

BINDER FOR OUTCOME "1"

*"An ability to identify, formulate, and solve complex engineering problems
by applying principles of engineering, science, and mathematics."*

**COLLEGE OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**

**BINDER CONTAINING REPRESENTATIVE
ASSIGNMENTS FROM ALL COURSES USED TO
ASSESS OUTCOME "1"**

Academic Years 2019-2020, 2020-2021, 2021-2022

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 - CVEG 3083/3305 Steel Design**
 - CVEG 4043/4301 Environmental Engineering Design**
 - CVEG 4053/4302 Transportation Engineering Design**
 - CVEG 4063/4303 Water Resources Engineering**
 - CVEG 4482/4201 Sr. Design & Professionalism II**

2. Description of Outcome "1" and its Performance Criteria

Outcome 1:

An ability to identify, formulate and solve complex engineering problems by applying the principles of engineering, science, and mathematics

Sub-Outcomes and Performance Criteria

- 1.1: Identify & Formulate CEP (i-vi) based on Engineering , Science , and Mathematics
- 1.2: Solve CEP (i-vi) based on Engineering , Science , and Mathematics

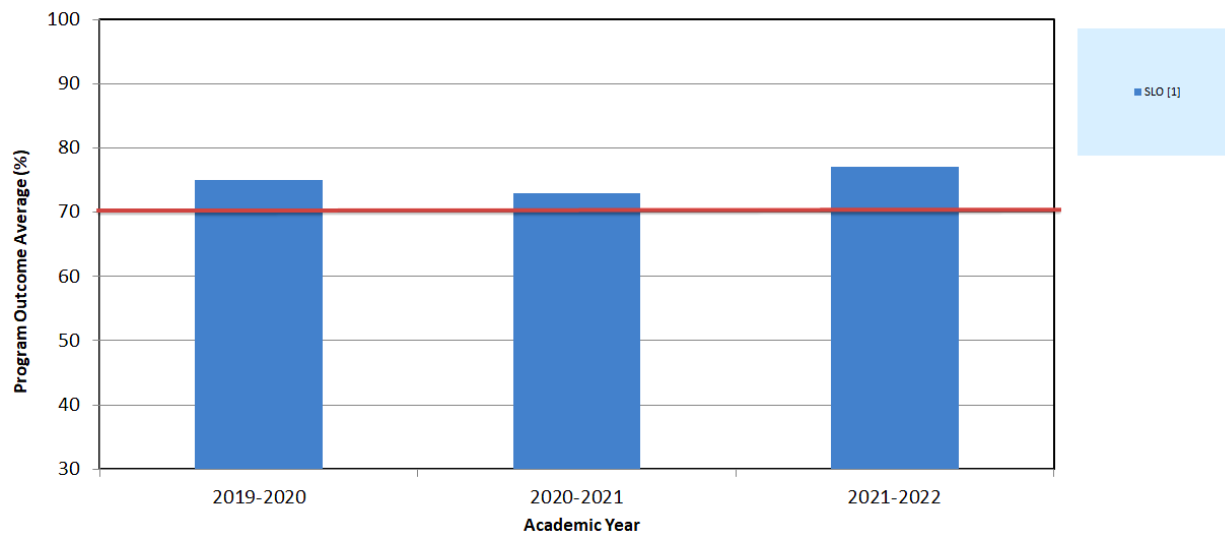
3. List of Courses Used to Assess the Outcome

Outcome 1 is assessed in the following courses:

CVEG 3083/3305 Steel Design
CVEG 4043/4301 Environmental Engineering Design
CVEG 4053/4302 Transportation Engineering Design
CVEG 4063/4303 Water Resources Engineering
CVEG 4482/4201 Sr. Design & Professionalism II

4. Summary Assessment Results and Continuous Improvements for Outcome “1” over the Assessment Years.

The direct average performance for all students in the 5 courses used to assess outcome 1 for the past three academic years are shown below



5. Problems identified and recommended actions to be taken to address problems

1. At the course level

Problems Identified in the Various Courses	Recommended Actions Taken	Basis for Action
1. Students struggled with various aspects of the term project scope of work and the constraints in CVEG 4053. 2. Students have difficulty comprehending given problem, break it down in manageable modules, identify variables and solve for unknowns in CVEG 4043. 3. Few students had problems in systematically approaching and solving problems in CVEG 4063. 4. It was observed in CVEG 4482 that some students were not able to recollect methods learned in pre-requisite courses to identify and solve problems of the capstone design project. When proper help was given, student performance enhanced.	(1) Present the students with case studies involving design performance of work in order to develop their reading comprehension skills in CVEG 4053 (2) Emphasize problem solving skills in CVEG 4043 that students should have learned in pre-requisite classes. Develop one or two problem solving sessions that highlight these skills. (3) Broke down the class lectures in CVEG 4063 into smaller modules to help students better comprehend the complex topics. (4) The interaction in CVEG 4482 with professional practitioner as guest lecturer, guidance and evaluation throughout the semester was very beneficial. This may be continued, if possible, by the involvement of the Industrial Advisory Committee members and recent graduates.	To support continuous improvement and meet the Departmental target direct average of 70%

2. At Department Level

- (1) Faculty enforced students to study the review material by considering assignments and quizzes from those materials.
- (2) Faculty simplified some of the problematic topics and implemented more straightforward approaches instead of just focusing on suggested questions and approaches from textbook.

Basis of Action:

To support continuous improvement and meet the Departmental target direct average of 70%

6. Sample Assignments and Justification of suitability of assignment for measuring the outcome in the following courses:

CVEG 3083 Steel Design

CVEG 4043 Environmental Engineering Design

CVEG 4053 Transportation Engineering Design

CVEG 4063 Water Resources Engineering

CVEG 4482 Sr. Design & Professionalism II

**OUTCOME “1” SPECIFIC ASSIGNMENTS
USED TO ASSESS THE OUTCOME IN**

**CVEG 3083
STEEL DESIGN**

OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

CVEG 3083-Steel Design
Instructor: Dr. Abdul M Choudhury

Title of Assignment

Homework #3

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Brief justification of the suitability of this assignment for the outcome

The questions on this section of the Homework show student's ability to solve problems in steel design
By applying engineering, mathematical and scientific concepts

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT
CVEG 3083- STEEL DESIGN
COURSE ASSIGNMENT GRADING
AND OUTCOME ASSESSMENT SHEET

ASSIGNMENT TITLE: Homework # 3

DUE DATE: 03/07/2021 _____ DATE SUBMITTED: 03/07/2021
Name of Student: Zain qureshi

Title of Assignment: ___Analysis of compression member

Competency Area	Max for this Assignment	Student's Score
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	100	100
TOTAL	100	100

**Prairie View A&M University Department of Civil and
Environmental Engineering**

Homework Assignment 3

Submitted by: Zain Qureshi

Class: CVEG 3083 Steel Design

Date: 4/07/2021

100
100
Good

5-5) $F_y = 50 \text{ ksi}$



Using Table 4-1 for W12x50

$A_g = 14.6 \text{ in}^2$

$r_x = 1.96 \text{ in}$

Slenderness ratio: $\frac{KL}{r} = \frac{0.8 \times 25 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}}}{1.96 \text{ in}} = 122.45$

 $K=0.8$ since both ends are non-slender and stiffenedTable 4-22: Using interpolation $\phi_c F_c = 15.07 \text{ ksi}$

$ASD = \frac{10.03}{\text{ksi}} F_c / \Omega_c$

$y = y_1 + \frac{(y_2 - y_1)}{(x_2 - x_1)} \times (x - x_1)$

$\phi P_n = \phi_c F_c \times A_g = 15.07 \text{ ksi} \times 14.6 \text{ in}^2$

$\frac{P_n}{\Omega} = \frac{F_c}{\Omega_c} \times A_g = 10.03 \text{ ksi} \times 14.6 \text{ in}^2$

$\phi P_n = 220.02 \text{ K}$

$\frac{P_n}{\Omega} = 146.44 \text{ K}$

Table 4-1:

$L_c = KL = 0.8 \times 25 \text{ ft} = 20$

$ASD = 146 \text{ K}$
 $LRFD = 220 \text{ K}$

AISC Eq. 3: slenderness ratio = 122.45

3-4: $F_e = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2} = \frac{\pi^2 \times 29,000 \text{ ksi}}{122.45^2} = 19.09 \text{ ksi}$

3-2: $4.71 \times \sqrt{\frac{E}{F_y}} = 4.71 \times \sqrt{\frac{29,000 \text{ ksi}}{50 \text{ ksi}}} = 113.43 < \frac{L_c}{r} = 122.45$

$F_c = 0.658^{F_y/F_e} \times F_y = 0.658^{\frac{50 \text{ ksi}}{19.09 \text{ ksi}}} \times 50 \text{ ksi} = 16.7 \text{ ksi}$

LRFD: $\phi_c F_c = 0.9 \times 16.7 \text{ ksi} = 15.04 \text{ ksi}$

ASD: $\frac{16.7 \text{ ksi}}{1.67} = 10 \text{ ksi} \times 14.6 \text{ in}^2$

$\phi_c P_n = \phi_c F_c A_g = 15.04 \text{ ksi} \times 14.6 \text{ in}^2$

$\phi_c P_n = 219.5 \text{ K}$

$146 \text{ K} = \frac{P_n}{\Omega_c}$

5-(b)

11.7 in



W8x40

15'

using Table 4-1: $A_g = 11.7 \text{ in}^2$ $r_{min} = 2.04 \text{ in}$ $K = 1.0$ since both ends can rotate freely.

$$\frac{KL}{r} = \frac{1.0 \times 15 \text{ ft} \times 12 \text{ in}}{2.04 \text{ in}} = 88.24$$

Table 4-22: using interpolation $\phi_c F_{cr} = 25.43 \text{ ksi}$

$$\frac{F_{cr}}{\Omega_c} = 16.95 \text{ ksi}$$

LRFD: $\phi P_n = \phi_c F_{cr} \times A_g$

$$= 25.43 \text{ ksi} \times 11.7 \text{ in}^2 = \boxed{297.53 \text{ K}}$$

$$\text{ASD: } \frac{P_n}{\Omega} = \frac{F_{cr}}{\Omega_c} \times A_g = 16.95 \text{ ksi} \times 11.7 \text{ in}^2 = \boxed{198.32 \text{ K}}$$

Table 4-1: $K \times L = 1.0 \times 15 \text{ ft} = 15 \text{ ft}$

ASD: 198 K

LRFD: 298 K

$$\text{AISC Eq. 3: } 3-4: F_c = \frac{2^2 \times 29000 \text{ ksi}}{88.24^2} = 36.8 \text{ ksi}$$

$$3-2: 4.71 \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 113.43 > \frac{KL}{r} = 88.24$$

$$F_{cr} = 0.658^{88.24^2} \times 50 \text{ ksi} = 29.31 \text{ ksi}$$

$$\text{LRFD: } \phi_c F_{cr} = 0.9 \times 29.31 \text{ ksi} = 26.38 \text{ ksi}$$

$$\phi P_n = 26.38 \text{ ksi} \times 11.7 \text{ in}^2 = \boxed{308.65 \text{ K}}$$

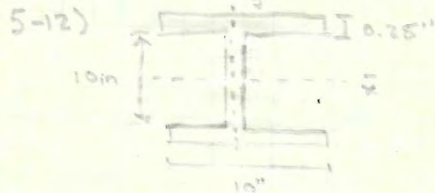
$$\text{ASD: } \frac{29.31 \text{ ksi}}{1.67} = 16.95 \text{ ksi} \times 11.7 \text{ in}^2 = \boxed{198.3 \text{ K}} = \frac{P_n}{\Omega_c}$$

5-9) W10x77, $L_c = K \times L = 20ft$

Using Table 4-1

LRFD: $\phi P_n = 548k$

ASD: $\frac{P_n}{\Omega_c} = 365k$



$$A_g = L \times t = (10 \text{ in} \times 0.25 \text{ in}) \times 2$$

$$A_g = 7.5 \text{ in}^2$$

$$d = \frac{t}{2} + \frac{L}{2} = \frac{0.25 \text{ in}}{2} + \frac{10 \text{ in}}{2} = 5.125 \text{ in}$$

$$I_{xx} = 2 \times \left[\frac{(10 \text{ in} \times (0.25 \text{ in})^3)}{12} \right] + 2 \left(0.25 \text{ in} \times (5.125 \text{ in})^2 \right) + \left(\frac{0.25 \text{ in} \times (10 \text{ in})^3}{12} \right)$$

$$I_{xx} = 152.19 \text{ in}^4$$

$$I_{yy} = 2 \times \left[\frac{(0.25 \text{ in} \times 10 \text{ in}^3)}{12} \right] + \left(10 \text{ in} \times \frac{0.25 \text{ in}^3}{12} \right) = 41.68 \text{ in}^4$$

$$r_{min} = \sqrt{\frac{I_{yy}}{A_g}} = \sqrt{\frac{41.68 \text{ in}^4}{7.5 \text{ in}^2}} = 2.36 \text{ in} \rightarrow \frac{K L}{r} = \frac{1.0 \times 15 \text{ ft} \times 12 \text{ in}}{2.36 \text{ in}} = 76.27$$

LRFD: Using Table 4-14, $\phi F_{cr} = 23.25 \text{ ksi}$; $F_{cr} = 15.27$

$$\phi P_n = \phi F_{cr} \times A_g = 23.25 \text{ ksi} \times 7.5 \text{ in}^2 = 178.88 k$$

Found
using
interpolation

$$\text{ASD: } \frac{P_n}{\Omega_c} = \frac{F_{cr}}{\Omega_c} \times A_g = 15.27 k \times 7.5 \text{ in}^2 = 119.03 k$$

OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

CVEG 3083-Steel Design
Instructor: Dr. Abdul M Choudhury

Title of Assignment

Homework #4

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Brief justification of the suitability of this assignment for the outcome

The questions on this section of the Homework show student's ability to solve problems in steel design
By applying engineering, mathematical and scientific concepts

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT
CVEG 3083- STEEL DESIGN
COURSE ASSIGNMENT GRADING
AND OUTCOME ASSESSMENT SHEET

ASSIGNMENT TITLE: Homework # 4

DUE DATE: 04/13/2021 _____ DATE SUBMITTED: 04/13/2021
Name of Student: Nathaniel Smith & Dekaylan Senegal

Title of Assignment: ___Analysis of compression member

Competency Area	Max for this Assignment	Student's Score
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	100	95
TOTAL	100	95

Prairie View A&M University



CVEG 3083-Z01 Steel Design

Homework #4:

Due April 13, 2021

Submitted by: Group 9 members: Nathaniel Smith and Dakaylon Senegal

Submitted to: Dr. Choudhury

Scanned with CamScanner

SCORE 95/100

6.-1 Given: $P_D = 150k$

$$P_L = 230k$$

$$L_C = 18ft$$

A992

Grade 50 steel

Find: Lightest available W12 section

$$F_y = 50ksi$$

LRFD

$$P_u = 1.2(150k) + 1.4(230k) = 502k$$

$$\text{Assume } \frac{L_c}{r} = 50$$

$$\phi_c F_{cr} \xrightarrow{\text{Table 4-22}} 37.5 ksi$$

$$A = \frac{P_u}{\phi_c F_{cr}} = \frac{502}{37.5} = 13.4 in^2$$

$$\text{Try W12} \times 65 (A = 19.1 in^2, r_y = 3.02 in)$$

$$\frac{L_c}{r} = \frac{18(12)}{3.02} = 71.5$$

$$\phi_c F_{cr} = 31.1 + (71.5 - 71) \left(\frac{30.8 - 31.1}{72 - 71} \right) = 30.95 ksi$$

$$P_u = \phi_c F_{cr} A = 30.95(19.1) = 591.17502$$

ASD

$$P_a = 150k + 230k = 380k$$

$$\text{Assume } \frac{L_c}{r} = 50$$

$$\frac{F_{cr}}{\Omega_c} \xrightarrow{\text{Table 4-22}} 24.9 ksi$$

$$A = \frac{P_a}{\frac{F_{cr}}{\Omega_c}} = \frac{380}{24.9} = 15.3 in^2$$

$$\text{Try W12} \times 65$$

$$\frac{L_c}{r} = \frac{18(12)}{3.02} = 71.5$$

$$\frac{F_{cr}}{\Omega_c} = 20.7 + (71.5 - 71) \left(\frac{20.5 - 20.7}{72 - 71} \right) = 20.6 ksi$$

$$P_a = \frac{F_{cr}}{\Omega_c} A = 20.6(19.1) = 393.5 > 380$$

W12 x 65 should be used

6-5

Repeat prob. 6-2

LRFD:

$$P_u = 1.2 P_D + 1.6 P_L$$

$$= 1.2(90) + 1.6(120)$$

$$= 300 \text{ k}$$

$$F_y = 50 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 70 \text{ is } 31.4 \text{ ksi}$$

$$A_{req} = \frac{300}{31.4}$$

$$= 9.55 \text{ in}^2$$

$$F_y = 50$$

$$ASD: P_a = P_D + P_L$$

$$= 90 + 120$$

$$= 210 \text{ k}$$

$$\left(\frac{KL}{r}\right) \text{ of } 70 \text{ is } 20.9 \text{ ksi}$$

$$A_{req} = \frac{210}{20.9} = 10.05 \text{ in}^2$$

Trail 1: $W10 \times 39$

$$(A) \text{ is } 11.5 \text{ in}^2$$

$$(r_{min}) \text{ is } 1.98 \text{ in}$$

$$\lambda = (15 \text{ ft}) \times \frac{12 \text{ in}}{1 \text{ ft}}$$

$$F_y = 50 \text{ ksi}$$

$$= 90.91$$

$$F_y = 50 \text{ ksi}$$

$$ASD: \left(\frac{KL}{r}\right) \text{ of } 90 \text{ is } 16.6 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 91 \text{ is } 16.3 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 90.91 \dots$$

$$\frac{F_{cr}}{A_c} = 16.6 - \left(\frac{90.91 - 90}{91 - 90}\right)(16.6 - 16.3)$$

$$LRFD: \left(\frac{KL}{r}\right) \text{ of } 90 \text{ is } 24.9 \text{ ksi}$$

$$= 16.33 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 91 \text{ is } 24.6 \text{ ksi}$$

$$\phi_c P_n = (11.5)(16.33)$$

$$= 187.8 \text{ k}$$

Section not safe $< 300 \text{ k}$

$$\left(\frac{KL}{r}\right) \text{ of } 90.1 \dots$$

$$\phi_c F_{cr} = 24.9 - \left(\frac{90.91 - 90}{91 - 90}\right)(24.9 - 24.6)$$

$$= 24.63 \text{ ksi}$$

$$\phi_c P_n = (11.5)(24.63)$$

$$= 283.2 \text{ k}$$

Section not safe $< 300 \text{ k}$

Trial 2: W10x45

(A) is 13.3 in^2

(r_{min}) is 2.01 in.

$$\lambda = (15 \text{ ft}) \times \frac{12 \text{ in}}{1 \text{ ft}} \\ \frac{2.01}{2.01} \\ = 89.55$$

$F_y = 50 \text{ ksi}$
LRFD: $\left(\frac{KL}{r}\right)$ of 89 is 25.2 ksi

$\left(\frac{KL}{r}\right)$ of 90 is 24.9 ksi

$\left(\frac{KL}{r}\right)$ of 89.55 ...

$$\phi_c F_{cr} = 25.2 - \left(\frac{89.55 - 89}{90 - 89} \right) (25.2 - 24.9) \\ = 25.03 \text{ ksi}$$

$$\phi_c P_n = (13.3)(25.03)$$

$$= 332.9 \text{ k}$$

section is safe $\checkmark > 300 \text{ k}$
W10x45

$F_y = 50 \text{ ksi}$

ASD: $\left(\frac{KL}{r}\right)$ of 89 is 16.8 ksi

$\left(\frac{KL}{r}\right)$ of 90 is 16.6 ksi

$\left(\frac{KL}{r}\right)$ of 89.55 ...

