Lafayette College
Department of Civil and Environmental Engineering

CE 321: Introduction to Environmental Engineering and Science **Fall 2019**

Homework #9
Due: Friday, 11/15/19
SOLUTIONS

1) Differentiate between water quality regulations and drinking water regulations. Briefly review the evolution of the water quality regulations in the United States.

2) A water sample is found to contain the following:
   pH = 8.2
   Na^{+} = 14 mg/L
   Ca^{+2} =15 mg/L
   Mg^{+2} = 12 mg/L
   Sr^{+2} = 2 mg/L
   K^{+} = 13 mg/L
   HCO_3^{-} = 80 mg/L
   NO_3^{-} = 9 mg/L
   Cl^{-} = 28 mg/L
   SO_4^{-2} = 45 mg/L
   What is the TDS, conductivity, and alkalinity of this sample. Express your alkalinity result as mg/L of $CaCO_3$.

3) A water treatment plant has reported that a TC test has come up positive (20 colonies counted). What does this mean and what do the technicians need to do? Explain you answer in detail, including an explanation of the reported 20 colonies.

4) Jerome Thumbly, a new C.E. student at Lafayette, has conducted a solids test on a water sample. From his data find the TOTAL FILTERABLE SOLIDS of the sample.

Test No. 1 (Total Solids Data):
Sample = 500 ml.
Tare wt. = 18.428 g
weight @ 105ºC = 18.947 g
weight @ 550ºC = 18.928 g

Test No. 2 (Suspended Solids Data):
Sample = 500 ml.
Tare wt. = 17.921 g (Gooch crucible w/fritted glass disk)
weight @ 105ºC = 18.243 g
weight @ 550ºC = 18.238 g

5) What is the drinking water standard for turbidity based on the most current EPA drinking water regulations (include the web-page information). – Provide information from CFR.

Name Kathy Delsener
Course CE-321
Subject HW # 8
Date 11/11/11
Sheet 1 of 7

1. Differentiate between water quality regulations and drinking water regulations. Briefly review the evolution of the water quality regulations in the United States

There are many differences between water quality regulations and drinking water regulations. Water quality regulations protects the water that has been used by humans, which is then cleaned by a wastewater treatment plant and then released back into a river These regulations are different than the ones in place for the water that people drink, which are covered by the drinking water regulations.

Physicians, like John Snow, discovered early in 1854 that water could cause illness to its drinkers if not treated corrected. It wasn't until 1912, however, that the first water treatment was mandated, requiring filtering and chlorination at all water treatment plants on the federal level. After the Public Health Service Act in the early 1900s there was break in any legislation until the 1970s, where they established a maximum containment level of hazardous substances and then ten years later they started instigating lead free pipes. Now environmental engineers are much more vigilant about the quality of water and regulations are constantly getting updated.

Unlike drinking water regulations, water quality regulations were not created until many years later. Society had very few concerns about the quality of water that they were not drinking so no one paid attention certain rivers. I wasn't until the ships could not move in New York Harbor that people started realizing the effects of their actions. In 1899 people were no longer to dump solid waste into rivers or harbors, but it wasn't until 1924 people started thinking about wastewater treatments plants. Finally in 1972 the Water Pollution Control Act was written that put much more money into wastewater treatments plants. Slowly the US government revised and added amendments to the act, which has formed it to the value that it is today.

2. A water sample. What is the TDS, conductivity, and alkalinity.

known

pH = 8.2

Na^+ = 14 mg/L
Ca^{+2} = 15 mg/L
Mg^{+2} = 12 mg/L
Sr^{+2} = 2 mg/L
K^+ = 13 mg/L

HCO_3^- = 80 mg/L
NO_3^- = 9 mg/L
Cl^- = 28 mg/L
SO_4^{-2} = 45 mg/L

Find:
a) TDS
b) Conductivity
c) alkalinity (mg/L of $CaCO_3$)

Assumptions:
No other reactions, sources.

