed to handle 19 000 m³/d (5 mgd) or more (and smaller ones with *interference* and pass-through problems) must establish pretreatment programs to regulate industrial and other nondomestic wastes discharged into sewers. A pretreatment program

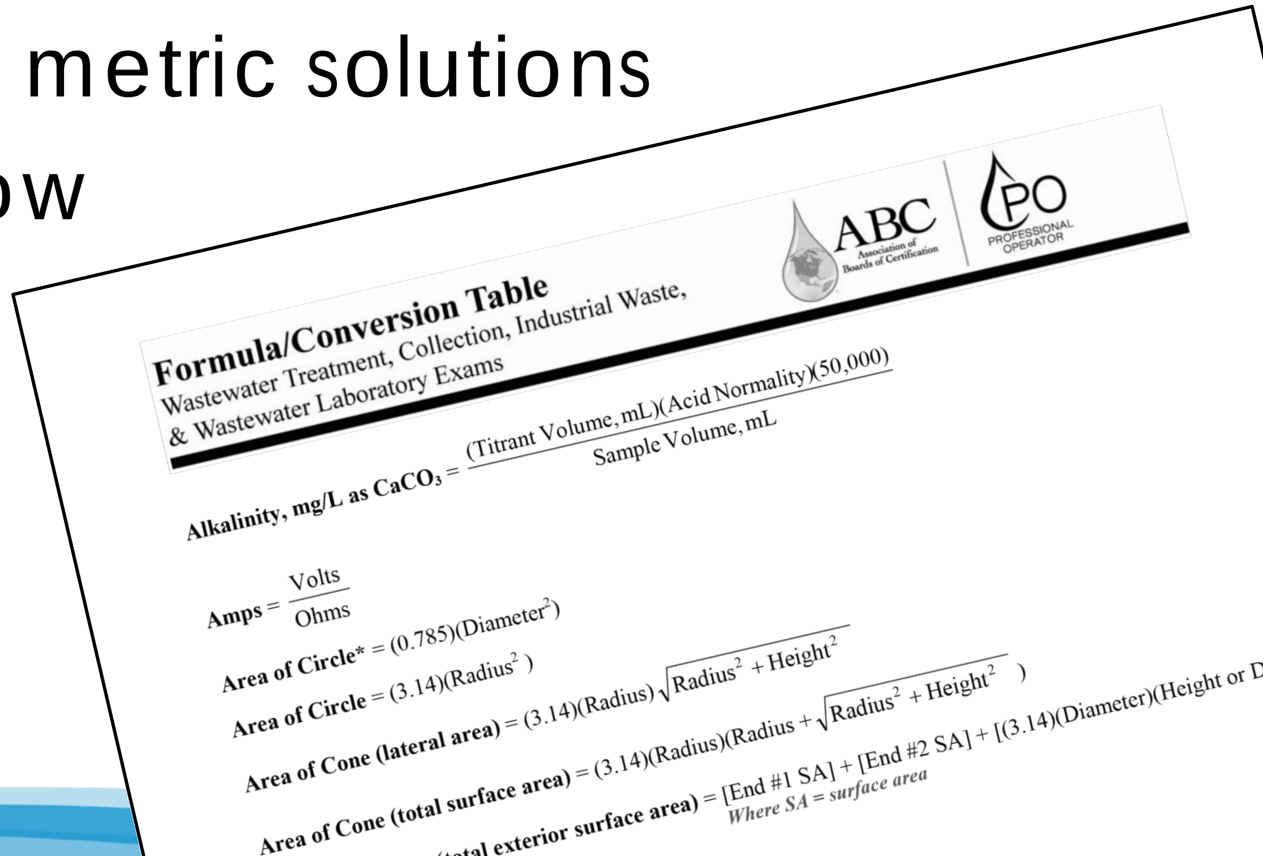
U.S. EPA defines *interference* as a discharge that inhibits or disrupts the WRRF, its treatment processes or operations, or its sludge processes, use, or disposal and, therefore, causes a violation of any requirement of the WRRFs discharge permit.