$$\phi_c F_{cr} = 16.8 - \left(\frac{89.55 - 89}{90 - 89} \right) (16.8 - 16.6) \\ = 16.69 \text{ ksi}$$

$$\frac{P_n}{A_g} = (13.3)(16.69)$$

$$= 222 \text{ k}$$

section is safe $\checkmark > 210 \text{ k}$
W10x45

6-7 (a) Given: $P_D = 90k$
 $P_L = 160k$
 $L_c = 20ft$
 W14

LRFD

$$P_u = 1.2(90) + 1.4(160) = 332k$$

$$\text{Assume } \frac{L_c}{r} = 50$$

$$\phi_c F_{cr} = 37.5k$$

$$A = \frac{P_u}{\phi_c F_{cr}} = \frac{332}{37.5} = 8.85 \text{ in}^2$$

$$\text{Try W14} \times 61 (A = 17.9 \text{ in}^2, r_y = 2.45)$$

$$\frac{L_c}{r} = \frac{20(12)}{2.45} = 97.96$$

$$\phi_c F_{cr} = 22.6 + (97.96 - 97) \left(\frac{22.3 - 22.6}{98 - 97} \right)$$

$$= 22.312 \text{ ksi}$$

$$P_u = \phi_c F_{cr} A = 22.312(17.9) = 399.4k$$

ASD

$$P_a = 90 + 160 = 250k$$

$$\text{Assume } \frac{L_c}{r} = 50$$

$$\frac{F_{cr}}{\Omega_c} = 24.9k$$

$$A = \frac{P_a}{\frac{F_{cr}}{\Omega_c}} = \frac{250}{24.9} = 10.04 \text{ in}^2$$

$$\text{Try W14} \times 61 (A = 17.9 \text{ in}^2, r_y = 2.45)$$

$$\frac{L_c}{r} = \frac{20(12)}{2.45} = 97.96$$

$$\frac{F_{cr}}{\Omega_c} = 15.0 + (97.96 - 97) \left(\frac{14.8 - 15.0}{98 - 97} \right)$$

$$= 14.808 \text{ ksi}$$

$$P_a = \frac{F_{cr}}{\Omega_c} A = 14.808(17.9) = 265.1k$$

W14 x 61 should be used

6-18

$$\text{LRFD: } P_u = 1.2(123) + 1.6(215) = 494 \text{ k}$$

→ W10 x 49

$$(A) = 14.4 \text{ in}^2$$

$$(d) = 10 \text{ in}$$

$$(b_f) = 10 \text{ in}$$

$$(I_x) = 272 \text{ in}^4$$

$$(I_y) = 93.4 \text{ in}^4$$

$$(r_x) = 4.35 \text{ in}$$

$$(r_y) = 2.54 \text{ in}$$

L_c of 24 ft is 253 k

→ section not safe < 494 k

$$r_{avg} = \frac{4.35 + 2.54}{2} = 3.45 \text{ in}$$

$$\frac{KL}{r_{avg}} = \frac{(24 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}})}{3.45} = 83.5$$

$\phi_t = 50 \text{ ksi}$

$$\left(\frac{KL}{r}\right) \text{ of } 83 \text{ is } 27.2 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 84 \text{ is } 26.9 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 83.5 \text{ ---}$$

$$\phi_{t_{cr}} = \frac{27.2 + 26.9}{2} = 27.05 \text{ ksi}$$

$$A_{req} = \frac{494}{27.05} = 18.26 \text{ in}^2$$

$$A_{req} = A + 2(t_{PL} \times L_{PL})$$

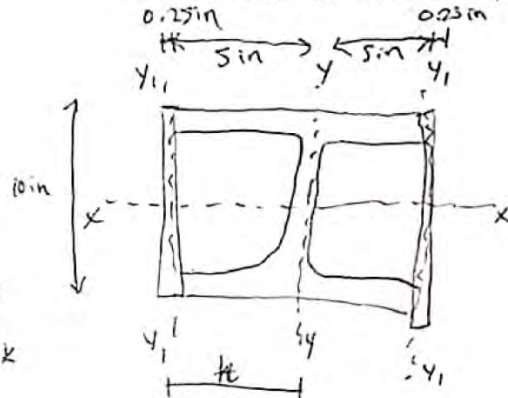
$$18.26 = 14.4 + 2(t_{PL} \times 10)$$

$$2(t_{PL} \times 10) = 3.86$$

$$t_{PL} \times 10 = 1.93$$

$$t_{PL} = 0.19 \text{ in}$$

Take 0.25 in for thickness of plate



$$h = 5 + \frac{0.25}{2} = 5.125 \text{ in.}$$

$$A_{total} = 14.4 + 2(0.25 \times 10) = 19.4 \text{ in}^2$$

$$(I_x)_T = 272 + 2\left(\frac{1}{12}\right)(0.25)(10)^3 = 313.67 \text{ in}^4$$

$$(I_y)_T = 93.4 + 2\left(\frac{1}{12}\right)(10)(0.25)^3 + 2(0.25)(10)(5.125)^2 = 93.4 + 0.026 + 131.328 = 224.75 \text{ in}^4$$

$$I_{min} = 224.75 \text{ in}^4$$

$$r_{min} = \sqrt{\frac{224.75}{19.4}} = 3.40 \text{ in}$$

$$\left(\frac{KL}{r}\right) = \frac{(24 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}})}{3.40} = 84.7$$

Table 4-14

$$\left(\frac{KL}{r}\right) \text{ of } 84 \text{ is } 26.9 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 85 \text{ is } 26.5 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 84.7 \text{ is } \dots$$

$$\phi_c F_{cr} = 26.9 - \left(\frac{84.7 - 84}{84 - 83}\right)(26.9 - 26.5)$$

$$= 26.62 \text{ ksi}$$

$$\phi_c P_n = (19.4)(26.62)$$

$$= 516.4 \text{ k}$$

Section is safe $\checkmark > 494 \text{ k}$

W10x49 with 2 fls. of 0.25 in $\times$ 10 in plates
in LRFD method $\checkmark$

ASD: Table 4-14

$$P_u = (150) + (230)$$

$$= 380 \text{ k}$$

$$L_c \text{ of } 24 \text{ ft is } 1168 \text{ k}$$

W10x49 section is not safe $< 380 \text{ k}$

$$\left(\frac{KL}{r}\right) \text{ of } 83 \text{ is } 18.1 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 84 \text{ is } 17.9 \text{ ksi}$$

$$\left(\frac{KL}{r}\right) \text{ of } 83.5 \text{ is } \dots$$

$$F_{cr} = \frac{18.1 + 17.9}{2}$$

$$= 18 \text{ ksi}$$

$$A_{req} = A + 2(t_{pl} \times L_{pl}) \quad A_{req} = \frac{346}{18} = 18.89 \text{ in}^2$$

$$18.89 = 14.4 + 2(t_{pl} \times 10)$$

$$2(t_{pl} \times 10) = 4.49$$

$$t_{pl} \times 10 = 2.2$$

$$t_{pl} = 0.22 \text{ in}$$

Table 4-14 available critical stress
for compression members

$\left(\frac{KL}{r}\right)$ of 84 is 17.9 ksi

$\gamma = 50 \text{ ksi}$
 $\left(\frac{KL}{r}\right)$ of 85 is 17.7 ksi

$\left(\frac{KL}{r}\right)$ of 84.7 ---

$$\frac{f_{cr}}{A_c} = 17.9 - \left(\frac{84.7 - 84}{85 - 84} \right) (17.9 - 17.7)$$
$$= 17.76 \text{ ksi}$$

$$\phi_c P_n = (19.4)(17.76)$$
$$= 344.5 \text{ k}$$

section is safe $\checkmark > 340 \text{ k}$

W10x49 with 2 Nos. of 0.25 in x 10 in plates
ASD method $\rightarrow$

ASSIGNMENTS FOR OUTCOME “1”

- 1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(As it relates to Steel Design)**

OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

CVEG 3305-Steel Design
Instructor: Dr. Abdul M Choudhury

Title of Assignment

Homework #3

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Brief justification of the suitability of this assignment for the outcome

The questions on this section of the Homework show student's ability to solve problems in steel design
By applying engineering, mathematical and scientific concepts

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT
CVEG 3305- STEEL DESIGN
COURSE ASSIGNMENT GRADING
AND OUTCOME ASSESSMENT SHEET

ASSIGNMENT TITLE: Homework # 3

DUE DATE: 03/08/2022 DATE SUBMITTED: 03/08/2022
Name of Student: Maalvika Aggarwal

Title of Assignment: ___Analysis of compression member

Competency Area	Max for this Assignment	Student's Score
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	100	100
TOTAL	100	100

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 3305 P01 – Steel Design

Spring 2022

Homework #3

Maalvika Aggarwal

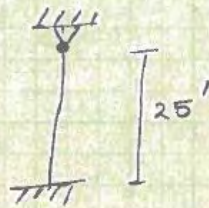
Date Assigned: 01 March 2022

Date Submitted: 08 March 2022

100!
100!
Excellent!

Problem 1 [5-5]AISC MANUAL
15th Edition

W12 X 50



$$F_y = 50 \text{ ksi}$$

a) Table 4-14.

Properties from table 4-1

$$A = 14.6 \text{ in}^2, r_x = 5.18", r_y = 1.96"$$

$$d_o, r_{min} = r_y = 1.96 \text{ in.}$$

from table 5-1,

$$K = 0.8$$

$$\text{Slenderness ratio} = \frac{L_e}{r} = \frac{KL}{r_{min}} = \frac{(0.8)(25)(12)}{1.96}$$

$$= 122.45$$

Now, using table 4-14,

d	Stress LRFD (ksi)	Stress ASD (ksi)
122	15.2	10.1
123	14.9	9.94
Interpolation = 122.45	$\frac{123-122.45}{123-122} (15.2 - 14.9) + 14.9$ $= 15.065 \text{ ksi}$	$\frac{123-122.45}{123-122} (10.1 - 9.94) + 9.94$ $= 10.028 \text{ ksi}$

$$\text{So, LRFD} = \phi P_n = (15.065)(14.6) = 219.95 \text{ k}$$

$$\text{ASD} = \frac{P_n}{\Omega} = (10.028)(14.6) = 146.41 \text{ k}$$

b) Using table 4-1a,

$$KL = (0.8)(25) = 20 \text{ ft}$$

So, for W12x50,

$$\boxed{\text{LRFD} = 220 \text{ k}} \quad \checkmark \quad \boxed{\text{ASD} = 146} \quad \checkmark$$

c) $\frac{KL}{r} = \frac{(0.8)(25)(12)}{1.96} = 122.45$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{3.14^2 \times 29000}{122.45^2} = 19.069 \text{ ksi}$$

Flexural buckling stress for

Now, $\frac{KL}{r} = 122.45$

$$4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29000}{50}} = 113.43$$

Since $\frac{KL}{r} > 4.71 \sqrt{\frac{E}{F_y}}$

$$F_{cr} = 0.877 F_e = 0.877 (19.069) = 16.724 \text{ ksi} \quad \checkmark$$

So,

LRFD

$$\phi F_{cr} = (0.9)(16.724) = 15.052 \text{ ksi} \quad \checkmark$$

$$\phi P_n = (15.052)(14.6)$$

$$= \boxed{219.75 \text{ k}} \quad \checkmark$$

ASD

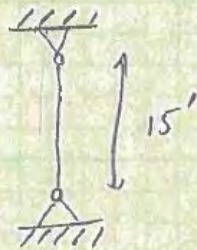
$$\frac{F_{cr}}{\Omega} = \frac{16.724}{1.67} = 10.014 \text{ ksi} \quad \checkmark$$

$$\frac{P_n}{\Omega} = (10.014)(14.6)$$

$$= \boxed{146.21 \text{ k}} \quad \checkmark$$

Problem 2 [5-6]

W8x40
F_y = 50 ksi



AISC MANUAL
15th edition

- a) Properties from table 1-1, A = 11.7 in², r_x = 3.53", r_{min} = r_y = 2.04"
from table 5-1, K = 1
 $\lambda = \frac{KL}{r} = \frac{(1)(15)(12)}{2.04} = 88.24$
Using table 4-14 from AISC

	LRFD	ASD
88	25.5	17
89	25.2	16.8
88.24	$\frac{89-88.24}{89-88} \frac{(25.5-25.2)}{25.2} = 25.43$ ksi	$\frac{89-88.24}{89-88} \frac{(17-16.8)}{16.8} = 16.95$ ksi
Strength	LRFD = $\phi P_n = 25.43(11.7) = 297.508$ K	ASD = $P_n/\Omega = 16.95(11.7) = 198.34$ K

- b) From table 4-1a,
KL = (1)(15) = 15 ft
So, LRFD = 298 & ASD = 198 K

- c) $\frac{KL}{r} = 88.24$
 $f_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{3.14^2 (29000)}{88.24^2} = 36.72$ ksi
 $4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29000}{50}} = 113.43$ (since $f_e < 4.71 \sqrt{\frac{E}{F_y}}$, $F_{cr} = \left(0.658^{\frac{F_y}{f_e}}\right) F_y$)
 $F_{cr} = \left(0.658^{\frac{50}{36.72}}\right) 50 = 28.28$ ksi ✓
So, LRFD
 $\phi F_{cr} = (0.9)(28.28) = 25.45$ ksi
 $\phi P_n = (25.45)(11.7) = 297.77$ K
ASD
 $F_{cr}/\Omega = 28.28/1.67 = 16.93$ ksi ✓
 $P_n/\Omega = (16.93)(11.7) = 198.12$ K

Problem 3(5.9)

using AISC specifications.

a) W10 X 77

$$K_c = K_L = 20 \text{ ft}$$

using Table 4-1a,

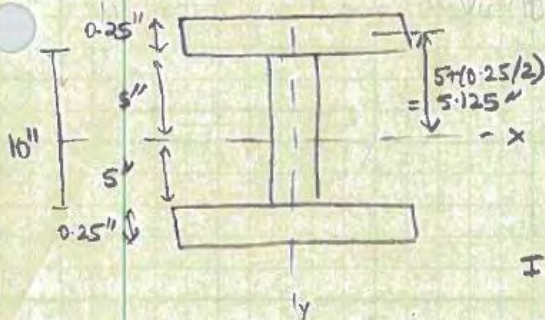
$$\phi R_{FD} = \phi_c P_n = \boxed{548 \text{ k}}$$

$$ASD = \frac{P_n}{\Omega} = \boxed{365 \text{ k}}$$

20

Problem 4 (5-12)

AISC MANUAL
1ST EDITION



$$KL = 15 \text{ ft}$$

$$F_y = 36 \text{ ksi}$$

$$\text{Area of plate, } A_p = (10 \times 1/4) \times 2 \text{ (symmetrical)} = 7.5 \text{ in}^2$$

$$\text{Along x-x, } I_x = \left[2 \left(\frac{bh^3}{12} \right) + 2bhd^2 \left(\frac{b^3h}{12} \right) \right]$$

$$I_{xx} = 2 \left(\frac{10 \times 0.25^3}{12} \right) + 2(10)(0.25)(5.125)^2 \left(\frac{10^3(0.25)}{12} \right)$$

$$I_{xx} = 152.19 \text{ in}^4$$

Along y-y axis,

$$I_{yy} = 2 \left(\frac{b^3h}{12} \right) + \left(\frac{bh^3}{12} \right) = 2 \left(\frac{10^3(0.25)}{12} \right) + \left(\frac{10 \times 0.25^3}{12} \right)$$

$$I_{yy} = 41.66 + 0.013 = 41.679 \text{ in}^4$$

$$I_{yy} \text{ controls, so, } \sigma_{min} = \sqrt{\frac{I_{yy}}{A}} = \sqrt{\frac{41.679}{7.5}} = 2.36 = r_y$$

$$\lambda = \frac{KL}{r} = \frac{15(12)}{2.36} = 76.271$$

Using table 4-1a,

	LRFD	ASD
76	23.9	15.9
77	23.7	15.8
76.271	$\frac{77-76.271}{77-76} (23.9-23.7)$	$\frac{77-76.271}{77-76} (15.9-15.8)$
	$= 23.845 \text{ ksi}$	$= 15.873 \text{ ksi}$
Strength	LRFD = ϕP_n $= (23.845)(7.5)$ $= 178.84 \text{ k}$	ASD = P_n/Ω $= (15.873)(7.5)$ $= 119.05 \text{ k}$

20

OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

CVEG 3305-Steel Design
Instructor: Dr. Abdul M Choudhury

Title of Assignment

Homework #4

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Brief justification of the suitability of this assignment for the outcome

The questions on this section of the Homework show student's ability to solve problems in steel design
By applying engineering, mathematical and scientific concepts

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT
CVEG 3305- STEEL DESIGN
COURSE ASSIGNMENT GRADING
AND OUTCOME ASSESSMENT SHEET

ASSIGNMENT TITLE: Homework # 4

DUE DATE: 04/30/2022 _____ DATE SUBMITTED: 04/30/2022
Name of Student: Austin Bates

Title of Assignment: ___Design of compression member

Competency Area	Max for this Assignment	Student's Score
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	100	90
TOTAL	100	90

Prairie View A&M University
College Of Engineering
Department of Civil and Environmental Engineering



CVEG 3305-P01: Steel Design

Homework #4

By: Austin Bates

Due: March 30, 2022

Submitted to Dr. A. Choudury

90
/w

6-1

$$P_D = 150 \quad P_L = 230 \quad L_c = 18 \text{ ft} \quad F_y = 50 \text{ ksi}$$

$$P_u = (1.2 + 150) + (1.6 \times 230) = 548 \text{ k}$$

$$F_{cr} = 35 \text{ ksi}$$

$$\phi P_n = 0.9 (F_{cr}) (A_g)$$

$$548 = 0.9 \times 35 (A_g)$$

$$\frac{548}{0.9} = \frac{31.5}{0.9} A_g \quad A_g = 17.4 \text{ in}^2$$

$$\text{Try } W12 \times 58 \quad (A = 17 \text{ in}^2, \lambda = 2.51 \text{ in})$$

$$L_e = \left(\frac{18 \times 12}{2.51} \right) = 86$$

$$\phi F_{cr} = 26.2$$

$$\phi P_n = (0.9)(26.2)(17.) = 445 < 548 \quad \text{X}$$

$$\text{Try } W12 \times 65 \quad (A = 19.1 \text{ in}^2, \lambda = 3.02 \text{ in})$$

$$L_e = \left(\frac{18 \times 12}{3.02} \right) = 71.5$$

$$\phi F_{cr} = 30.95$$

$$\phi P_n = 30.95(19.1) = 591 > 548 \quad \checkmark$$

W12 x 65 section

20

6-5

$$P_D = 90 \quad P_L = 120 \quad L_c = 15 \quad F_y = 50$$

$$P_u = (1.2 \times 90) + (1.6 \times 120) = 300 \text{ k} / P_u = (90 + 120) = 210$$

Try W10x45 ($A = 13.3$, $r = 2.01$)

$$K_e = \frac{(15 \times 12)}{2.01} = 89.55$$

$$F_e = \frac{\pi^2 E}{K_e^2} = \frac{\pi^2 (29000)}{89.55^2} = 35.69 \text{ ksi}$$

$$4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29000}{50}} = 113 > 89.55$$

$$F_{cr} = \left(0.658^{\frac{F_y}{F_e}} \right) (F_y) = \left(0.658^{\frac{50}{35.69}} \right) (50)$$

$$P_n = F_{cr} \cdot A_g = (27.81)(13.3) = 370 \text{ kip} = 27.81 \text{ ksi}$$

$$\phi P_n = (0.9)(370) = 333 > 300 \quad \checkmark$$

$$\frac{P_u}{\phi} = \frac{370}{1.67} = 221 > 210 \quad \checkmark$$

use table
5
⓪

W10x45 section

$$6-7 \quad L_c = 20$$

$$a) \quad P_u = (1.2 \times 90) + (1.6 \times 160) = 364 \text{ k}$$

$$P_u = (90 + 160) = 250 \text{ k}$$

Try W14x61 Section ($A = 17.9$, $\lambda = 2.45$)

$$L_e = \frac{20 \times 12}{2.45} = 97.9 \text{ in}$$

$$F_e = \frac{\pi^2 29000}{L_e^2} = \frac{\pi^2 29000}{97.9^2} = 29.8$$

$$4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29000}{50}} = 113 > 97.9$$

$$F_{cr} = (0.658^{F_y/F_e}) (F_y) = (0.658^{50/29.8}) (50) = 24.7$$

$$\phi P_n = F_{cr} A_g = (24.7 \cdot 17.9) (0.9) = 399 \text{ k} > 364 \text{ k} \checkmark$$

$$\frac{P_u}{\phi} = \frac{(24.7)(17.9)}{1.67} = 265.7 \text{ k} > 250 \text{ k} \checkmark$$