Solutions:

a) TDS = sum of ions (in mg/L)

TDS = 14 mg/L + 15 mg/L + 12 mg/L + 2 mg/L + 12 mg/L + 80 mg/L + 9 mg/L + 28 mg/L + 45 mg/L = **218 mg/L**

b) $TDS = \frac{\text{Conductivity}}{x}$ ∴ Conductivity = TDS × x

TDS in mg/L
x = 1.8
Conductivity = µs/cm

Conductivity = (218 mg/L)(1.8)
Conductivity = **392.4 µs/cm**

c) Alkalinity | pH = 8.2 ∴ Alk is HCO_3^-

HCO_3^- = 80 mg/L

$EW_{HCO_3^-} = \frac{61 \text{ g/mol}}{1 \text{ eq/mol}} = 61 \text{ g/eq. } HCO_3^-$

$EW_{CaCO_3} = \frac{100 \text{ g/mol}}{2 \text{ eq/mol}} = 50 \text{ g/eq } CaCO_3$

$Alk = 80 \frac{mg}{L} HCO_3^- \left(\frac{50 \text{ g/eq } CaCO_3}{61 \text{ g/eq } HCO_3^-} \right) =$ **65.57 mg/L $CaCO_3$**

3. A water treatment plant has reported that a TC test has come up positive (20 colonies counted). What does this mean and what do the technicians need to do? Explain you answer in detail, including an explanation of the reported 20 colonies.

   Indicator organisms, such as coliforms are used to indirectly test for the possibility that pathogens (disease causing agents) may be present in a sample of water. An ideal indicator organism should be able to survive under a greater variety of conditions than the pathogen it is being used to test for so that it will always be present when the pathogen is present. As a result, the presence of the indicator does not imply that the pathogen is present, but merely the possibility that it is present.

   When we report coliforms we report as "# of Colonies/100 ml of sample", therefore 20 colonies in a Total Coliform (TC) test refers to "20 Colonies/100 ml". The EPA recommends a Total Coliform count of zero for drinking water. The standard mandated by the EPA is slightly less strict:

   > No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli if two consecutive TC-positive samples, and one is also positive for E.coli fecal coliforms, system has an acute MCL violation.
   > – (http://water.epa.gov/drink/contaminants/index.cfm#4)

   In order to more accurately determine if pathogens are in fact present in the water, more extensive testing should be done, beginning with Fecal Coliform (FC) Tests and additional Total Coliform Tests. This will also help the plant to comply with the EPA's standards.

   If this was a sample of the Plant's effluent, a boil-water-notice should be issued (as a precaution, and for legal reasons), and a serious investigation should be conducted to determine why the plant's chlorination system is not functioning properly. If the sample was taken from the plant's influent, the technicians should test the plant's effluent. Presumably, the plant was designed to remove coliforms from the water. If these coliforms are not being removed, then the plant may need to be redesigned to meet the EPA's specifications. For example, they might need to increase the length of their Clearwell or use more chlorine.

4.

GIVEN: JEROME THOMBLY, A NEW C.E. STUDENT AT LAFAYETTE, HAS CONDUCTED A SOLIDS TEST ON A WATER SAMPLE.

TEST No. 1 (TOTAL SOLIDS DATA)

SAMPLE = 500mL
TARE WT. = 18.428g
WEIGHT@105°C = 18.947g
WEIGHT@550°C = 18.928g

TEST No. 2 (SUSPENDED SOLIDS DATA)

