# Delegated Agency Training
# October 28, 2024
# by Raymond Morgan, PE

Organic, Nitrogen, and Hydraulic Loading of a Single Family Residence Onsite Wastewater Treatment Facility

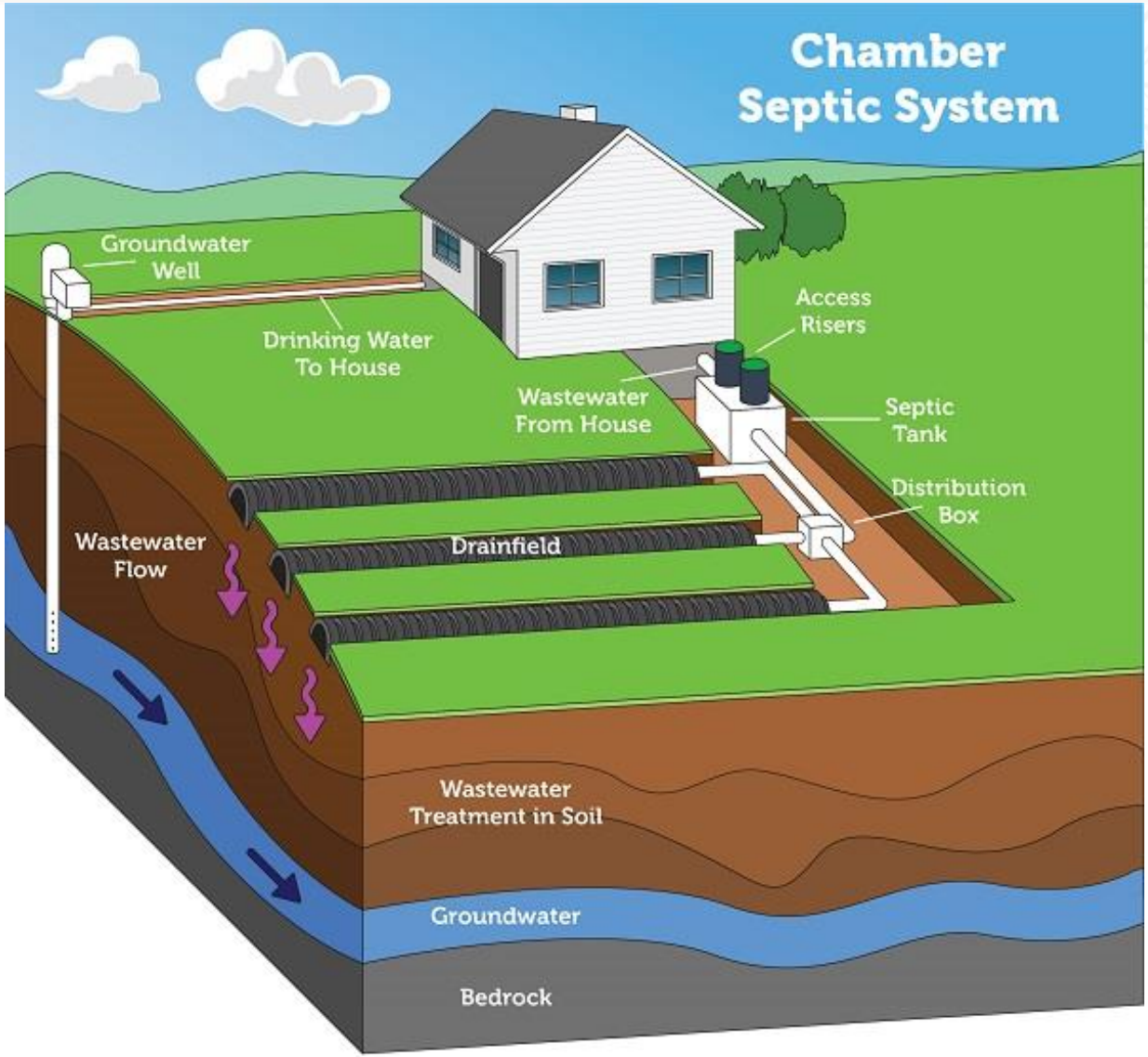
As-Built Construction Submittal Clarification

Site Inspection and Construction Inspection Clarification

ADEQ Arizona Department of Environmental Quality

Clean Air, Safe Water, Healthy Land for Everyone

# Organic, Nitrogen, and Hydraulic Loading




Please note: The ends of the chamber system lines are open for illustrative purposes only. In reality, and when properly installed, these lines are closed at the end. Septic systems vary. Diagram is not to scale.