W14x61 Section

Use Table

20

6-7

B) $L_c = 30$

$$P_u = (1.2 \times 150) + (1.6 \times 190) = 484 \text{ k}$$

$$P_u = (150 + 190) = 340$$

Try $W12 \times 72$ ($A = 21.1$, $\lambda = 3.04$)

$$L_e = \frac{30 \times 12}{3.04} = 94.7 \text{ in}$$

$$F_e = \frac{\pi^2 29000}{94.7^2} = 31.89$$

$$F_{cr} = (0.658^{50/31.89})(50) = 25.9$$

$$\phi P_n = (0.9)(25.9 \times 21.1) = 492 > 484 \checkmark$$

$$\frac{P_n}{2} = \frac{(25.9 \times 21.1)}{1.67} = 327 < 340 \times$$

Try $W12 \times 79$ ($A = 23.2$, $\lambda = 3.05$)

$$L_e = \frac{30 \times 12}{3.05} = 94.4$$

$$F_e = \frac{\pi^2 29000}{94.4^2} = 32.1$$

$$F_{cr} = (0.658^{50/32.1})(50) = 26.05$$

$$\frac{P_n}{2} = \frac{(26.05 \times 23.2)}{1.67} = 361 > 340 \checkmark$$

$W12 \times 72$	LRFD
$W12 \times 79$	ASD

Not
read

6-7

c) $L_c = 20$

$$P_u = (80 \times 12) + (1.6 \times 150) = 308 \quad P_u = (80 + 150) = 230$$

Try $W10 \times 39$ ($A = 11.5$, $\lambda = 1.98$)

$$L_e = \frac{20 \times 12}{1.98} = 78.7$$

$$F_e = \frac{\pi^2 29000}{78.7^2} = 46.1$$

$$F_{cr} = (0.658^{50/46.1})(50) = 31.7$$

$$\phi P_n = (0.9)(31.7 \times 11.5) = 328 > 308 \quad \checkmark$$

$$\frac{P_n}{A} = \frac{(31.7 \times 11.5)}{1.67} = 218 < 230 \quad \times$$

Try $W10 \times 45$ ($A = 13.3$, $\lambda = 2.01$)

$$L_e = \frac{20 \times 12}{2.01} = 77.6$$

$$F_e = \frac{\pi^2 29000}{77.6^2} = 47.5$$

$$F_{cr} = (0.658^{50/47.5})(50) = 32.1$$

$$\frac{P_n}{A} = \frac{(32.1 \times 13.3)}{1.67} = 256 > 230 \quad \checkmark$$

W10x39 LRFD
W10x45 ASD

6-7

D) $L_c = 16$

$$P_u = (1.2 \times 50) + (1.6 \times 120) = 224 \text{ k}$$

$$P_u = (50 + 120) = 170 \text{ k}$$

Try W8X35 ($A = 10.3$, $\lambda = 2.03$)

$$L_c = \frac{16 \times 12}{2.03} = 94.5$$

$$F_c = \frac{\pi^2 29000}{94.5^2} = 31.9$$

$$F_{cr} = (0.658^{50/31.9})(50) = 25.9$$

$$\phi P_n = (0.9)(25.9 \times 10.3) = 240 > 224 \checkmark$$

$$\frac{P_n}{2} = \frac{(25.9 \times 10.3)}{1.67} = 160 < 170 \text{ X}$$

Try W8X40 ($A = 11.7$, $\lambda = 2.04$)

$$L_c = \frac{16 \times 12}{2.04} = 94.1$$

$$F_c = \frac{\pi^2 29000}{94.1^2} = 32.3$$

$$F_{cr} = (0.658^{50/32.3})(50) = 26.1$$

$$\frac{P_n}{2} = \frac{(26.1)(11.7)}{1.67} = 183.2 > 170 \checkmark$$

W8X35	LRFD
W8X40	ASD

6-21

$$A = 1.44 \text{ in}^2$$

$$I_x = I_y = 1.23 \text{ in}^4$$

$$I_y = 4(1.23 + (1.44 \cdot 5.164^2))$$

$$I_y = 4(39.63) = 158.5 \text{ in}^4$$

$$r_x = \sqrt{\frac{I}{A}} = \sqrt{\frac{158.5}{4(1.44)}} = \sqrt{27.52} = 5.25$$

Minimum Permissible

$$\frac{114 \times 12}{5.25} = 32$$

$$F_e = \frac{\pi^2 E}{L_e^2} = \frac{\pi^2 29,000}{32^2}$$

$$F_{cr} = (0.658^{50/43})(50) = 30.7$$

$$\phi F_{cr} = 27.62 \text{ ksi}, \quad \phi P_n = 27.62 \times 5.76 = 159.1 \text{ k}$$

$$\frac{F_{cr}}{2} = 18.4 \text{ ksi}, \quad 18.4 \times 5.76 = 106 \text{ k}$$

$$\text{min width} = 8.5 + 2(1\frac{1}{4}) = 11 \text{ in}$$

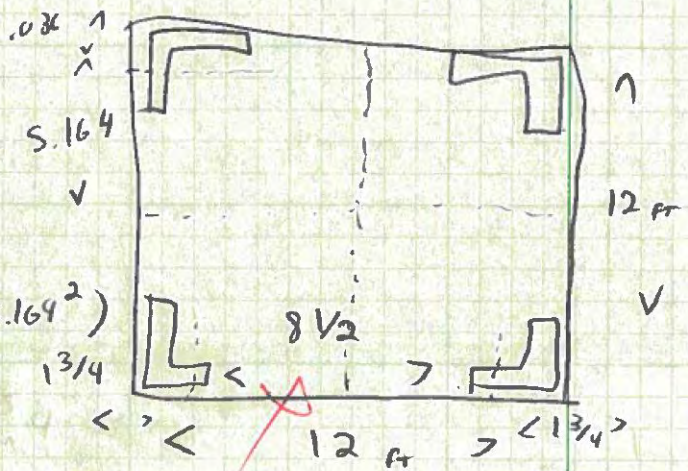
$$\text{min } t = \frac{1}{50}(8.5) = 0.17 \text{ in}$$

$$\text{Shear} = 0.02(159.1) = 3.18 \text{ k}$$

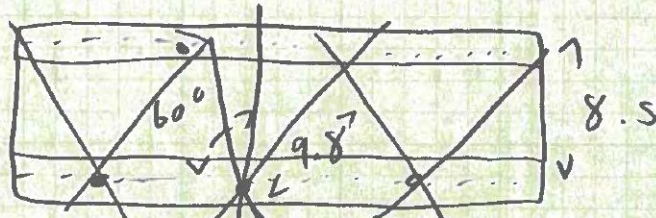
$$\frac{1}{2} V_u = 159 \text{ k}$$

End tie

$$P_{L_s} \frac{3}{16} \times 8\frac{1}{2} \times 0-11 \text{ in}$$



6-21 < 9.8 >



$$L = 9.81 + 2(1 \frac{1}{4}) = 12.31 \text{ in}$$

$$F_r = \frac{9.81}{8.5} (1.54) = 1.84 \text{ k}$$

$$r = \sqrt{\frac{1}{12} b + \frac{1}{12} t^2} = 0.289 \text{ in}$$

$$\text{Thickness } \frac{9.81}{0.289} = 140 \rightarrow \frac{9.81}{140} = \frac{140}{140} (0.289 +)$$

$$\frac{L}{r} = \frac{9.81}{(0.289)(0.25)} = 135.43 \quad T = 0.243 \text{ in}$$

$$\text{min width} = 2(1 \frac{1}{4}) = 2 \frac{1}{2}$$

$$A_{req} = \frac{1.84}{12.21} = 0.15 \text{ in}^2$$

$$\text{width req} = \frac{0.15}{0.25} = 0.60 \text{ in} \quad \checkmark$$

$$\text{Lacing bars } \frac{1}{4} \times 2 \times \frac{1}{2} \times 1 - 0 \frac{1}{2} \text{ in}$$

$$LRF = 159.1 \text{ k}$$

$$ASD = 106 \text{ k}$$

6-18

$$P_U = (1.2 \times 125) + (1.6 \times 215) = 494$$

$$P_U (125 + 215) = 340 \text{ k}$$

$$L_c = 24$$

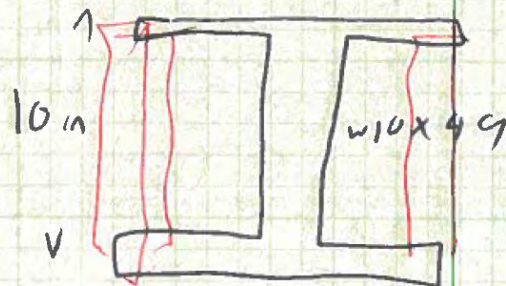
W10 x 49

$$A = 14.4 \quad I_x = 272$$

$$d = 10 \quad I_y = 93.4$$

$$b_f = 10 \quad r_x = 4.35$$

$$r_y = 2.54$$



$$r_{avg} = \frac{r_x + r_y}{2} = \frac{4.35 + 2.54}{2} = 3.45 \text{ in}$$

$$\frac{KL}{r} = \frac{24 \times 12}{3.45} = 83.5$$

13	27.2
84	26.9
83.5	27.05

$$\frac{27.2 + 26.9}{2} = 27.05$$

$$A_{req} = \frac{P_U}{\phi F_{cr}} = \frac{494}{27.05} = 18.26 \text{ in}^2$$

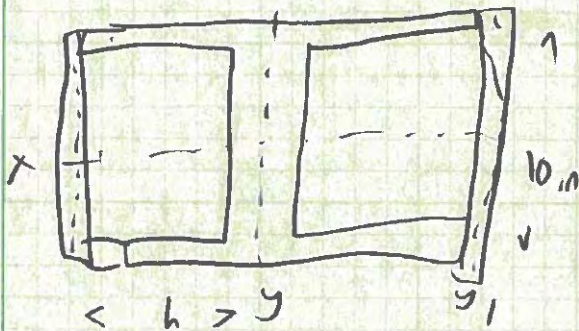
$$A_{req} = A + 2(t_{PL} \times L_{PL})$$

$$18.26 = 14.4 + 2(t_{PL} \times 10)$$

$$\frac{3.86}{20} = \frac{2(10 + t_{PL})}{20}$$

$$t_{PL} = 0.19 \text{ in} \approx .25 \text{ in}$$

$$2.25 < S_n < 2.5 \text{ in} > 2.25 \text{ in}$$



$$h = S + \frac{2s}{2}$$

$$= 5.125$$

$$A_{tot} = A + 2(t_{pl} \cdot L_{pl})$$

$$= 14.4 + 2(0.25 \times 10)$$

$$= 19.4 \text{ in}^2$$

$$I_{x_t} = I_x + 2\left(\frac{1}{12}\right)(t_{pl})(10)^3 + 2\left(\frac{1}{12}\right)(0.25)(10)^3$$

$$= 272 + 2(0.25)(10)^3$$

$$= 313.67 \text{ in}^4$$

$$I_{y_t} = I_y + 2\left(\frac{1}{12}\right)(10)(t_{pl})^3 + 2(t_{pl})(10)(h)^3$$

$$= 93.4 + \frac{2}{12}(10)(0.25)^3 + 2(0.25)(10)(5.125)^3$$

$$= 93.4 + 0.026 + 131.328 = 224.75 \text{ in}^4$$

$$r_{mh} = \sqrt{\frac{I}{A}} = \frac{224.75}{19.4} = 3.40 \text{ in}$$

$$\frac{KL}{r} = \frac{24 \times 12}{3.4} = 84.7$$

84	26.9
85	26.5
84.7	26.62

$$26.9 - \left(\frac{84.7 - 84}{84 - 83}\right)(26.9 - 26.5)$$

$$= 26.62 \text{ ksi}$$

$$\phi P_n = (19.4)(26.62) = 516.4 \text{ k}$$

$$516 > 494 \checkmark$$

W10x49 with
2 0.25 in x 10 in plates
LRFD

25

6-18

$$P_u = 340 \text{ k}, r_{wy} = 3.45, \frac{K L}{r} = 83.5$$

83	18.1
84	17.9
83.5	18

$$\frac{18.1 + 17.9}{2} = 18$$

$$A_{req} = \frac{340}{18} = 18.89 \text{ in}^2$$

$$A_{req} = A + 2(t_{PL} \times L_{PL})$$

Same as LRFD

$$18.89 = 14.4 + 2(t_{PL} \times 10)$$

$$\frac{4.49}{20} = \frac{20}{2} t_{PL}$$

$$t_{PL} = .22 \approx .25 \text{ in}$$

84	17.9
85	17.7
84.7	17.76

$$17.9 - \left(\frac{84.7 - 84}{85 - 84} \right) (17.9 - 17.7) = 17.76 \text{ ksi}$$

$$\frac{P_u}{2} = (19.4)(17.76) = 344.5 > 340 \checkmark$$

ASD

W10x49

with 2 0.25 in x 10 in plates

**OUTCOME “1” SPECIFIC ASSIGNMENTS
USED TO ASSESS THE OUTCOME IN**

**CVEG 4043
ENVIRONMENTAL ENGINEERING DESIGN**

**CVEG 4043– Environmental Engineering Design
Fall 2019**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Homework # 2

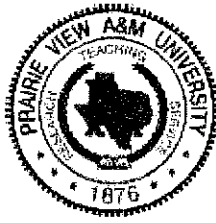
Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

All the problems in this Homework are developed to test the students' ability to identify, formulate and solve complex engineering problems



PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

CVEG 4043: Environmental Engineering Design Fall 2019

Raghava R. Kommalapati, PhD., PE, BCEE, F. ASCE
Homework # 2: Due: 09/17/2019

Name Milton Cruz

Grade 80 /80

Topics Covered

Introduction to Water and Wastewater Treatment

1. Design a rectangular sedimentation tank (L/W is 2.5) with a hydraulic detention time of 2.5 hours and a surface overflow rate of $40 \text{ m}^3/\text{m}^2\cdot\text{d}$ for a town with a population of 50,000. Assume wastewater flow is 450 L/capita. Determine the tank dimensions (L, W, and D). Also determine the diameter if a circular tank is used instead.

Solve the following problems from the Handout (see backside)

2. Problem 11.8
3. Problem 11.9
4. Problem 11.10
5. Problem 11.11
6. Problem 11.12
7. Problem 11.13
8. Problem 11.14

- 11.8. Determine the hydraulic detention time and overflow (hydraulic surface loading) rate in a 30-m-diameter by 4-m-deep sedimentation tank for a flow rate of $12,000 \text{ m}^3/\text{d}$.
- 11.9. What diameter and sidewall depth is needed for a circular clarifier for a flow of $20,000 \text{ m}^3/\text{d}$ to achieve an overflow (hydraulic surface loading) rate of $20 \text{ m}^3/\text{m}^2 \cdot \text{d}$ and a detention time of 3.0 hr?
- 11.10. Solve Problem 11.9, but assume that a rectangular settling tank with a length-to-width ratio of 3 to 1 is to be used.
- 11.11. A water treatment plant has a sedimentation tank with a volume of 1400 m^3 , a water depth of 3.0 m, and a length-to-width ratio of 2.5 to 1. If the plant flow rate is $9000 \text{ m}^3/\text{d}$ determine (a) the detention time in hours, (b) the surface loading rate, and (c) the horizontal flow-through velocity.
- 11.12. The influent flow and BOD_5 to a wastewater treatment plant are $4000 \text{ m}^3/\text{d}$ and $250 \text{ g}/\text{m}^3$, respectively. What is the plant loading expressed in kilograms per day?
- 11.13. If 250 kg of chlorine is used to treat $125,000 \text{ m}^3$ of water, what is the dosage in milligrams per liter?
- 11.14. The recommended chlorine dosage for effluent disinfection is 4.0 mg/L. What amount of chlorine (in kilograms per day) is required for flows of (a) $5000 \text{ m}^3/\text{d}$, (b) $200 \text{ L}/\text{min}$, and (c) $0.5 \text{ m}^3/\text{s}$?

1.)

$$\text{Hydraulic Detention time} = \theta = 2.5 \text{ hrs}$$

$$\text{Surface overflow rate} = \text{FR} = 40 \text{ m}^3/\text{d} \cdot \text{m}^2$$

$$\text{Pop.} = 50,000$$

$$Q_{\text{demand}} = 450 \text{ L/capita}$$

$$\theta = \frac{V}{Q}$$

$$L/W = 2.5$$

$$Q = \text{Pop.} \times Q_{\text{demand}}$$

$$= 50,000 (450 \text{ L/capita} \cdot \text{d})$$

$$Q = 22.5 \times 10^6 \text{ L/d}$$

$$V = Q \theta = 22.5 \times 10^6 \text{ L/d} (2.5 \text{ hrs}) \left(\frac{1 \text{ d}}{24 \text{ hrs}} \right)$$

$$= 2.34375 \times 10^6 \text{ L}$$

$$V = 2.344 \times 10^6 \text{ L}$$

$$V = 2344 \text{ m}^3 \checkmark$$

$$L/W = 2.5$$

$$L = W(2.5)$$

$$A = L \times W$$

$$A = (W)(W)(2.5)$$

$$A = W^2 (2.5)$$

$$W = \sqrt{\frac{A}{2.5}}$$

$$W = \sqrt{\frac{562.5 \text{ m}^2}{2.5}}$$

$$* \boxed{W = 15 \text{ m}} \checkmark$$

$$L = 2.5(W)$$

$$= 2.5(15)$$

$$* \boxed{L = 37.5 \text{ m}} \checkmark$$

$$A = \frac{Q}{\text{FR}} = \frac{22.5 \times 10^6 \text{ L/d} \times \frac{1 \text{ m}^3}{1000 \text{ L}}}{40 \text{ m}^3/\text{d} \cdot \text{m}^2} = \frac{22,500 \text{ m}^3/\text{d}}{40 \text{ m}^3/\text{d} \cdot \text{m}^2}$$

$$A = 562.5 \text{ m}^2 \checkmark$$

$$V = A \times h$$

$$h = \frac{V}{A}$$

$$= \frac{2344 \text{ m}^3}{562.5 \text{ m}^2}$$

$$* \boxed{h = 4.167 \text{ m}} \checkmark$$

$$A = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4A}{\pi}}$$

$$= \sqrt{\frac{4(562.5 \text{ m}^2)}{\pi}}$$

$$* \boxed{d = 26.76 \text{ m}} \checkmark$$

11.8) Determine the hydraulic detention time and overflow (hydraulic surface loading).

$$D = 30 \text{ m}$$

$$H = 4 \text{ m}$$

$$Q = 12,000 \text{ m}^3/\text{d}$$

$$A = \frac{\pi D^2}{4}$$

$$= \frac{\pi (30)^2}{4}$$

$$= 225\pi$$

$$A = 706.86 \text{ m}^2$$

$$\text{OFR} = \frac{Q}{A}$$

$$= \frac{12,000 \text{ m}^3/\text{d}}{706.86 \text{ m}^2}$$

$$\text{OFR} = 16.98 \text{ m/d}$$

$$\theta = \frac{V}{Q}$$

$$V = A \times h$$

$$= 706.86 \text{ m}^2 \times 4 \text{ m}$$

$$V = 2827.43 \text{ m}^3$$

$$\theta = \frac{2827.43 \text{ m}^3}{12,000 \text{ m}^3/\text{d}}$$

$$\theta = 0.2356 \text{ days}$$

11.9) Determine the diameter and side wall depth needed for a circular clarifier.

$$Q = 20,000 \text{ m}^3/\text{d}$$

$$\text{OFR} = 20 \text{ m}^3/\text{d} \cdot \text{m}^2$$

$$\theta = 3 \text{ hrs}$$

$$A = \frac{Q}{\text{OFR}}$$

$$= \frac{20,000 \text{ m}^3/\text{d}}{20 \text{ m}^3/\text{d} \cdot \text{m}^2}$$

$$A = 1000 \text{ m}^2 \quad \checkmark$$

$$A = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4A}{\pi}}$$

$$= \sqrt{\frac{(1000)4}{\pi}}$$

$$d = 35.68 \text{ m} \quad \checkmark$$

$$\theta = \frac{V}{Q}$$

$$V = \theta Q$$

$$= 3 \text{ hrs} (20,000 \text{ m}^3/\text{d}) \left(\frac{1 \text{ day}}{24 \text{ hrs}} \right)$$

$$V = 2,500 \text{ m}^3$$

$$V = A \times h$$

$$h = \frac{V}{A}$$

$$= \frac{2,500 \text{ m}^3}{1000 \text{ m}^2}$$

$$h = 2.5 \text{ m} \quad \checkmark$$

11.10) Solve Problem 11.9, but assume a rectangular settling tank with L 3 to 1 2 and W ratio.