SAMPLE = 500mL
TARE WT. = 17.921g (GOOCH CRUCIBLE)
WEIGHT@105°C = 18.243g
WEIGHT@550°C = 18.238g

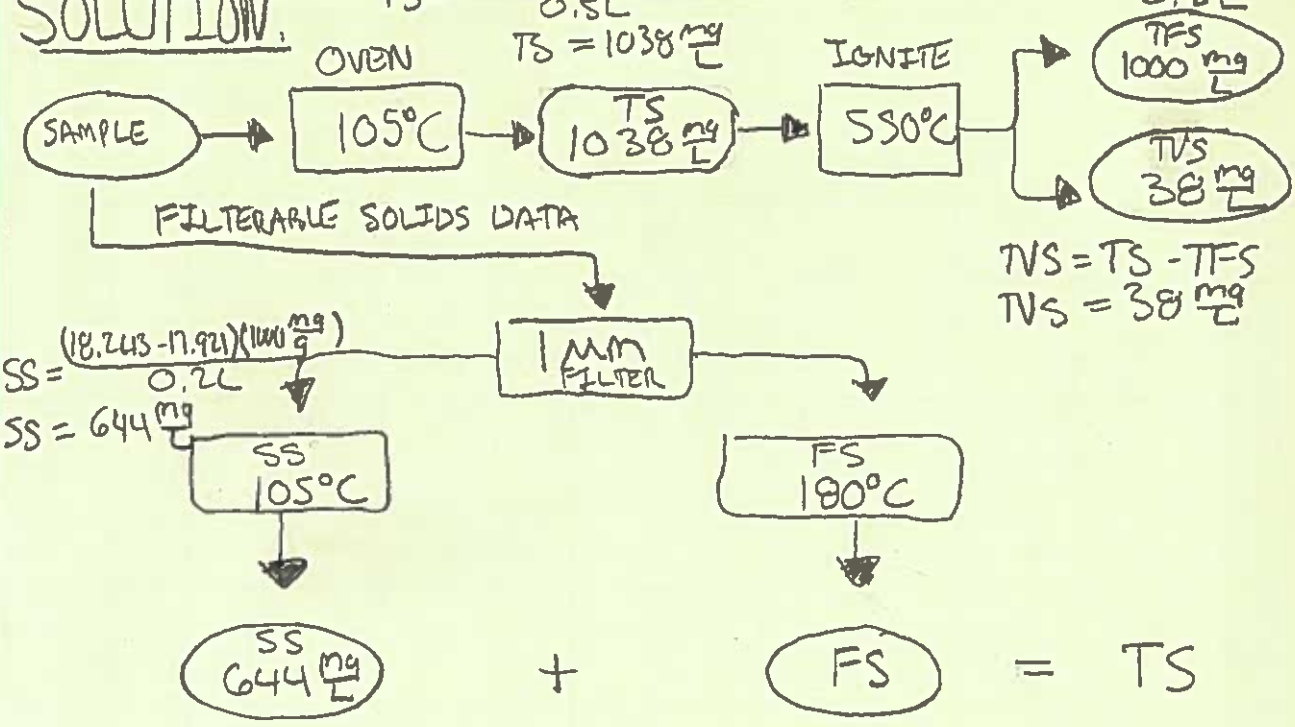
FIND: THE TOTAL FILTERABLE SOLIDS.

SOLUTION:

$$TS = \frac{(18.947 - 18.428)(g)\left(\frac{1000mg}{1g}\right)}{0.5L}$$

$$TS = 1038\ \frac{mg}{L}$$

$$TFS = \frac{(18.928 - 18.428)\left(\frac{1000mg}{1g}\right)}{0.5L}$$



$$TVS = TS - TFS$$
$$TVS = 38\ \frac{mg}{L}$$

$$SS = \frac{(18.243 - 17.921)(1000\frac{mg}{g})}{0.2L}$$

$$SS = 644\ \frac{mg}{L}$$

$$FS = TS - 644 = 1038 - 644$$

$$FS = 394\ \frac{mg}{L}$$

4. Problem: A student has conducted a solids test on a water sample.

Find: The total filterable solids of the sample.

Knowns:

Test #1 (Total Solids Data)
sample: 500 mL
Tare wt: 18.428g
Weight @ 105°C = 18.947g
weight @ 550°C = 18.928g

Test #2 (Suspended solids data)
sample: 500 mL
Tare wt = 17.921 (Gooch Crucible w/ fritted disk)
weight @ 105°C = 18.243g
weight @ 550°C = 18.238g

Solution: Flow chart on next page.

① Total Solids (TS):
weight @ 105°C − Tare wt → 18.947g − 18.428g = 0.519g
$= \frac{519\,mg}{0.5\,L} = 1038\,mg/L$

② Total Fixed Solids (TFS):
weight @ 550°C − Tare wt → 18.928g − 18.428g = 0.500g
$= \frac{500\,mg}{0.5\,L} = 1000\,mg/L$

③ Total Volatile Solids (TVS):
Total Solids (TS) − Total Fixed Solids (TFS) → 1038 mg/L − 1000 mg/L =
= 38 mg/L

④ Suspended Solids (SSS):
weight @ 105°C (SS) − Tare wt (SS) → 18.243g − 17.921g = 0.322g
$= \frac{322\,mg}{0.5\,L} = 644\,mg/L$

⑤ Filterable Solids (FS):
Total Solids − Suspended Solids → 1038 mg/L − 644 mg/L
= 394 mg/L