Table 1.3 Secondary Treatment Standards

	30-Day Average, mg/L	7-Day Average, mg/L	Minimum Percent Removal
BOD_5	30	45	85%
$cBOD_5$	25	40	85%
TSS	30	45	85%

Step-by-Step Math Examples

- Uses ABC formulas
- English and metric solutions
- Easy to follow


Formula/Conversion Table
Wastewater Treatment, Collection, Industrial Waste, & Wastewater Laboratory Exams

ABC Association of Boards of Certification

PO PROFESSIONAL OPERATOR

Alkalinity, mg/L as $CaCO_3$ $= \frac{(\text{Titrant Volume, mL})(\text{Acid Normality})(50{,}000)}{\text{Sample Volume, mL}}$

Amps $= \frac{\text{Volts}}{\text{Ohms}}$

Area of Circle* $= (0.785)(\text{Diameter}^2)$

Area of Circle $= (3.14)(\text{Radius}^2)$

Area of Cone (lateral area) $= (3.14)(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) $= (3.14)(\text{Radius})(\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$

...total exterior surface area) = [End #1 SA] + [End #2 SA] + [(3.14)(Diameter)(Height or D...

Where SA = surface area

Step 1 – Convert the influent flow from mgd to gpd.

$$\frac{7.5\ mil\ gal}{d}\left|\frac{1\,000\,000\ gal}{1\ mil\ gal}\right| = 7\,500\,000\ gal$$

Step 2 – Find the total surface area of the clarifiers.

$$\frac{2\ clarifiers}{}\left|\frac{7850\ sq\ ft}{1\ clarifier}\right| = 15\,700\ sq\ ft$$

Step 3 – Calculate the surface overflow rate.

$$Surface\ Overflow\ Rate, \frac{gpd}{sq\ ft} = \frac{Influent\ Flow, gpd}{Area,\ sq\ ft}$$

$$Surface\ Overflow\ Rate, \frac{gpd}{sq\ ft} = \frac{7\,500\,000\ gpd}{15\,700\ sq\ ft}$$

$$Surface\ Overflow\ Rate, \frac{gpd}{sq\ ft} = 478$$

Tons of Practice Questions!

- True/False
- Multiple Choice
- Fill in the Blank
- Matching
- Label a Diagram
- Perform Calculations