$$Q = 20,000 \text{ m}^3/\text{d}$$

$$\text{OFR} = 20 \text{ m}^3/\text{d} \cdot \text{m}^2$$

$$\theta = 3 \text{ hrs}$$

$$L/W = 3$$

$$L = 3W$$

$$A = \frac{Q}{\text{OFR}} \\ = \frac{20,000 \text{ m}^3/\text{d}}{20 \text{ m}^3/\text{d} \cdot \text{m}^2}$$

$$A = 1,000 \text{ m}^2$$

$$A = L \cdot W$$

$$A = W^2(3)$$

$$W = \sqrt{\frac{1000 \text{ m}^2}{3}}$$

$$\begin{array}{l} * \boxed{W = 18.26 \text{ m}} \\ \boxed{L = 54.77 \text{ m}} \end{array} \checkmark$$

$$\theta = \frac{V}{Q}$$

$$V = \theta Q$$

$$= 20,000 \text{ m}^3/\text{d} \cdot (3 \text{ hrs}) \frac{1 \text{ d}}{24 \text{ hrs}}$$

$$V = 2,500 \text{ m}^3$$

$$V = A \times h$$

$$h = \frac{V}{A}$$

$$= \frac{2,500 \text{ m}^3}{1000 \text{ m}^2}$$

$$* \boxed{h = 2.5 \text{ m}} \checkmark$$

11.11) Determine the detention time in hrs, the surface loading, and the horizontal flow rate through velocity

$$V = 1400 \text{ m}^3$$

$$V = A \times h$$

$$A = (13.66 \text{ m})^2 (2.5)$$

$$h = 3 \text{ m}$$

$$A = L \times W$$

$$A = 466.67 \text{ m}^2$$

$$L/W = 2.5$$

$$L = 2.5 W$$

$$A = W^2 (2.5)$$

$$Q = 9000 \text{ m}^3/\text{d}$$

$$V = W^2 (2.5) 3 \text{ m}$$

$$\theta = \frac{V}{Q}$$

$$= \frac{1400 \text{ m}^3}{9000 \text{ m}^3/\text{d}}$$

$$= 0.1555 \text{ d} \left(\frac{24 \text{ hrs}}{1 \text{ d}} \right)$$

$$* \theta = 3.73 \text{ hrs} \checkmark$$

$$W = \sqrt{\frac{(1400 \text{ m}^3)}{2.5 (3 \text{ m})}}$$

$$* W = 13.46 \text{ m} \checkmark$$

$$L = 2.5 (13.46 \text{ m})$$

$$* L = 34.156 \text{ m} \checkmark$$

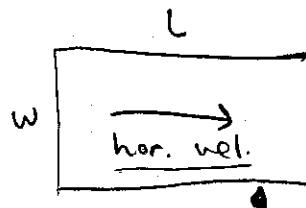
$$A = \frac{Q}{\text{OFR}}$$

$$\text{OFR} = \frac{Q}{A}$$

$$= \frac{9000 \text{ m}^3/\text{d}}{466.67 \text{ m}^2}$$

$$= 19.2857 \text{ m/d}$$

$$* \text{OFR} = 19.29 \text{ m}^3/\text{d} \cdot \text{m}^2 \checkmark$$



$$V = \frac{Q}{A_{cs}}$$

$$= \frac{9000 \text{ m}^3/\text{d}}{3 \text{ m} (13.66 \text{ m})}$$

$$= 219.58 \text{ m/d}$$

$$* V = 219.58 \text{ m/d} \checkmark$$

$$219.58 \frac{\text{m}}{\text{d}} \times \frac{1 \text{ d}}{24 \text{ hrs}} \times \frac{1 \text{ hrs}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}}$$

$$* V = 0.00254 \text{ m/s}$$

11.12.) What is the plants loading expressed in kilograms per day?

$$Q = 4000 \text{ m}^3/\text{d}$$

$$\text{Bod}_5 = 250 \text{ g/m}^3$$

$$= 4000 \text{ m}^3/\text{d} (250 \text{ g/m}^3)$$

$$= 1,000,000 \text{ g/d} \left(\frac{1 \text{ kg}}{1000 \text{ g}} \right)$$

$$\boxed{\text{loading} = 1000 \text{ kg/d}} \quad \checkmark$$

11.13) What is the dosage in milligrams per liter?

250 kg of chlorine

$$V = 125,000 \text{ m}^3$$

$$\frac{250 \text{ kg}}{125,000 \text{ m}^3} = 0.002 \frac{\text{kg}}{\text{m}^3} \left(\frac{10^6 \text{ mg}}{1 \text{ kg}} \right)$$

$$= 2000 \frac{\text{mg}}{\text{m}^3} \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right)$$

$$\boxed{\text{dosage} = 2 \text{ mg/L}}$$



11.14) What amount of chlorine (in kilograms per day) is required for flows of (a.) $5000 \text{ m}^3/\text{d}$, (b.) $200 \text{ L}/\text{min}$, and (c.) $0.5 \text{ m}^3/\text{s}$?

Chlorine dosage = 4.0 mg/L

a.) $5000 \text{ m}^3/\text{d} \cdot \left(\frac{1000 \text{ L}}{1 \text{ m}^3} \right)$

$= 5,000,000 \text{ L/d}$

$4.0 \text{ mg/L} (5 \times 10^6 \text{ L/d})$

$\ast = 20,000,000 \text{ mg/d} \left(\frac{1 \text{ kg}}{10^6 \text{ mg}} \right)$

Chlorine dose = 20 kg/d ✓

b.) $200 \text{ L}/\text{min}$

$= 200 \text{ L}/\text{min} \left(\frac{60 \text{ min}}{1 \text{ hr}} \right) \left(\frac{24 \text{ hr}}{1 \text{ d}} \right)$

$= 288,000 \text{ L/d}$

$= 288,000 \text{ L/d} (4.0 \text{ mg/L})$

$= 1,152,000 \text{ mg/d} \left(\frac{1 \text{ kg}}{10^6 \text{ mg}} \right)$

Chlorine Dose = 1.152 kg/d ✓

c.) $0.5 \text{ m}^3/\text{s}$

$= 0.5 \text{ m}^3/\text{s} \left(\frac{1000 \text{ L}}{1 \text{ m}^3} \right) \left(\frac{60 \text{ sec}}{1 \text{ min}} \right) \left(\frac{60 \text{ min}}{1 \text{ hr}} \right) \left(\frac{24 \text{ hr}}{1 \text{ d}} \right)$

$= 432,000,000 \text{ L/d}$

$4.0 \text{ mg/L} (43,200,000 \text{ L/d})$

$= 172,800,000 \text{ mg/d} \left(\frac{1 \text{ kg}}{10^6 \text{ mg}} \right)$

Chlorine Dose = 172.8 kg/d ✓

**CVEG 4043– Environmental Engineering Design
Fall 2019**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Wastewater Treatment Plant Design Project

Outcome Measured Using this Assignment

Outcome 1

**An ability to identify, formulate, and solve complex engineering problems
by applying principles of engineering, science, and mathematics**

Brief Description of the suitability of this assignment for the outcome

In this project, the students need to identify needs and various components for a wastewater treatment plant. Portion of the design include solving complex engineering problems. This project is assigned 40 points out of 100 points for the outcome 1 and the rest for outcome 2.

Wastewater Treatment Plant Design

El Paso, Texas

CVEG 4043: Environmental Engineering Design
Fall 2019

ABET Criteria

3(1)

34/40

3(2)

55/60

89/100

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Date: Dec. 11, 2019

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Executive Summary

The objective of this design project is to engineer a design for a wastewater plant with a US city population of 100,000 or greater. Presented in this report is the design for the wastewater treatment plant for El Paso, Texas. The primary source of drinking water for residents is Rio Grande River. Several parameters need to be considered such as population projection, water demand, as well as its sources. With those values in mind, they are then implemented into the design process of each plant to assure the calculations are within a certain range to fit the criteria. It is important for engineers to analyze the multiple components to successfully design a functional plant for the population's safety and welfare.

1.0 Population Projection

The population projection is important as it helps us design wastewater systems to adequately and economically serve the present and future population of the community. In order to calculate the future growth for the city of El Paso in 2050 one must first gather historical data and trends which can be shown in Table 1. The population data for El Paso was obtain using the U.S. Census Bureau starting from 1900 and increasing by every decade to 2010; from the table one can see that that the City of El Paso is consistently increasing in population at each decade.

Table 1 - Population Growth from 1900-2010

year	population
1900	24,886
1910	52,599
1920	101,877
1930	131,597
1940	131,067
1950	194,968
1960	314,070
1970	359,291
1980	479,899
1990	591,000
2000	679,622
2010	800,647

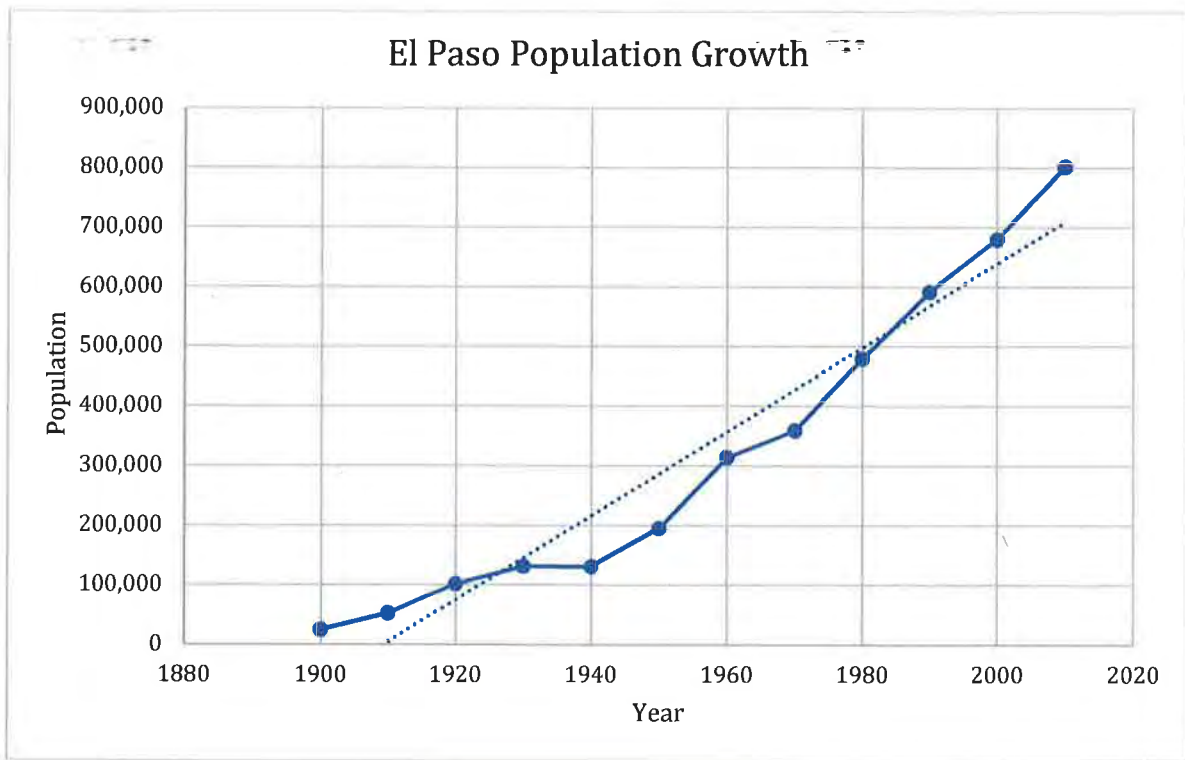


Figure 1 - Population Trend Growth

In the population growth rate shown in Figure 1, one can see that the population is constantly increasing as the decade increase. For that reason, the method chosen to project the population of 2050 was the geometric method, which assumes that the percent change in the population remains constant. For this calculation, data from 1980 to 2010 were used due to the comparison between the population and the years had a steady consistency of increasing. Where prior to 1900 to 1980 there were fluctuated in the population.

Table 2- El Paso Population Growth rate over 30 years

Year	Population	ΔP	$\Delta P/P$
1980	479,899	-	-
1990	591,000	111,101	0.19
2000	679,622	88,662	0.13
2010	800,647	121,025	0.15
Total	2,551,168	320,788	0.47
Average	850389.33	106929.33	0.16

1.1 Geometric Method

The geometric Method, estimate the projected population using the following equation:

$$\ln P = \ln P_0 + K' \Delta t \quad (1)$$

Where

P = Future Population in persons

P₀ = Current Population in persons

K' = Growth Rate Percentage

t = Number of Decades

$$P = P_0 e^{K' \Delta t} \quad (2)$$

$$P_{40} = 800,647 e^{0.16(4)} \quad (3)$$

$$P_{40} = 1,518,412 \quad (4)$$

The population for El Paso, Tx in 2050 was estimated to be **1,518,412 people**.

2.0 Wastewater Treatment Plant Design

2.1 Introduction

Wastewater treatment is a process used to remove contaminants from wastewater (water that is no longer needed or is no longer suitable for use) to convert it into an effluent that can be return back into the environment. The Wastewater Treatment plant design will be utilizing standards obtained from the Texas Commission of Environmental Quality (TCEQ) and the Texas Administrative Code (TAC) Chapter 30.

The standards from Texas Commission of Environmental Quality will be used to determine the wastewater characteristics shown in table 3 and wastewater flow demand.

Table 3 - Typical Wastewater Characteristics from TCEQ

Constituent	Concentration, mg/l		
	Strong	Medium	Weak
Total solids	1200	700	350
Dissolved solids (TDS) ¹	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride ¹	100	50	30
Alkalinity (as CaCO ₃)	200	100	50
Grease	150	100	50
BOD ₅ ²	300	200	100

2.2 Wastewater Flow

In accordance with the Texas Commission of Environmental Quality (TCEQ) Design Organic Loadings and Flows for a New Wastewater Treatment Facility table 3, a range of 75 to 100 gallons per person of wastewater produced, of which the higher end of the range will be assumed to account for maximum capacity.

Table 4 - Design Organic Loadings and Flows for a New Wastewater Treatment Facility

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Municipality	Residential	75-100	250-400	15-75
Subdivision	Residential	75-100	250-400	15-75
Trailer Park (Transient)	2½ Individuals per Trailer	50-60	250-350	15-75
Mobile Home Park	3 Individuals per Trailer	50-75	300	15-75
School	Cafeteria & Showers	20	300	15-75
	Cafeteria/No Showers	15	300	15-75
Recreational Parks	Overnight User	30	200	15-75
	Day User	5	100	15-75
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75
Hotel/Motel	Per Bed	50-75	300	15-75
Restaurant	Per Meal	7-10	1000*	15-75
Restaurant with bar or cocktail lounge	Per Meal	9-12	1000*	15-75
Hospital	Per Bed	200	300	15-75
Nursing Home	Per Bed	75-100	300	15-75
Alternative Collection Systems (Subchapter D of this chapter)	Per Capita	75	N/A	N/A
*Based on a restaurant with a grease trap				

With this information, the projected wastewater flow can be determined by multiplying the flow per person by the projected population defined in Equation 4 and then by using the conversion factor, the units can be obtained in meters cubed per day.

$$AADF = (P_{2050}) * (\text{Average daily flow per capita}) \quad (5)$$

$$Q = 1,518,412 \text{ capita} * 100 \frac{\text{gallons}}{\text{day-capita}} = 151,841,200 \frac{\text{gallons}}{\text{day}} \quad (6)$$

$$151,841,200 \frac{\text{gallons}}{\text{day}} * \frac{.003785 \text{ m}^3}{\text{gallon}} = 574,718.942 \frac{\text{m}^3}{\text{day}} \quad (7)$$

2.3 Wastewater Design

The treatment process that will be used to treat the water flowing through the wastewater treatment plant shown in figure 2 are: screening, grit chambers, primary clarifiers, trickling filters, secondary clarifiers, and disinfection methods.

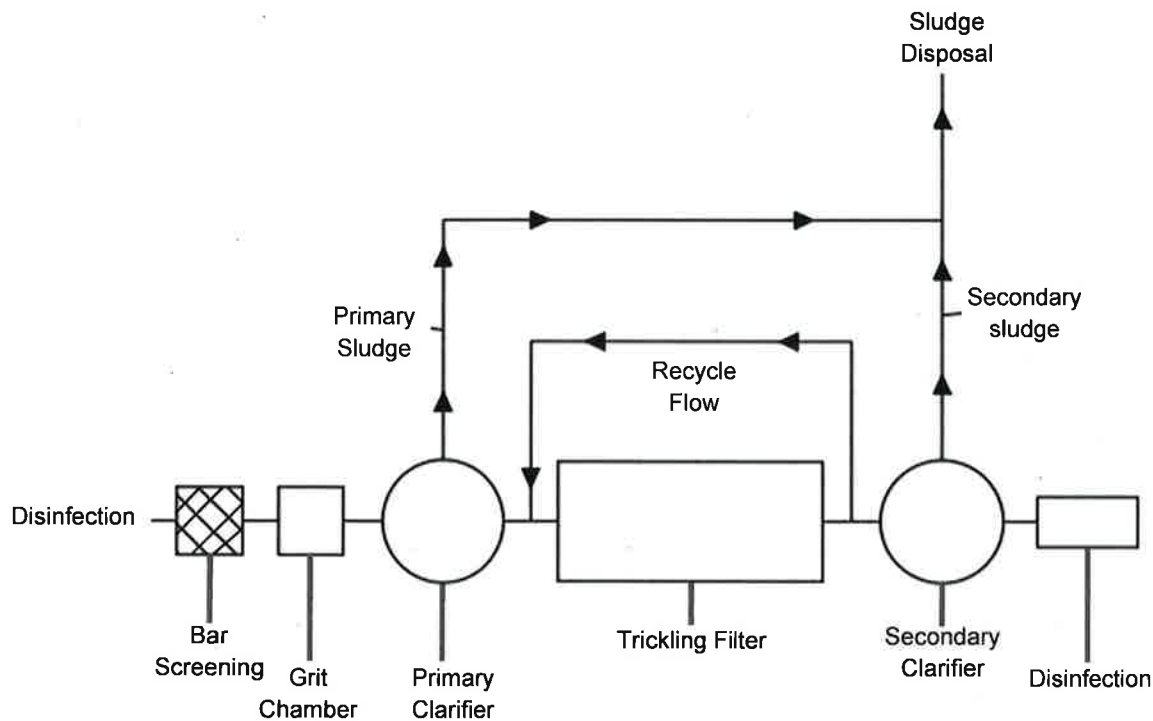


Figure 2- Diagram of Wastewater Treatment

2.3.1 Bar Screening

A bar screen is a mechanical filter used to remove large objects from wastewater, such as rags and plastics. It is part of the primary filtration flow and is typically the first or preliminary filtration level to be installed at a wastewater treatment facility.

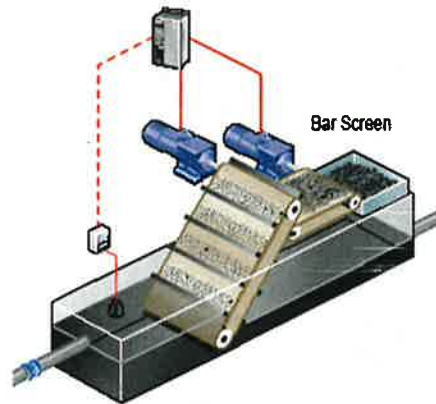


Figure 3 - Bar Screen

2.3.2 Grit Chamber

For the grit chamber Horizontal flow grit chamber channel is designed to minimize turbulence and provide a uniform velocity across the channel. Particles will start to settle at the channel before reaching the outlet point, and once the grit settles to the bottom of the chamber, it can then be taken out from the system using conveyor belt. The channel size of a horizontal flow grit chamber accommodates both the grit removal equipment capacity and grit storage.

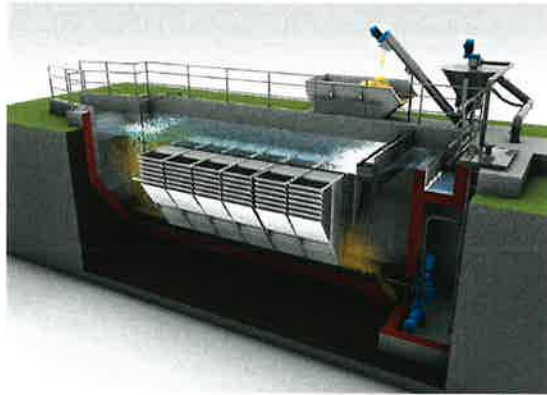


Figure 4 - Horizontal Flow Grit Chamber

Design

For this design, a length to width ratio of 1:4 and a depth of 4 meters will be used with a detention time of 3 minutes. Two chambers capable of operating at peak flow is required by TAC title 30 chapter 217 subchapter E.

$$Q_{peak} = 574,718.942 \frac{m^3}{day} * 2(\text{Peak Factor}) = 1,149,437.88 \frac{m^3}{day} \quad (8)$$

$$\frac{L}{W} = 4 \quad (9)$$

$$Volume_{required} = Q_{peak} * \theta = 1,149,437.88 \frac{m^3}{day} (3 \text{ minutes}) \left(\frac{1 \text{ day}}{1440 \text{ minutes}} \right) \quad (10)$$

$$Volume_{required} = 2394.66 m^3 \quad (11)$$

$$Area = \frac{Volume}{Depth} = \frac{2394.66 m^3}{4m} = 598.67 m^2 \quad (12)$$

$$L * \frac{L}{4} = 598.67 m^2 \quad (13)$$

$$L = 48.94 m (\text{use } 49m) \quad (14)$$

$$W = 12.25m \quad (15)$$

Two grit chambers with dimensions 49m x 12.25m x 4m will be created for the municipality of El Paso, TX.