⑥ Fixed Suspended Solids (FSS)
weight @ 550°C (SS) − Tare wt (SS) → 18.238g − 17.921g = 0.317g
$= \frac{317\,mg}{.5} = 634\,mg/L$

⑦ Volatile Suspended Solids (VSS)
Suspended Solids − Fixed Suspended Solids → 644 mg/L − 634 mg/L =
= 10 mg/L

4. (continued):

⑧ Volitile Filterable Solids (VFS) =
Total Volatile Solids − Volatile Suspended Solids → 38 mg/L − 10 mg/L =
= 28 mg/L

⑨ Fixed Filterable Solids (TFS)
Total Fixed Solids − Fixed Suspended Solids → 1000 mg/L − 634 mg/L =
= 366 mg/L

Total Filterable Solids: 394 mg/L

Total Solids Worksheet

LAFAYETTE COLLEGE ENGINEERING DIVISION

Name Kathy Delsener
Subject HW# 8

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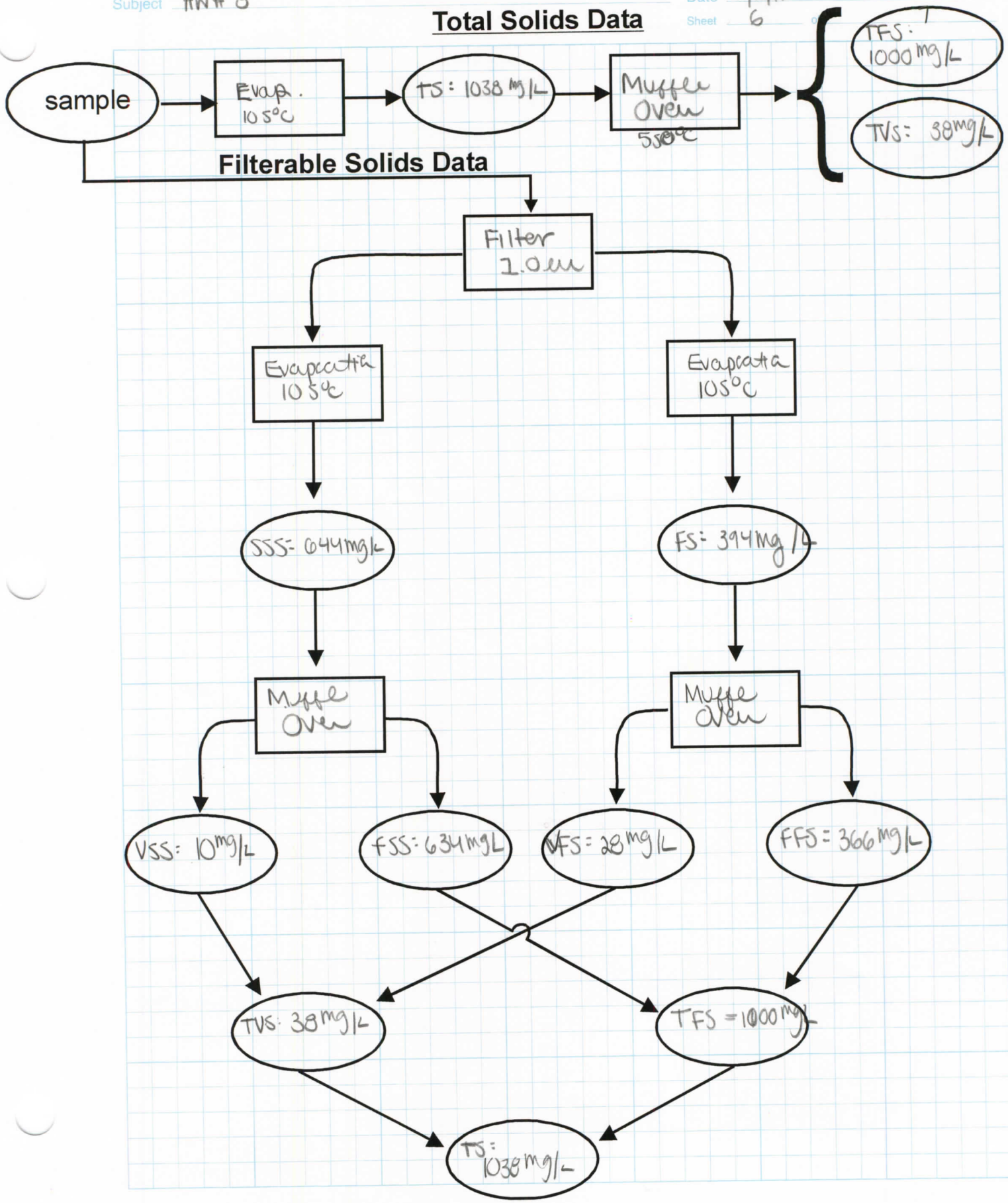