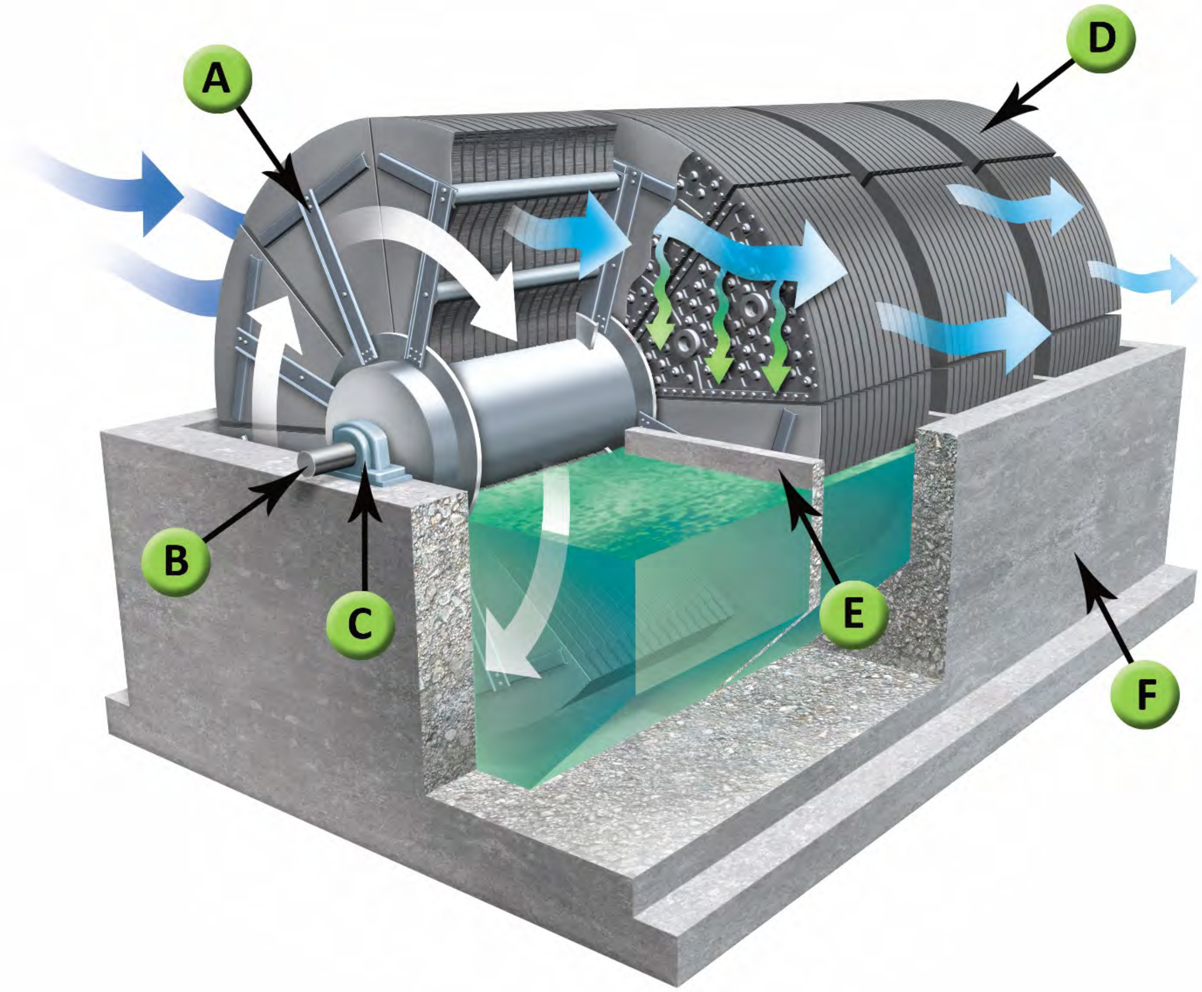
TEST YOUR KNOWLEDGE

13. This term is used to describe a collection of microorganisms growing on and attached to a media surface such as a rock.
    a. Floc
    b. Slime
    c. Biofilm
    d. Algae
14. In a pond treatment system, what is the purpose of the last pond in the series?
    a. Increases the risk of short-circuiting
    b. Removes the biological solids produced in the first two ponds
    c. Warms the wastewater before discharge
    d. Acts as a primary clarifier or grit basin
15. What is the primary difference between a pond treatment system and an activated sludge system?
    a. Activated sludge recycles settled solids to the beginning of the process.
    b. Pond treatment systems use specialized, cold-tolerant bacteria.
    c. Activated sludge systems use algae for treatment.
    d. Pond treatment systems perform better at higher elevation.
16. For an activated sludge system, which of the following statements is FALSE?
    a. Activated sludge requires less time to treat wastewater than ponds.
    b. Activated sludge is a suspended growth biological process.
    c. Activated sludge uses fungus to treat wastewater.
    d. Activated sludge holds the biological solids longer than the wastewater.
17. An example of a fixed-film treatment process is
    a. Activated sludge
    b. Pond
    c. Rotating biological contactor
    d. Clarifier
18. Which two methods of disinfection are most commonly used in domestic WRRFs?
    a. Ozone and chlorine
    b. Chlorine and UV light
    c. Bleach and ozone
    d. Ultraviolet light and boiling
19. Match the unit process to its place in the liquid treatment side.