2.3.3 Primary Sedimentation

The method of allowing particles to settle by gravitational forces is sedimentation. The primary sedimentation tanks are designed to reduce the wastewater velocity flow, allowing for the settlement of heavy organic solids. The design for this primary sedimentation tank will be based on average design criteria. On average, 50-70% of suspended solids and 30-40% of BOD₅ are removed by a primary clarifier. Mechanical scrapers collect the settled solids at the bottom of the tank and move them to the sludge-processing area.

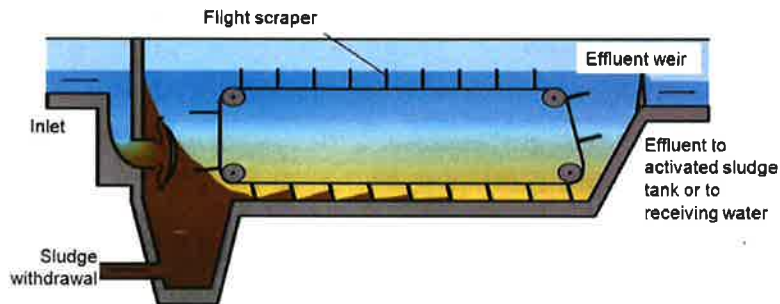


Figure 5 - Rectangle Clarifier (Sedimentation tank)

Design

Design Criteria:

Flow Rate (Q) = 574,718.942 m³/day

Influent SS = 200 mg/L

Efficiency = 80%

L:W = 6:1

Influent BOD₅ = 250 mg/L

Effluent BOD limit: 20 mg/L

Effluent SS limit: 20 mg/L

Liquid Depth = 3 m

Detention Time = 1.5 hr.

WLR = 320 m³/(day-m)

$$V_{required} = Q * \theta = 574,718.942 \frac{m^3}{day} * 1.5hrs \left(\frac{1 day}{24 hrs} \right) = 35,919.93 m^3 \quad (16)$$

$$V = A * 3m \rightarrow A = \frac{35,919.93m^3}{3m} = 11,973.31m^2$$

$$\# \text{ of tanks} = \frac{A}{600m^2} = \frac{11,973.31m^2}{600m^2} = 19.96 \text{ tanks} \rightarrow 20 \text{ tanks}$$

$$\frac{11,973.31m^2}{20} = L * W = L * \frac{L}{6} \rightarrow L = 59.93 m \rightarrow 60m$$

$$W = \frac{60m}{6} = 10m \rightarrow 10m$$

$$V_{\text{tank}} = L * W * d = 60m * 10m * 3m = 1,800m^3$$

$$V_{\text{total}} = V_{\text{tank}} * 20 = 1,800m^3 * 20 = 36,000m^3$$

$$OFR = \frac{Q}{A} = \frac{574,718.942 \text{ m}^3/\text{day}}{11,973.31m^2} = 48 \frac{m^3}{d-m^2}$$

$$L_w = \frac{Q_{\text{tank}}}{WLR} = \frac{28,735.95 \text{ m}^3/\text{day}}{320 \frac{m^3}{\text{day-m}}} = 89.79 m$$

$$A = \frac{Q}{OFR}$$

avg (17) loads
7 pic

no

X

The designed primary sedimentation tanks will have the dimensions of 60 meters in length, 10 meters in width, and 3 meters in depth. They will accommodate for an overflow rate of 48 meters cubed per day-meter squared and will have a weir length of 89.79 meters.

2.3.4 Trickling Filter

A trickling filter is a biological treatment system that reduces BOD and suspended solids from wastewater. Figure 6 illustrates the simple structure of a trickling filter. Wastewater from the main clarifier is pumped through the feed pipe, well into the distributor, and out the rotary distributor arm. filter material, such as rocks or plastic are used to trickles wastewater and then the wastewater comes into contact with the microorganism film attached to the outside of the filter material. The microorganisms feed on the wastewater organic material as it flows through. Underneath the filter material, the underdrain collects the treated wastewater and sludge and sends it to the outlet.

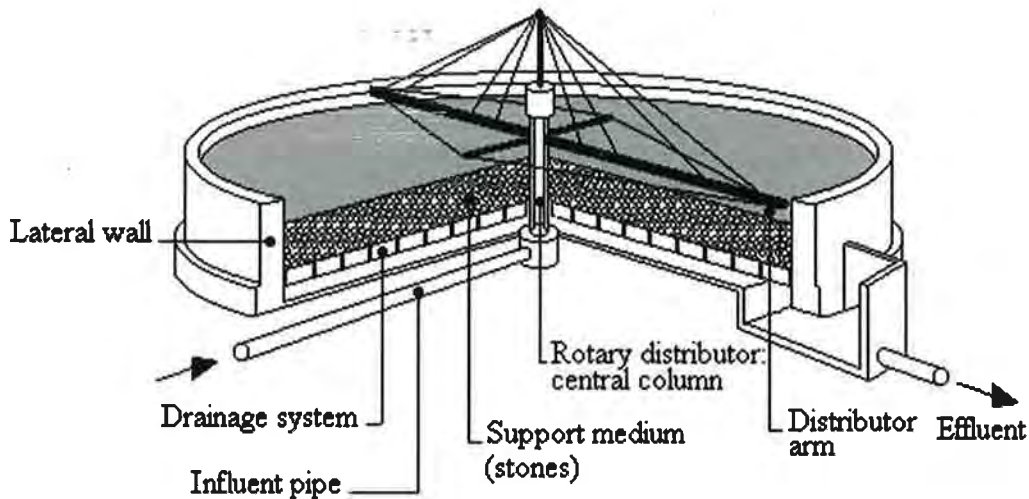


Figure 6 - Trickling Filter

Design

A recirculation ratio of 2 and a hydraulic loading rate of 50 meters cubed per day-meter squared, while maintaining a cylinder chamber.

$$BOD_5 = 250 \frac{mg}{L} * (1 - 0.35) = 162.5 \frac{mg}{L} \quad (25)$$

$$E = \frac{162.5 - 20}{165} (100\%) = 87.69\% \quad (26)$$

$$A_{tank} = \frac{Q(1+R)}{L_H} = \frac{574,718.942 \frac{m^3}{d} (3)}{50 \frac{m^3}{d-m^2}} = 34,483.14 m^2 \quad (27)$$

$$A_{tank} = \frac{\pi}{4} D^2 \rightarrow D = \sqrt{\frac{4}{\pi} A} = 209.54 \rightarrow 210 m \quad (28)$$

$$V_{tank} = \frac{\pi}{4} 210^2 * 3m = 103,908.18 m^3 \quad (29)$$

must ok
NRC
eq

A trickling filter with a Diameter of 210 meters, and a depth of 3 meters operating at an efficiency of 87.69% was designed for the municipality of El Paso.

2.3.5 Secondary Sedimentation

Secondary sedimentation tanks or clarifiers are designed to remove the stabilized organic solids from the wastewater. Typically, these solids are created during the process of activated sludge or trickling filter. In order to treat the wastewater, some of the solids collected in the secondary clarifier are returned to the aeration tank. The secondary clarifier functions the same as the primary clarifier and is tested for peak flow and average flow

Design

Design Criteria:

Average Design flow = $236,551.12 \text{ m}^3/\text{s}$

Peak Design Flow = $473,102.24 \text{ m}^3/\text{s}$

Overflow Rate for Average Design flow = 24.44 to $32.6 \text{ m}^3/\text{m}^2\text{-d}$

Overflow Rate for Peak Design flow = $61.12 \text{ m}^3/\text{m}^2\text{-d}$

Detention time, $\theta = 2$ hours

Depth = 3 m

Freeboard = 0.6 m

$$Q_{tot-avg} = Q + RQ = 3 \left(574,718.942 \frac{\text{m}^3}{\text{d}} \right) = 1,724,156.825 \frac{\text{m}^3}{\text{d}} \quad (30)$$

$$Q_{tot-peak} = 1,724,156.825 \frac{\text{m}^3}{\text{d}} (2) = 3,448,313.852 \frac{\text{m}^3}{\text{d}} \quad (31)$$

$$A_{avg} = \frac{Q_{avg}}{OFR_{avg}} = \frac{1,347,728.766 \frac{\text{m}^3}{\text{d}}}{32.6 \frac{\text{m}^3}{\text{d-m}^2}} = 32,888.25 \text{ m}^2 \quad (32)$$

$$A_{peak} = \frac{Q_{peak}}{OFR_{peak}} = \frac{3,448,313.852 \frac{\text{m}^3}{\text{d}}}{61.12 \frac{\text{m}^3}{\text{d-m}^2}} = 56,418.74 \text{ m}^2 \quad (33)$$

Area based on peak flow is greater than area base on Average flow which will be used in the future equations.

$$\frac{56,418.74 \text{ m}^2}{6000 \text{ m}^2} = 9.48 \text{ tanks} \rightarrow 10 \text{ Tanks} \quad (34)$$

$$A_{tank} = \frac{56,418.74 \text{ m}^2}{9} = 5641.87 \text{ m}^2 \quad (35)$$

$$5641.87 \text{ m}^2 = \frac{\pi}{4} D^2 \quad (36)$$

$$D = \sqrt{\frac{4}{\pi} 5641.87} = 84.75 \text{ m} \rightarrow 90 \text{ m} \quad (37)$$

$$V_{tank} = \frac{\pi}{4} * 90^2 * 3 \text{ m} = 19,085.175 \text{ m}^3 \quad (38)$$

2.3.6 Disinfection

Before discharging the treated wastewater to the environment, the last process in the treatment facility will be disinfection. The disinfection process can be accomplished by adding chlorine or by exposing the wastewater to ultraviolet light (UV). The type of disinfection chosen for the municipality of El Paso is ultraviolet light (UV) disinfection. UV disinfection is a physical

process that instantaneously neutralizes microorganisms as they pass by ultraviolet lamps submerged in the effluent — the reason why it better to go with (UV) than chlorine. When chemicals such as chlorine are added to the water, it can be harmful to river life, and the environment. After microorganisms are killed, the treated wastewater effluent can be discharged to the surface waters (lakes, rivers).

3.0 Conclusion

The wastewater treatment plant has been designed under TAC 30 and TCEQ, which outlines wastewater treatment plant rules and regulations. The maximum daily flow into the plant has been calculated and used in calculations to ensure that each process is capable of the amount of wastewater going in. This plant is designed to treat wastewater and discharge efficiently into a river system that does not affect existing ecosystems.

El Paso will continue to grow a large population throughout the years. Considering a large amount of water used, the wastewater plant designed is large and may be impractical considering the other water treatment plants within the area. Therefore, it may need to be broken up into sub-plants to treat the wastewater produced by the citizens of El Paso in general standards.

4.0 References

U.S. Census Bureau, El Paso

factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk

Texas Commission of Environmental Quality (TCEQ)

tceq.texas.gov/assets/public/legal/rules/rules/pdflib/217b.pdf

Texas Administrative Code,

[texreg.sos.state.tx.us/public/readtac\\$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=217](https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=217).

**CVEG 4043– Environmental Engineering Design
Fall 2020**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Homework # 3

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

All the problems in this Homework are developed to test the students' ability to identify, formulate and solve complex engineering problems



PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

CVEG 4043 – ENVIRONMENTAL ENGINEERING DESIGN FALL 2020

Raghava Kommalapati, PhD, PE, BCEE, F. ASCE
Taskstream Assignment # 1: Due October 23, 2020

Student Name Nikea Keitt

Grade 91 /100

1. Design a rectangular sedimentation tank (L/W is 2.5) for a **monthly max flow** (factor 1.25) with a hydraulic detention time of 2.4 hours and a surface overflow rate of $42 \text{ m}^3/\text{m}^2 \cdot \text{d}$ for a town with a population of 150,000 with an average daily water demand of 400 L/capita. Determine the tank dimensions (L, W, and D). Determine the diameter if a circular tank is used instead. What is the flow through velocity for a rectangular tank? Estimate the solids loading to the sedimentation tank if the raw water solids concentration is 25 mg/l. **25 Pts.**

$$Q_{\text{avg}} = 150,000 \times 400 \text{ L/cd} \times \frac{\text{m}^3}{1000 \text{ L}} = 60,000 \text{ m}^3/\text{d}$$

$$2.5W^2 = 1785.7$$

$$Q_{\text{design}} = 1.25(60,000) = 75,000 \text{ m}^3/\text{d}$$

$$W = 26.7 \text{ m}$$

$$L = 66.8 \text{ m}$$

$$A = \frac{Q}{\text{OFR}} = \frac{75,000 \text{ m}^3/\text{d}}{42 \text{ m}^3/\text{m}^2 \cdot \text{d}} = 1785.7 \text{ m}^2$$

$$\text{Depth} = \frac{V}{A} = \frac{75,000}{1785.7} = 4.2 \text{ m}$$

$$V = Q\theta = 75,000 (2.4 \text{ h}) \left(\frac{\text{d}}{24 \text{ h}}\right) = 7500 \text{ m}^3$$

$$\boxed{\begin{array}{l} L = 66.8 \text{ m} \\ W = 26.7 \text{ m} \\ D = 4.2 \text{ m} \end{array}}$$

circular tank $\frac{\pi d^2}{4} = 1785.7$ $\boxed{d = 47.7 \text{ m}}$

$$v = \frac{Q}{A_c} = \frac{75,000 \text{ m}^3/\text{d}}{112.14 \text{ m}^2} = 668.8 \frac{\text{m}}{\text{d}} = 0.0077 \frac{\text{m}}{\text{s}}$$

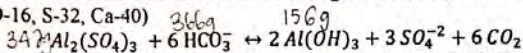
$$\text{solids loading} = Q \cdot C = 75,000 \frac{\text{m}^3}{\text{d}} \cdot 25 \frac{\text{mg}}{\text{L}} \cdot \frac{1000 \text{ L}}{\text{m}^3} \cdot \frac{\text{kg}}{10^6 \text{ mg}}$$

$$\boxed{1875 \frac{\text{kg}}{\text{d}}}$$

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2. Coagulant dosage and optimum pH were determined to be 50 mg/l of alum $Al_2(SO_4)_3$ and 6.05 respectively from Jar tests. The bicarbonate alkalinity in the water is found to be 30 mg/l as $CaCO_3$. The plant treats 40,000 m³/day of water and has 30 mg/l of suspended and colloidal solids. The alum salt reaction in water is given below: (Atomic Weights: Al-27, C-12, H-1, O-16, S-32, Ca-40) 25 Pts.



- How much alkalinity (mg/l as $CaCO_3$) will remain in water? If alkalinity is deficient then how much alum salt will need to be neutralized and how do we neutralize the water?
- What would be the yearly cost of coagulant if it costs \$225 per 100 Kg and is available at 88% purity?
- How much floc (precipitate) would be produced per day for coagulation of water
- Estimate the total solids (including floc) produced in a sedimentation basin if the basin removes 88% of the incoming solids and all the precipitate.

$$i) \frac{366}{342} (50 \text{ mg/L}) = 53.5 \text{ mg/L}$$

$$30 \text{ mg/L as } CaCO_3 \cdot \frac{61}{50} = 36.6 \text{ mg/L } HCO_3^-$$

Neutralization

$$53.5 \text{ mg/L} \rightarrow 50 \text{ mg/L Alum}$$

$$36.6 \text{ mg/L} \rightarrow \frac{50}{53.5} (36.6) = 34.2 \text{ mg/L}$$

$$50 - 34.2 = 15.8 \text{ mg/L of Alum needs to be neutralized}$$

$$ii) \frac{50 \text{ mg}}{L} \cdot 40,000 \frac{m^3}{d} \cdot \frac{1000 L}{m^3} \cdot \frac{Kg}{10^6 mg} = 2272.7 \frac{Kg}{d}$$

0.88

$$2272.7 \frac{Kg}{d} \cdot \frac{Kg}{100 Kg} \cdot \frac{\$225}{YR} = \$1,866,454/YR$$

$$iii) \frac{156}{342} (50) = 22.8 \text{ mg/L} \cdot 40,000 \frac{m^3}{d} \cdot \frac{1000 L}{m^3} \cdot \frac{Kg}{10^6 mg} = 912 \frac{Kg}{d}$$

$$iv) 30 \text{ mg/L} \cdot 40,000 \frac{m^3}{d} \cdot \frac{1000 L}{m^3} \cdot \frac{Kg}{10^6 mg} = 1200 \frac{Kg}{d} \cdot (0.88) = 1056 \frac{Kg}{d}$$

$$1056 + 912 = 1968 \frac{Kg}{d}$$

3. Lime and soda process is to be designed for the water analysis presented below. The quantity of water to be treated is 10 MGD.

25 Pts

- Determine the amount of lime and soda to soften the water to a final hardness of 90 mg/l as CaCO_3
- Estimate the annual cost of softening if the cost of dry lime (CaO) is a dime per kilogram and cost of soda ash (Na_2CO_3) is 20 cents per kilogram (assume both compounds to be 90% pure).