5) What is the drinking water standard for turbidity based on the most current EPA drinking water regulations (including the web-page information). Provide information from CFR.

According to the EPA, "Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches."

The EPA states that for turbidity, "for systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 Nephelometric Turbidity Unit (NTU), and sample for turbidity must be less than or equal to 0.3 NTUs in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow states limits, which must include turbidity at no time exceeding 5 NTUs." (https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf)

The CFR or Code of Federal Regulations states that the National Primary Drinking Water Regulations are in Part 141 (http://www.ecfr.gov/cgi-bin/text-idx?SID=adfc892d28fb0d80234db91adcac5724&mc=true&node=se40.25.141_113&rgn=div8):

§ 141.13 Maximum contaminant levels for turbidity.
The maximum contaminant levels for turbidity are applicable to both community water systems and non-community water systems using surface water sources in whole or in part. The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system, are:
(a) One turbidity unit (TU), as determined by a monthly average pursuant to § 141.22, except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not do any of the following:
(1) Interfere with disinfection;
(2) Prevent maintenance of an effective disinfectant agent throughout the distribution system; or
(3) Interfere with microbiological determinations.
(b) Five turbidity units based on an average for two consecutive days pursuant to § 141.22.
[40 FR 59570, Dec. 24, 1975]
Editorial Note:
At 54 FR 27527, June 29, 1989, § 141.13 was amended by adding introductory text; however, the amendment could not be incorporated because introductory text already exists.

#5 (continued)

For reference:
§ 141.22 Turbidity sampling and analytical requirements.
The requirements in this section apply to unfiltered systems until December 30, 1991, unless the State has determined prior to that date, in writing pursuant to section 1412(b)(7)(iii), that filtration is required. The requirements in this section apply to filtered systems until June 29, 1993. The requirements in this section apply to unfiltered systems that the State has determined, in writing pursuant to section 1412(b)(7)(C)(iii), must install filtration, until June 29, 1993, or until filtration is installed, whichever is later.
(a) Samples shall be taken by suppliers of water for both community and non-community water systems at a representative entry point(s) to the water distribution system at least once per day, for the purposes of making turbidity measurements to determine compliance with § 141.13. If the State determines that a reduced sampling frequency in a non-community will not pose a risk to public health, it can reduce the required sampling frequency. The option of reducing the turbidity frequency shall be permitted only in those public water systems that practice disinfection and which maintain an active residual disinfectant in the distribution system, and in those cases where the State has indicated in writing that no unreasonable risk to health existed under the circumstances of this option. Turbidity measurements shall be made as directed in § 141.74(a)(1).
(b) If the result of a turbidity analysis indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be confirmed by resampling as soon as practicable and preferably within one hour. If the repeat sample confirms that the maximum allowable limit has been exceeded, the supplier of water shall report to the State within 48 hours. The repeat sample shall be the sample used for the purpose of calculating the monthly average. If the monthly average of the daily samples exceeds the maximum allowable limit, or if the average of two samples taken on consecutive days exceeds 5 TU, the supplier of water shall report to the State and notify the public as directed in § 141.31 and subpart Q.
(c) Sampling for non-community water systems shall begin within two years after the effective date of this part.
(d) The requirements of this § 141.22 shall apply only to public water systems which use water obtained in whole or in part from surface sources.
(e) The State has the authority to determine compliance or initiate enforcement action based upon analytical results or other information compiled by their sanctioned representatives and agencies.
[40 FR 59570, Dec. 24, 1975, as amended at 45 FR 57344, Aug. 27, 1980; 47 FR 8998, Mar. 3, 1982; 47 FR 10998, Mar. 12, 1982; 54 FR 27527, June 29, 1989; 59 FR 62466, Dec. 5, 1994; 65 FR 26022, May 4, 2000]