1. Collection system	a. Pretreatment
2. Grit basin	b. Primary treatment
3. Primary clarifier	c. Disinfection
4. Activated sludge	d. Preliminary treatment
5. Chlorine addition	e. Secondary treatment

20. Draw a line from the liquid treatment type to its treatment goal.

1. Preliminary treatment	a. Reduce number of bacteria and pathogens
2. Primary treatment	b. Increase particle size for separation step
3. Secondary treatment	c. Protect downstream equipment
4. Tertiary treatment	d. Remove nitrogen and phosphorus
5. Disinfection	e. Decrease size and cost of secondary treatment



1. Shaft
2. Media Support
3. Bearing
4. Baffle
5. Tank
6. Media

Scenario Worksheets

- Real world operational problems.
- Complex solutions with multiple steps.
- Operator must draw conclusions from chapter material and apply.

Sample Worksheet Scenario

- A small activated sludge facility can only control their wasting pump by manually turning it on and off. This means the operator must walk across the site each time they want to waste. The same operator also operates the water treatment plant and must frequently be away from the WRRF in the middle of the day. If they collect samples of the MLSS and RAS early in the morning, the laboratory can have results back by 2 pm each day. What can this operator do to make sure he wastes enough each day without overwasting?

Sample Worksheet Scenario

- A ski resort has an activated sludge process. The SRT is currently at 12 days and the MLSS concentration is 1800 mg/L. The resort has been open since September, but Christmas break is coming up in a few weeks, which is when they have the most visitors. The operator is concerned because the influent BOD_5 load will increase when all of the visitors show up. They don't think they have enough MLSS to maintain an F/M ratio of 0.2 kg BOD_5/kg MLVSS•d (0.2 lb BOD_5/lb MLVSS•d). The operator decides to decrease their wasting rate so they can build up their inventory before the new BOD_5 arrives. Was this the right decision? Why or why not?

Quick Reference Guides

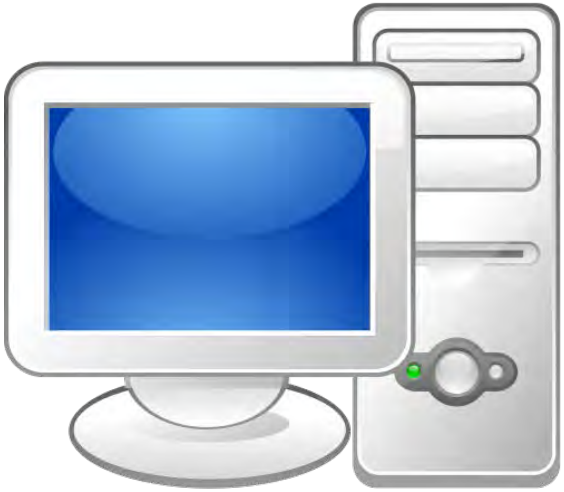
- Summary table ends every chapter
- Bulleted lists of main points by section
- Helps operators target areas for review
- Reinforces learned concepts
- Targeted refresher prior to exams