Constituent	mg/l	mg/l as CaCO_3	Lime	
Ca^{+2}	120	300		
Mg^{+2}	64	263.4	263.4	
Alkalinity		150	150	
CO_2		22	22	

$$\text{TH} = 104 \text{ mg/L}$$

$$\text{Ca}^{+2} \rightarrow 40 \text{ g/mol}$$

$$120 \times \frac{50}{20} = 300 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Mg}^{+2} \rightarrow 24.3 \text{ g/mol}$$

$$64 \times \frac{50}{12.15} = 263.4 \text{ mg/L as } \text{CaCO}_3$$

$$\text{TH} = 563.4 \text{ mg/L as } \text{CaCO}_3$$

$$\text{CH} = 150 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH} = 563.4 - 150 = 413.4 \text{ mg/L as } \text{CaCO}_3$$

$$\text{i) Lime} = 413.4 \text{ mg/L as } \text{CaCO}_3 \times \frac{28}{50} = \boxed{243.8 \text{ mg/L}}$$

$$\text{NCH} = 413.4 \text{ mg/L as } \text{CaCO}_3$$

$$\text{FH} = 90 \text{ mg/L as } \text{CaCO}_3$$

$$90 - 40 = 50 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH to be removed} = 413.4 - 50 = 363.4 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Soda} = 363.4 \text{ mg/L as } \text{CaCO}_3 \times \frac{53}{50} = \boxed{385.2 \text{ mg/L}}$$

$$\text{ii) Lime (kg/d)} = \frac{243.8 \frac{\text{mg}}{\text{L}} \cdot 10 \times 10^6 \frac{\text{L}}{\text{d}} \cdot \frac{3.705 \text{ L}}{\text{g}} \cdot \frac{\text{kg}}{10^6 \text{ mg}}}{0.9} = 10253.14 \frac{\text{kg}}{\text{d}}$$

$$10253.14 \frac{\text{kg}}{\text{d}} \cdot \frac{365 \text{ d}}{\text{yr}} \cdot \frac{\$10}{\text{kg}} = \boxed{\$374,239.61}$$

$$\text{Soda (kg/d)} = \frac{385.2 \frac{\text{mg}}{\text{L}} \cdot 10 \times 10^6 \frac{\text{L}}{\text{d}} \cdot \frac{3.705 \text{ L}}{\text{g}} \cdot \frac{\text{kg}}{10^6 \text{ mg}}}{0.9} = 16199.8 \frac{\text{kg}}{\text{d}}$$

$$16199.8 \frac{\text{kg}}{\text{d}} \cdot \frac{365 \text{ d}}{\text{yr}} \cdot \frac{\$.20}{\text{kg}} = \boxed{\$1,182,595.40}$$

4. Repeat problem #4 if a split treatment is desired and final hardness should be less than 150 mg/l as CaCO_3 .

25 Pts

$$\text{TH} = 563.37 \text{ mg/L as CaCO}_3$$

$$\text{CH} = 150 \text{ mg/L as CaCO}_3$$

$$\text{NCH} = 413.37 \text{ mg/L as CaCO}_3$$

$$\text{Mg} = 263.4 \text{ mg/L as CaCO}_3$$

$$x = \frac{\text{Mg}_f - \text{Mg}_i}{\text{Mg}_f - \text{Mg}_l} = \frac{40 - 10}{263.4 - 10} = 0.118$$

$$263.4(0.118) + (1 - 0.118)40 = 66.36 \text{ mg/L as CaCO}_3$$

↓ < 150 mg/L (OK)

Lime Const	conc	Lime
CO_2	28	28
Alk.	150	150
Mg	263.4	263.4
Excess Lime	223.4	40
		475.4 mg/L as CaCO_3

$$\text{Lime } 475.4 \text{ mg/L as CaCO}_3 \times \frac{28}{50} = 266.2 \text{ mg/L}$$

$$\frac{266.2 \frac{\text{mg}}{\text{L}} \cdot 10 \times 10^6 \frac{\text{g}}{\text{d}} \cdot \frac{3.785 \text{ L}}{\text{g}} \cdot \frac{\text{kg}}{10^6 \text{ mg}}}{0.9} = 11195.19 \frac{\text{kg}}{\text{d}}$$

$$11195.19 \frac{\text{kg}}{\text{d}} \cdot \frac{365 \text{ d}}{\text{YR}} \cdot \frac{\$10}{\text{kg}} = \$408624.39 \quad \times$$

$$\text{Soda } 413.37 \text{ mg/L as CaCO}_3 \times \frac{53}{50} = 438.17 \text{ mg/L}$$

$$\frac{438.17 \frac{\text{mg}}{\text{L}} \cdot 10 \times 10^6 \frac{\text{g}}{\text{d}} \cdot \frac{3.785 \text{ L}}{\text{g}} \cdot \frac{\text{kg}}{10^6 \text{ mg}}}{0.9} = 18427.40 \frac{\text{kg}}{\text{d}}$$

$$18427.40 \frac{\text{kg}}{\text{d}} \cdot \frac{365 \text{ d}}{\text{YR}} \cdot \frac{\$20}{\text{kg}} = \$1,345,206.04 \quad \times$$

**CVEG 4043– Environmental Engineering Design
Fall 2020**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Wastewater Treatment Plant Design Project

Outcome Measured Using this Assignment

Outcome 1

**An ability to identify, formulate, and solve complex engineering problems
by applying principles of engineering, science, and mathematics**

Brief Description of the suitability of this assignment for the outcome

In this project, the students need to identify needs and various components for a wastewater treatment plant. Portion of the design include solving complex engineering problems. This project is assigned 100 points out of 200 points for the outcome 1 and another 100 for outcome 2.



ABET 3(1) 90/100
3(2) 85/100

Wastewater Treatment Plant Design -
El Paso, Texas

CVEG 4043: Environmental Engineering Design
Fall 2020

Submitted by:

Merchae Dargins
Precious Kalu
Randelle Jones

Submitted to:

Dr. Raghava Kommalapati

Due Date: December 6, 2020

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Abstract

The objective of this project is to design a wastewater treatment plant within a city located in the U.S. that has a population greater than 100,000 people. Contained in this report, is the design for the wastewater treatment plant located in El Paso, Texas. A wastewater treatment plant is designed to help remove contaminants from wastewater or sewage water, and convert it into an effluent that can be returned to the water cycle with minimum impact on the environment.

More details about what is done in this report should
presented in the summary

I. Wastewater Treatment

The objective of a wastewater treatment is to produce an effluent that can be discharged without causing serious environmental impacts. The processes for wastewater and water treatment plants are similar except, the biological methods are different. The treatment required for a wastewater treatment plant will depend on the effluent discharge requirements. There are three different types of treatment identifications. They are identified as primary, secondary, and advanced. The primary treatment involves sedimentation of solid waste within the water, which occurs after filtering out large contaminants and solids. The secondary treatment utilizes oxidation to further purify wastewater. This is done by three different ways which are biofiltration, aeration, and oxidation ponds. The advanced treatment is normally used for removing phosphates and nitrates from the water supply. The most commonly used materials that assist in this process are substances like activated carbon and sand.

Standards from the Texas Administrative Code (TAC) and the Texas Commission on Environmental Quality (TCEQ) will be utilized when designing the wastewater treatment plant. Some assumptions must be made in order to design, such as the quality of wastewater, the flow through the plant, and the total waste being produced. The treatments that will be designed are: screening, grit chambers, primary clarifiers, trickling filters, secondary clarifiers, and disinfection methods. Below is a table provided by TCEQ of standards to follow for wastewater characteristics, along with a diagram showing the treatment processes.

Table 1 - Major Constituent of Typical Domestic Wastewater

Constituent	concentration in mg/l
Total Solids	1200 high
Dissolved Solid	850

Suspended Solid	350
Nitrogen	85
Phosphorus	20
Chloride	100
Alkalinity as Caco3	200
Grease	150
BOD5	400

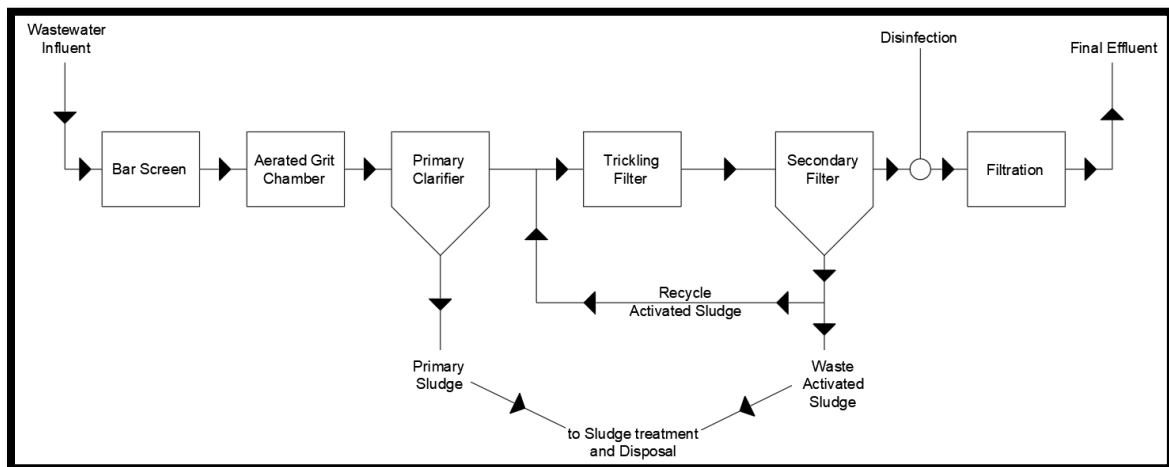


Figure 1. Diagram of Wastewater Treatment Facility Layout

Table 2 - The Wastewater Flow from TAC Title 30 Chapter 2.17

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Municipality	Residential	75-100	250-400	15-75
Subdivision	Residential	75-100	250-400	15-75
Trailer Park (Transient)	2½ Individuals per Trailer	50-60	250-350	15-75
Mobile Home Park	3 Individuals per Trailer	50-75	300	15-75
School	Cafeteria & Showers	20	300	15-75
	Cafeteria/No Showers	15	300	15-75
Recreational Parks	Overnight User	30	200	15-75
	Day User	5	100	15-75
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75
Hotel/Motel	Per Bed	50-75	300	15-75
Restaurant	Per Meal	7-10	1000*	15-75
Restaurant with bar or cocktail lounge	Per Meal	9-12	1000*	15-75
Hospital	Per Bed	200	300	15-75
Nursing Home	Per Bed	75-100	300	15-75
Alternative Collection Systems (Subchapter D of this chapter)	Per Capita	75	N/A	N/A
*Based on a restaurant with a grease trap				

El Paso, Tx Wastewater Estimations:

The wastewater usage for 2050 was obtained by the assumption that 80% of the water that will be provided to the forecast population will come back as wastewater. It was obtained by getting 80% of 35.4 MGD which is 28.32 MGD. The wastewater per gal/capita*day came out to be 102.4 gal/capita*day which is out the range provided by TAC title 30 chapter 2.17 (75-100 gal/capita*day). For design purposes a wastewater of 100 gal/capita*day will be used in the design year.

$$Q_{2050} = \text{Average Wastewater Daily Flow per capita} * P_{2050}$$

$$= 100 \text{ gal/capita*day} * 1,192,744 \text{ persons}$$

$$119.2 \text{ MGD} * 0.003785 \frac{m^3}{d} = 451,453 \frac{m^3}{d}$$

The Average peak factor is 2. It is necessary to calculate the average peak flow

$$Q_{\text{peak}} = 119.2 \text{ MGD} * 2 = 238.4 \text{ MGD} * 0.003785 \text{ m}^3/\text{d} = 902,344 \text{ m}^3/\text{d}$$

II. Aerated Grit Chamber

An aerated grit chamber removes grit from wastewater streams. As shown in Figure 1, grit is removed by causing the wastewater to flow in a spiral pattern. Air is introduced in the grit chamber along one side, causing a perpendicular spiral velocity pattern to flow through the tank. Heavier particles are accelerated and diverged from the streamlines, dropping to the bottom of the tank, while lighter organic particles are suspended and eventually carried out of the tank.

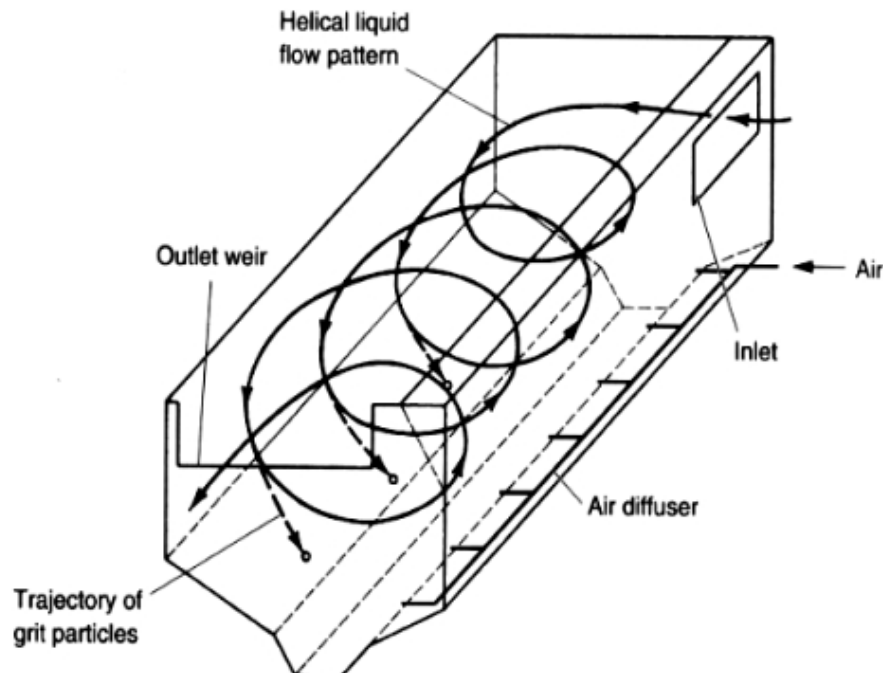


Figure 2. Aerated Grit Chamber

Using a detention time of 3 minutes, a peak flow of 238.4 MGD, and a depth of 10 feet. The dimensions of the grit chamber were found by using the following equation:

$$V = Q * \theta$$

Where,

V = Volume

Q = Flow

θ = Detention Time

where are the numbers?

What detention time did you use and how did you come up with the numbers in the table?

$$Area = \frac{Volume}{Depth}$$

The final results of the dimension calculations are as follows in the table.

Table 3 - Aerated Grit Chamber Dimensions

Designed element	Dimension
Volume required	3,983,247 ft^3
Length	2212ft
Width	180ft
Depth	10 ft

III. Primary Clarifier

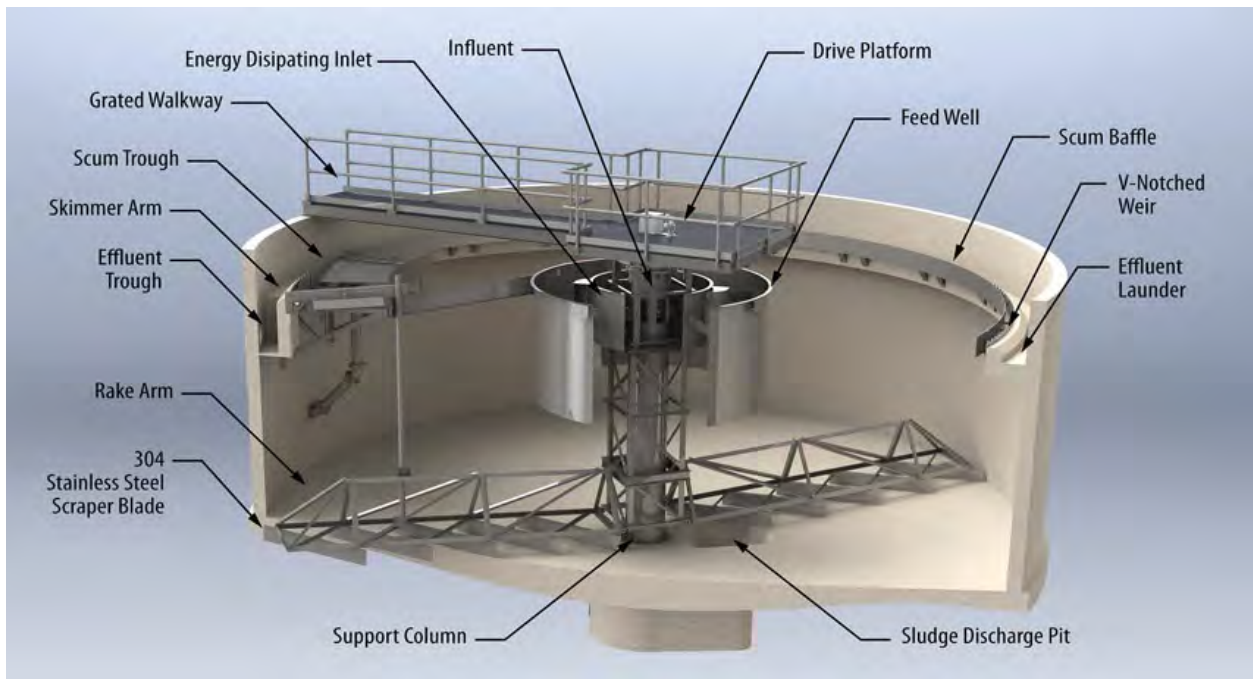


Figure 3. Example of a Circular Clarifier

After preliminary treatment, the wastewater is introduced into a sedimentation tank or clarifier. Since this is the first phase of the clarification the tank is often called a primary clarifier. Primary Clarification is the physical treatment process of removing solids by gravity before the biological treatment process. This process is the most cost effective way to remove these solids after basic screening. When the effluent leaves the primary clarifier and goes into the biological treatment process by overflowing over a weir. The expected range for percent removal in a primary clarifier is 90%-95% settleable solids, 40%-60% suspended solids, and 25%-50% total BOD_5 . Some of the factors that affect the clarifier efficiency are based on hydraulic detention time, temperature of the water, the design of the tank and the condition of the equipment.

For primary clarifier the typical detention time is 2 hrs. ^{why?} For this clarifier, a circular tank will be design. The diameter for a circular than ranges from 50 ft - 100 ft.

$$Total\ Area\ Required = \frac{Q}{SLD}$$

Where:

Q (peak) = 119.2 MGD

Q (avg.) = 238.4 MGD **what is peak factor?**

SLR= surface loading rate (2500 gal/ft²-day) **from where?**

Total area required was found 39,832ft²
how?

Next, the number of tanks was calculated:

$$A = \frac{\pi d^2}{4}$$

Trial 1:

Assuming 1 tank, and using a max diameter of 100 ft,

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 225.2 > 100\text{ft NO GOOD}$$

Trial 2:

Assuming 2 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 39832\ ft^2 / 2 = 19916\ ft^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 159.24\text{ft} > 100\text{ft}$$

Trial 3:

Assuming 3 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 39832\ ft^2 / 3 = 13277.3\ ft^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 130ft > 100ft$$

Trial 4:

Assuming 4 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 39832 ft^2 / 4 = 9958 ft^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 112.6ft < 100ft$$

Trial 5:

Assuming 5 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 39832 ft^2 / 5 = 7966.4 ft^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 100.7ft \leq 100ft \text{ GOOD}$$

Therefore, five tanks with a diameter of 100ft will be used. And the depth is calculated to be: 31865978

$$V = Q * \theta$$

$$V = 31865978 \frac{ft^3}{day} * 2hrs * \frac{1day}{24hrs} = 2655498.16 ft^3$$

$$V = A * Depth$$

$$Depth = \frac{V}{A} = \frac{2655498.16 \text{ ft}^3}{398324 \text{ ft}^2} = 6.66 \text{ ft} / 2 = 3.33 \text{ ft}$$

The weir length is calculated,

$$\text{Weir length for a circular basin} = \pi * d = \pi * 100 \text{ ft} = 314.159 \text{ ft}$$

And the Weir loading,

$$WLR = \frac{Q}{L_w} = \frac{31865978 \text{ ft}^3 \text{ day}}{314.159 \text{ ft}} = 101432 \frac{\text{ft}^2}{\text{day}}$$

Table 4 - Primary Clarifier Tank Dimensions

Design	Dimension
Number of tanks	5
Diameter	100ft
Depth	3.33 ft
Weir Length	314.159 ft
Weir Loading	$101432 \frac{\text{ft}^2}{\text{day}}$
Free board	2ft

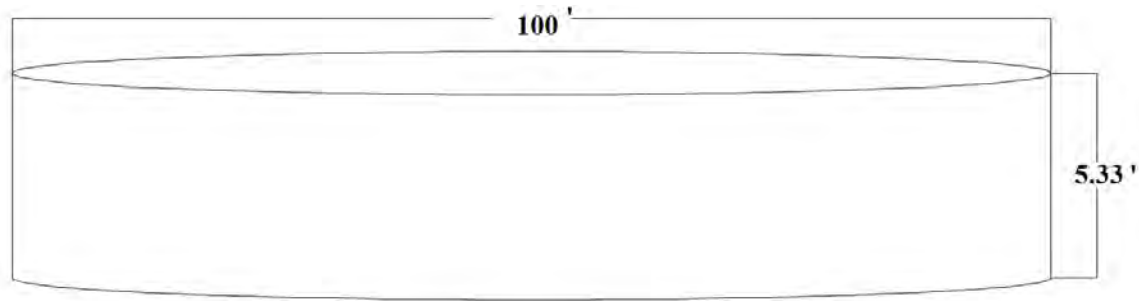


Figure 4. Primary Clarifier Design

IV. Trickling Filter

After organic matter has passed through the primary clarifier, trickling filters are used to remove it from the wastewater. The trickling filter is an aerobic treatment system that uses microorganisms attached to a medium to remove organic matter from wastewater. This enables organic material in the wastewater to be absorbed, or microorganisms attach to the medium as a biological film. Water then flows into a thin film over the medium to allow time for treatment. Oxygen cannot penetrate the medium face, because of the microorganisms gradually attaching themselves to the medium, while the layer thickens. As the biological film keeps growing, the microorganism near the surface starts to die and therefore loses the ability to cling to the medium, and a portion of the layer falls off of the filter. The solids are then transported to the secondary clarifier for removal from the wastewater.

The trickling filter is designed to provide a final effluent of 20 mg/L, with primary settling tank removing 45% of BOD and 65% of Total Suspended Solids. Trickling filters will be designed for this wastewater treatment plant. The removal efficiency is approximately 89.6% with each filter seeing about 119.2 MGD.

BOD = 350 mg/L BOD eff = 20 mg/L Depth = 6 ft

TSS = 90 mg/L R = 2

45 % BOD removal **too high for primary removal**

$$1 - 0.45 = 0.55$$

$$0.55 \times (350 \text{ mg/L}) = 192.5 \text{ mg/L} = C_m$$

$$S_{eff} = 20 \text{ mg/L}$$

$$E = (192.5 - 20) / 192.5 = 0.896 \times 100 = 89.6\%$$

$$W = 192.5 \text{ mg/l} * 119.2 \text{ MGD} * 8.34 = 191,369.64 \text{ lb/day}$$

$$F = 1 + R / (1 + 0.1R)^2 = 2.083$$

$$89.6 = \frac{100}{1 + 0.0561 \left(\frac{191,369.64}{V * 2.083} \right)^{1/2}}$$

$$V = 21,461.4 \text{ ft}^3$$

and other details?