## Wastewater Treatment Definition

In its simplest form, wastewater treatment is simply a process which removes contaminants from wastewater. It converts the wastewater into an effluent that can be discharged to the ground surface or subsurface as long as it meets certain quality standards. Ultimately, the treatment process's goal is to protect the environment and the public health from the detrimental effects of contaminated water. The wastewater effluent may be reused in some cases with proper treatment.

## Aerobic Biotransformation

In order to convert organic matter into inorganic matter, you need a combination of oxygen plus aerobic microorganisms.

The following chemical equation illustrates this process:

Organic Carbon + Oxygen + Microorganisms → Energy + Carbon Dioxide + Water + Residue

## Organic Matter

- Contains more than
  - Carbon
  - Hydrogen
  - Oxygen
- Can also contain
  - Nitrogen
  - Phosphorus
  - Sulfur
  - Many other compounds

## Nitrogen Cycle

- Nitrogen is a component of protein
  - ❖ As protein is degraded, nitrogen is released
  - ❖ Nitrogen converts to ammonia/ammonium
  - ❖ Process of ammonification then takes place

Organic – N + Microorganisms → Ammonia/Ammonium

## Biological Nitrification

- Ammonia/ammonium is then converted to nitrite and nitrate
  - ❖ Nitrification
  - ❖ Oxygen demand
- Nitrification is a two-step autotrophic process
  - ❖ Autotrophs are organisms that can produce their own food, using materials from inorganic sources.
  - ❖ The conversion from ammonium to nitrate

Step 1: $NH_4^+ + 3/2O_2 + \text{Nitrosomonas} \rightarrow NO_2^{2-} + 2H^+ + H_2O$

Step 2: $NO^{2-} + 1/2O_2 + \text{Nitrobacter} \rightarrow NO^{3-}$

## Denitrification

- $NO_3^-$ can be reduced,
  - ❖ Under anoxic conditions, to $N_2$ gas through heterotrophic biological denitrification
  - ❖ You need two conditions for this to take place
    - ➢ Anoxic conditions
    - ➢ Heterotrophic bacteria
      - ▪ A heterotroph is an organism that cannot make its own food and gets its nutrition from other sources of organic carbon, such as plants or animals.

# Organic, Nitrogen, and Hydraulic Loading

**Given:**

1. Three-bedroom single family residence
2. Design flow – 450 gpd
3. Treatment System (Option A) – Septic Tank Only
4. Treatment System (Option B) – Septic Tank followed by an Aerobic Treatment Unit (ATU)
5. Typical sewage values for a residence –
   a. BOD5 – 380 mg/l
   b. TSS – 430 mg/l
   c. Total Nitrogen (TN) – 53 mg/l
   d. FOG – 75 mg/l
6. Septic Tank (Type 4.02 Permit) Effluent Standards
   a. BOD5 – 150 mg/l
   b. TSS – 75 mg/l
   c. TN – 53 mg/l
7. Type 4.15 Permit Effluent Standards
   a. BOD5 – 30 mg/l
   b. TSS – 30 mg/l
   c. TN – 53 mg/l Normal Use Area
   d. TN – 15 mg/l Nitrogen Management Area

# Organic, Nitrogen, and Hydraulic Loading

8. Brand X ATU (Type 4.15 Permit)
    a. BOD5 – 4 mg/l
    b. TSS – 5 mg/l
    c. TN – 17 mg/l
9. Brand X ATU National Sanitation Foundation (NSF) 245 Report
    a. BOD5
        1) Influent – 240 mg/l
        2) Effluent – 4 mg/l
        3) Removal – 236 mg/l
    b. TN
        1) Influent – 38 mg/l
        2) Effluent – 17 mg/l
        3) Removal – 21 mg/l