CHAPTER SUMMARY

	Liquid Treatment Processes	Solids Treatment Processes	
REGULATIONS	1. Clean Water Act amended 1972. 2. All dischargers must have a permit. 3. Sets secondary treatment standards of 30 mg/L each for BOD_5 and TSS and 25 mg/L for CBOD. 4. Direct dischargers are permitted by U.S. EPA or their state agency. 5. Indirect dischargers are permitted by the WRRF. 6. Depends on self-monitoring with monthly reports.	1. The Standards for the Use or Disposal of Sewage Sludge, also known as the 503 regulations, were promulgated in 1993. 2. Applies to the use or disposal of biosolids when they are land applied. 3. Sets standards for Class A and Class B biosolids. 4. Limits concentrations of heavy metals and other chemical compounds in biosolids. 5. Requires pathogen reduction and vector attraction reduction before land application.	REGULATIONS
PRELIMINARY	1. Physical treatment process. 2. Takes place at WRRF headworks. 3. Removes large debris to protect downstream processes and equipment. 4. May include screening, grit removal, flow measurement, and/or flow equalization. 5. Volume of screenings and grit produced is service-area dependent.	1. Physical treatment process. 2. Reduces the total volume of sludge by removing water. Polymer addition may be necessary. 3. Thickened sludges are typically between 2 and 8% total solids. 4. Takes place before sludge stabilization. 5. Many different technologies are available, including DAFTs, rotary drum thickeners, gravity belt thickeners, and others.	THICKENING
PRIMARY	1. Physical treatment process. 2. Decreases velocity of wastewater to remove settleable and floatable material. 3. May use gravity or flotation. 4. Reduces the size and cost of operation of secondary treatment processes. 5. Cannot remove colloidal material, soluble BOD, soluble phosphorus, or ammonia.	1. Biological or chemical treatment process. 2. Converts sludge to biosolids. 3. Reduces pathogens. 4. Biological treatment consists of aerobic or anaerobic digestion. Either method can reduce the total mass of biosolids by 40%. 5. Biological treatment can reduce the volatile solids content by as much as 50%.	STABILIZATION

Companion On-Line Training Course

- Interactive training follows and compliments text
- Modules completed in small sections as time allows.
- Randomly generated final exam from extensive question bank
- Course time and progress validated for awarding CEUs
- SCORM compliant



Influent Flow

Figure 2.1 shows an influent flow pattern for a community of approximately 20 000 residents. Notice that there are two distinct high points on the graph, the first appearing at about 10:00 a.m. and the second appearing at about 9:00 p.m. The first high point is larger. This is the peak hour flow or the highest hourly flow that occurs over a 24-hour period. Even though most of the residents in this community began going about their day at about the same time, the wastewater they generated did not make an instant appearance in the influent to the WRRF. It takes time for the flow to travel through the collection system.

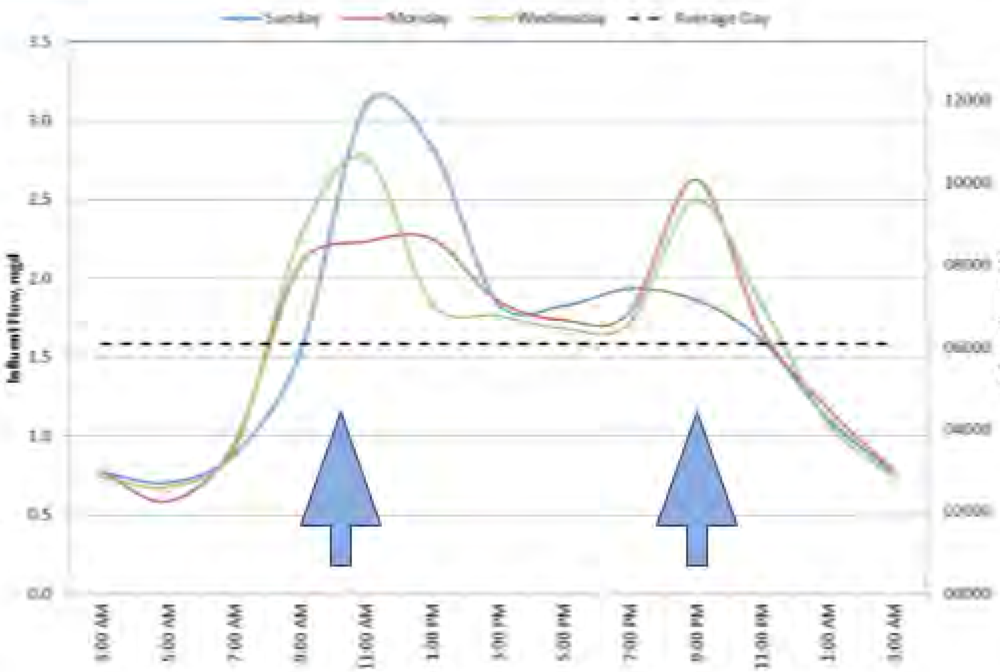


Figure 2.1 Diurnal Flow Pattern for a City with 20,000 Residents (Reprinted with permission by Indigo Water Group)