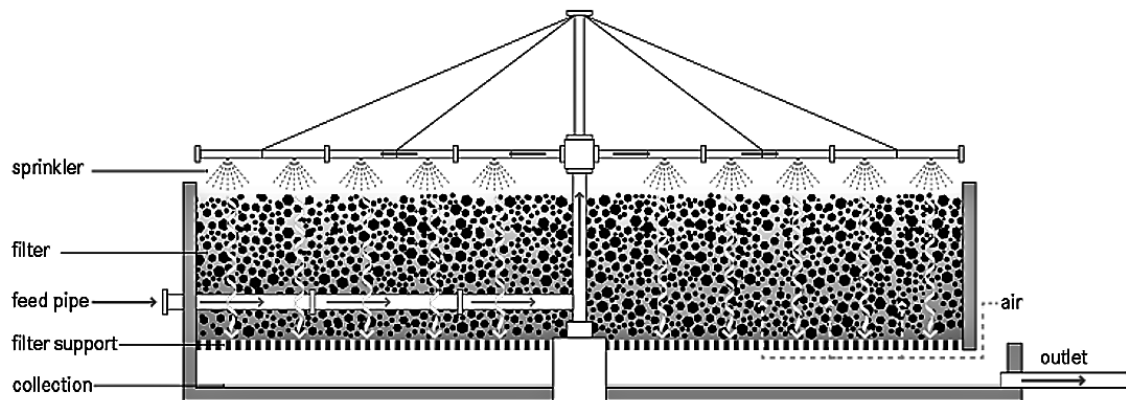


Figure 5. Cross-Section of a Trickling Filter

V. Secondary Clarifier

The key function of a secondary clarifier is to separate the biological floc from the treated liquid waste stream and the thickening and storage of the sludge from the biological treatment process. The secondary clarifier operates the same way a primary clarifier does, previously described. Some of the solids that are collected in the secondary clarifier are sent back to the trickling filter to go through the same process. Secondary clarifiers are designed based on detention time, overflow rates and weir loading rates.

For a secondary clarifier, the typical detention time is 2 hours. A circular tank will be designed for this second clarifier. The diameter for a circular ranges from 50-100 feet.

$$\text{Total Area Required} = \frac{Q}{SLD}$$

Where:

$$Q (\text{peak}) = 119.2 \text{ MGD}$$

$$Q (\text{avg.}) = 238.4 \text{ MGD}$$

SLR= surface loading rate (1500 gal/ft²-day)

Total area required was found 79,466 ft²

Next, the number of tanks was calculated:

$$A = \frac{\pi d^2}{4}$$

Trial 1:

Assuming 1 tank, and using a max diameter of 100 ft,

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 318 > 100\text{ft NO GOOD}$$

Trial 2:

Assuming 2 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 79,466 \text{ ft}^2 / 2 = 39,733 \text{ ft}^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 224.9\text{ft} > 100\text{ft NO GOOD}$$

Trial 3:

Assuming 3 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 79,466 \text{ ft}^2 / 3 = 26,488.7 \text{ ft}^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 183.6 \text{ ft} > 100\text{ft NO GOOD}$$

Trial 4:

Assuming 4 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 79,466 \text{ ft}^2 / 4 = 19,866.5 \text{ ft}^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 159 \text{ ft} < 100\text{ft NO GOOD}$$

Trial 5:

Assuming 5 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 79,466 \text{ ft}^2 / 5 = 15,893.2 \text{ ft}^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 142.2 \text{ ft} < 100\text{ft NO GOOD}$$

Trial 6:

Assuming 10 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 79,466 \text{ ft}^2 / 10 = 7946.6 \text{ ft}^2$$

$$d = \sqrt{\frac{4 * A}{\pi}}$$

$$d = 100 \text{ ft} < \text{or} = 100\text{ft GOOD}$$

Therefore, 10 tanks with a diameter of 100 ft will be used. And the depth is calculated to be:

$$V = Q * \emptyset$$

$$V = 31865978 \frac{ft^3}{day} * 24 \text{ hrs} * \frac{1day}{24 \text{ hours}} = 31,865,978 \text{ ft}^3$$

$$V = A * \text{Depth}$$

$$\text{Depth} = \frac{V}{A} = \frac{31,865,978 \text{ ft}^3}{14240 \text{ ft}^2} = 2237.7 \text{ ft}/2 = 1118.9 \text{ ft}$$

The weir length is calculated,

$$\text{Weir length for a circular basin} = \pi * d = \pi * 100 \text{ ft} = 314 \text{ ft}$$

And the Weir loading,

$$WLR = \frac{Q}{L_w} = \frac{31865978 \text{ ft}^3 \text{ day}}{314 \text{ ft}} = 101,484 \frac{\text{ft}^2}{\text{day}}$$

Table 5 - Secondary Clarifier Tank Dimensions

Design	Dimension
Number of tanks	10
Diameter	100 ft
Weir Loading	$101,484 \frac{\text{ft}^2}{\text{day}}$

VI. Conclusion

For the next 50 years, this report has planned a wastewater treatment system for the city of El Paso. With the rise of requirements for water regulation by organisations such as the EPA, waste water must be properly treated and each element of waste properly disposed of. The necessity of wastewater treatment is based on factors such as expanding population, and the subsequent high-demand for a natural commodity. Not only does this wastewater treatment plant supports community needs, but it ensures the natural resources are properly cared for.

Disinfection??

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PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

**CVEG 4301– Environmental Engineering Design
Fall 2021**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

ASSIGNMENTS FOR OUTCOME "1"

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

**CVEG 4301– Environmental Engineering Design
Fall 2021**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Homework # 3

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

All the problems in this Homework are developed to test the students' ability to identify, formulate and solve complex engineering problems



CVEG 4043 – ENVIRONMENTAL ENGINEERING DESIGN

Fall 2021

Homework # 3: Due: October 28, 2021

Raghava R. Kommalapati, Ph.D., PE, BCEE, F. ASCE

Student Name Michael LeBlanc Grade: 106/120

Topics Covered

Water Treatment-Lime and Soda Softening

Solve the following problems

1. Problem # 4.18
2. Problem # 4.19
3. Problem # 4.20
4. Problem # 4.22
5. Problem # 4.23
6. Problem # 4.24

4-18. Determine the lime and soda ash dose, in mg/L as CaCO_3 , to soften the following water to a final hardness of 90.0 mg/L as CaCO_3 . If the price of lime, purchased as CaO , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as Na_2CO_3 is \$172.50 per Mg, what is the annual chemical cost of treating $0.050 \text{ m}^3/\text{s}$ of this water? Assume the lime is 90% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as CaCO_3 .

$$\begin{aligned}\text{Ca}^{2+} &= 137.0 \\ \text{Mg}^{2+} &= 40.0 \\ \text{HCO}_3^- &= 197.0 \\ \text{CO}_2 &= 9.0\end{aligned}$$

4-19. What amount of lime and/or soda ash, in mg/L as CaCO_3 , is required to soften the Village of Lime Ridge's water to less than 120 mg/L hardness as CaCO_3 ?

Compound	Concentration, mg/L as CaCO_3
CO_2	4.6
Ca^{2+}	257.9
Mg^{2+}	22.2
HCO_3^-	248.0
SO_4^{2-}	32.1

- 4-20.** Determine the lime and soda ash dose, in mg/L as CaO and Na_2CO_3 , to soften the following water to a final hardness of less than 130 mg/L as CaCO_3 . The ion concentrations reported below are all mg/L as CaCO_3 . Assume the lime is 90% pure and the soda ash is 97% pure.

$$\begin{aligned}\text{Ca}^{2+} &= 210.0 \\ \text{Mg}^{2+} &= 23.0 \\ \text{HCO}_3^- &= 165.0 \\ \text{CO}_2 &= 5.0\end{aligned}$$

- 4-22.** Determine the lime and soda ash dose, in mg/L as CaCO_3 to soften the following water to a final hardness of less than 120.0 mg/L as CaCO_3 . If the price of lime, purchased as CaO , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as Na_2CO_3 , is \$172.50 per Mg, what is the annual chemical cost of treating 1.35 m³ of this water? Assume the lime is 87% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as CaCO_3 .

$$\begin{aligned}\text{Ca}^{2+} &= 293.0 \\ \text{Mg}^{2+} &= 55.0 \\ \text{HCO}_3^- &= 301.0 \\ \text{CO}_2 &= 5.0\end{aligned}$$

- 4-23.** Determine the lime and soda ash dose, in mg/L as CaCO_3 , to soften the following water to a final hardness of less than 90.0 mg/L as CaCO_3 . If the price of lime, purchased as CaO , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as Na_2CO_3 , is \$172.50 per Mg. What is the annual chemical cost of treating 0.050 m³/s of this water? Assume the lime is 90% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as CaCO_3 .

$$\begin{aligned}\text{Ca}^{2+} &= 137.0 \\ \text{Mg}^{2+} &= 60.0 \\ \text{HCO}_3^- &= 197.0 \\ \text{CO}_2 &= 9.0\end{aligned}$$

- 4-24.** Determine the lime and soda ash dose, in mg/L as CaCO_3 , to soften the Kool Artesian (Problem 4-10) water to a final hardness of ≤ 115 mg/L as CaCO_3 . Assume the water temperature as pumped from the ground is 10°C. If the price of lime, purchased as CaO , is \$100 per megagram (Mg), and the price of soda ash, purchased as Na_2CO_3 is \$200 per Mg, what is the annual chemical cost of treating 0.500 m³/s of this water? Assume all the alkalinity is bicarbonate, lime is 88% pure, and soda ash is 98% pure.

Kool Artesian Water

Calcium	37.0	Silica	11.5
Magnesium	18.1	Sulfate	5.0
Sodium	2.1	Potassium	1.6
Fluoride	0.1	Zinc	0.02
Alkalinity	285.0 mg/L as CaCO_3		
pH	7.6 units		

NOTE: All units are mg/L as the ion unless stated otherwise

4.18)

Given

Price of lime (CaO) = \$61.70 per Mg Lime is 90% pure
 Price of soda (Na_2CO_3) = \$172.50 per Mg Soda Ash is 97% pure

Constituent	Cons	Lime (mg/L as CaCO_3)	TH = $\text{Ca}^{+2} + \text{Mg}^{+2}$
CO_2	9	9	TH = 137 + 40 ✓ = 177 mg/L as CaCO_3
ALK	197	197	✓ ALK = CH = 197 mg/L as CaCO_3
Mg-40	0	20	NCH = TH - CH

Total lime ✓ 226

$$= (177 - 197)$$

$$= -20 \text{ mg/L as } \text{CaCO}_3$$

$$\frac{226}{.9} = 251.1 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Soda} = \$0/\text{yr}$$

$$226 \text{ mg/L as } \text{CaCO}_3 \left(\frac{28}{50} \right) \checkmark = 126.6 \text{ mg/L}$$

$$126.6 \text{ mg/L} \cdot (0.05 \text{ m/s}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Kg}}{10^6 \text{ Mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}}$$

$$= 546.9 \frac{\text{Kg}}{\text{d}} \cdot \frac{1 \text{ Mg}}{1000 \text{ Kg}} \cdot \frac{365 \text{ d}}{1 \text{ yr}} = 199.6 \text{ Mg/yr}$$

$$\frac{199.6 (\$61.70)}{.9} \checkmark = \$13,683.7/\text{yr}$$

4.19)

Constituent	Cons	lime mg/L as CaCO_3
CO_2	4.6	4.6
Alk	280.1	248
Mg-40	0	20
Total lime	✓ 272.6 mg/L as CaCO_3	

$$\text{TH} = \text{Ca}^{+2} + \text{Mg}^{+2}$$

$$= 257.9 + 22.2$$

$$\checkmark 280.1 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Alk} = \text{CH} \checkmark 248 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH} = 280.1 - 248 \checkmark 32.1 \text{ mg/L as } \text{CaCO}_3$$

$$120 - 40 \checkmark 80 \text{ mg/L as } \text{CaCO}_3 \text{ to be treated}$$

NCH - Treated

$$32.1 \text{ mg/L as } \text{CaCO}_3 - 80 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Soda} = -47.9 \text{ mg/L as } \text{CaCO}_3$$

Since its negative

$$\text{Soda} \checkmark 0 \text{ mg/L as } \text{CaCO}_3$$

4.20)

Constituent	Cons	lime mg/L as CaCO_3
CO_2	5	5
Alk	165	165
Mg^{+2}	0	20
Total lime		✓ 90 mg/L as CaCO_3

$$\begin{aligned} \text{TH} &= \text{Ca}^{+2} + \text{Mg}^{+2} \\ &= 210 + 23 \\ &= 233 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\begin{aligned} \text{Alk} &= \text{CH} \quad \checkmark 165 \text{ mg/L as } \text{CaCO}_3 \\ \text{NCH} &= \text{TH} - \text{CH} \\ &= 233 - 165 \\ &= 68 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\frac{90 \text{ mg/L as } \text{CaCO}_3}{0.9} = \cancel{211.1 \text{ mg/L as CaO}}$$

$$130 - 40 \quad \checkmark 90 \text{ mg/L as } \text{CaCO}_3$$

$$(68 - 90) \text{ mg/L as } \text{CaCO}_3 = -22 \text{ mg/L} \cdot \left(\frac{56}{50}\right) = -24.64 \text{ mg/L as } \text{Na}_2\text{CO}_3$$

Since it's negative

$$\boxed{\text{Soda} \quad \checkmark 0 \text{ mg/L}}$$

4.22)

Constituent	Cons	lime (mg/L as CaCO_3)
CO_2	5	5
Alk	301	301
$\text{Mg} - 40$	15	15
Excess lime	($\text{Mg} - 40$) < 20	20
Total lime		341

lime = 87% pure = \$61.70 per (M_0)

soda = 97% pure = \$172.50 per (M_0)

$$\text{TH} = \text{Ca}^{+2} + \text{Mg}^{+2}$$

$$= 293 + 55$$

$$\checkmark 348 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Alk} = \text{CH} \checkmark 301 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH} \checkmark \text{TH} - \text{CH} = 348 - 301 = 47 \text{ mg/L as } \text{CaCO}_3$$

$$\frac{\text{M}_{\text{Si}} - \text{M}_{\text{Sr}}}{\text{M}_{\text{Sr}} - \text{M}_{\text{Si}}} = \frac{40 - 10}{55 - 10} = \frac{10}{15}$$

$$\checkmark X = 0.67$$

$$\text{TH}_R(x) + \text{TH}_i(1-x) = \text{TH}_f$$

$$348 \text{ mg/L as } \text{CaCO}_3(0.67) + 40(1-0.67) \checkmark = 246.4 \text{ mg/L as } \text{CaCO}_3$$

From previous Page

Total lime ~~341~~ 341 mg/L as CaCO_3

$$341 \text{ mg/L as } \text{CaCO}_3 \left(\frac{28}{50} \right) = 190.96 \text{ mg/L}$$

$$190.96 \text{ mg/L} \cdot 1.35 \text{ m}^3/\text{s} \cdot \left(\frac{1000 \text{ L}}{1 \text{ m}^3} \right) \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$= \frac{8129.9 \text{ Mg/yr} \cdot (\$61.70)}{0.87} = \text{\$576,565.6} \quad \text{Lime cost per Year}$$

Total lime (87% Pure)

$$\frac{341 \text{ mg/L as } \text{CaCO}_3}{0.87} = \text{\$391.95 mg/L } \text{CaCO}_3$$

$\text{TH}_f - \text{PL}$

$$(120 - 40) \text{ mg/L as } \text{CaCO}_3 = 80 \text{ mg/L as } \text{CaCO}_3$$

$$(47 - 80) \text{ mg/L as } \text{CaCO}_3 = -33 \text{ mg/L as } \text{CaCO}_3$$

Since negative

$$\text{Soda } \text{\$0 mg/L as } \text{CaCO}_3$$

4.23)

Lime = 90% pure = \$61.70/Mg

Soda = 97% pure = \$172.50/Mg

Constituent	Cons	lime
CO ₂	9	9
Alk	197	197
Mg-40	20	20
Excess lime	20	20

$$TH = Ca^{+2} + Mg^{+2}$$

$$= 137 + 60$$

✓ 197 mg/L as CaCO₃

Alk = CH ✓ 197 mg/L as CaCO₃

NCH = ✓ 0 mg/L as CaCO₃

FINAL HARDNESS

Total lime = 246 mg/L as CaCO₃

$$246 \text{ mg/L as CaCO}_3 \cdot \frac{28}{60} \times 137.76 \text{ mg/L}$$

$$137.76 \text{ mg/L} \cdot (0.05 \frac{\text{m}^3}{\text{s}}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$= \times 217.2 \text{ Mg/yr}$$

$$\frac{217.2 \text{ Mg/yr}}{9} \cdot \$61.70/\text{Mg} = \times \$14,891.63/\text{yr}$$

lime cost per year

Since NCH = 0

Soda ✓ \$0

4.24)

lime = 88% pure = \$100/Mg
Soda = 98% pure = \$200/Mg

Constituent	Cons	lime (mg/L as CaCO_3)
Alk	285	285
Mg-40	34.5	34.5
Excess lime	(Mg-40) 20×240	34.5

Total lime ~~354~~ mg/L as CaCO_3

$$\frac{354}{.88} = \boxed{402.3 \text{ mg/L as } \text{CaCO}_3}$$

Total pure lime

$$\begin{aligned} \text{TH} &= \text{Ca}^{2+} + \text{Mg}^{2+} \\ &= 92.5 + 74.5 \\ &= \checkmark 167 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\text{Alk} = \text{CH} = 285 \text{ mg/L as } \text{CaCO}_3$$

$$\begin{aligned} \text{NCH} &= \text{TH} - \text{CH} \\ &= 167 - 285 \\ &= -120 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

Since Negative

Split Treatment

Soda $\checkmark$ 0 mg/L as CaCO_3 also, \$0/yr

$$354 \text{ mg/L as } \text{CaCO}_3 \cdot \frac{28}{50} \times 198.3 \text{ mg/L}$$

$$198.3 \text{ mg/L} \cdot (0.5 \text{ m}^3/\text{s}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$\times = 3126.8 \text{ Mg/yr}$$

$$\frac{3126.8 \text{ Mg/yr} \cdot (\$100/\text{yr})}{.88} \times \boxed{\$355318.5/\text{yr}}$$

Lime cost Per Year

**CVEG 4301– Environmental Engineering Design
Fall 2021**

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

Title of Assignment

Water Treatment Plant Design Project

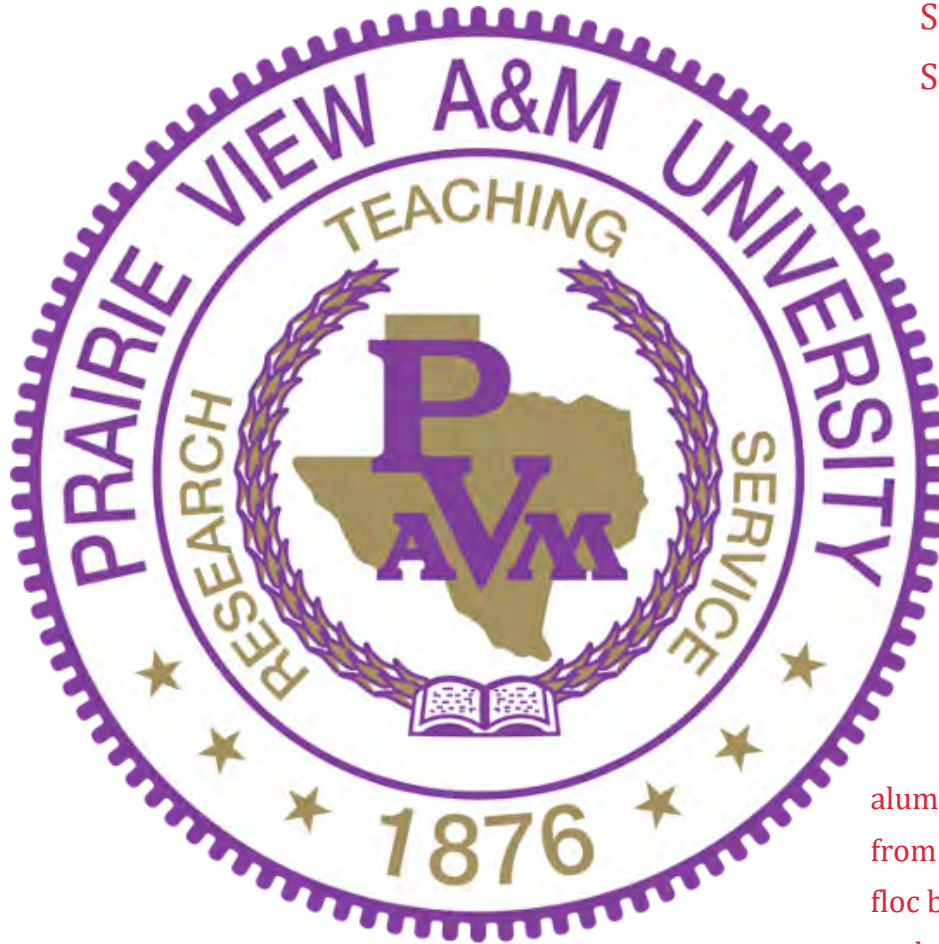
Outcome Measured Using this Assignment

Outcome 1

**An ability to identify, formulate, and solve complex engineering problems
by applying principles of engineering, science, and mathematics**

Brief Description of the suitability of this assignment for the outcome

In this project, the students need to identify needs and various components for a water treatment plant. Portion of the design include solving complex engineering problems. This project is assigned 200 points out of 500 points for the outcome 1 and 300 for outcome 2.