# Organic, Nitrogen, and Hydraulic Loading

**Calculations:**

1. **Organic Loading**
   a. **Treatment Plant (TP)** – (Design Flow gpd/1000,000 gpd/MGD) x 8.34 x Concentration in mg/l = #/d BOD5) (450 gpd/1,000,000 gpd/MGD) x 8.34 x 236 (240-4) mg/l = 0.89 #/d BOD5
   b. **Design Loading 1** – (450 gpd/1,000,000 gpd/MGD) x 8.34 x 350 (380-30) mg/l = 1.31 #/d BOD5
   c. % of Actual Loading = 1.31/0.89 = 1.47 = ***147% of actual capacity***
   d. **Design Loading 2** – (450 gpd/1,000,000 gpd/MGD) x 8.34 x 210 (240-30) mg/l = 0.79 #/d BOD5
   e. % of Actual Loading = 0.79/0.89 = 0.89 = ***89% of actual capacity***

# Organic, Nitrogen, and Hydraulic Loading

f. **Design Loading 3** – ((56 gpd x 2 people) /1,000,000 gpd/MGD) x 8.34 x 350 (380-30) mg/l = 0.33 #/d BOD5

g. % of Actual Loading = 0.33/0.89 = 0.37 = ***37% of actual capacity***

h. **Design Loading 4** – (0.17 #/p/d x 2 people) = 0.34 #/d BOD5

i. % of Actual Loading = 0.34/0.89 = 0.38 = ***38% of actual capacity***

j. **Design Loading 5** – ((56 gpd x 6 people) /1,000,000 gpd/MGD) x 8.34 x 350 (380-30) mg/l = 0.98 #/d BOD5

k. % of Actual Loading = 0.98/0.89 = 1.10 = ***110% of actual capacity***

l. **Design Loading 6** – (0.17 #/p/d x 6 people) = 1.02 #/d BOD5

m. % of Actual Loading = 1.02/0.89 = 1.15 = ***115% of actual capacity***

# Organic, Nitrogen, and Hydraulic Loading

**D. Nitrogen Management Area requirements**. Within a Nitrogen Management Area:

1. The Department shall issue a Construction Authorization, under R18-9-A301(D)(1)(c), for an on-site wastewater treatment facility only if the applicant proposes, in the Notice of Intent to Discharge, to employ one or more of the technologies allowed under R18-9-E302 through R18-9-E322 that achieves a discharge level containing not more than 15 mg/l of total nitrogen.

# Organic, Nitrogen, and Hydraulic Loading

**Calculations:**

1. Nitrogen Loading In a Nitrogen Management Area
   a. **Treatment Plant (TP)** – (450 gpd/1,000,000 gpd/MGD) x 8.34 x 21 (38-17) mg/l = 0.08 #/d TN
   b. **Design Loading 1** – (450 gpd/1,000,000 gpd/MGD) x 8.34 x 38 (53 - 15) mg/l = 0.14 #/d TN
   c. % of Actual Loading = 0.14/0.08 = 1.75 = ***175% of actual capacity***
   d. **Design Loading 2** – ((56 gpd x 2 people) /1,000,000 gpd/MGD) x 8.34 x 17 (38-21) mg/l = 0.02 #/d TN
   e. % of Actual Loading = 0.02/0.08 = 0.25 = ***25% of actual capacity***

# Organic, Nitrogen, and Hydraulic Loading

f. **Design Loading 3** – ((56 gpd x 6 people) /1,000,000 gpd/MGD) x 8.34 x 17 (38-21) mg/l = 0.05 #/d TN

g. % of Actual Loading = 0.05/0.08 = 0.625 = ***62% of actual capacity***

**h. Design Loading 4** – ((56 gpd x 6 people) /1,000,000 gpd/MGD) x 8.34 x 32 (53-21) mg/l = 0.09 #/d TN

i. % of Actual Loading = 0.09/0.08 = 0.625 = ***112% of actual capacity***

**j. Design Loading 5** – (0.0333 #/p/d x 2 people) = 0.07 #/d TN

k. % of Actual Loading = 0.07/0.08 = 0.875 = ***88% of actual capacity***

**l. Design Loading 6** – (0.0333 #/p/d x 6 people) = 0.20 #/d TN

m. % of Actual Loading = 0.20/0.08 = 2.50 = ***250% of actual capacity***

# Organic, Nitrogen, and Hydraulic Loading

I. NSF 245 Assumptions
   1) Minimum Influent Alkalinity > 175 mg/l
      - Actual - 290 mg/l in the influent and 170 mg/l in the effluent
      - NSF will supplement with sodium bicarbonate to maintain the minimum influent alkalinity.
   2) Minimum Influent Carbon to Nitrogen ratio of 5:1
      - NSF will use carbon supplementation if needed to maintain this ratio.