Water Environment Federation
the water quality people™

Water

Municipal wastewater contains various wastes; it typically consists of approximately 99.94% liquid and 0.06% solids.

A typical U.S. city, including its private dwellings, commercial establishments, and industrial contributors, produces between 379 and 455 L/d·person (100 and 120 gpd/person) of wastewater-not including the water that infiltrates and exfiltrates the collection system.

Infiltration

Infiltration refers to groundwater that enters the sewer through cracks in pipes and manholes.

Inflow

Inflow refers to groundwater, rain, and surface water that enter the sewer through direct openings such as open-drain cleanouts.

Exfiltration

Exfiltration can occur when the groundwater level falls below the sewer. In this case, wastewater can seep out of pipes and into the ground.

Per person water usage has been decreasing, particularly in the western United States, because of a combination of conservation, installation of water-saving fixtures, and modernization of sewer systems with plastic pipe.

A survey of 12 western cities with 1,188 homes measured median indoor water use between 204 and 241 L/d·person (54.0 and 63.8 gpd/person); however, this does not include contributions from commercial or industrial users (U.S. EPA, 2005).

Headworks Example

An example of a WRRF headworks is shown in Figure 1.4. Any given WRRF headworks may have all, some, or none of the unit processes shown in Figure 1.4. The individual unit processes may also be arranged in a different order, with flow measurement coming before screening and grit removal, for example.

In the example headworks shown in Figure 1.4, the first unit process is a screen. Screens remove larger debris and may have openings as small as a few millimeters or as wide apart as 5 cm (2-in.).

Select each of the arrows below to learn more.

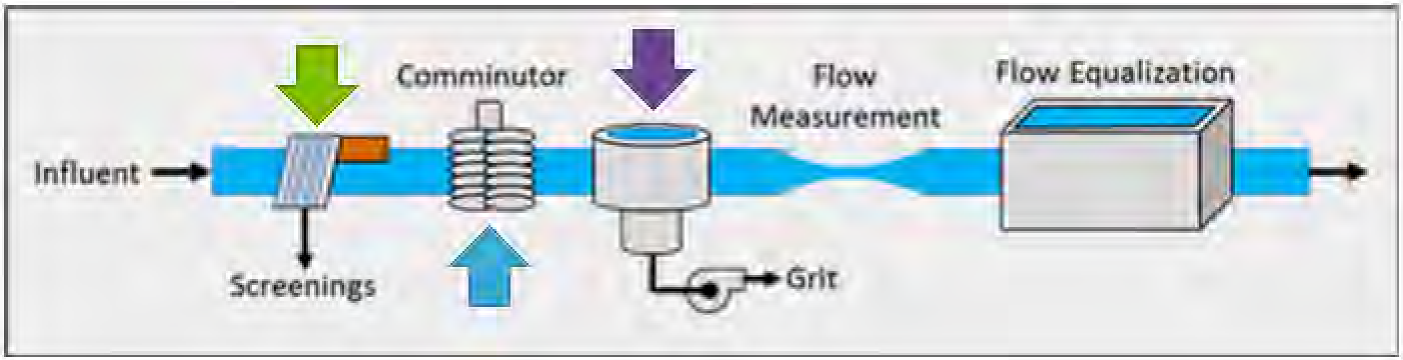


Figure 1.4 Typical WRRF headworks

WEF Seeking Training Unit Approvals