# Organic, Nitrogen, and Hydraulic Loading

**Calculations:**

1. Hydraulic Loading
    a. Refer to Table in R18-9-A314.4.a.i.

| Criteria for Septic Tank Size and Design Flow | | | |
|---|---|---|---|
| **Number of Bedrooms** | **Fixture Count** | **Minimum Design Liquid Capacity (gallons)** | **Design Flow (gal/day)** |
| 1 | 7 or less | 1000 | 150 |
| | More than 7 | 1000 | 300 |
| 2 | 14 or less | 1000 | 300 |
| | More than 14 | 1000 | 450 |
| 3 | 21 or less | 1000 | 450 |
| | More than 21 | 1250 | 600 |
| 4 | 28 or less | 1250 | 600 |
| | More than 28 | 1500 | 750 |

# Organic, Nitrogen, and Hydraulic Loading

- Questions?

# As-Built Construction Submittal Clarification

**R18-9-A301.D.** Type 4 General Permit review.

1. Pre-construction phase and facility construction. A person shall not begin facility construction until the Director issues a Construction Authorization.
   a. Inspection. The Department may inspect the facility site before construction to determine that the applicable terms of the general permit will be met.

e. Construction.

i. A person shall complete construction within two years of receiving a Construction Authorization.

ii. Construction shall conform with the plans and documents approved by the Department in the Construction Authorization. A change in location, configuration, dimension, depth, material, or installation procedure does not require approval by the Department if the change continues to conform with the specific standard in this Article used as the basis for the original design.

iii. The person shall record all changes made during construction, including any changes approved under R18-9-A312(G) on the site plan as specified in R18-9-A309(C)(1) or on documents as specified in R18-9-A309(C)(2) or R18-9-E301(E), as applicable.

# As-Built Construction Submittal Clarification

**R18-9-A309.C.** Additional requirements for a Request for Discharge Authorization and for the issuance of a Discharge Authorization under a Type 4 General Permit.

Please note that the A.A.C language states that “additional requirements” are found in R18-9-A309.C. Some people have tried to interpret R18-9-A309.C in such a way as to exclude the statements made in R18-9-A301.D.e.

# As-Built Construction Submittal Clarification

1. At what point in time does the designer of an OWTF need to submit proposed design changes to the permitting agency after that agency has issued a construction authorization?
    a. The answer to this question depends on the nature of the proposed design changes. Some changes do not require a prior approval. They only require an as-built of the changes meeting the AAC's standards. The following changes are covered by this section of the AAC:
        1) Location
        2) Configuration
        3) Dimension
        4) Depth
        5) Material
        6) Installation procedure
    b. A change in technology requires the prior approval of the permitting agency before construction occurs to implement this design change. Notice that technology is not listed in the allowable changes.

# As-Built Construction Submittal Clarification

2. Are there limits on how much change in location is permissible? Yes.
    a. All design work must be done in accordance with R18-9-A312.A.2. The designer is to "Locate and design the onsite wastewater treatment facility using good design judgment and relies on appropriate design methods and calculations."
    b. A permitting agency may have an ordinance that places a specific limit on how far an OWTF is moved from the original design location.
    c. The original site investigation report may give some information about how much the site conditions change between different locations on the overall property.

# As-Built Construction Submittal Clarification

- Questions?

# Site Inspection and Construction Inspection Clarification

**R18-9-A301.D.** Type 4 General Permit review.

1. Pre-construction phase and facility construction. A person shall not begin facility construction until the Director issues a Construction Authorization.
   a. Inspection. The Department may inspect the facility site before construction to determine that the applicable terms of the general permit will be met.

2. Post-construction phase.
   a. Inspection. The Department may inspect the facility before issuing a Discharge Authorization to determine whether:
      i. The construction conforms with the design authorized by the Department under subsection (D)(1)(c) and any changes recorded on the site plan as specified in R18-9-A309(C)(1) or other documents as specified in R18-9-A309(C)(2), or R18-9-E301(E), as applicable; and
      ii. Terms of the general permit and applicable terms of this Article are met.

# Acknowledgements

Some of the information shared in this presentation was obtained from an EPA funded presentation that Dr. John Buchanan of the University of Tennessee gave on the subject of Wastewater Basics.

ADEQ
Arizona Department
of Environmental Quality

Clean Air, Safe Water,
Healthy Land for Everyone