SLO 1: 185/200

SLO 2: 275/300

Wastewater Treatment Plant Design - **Part 1**

Brownsville, Texas

CVEG 4301: Environmental Engineering Design

Fall 2021

Submitted by:

Autumn Carter

Scott McGary

Submitted to:

Dr. Raghava Kommalapati, PE, BCEE, F. ASCE

Department of Civil and Environmental Engineering

Due Date: December 6th, 2021

alumn dose from jar test not
from alk

floc basins should match sed
tanks but you have way too
many units -- not practical

rectangular units are used for
water

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Executive Summary

The objective of this project is to design a water and wastewater plant within a city located in the U.S. that has a population greater than 150,000 people. Contained in this report, is the design for the water treatment plant located in Brownsville, Texas. For water planning purposes, the future population must be estimated. Regarding Brownsville, it has been decided that the arithmetic method will be used to determine future population growth. The city pulls from two different water sources for its drinking water needs: the Rio Grande River and the Nueces River. In preparation for the water treatment process, a water quality analysis must be performed. After doing this, the turbidity and hardness are elevated in both water sources. This is expected due to both water sources being surface water which typically tends to have higher levels of turbidity and hardness.

executive
summary should
highlight all the
salient features of
your design

I. Population Growth in the Year 2040

A. Population Projection

The population project is an important phase of the project because it helps us to observe and provide the present and future population of the community accurately and economically. To calculate the future growth and population for the city of Brownsville in 2040, historical data and trends must first be gathered. The population data were obtained using the U.S. Census Bureau (5) starting from 1900 to 2010. From the table, it can be observed and confirmed that the population growth did consistently increase from 1900 to 2010. Due to the location of the city near the U.S-Mexico border, the city will not face any economic boom. The percent growth method will be chosen to calculate the future population because of the percent growth rate after the year.

B. Algebraic Method

The algebraic method assumes that the rate of growth of the population is continuously growing each year, which means that each year the population growth in Brownsville is growing at a rapid pace.

$$P = P_o + K(\Delta t)$$

Where,

P = Future Population

P_o = Initial Population

K = Growth Rate

Δt = change in time (decades)

first present data before discussion the methods

Table 1. Population Projection of 2040

Decade	Population	ΔP	ΔP
1990	99,000	-	-
2000	139,700	40,700	0.291
2010	175,400	35,700	0.204

2020	183,200	7,800	0.043
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K	28,066
Avg	0.179

$$P = 183,200 + (28066)*(2) = \mathbf{239,332}$$

Percent Growth method is displayed below.

$$P_{2040} = P_0(1 + k)^2$$

Where:

P_{2040} = Design Period Population

P_0 = Current Population

K = Average population change each decade

t = Number of decades

$$P_{2040} = 183000(1 + 0.179)^2 = 254377.5 \cong 254,378$$

Log Growth = Exponential Growth = Geometric Growth

$$P_{2040} = P_0 e^{k\Delta t}$$

Where:

P_{2040} = Design Period Population

P_0 = Current Population

K = Average population change each decade

Δt = Elapsed time in years

$$P_{2040} = 183000e^{0.179*2} = 261775.2 \cong 261,775$$

Percent growth method was decided because the growth followed this pattern more than constant growth. The future population for Brownsville, Texas was determined to be 254,378 people for the year 2040. The census for 2020 was used to calculate the future population, which was required for the project's design criteria of 20 years, to get a precise population estimate.

how does this estimate compare t the city's own estimates?

2. Water Treatment Plant

From the population, it can be determined the water quantity that will be treated as water demand. The water demand for the different factors is shown below. The water demand for Brownsville will be determined from the fire demand calculated along with the max hourly quantity of water which will be used to design the water treatment plant. “The current estimated per capita raw water demand is about 144 gallons per person per day. With the successful implementation of advanced water conservation measures (i.e. high-efficiency washing machines, toilets, showerheads), the per capita demand can be gradually reduced conservatively by as much as 15 gallons per person per day by the year 2025.” (Brownsville Comprehensive Plan; Source 1) So for the year 2040, a water demand of 120 will be used.

$$AADF = Pop * Q_{demand}$$

$$254,378 * 120 \text{ gal/c*d} = 30.5 \text{ MGD}$$

$$\text{Max. Hourly Flow} = 30.5 \text{ MGD} * 2.7 = 82.42 \text{ MGD}$$

$$\text{Max. Daily Flow} = 30.5 \text{ MGD} * 1.8 = 54.9 \text{ MGD} \quad \text{Design Q?}$$

$$\text{Max. Weekly Flow} = 30.5 \text{ MGD} * 1.4 = 42.7 \text{ MGD}$$

$$\text{Max. Monthly Flow} = 30.5 \text{ MGD} * 1.2 = 36.6 \text{ MGD}$$

$$Q_{fire} = 1020\sqrt{P} * (1 - 0.01\sqrt{P}); P = \text{thousands}$$

$$Q_{fire} = 1020\sqrt{254.378} * (1 - 0.01\sqrt{254.378}) = 13673.56 \text{ GPM}$$

$$13673.56 \text{ GPM} * 60 \text{ min/hr} * 24 \text{ hrs/day} = 19.69 \text{ MGD}$$

$$Q_{total} = \text{Max hourly} + Q_{fire} = 82.42 \text{ MGD} + 19.69 \text{ MGD} = 102.1 \text{ MGD}$$

This Q_{total} will be used to design the maximum flow of water for the pipes.

what is your design Q?

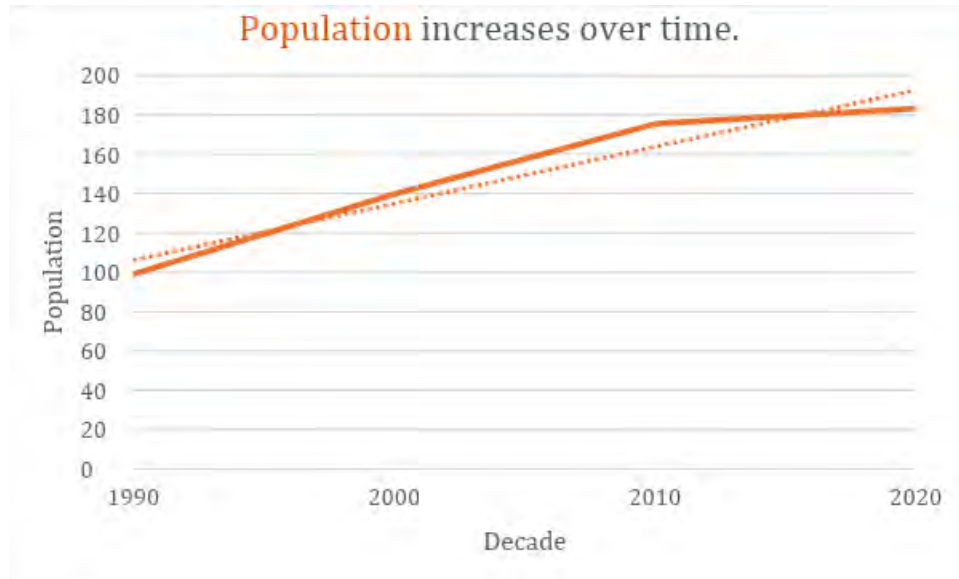


Figure 1. Population Growth Trend

From the collection of the census data the rate of change can be obtained and can be converted into a table and chart displaying the information. As seen in figure 1, it is observed that the population has increased by a percentage over the last 30 years.

Table 2. Water Quality

Water Sources		Rio Grande	Nueces River
Constituent	Units	Concentrations	
Turbidity	NTU	34.1	58.1
Total Alkalinity	mg/L	56.5	150
Calcium	mg/L	29.4	22.5
Magnesium	mg/L	3.625	6.16
pH	mg/L	8.34	8.34

Total Dissolved Solids	mg/L	132.5	230
Fluoride	mg/L	0.52	0.47
Chloride	mg/L	40	49
HAA5	ug/L	16	14
Total Hardness	mg/L	57	130

It is always important to know the maximum contaminant levels set by the state of Texas. The MCL and the respected units are listed below to compare our sources to the max levels of contaminants to see what treatment methods should be considered to properly clean and remove solids from surface water.

Table 3. Maximum Contaminant Level (State of Tx.)

Constituent	MCL	Units
Turbidity	4	NTU
Total Alkalinity	200	mg/L
Calcium	80	mg/L
Magnesium	30	mg/L
pH	500	mg/L
TDS	4	mg/L
Fluoride	5	mg/L

Chloride	60	ug/L
HAA5	120	mg/L

3.Source of Water

Due to the location of Brownsville, the nearby sources of water will generate enough demand to supply the city. The primary source of groundwater for the city comes from the Rio Grande River. For the project, it is assumed that Brownsville uses 100 percent surface water, where 50 percent comes from the Rio Grande River while the other 50 percent comes from the Nueces River.

- Rio Grande River

The Rio Grande River is the main source of surface water that is used in the Brownsville area at present time. Using this source will be beneficial to know what contaminants are being consumed, and how we can make changes to this water source.

- Nueces River

The Nueces River will also be surface water we will utilize through this design. For this project, the water quality from the two rivers, the Rio Grande River and the Nueces River was obtained from TCEQ and placed their values in the tables below. The water will then be combined to have an accurate method of treatment for both water sources at one water treatment plant.

4.Water Quality

With the main source of drinking water descending from surface water there are a lot of regulations to abide by for healthy human consumption. With expanding population growth and location of water sources a lot of pollutants get into the water then get sent to surrounding areas, which includes the Rio Grande Valley. In an area with an abundant value of individuals, most homes will have some type of filtration system to provide an efficient amount of sterilized clean water throughout their residence.

Reverse Osmosis is a form of filtration system that is recommended in the city of Brownsville. Reverse Osmosis removes sediment and chlorine from water with a pre-filter

before it forces water through a semipermeable membrane to remove dissolved solids. After water exits the reverse osmosis (RO) membrane, it passes through a postfilter to polish the drinking water before human consumption and/or usage. There are three filters used within the system; sedimentation filter- reduces particles such as dirt and rust, carbon filter- reduces volatile organic compounds, chlorine, and other contaminants that give water a bad taste or odor. Lastly, a semipermeable membrane removes up to ninety-eight percent (98%) of total dissolved solids (TDS).

The current estimated per capita raw water demand is about “144 gallons per person per day. With the successful implementation of more high-efficiency appliances and practices of conservation measures, the per capita demand can be gradually reduced conservatively by as much as 15 gallons per person per day by the year 2050.” (Brownsville Comprehensive Plan; Source 1). We will use 120 gallons per person per day. **thats too low if the current demand is 144**

5. Preliminary Water Treatment Design

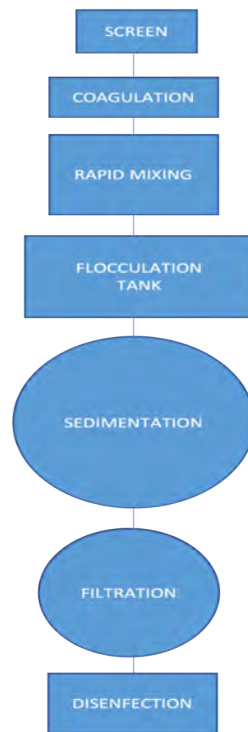


Figure 2. Water Treatment Design

6. Water Treatment Method

A. Screening

Screening is the first step of operation at all water treatment plants. The screen is the operative device used to retain solids found in the water such as logs and branches. The main purpose of screening is to remove solid materials that could cause damage to other process equipment, cause a reduction in efficiency of the operation system, and taint waterways. There is a classification of three types of screens which are coarse, fine, and micro screens. In this design, we will utilize coarse screens. Coarse screens have a clear space opening size that ranges from 3”- 6”, the screen is composed of parallel bars, rods or wires, wire mesh, or a perforated plate with an opening that is circular or rectangular. These openings are called “bar rack” which are

used to remove coarse solids such as large objects that may clog or cause damage to other apparatus.

The types of coarse screens include mechanically and manually cleaned bar screens to help with the process of screening. A mechanically cleaned bar screen is designed to extract large solids, rags, and debris. The opening size ranges from 0.25 to 1.5 inches, the bars are also set to 0-30° from vertical. This screening is predominately used in new installations because of the large number of advantages relative to other screens. Manual screens are designed to remove large solids, rags, and debris like mechanical screens. Its opening is 1 to 2 in., and the bars are set at 30 to 45° from vertical to facilitate cleaning. Manually bar screens are primarily used in older or smaller treatment facilities, or in bypass channels. Some advantages for both would be that manually cleaned screens require the bare minimum or no equipment maintenance and provide an excellent alternative for smaller plants with fewer screenings. Mechanically screens have a lower labor cost and offer the gain of improved flow conditions and screen captivity.

B. Rapid Mixing Tank

The rapid mixing tank is the first chamber in which the water will be entering for the water treatment process. The rapid mixing tank provides an aggressive mixing to ensure a uniform distribution of the coagulant used which in this treatment will be alum. With the water demand for Brownsville, the volume for different detention times can be calculated using the formula below.

$$\Theta = V/Q$$

Where;

Q = water flow

V = Total Volume for Rapid Mixing Tanks

Θ = Detention Time

For a rapid mixing tank, there are certain design criteria that is required from Texas Administrative Code requiring the volume of a tank not to exceed (8) cubic meters. The detention time for the tank is also required to be in a range of 20 to 60 seconds

with G values ranging from (750 – 1000) per second units (s-1). With these design parameters, calculations can be made to maximize the tanks.

$$V = Q * \theta$$

never mentioned how you decided on the design Q

The calculation for the different volumes that can be produced from different detention times can help choose a more viable option for a growing city. With the population growing at a constant rate the thirty (30) second detention allows for a larger number of tanks that can be efficiently used. The plant can have the option to run at a much slower detention time offering a more effective treatment at low flow throughout the different times of the day and the year.

$$Volume = 54.9 \text{ MGD} * 10^6 \frac{\text{gal}}{\text{d}} * \frac{3.785 \text{ L}}{1 \text{ gal}} * \frac{1 \text{ m}^3}{1000 \text{ L}} * 30 \text{ secs} * \frac{1 \text{ min}}{60 \text{ sec}} * \frac{1 \text{ hr}}{60 \text{ min}} * \frac{1 \text{ d}}{24 \text{ hr}} = 72.15 \text{ m}^3$$

$$72.15 \text{ m}^3 > 8 \text{ m}^3$$

$$\frac{72.15 \text{ m}^3}{8 \text{ m}^3} = 9.02 \approx 10 \text{ Tanks}$$

ok

The volume exceeds the recommended design criteria; there must be a total of ten tanks. Since the number of tanks is determined, the volume can be maximized by each tank since the required tank size is eight cubic meters.

$$10 * 8 \text{ m}^3 = 80 \text{ m}^3$$

Table 4 Detention Times

Detention (sec)	Volume (m ³)	Number of Tanks	Volume of each tank (m ³)	Total Volume (m ³)
20	48.10	8	6.01	64
30	72.15	10	7.215	80
40	96.20	14	8.02	112
50	120.30	16	7.52	128
60	144.30	18	8.02	144

The possibility of the different detention times and larger tank volumes are displayed above but the most reasonable option will be a rapid mixing tank with a thirty-second detention time. With having a moderate detention time there is no need to have an aggressive mixing for a long period when a moderate mixing can achieve similar values for a lower cost.

$$G = 850s^{-1}$$

$$P = G^2 * V * \mu$$

Where;

P = Power

G = Velocity Gradient

μ = Dynamic Viscosity

$$(850s^{-1})^2 * 80m^3 * 1.002 * 10^{-3} * \frac{N*s}{m^2} = 57,915.6 \frac{N*s}{m^2}$$

$$Power = 57.92 kWh$$

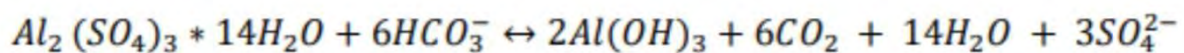
According to PayLess power in Brownsville, TX “Industrial Texas electricity consumers in both Brownsville and the state of Texas can get average energy rates as low as 5.57 cents per kWh” (PayLess power Source 2) Using this rate the total cost of electricity for the rapid mixing tank is calculated below.

$$\text{Monthly Electricity cost for rapid mixing tank}$$

$$57.92 kWh * \frac{\$0.057}{kWh} * \frac{24hr}{1day} * \frac{30days}{1month} = \$2,377.04$$

C. Coagulation-

The addition and rapid mixing of a coagulant to form a precipitate, resulting in the destabilization of the colloidal and fine suspended solids and the initial aggregation of the destabilized particles. This is done by turning small particles of color, turbidity, and bacteria into larger flocs either as precipitate or suspended particles which can then be removed. Regarding colloid stability they are too small to settle in a reasonable time, they are too small to be trapped in the pores of a filter, colloids also possess a negative charge that repels other particles. Using a jar test apparatus, the water should be tested at different PH levels to measure the different amounts of alum dosages necessary that can be launched into the treatment.



Where;

Molecular Weight of Alum = 594 g/mo

Molecular Weight of Bicarbonate = 366 g/mol

Molecular Weight of Alum Precipitate= 156 g/mol

The table below will show the water sources utilized to disburse water to Brownsville and their alkalinity values.

Water Sources	Alkalinity (mg/l)
Rio Grande River	56.5 mg/l
Nueces River	150 mg/l

Let's assume an equivalent amount of water will be pulled from each water source each day.

$$Avg\ Alkalinity = \frac{56.5 \frac{mg}{l} + 150 \frac{mg}{l}}{2} = 103.25 \frac{mg}{l}$$

$$Max\ Alum\ Dosage = \frac{Avg\ Alkalinity * Alum\ MW}{Alkalinity\ MW} = \frac{103.25 \frac{mg}{l} * 594 \frac{g}{mol}}{366 \frac{g}{mol}} = 167.57 \frac{mg}{l} \text{ of Alum}$$

The maximum amount of alum that can be used in the water is 167.57 mg/l. To maintain a stable amount of alkalinity in the water and to not use the maximum amount that could possibly surpass the amount, we'll reduce the dosage amount by 25%. The following calculation will show the reduced amount of alum that can be used and the cost of alum per month.

$$167.57 \frac{mg}{l} * (0.25) = 41.89 \frac{mg}{l} \quad \text{you conduct jar test to find Alum dosage}$$

$$167.57 \frac{mg}{l} - 41.89 \frac{mg}{l} = 125.67 \frac{mg}{l}$$

Alkalinity left after treatment,

$$103.25 \frac{mg}{l} - \frac{125.67 \frac{mg}{l} * 366 \frac{g}{mol}}{594 \frac{g}{mol}} = 25.81 \cong 26 \frac{mg}{l}$$

$$Remaining\ Alkalinity = 26 \frac{mg}{l}$$

Alum per month,

$$167.57 \frac{mg}{l} * 54.9\ MGD * 10^6 * \frac{3.785\ L}{1\ gal} * \frac{1\ kg}{10^6} * \frac{30d}{1\ month} = 1,044,613.79 \frac{kg}{mon}$$

Cost of alum per ton = \$425.00

$$Cost\ of\ alum\ per\ kilogram = \frac{1\ ton}{907\ kg} * \frac{\$425.00}{1\ ton} = \$0.47/kg$$

Alum cost per month,

$$1,044,613.79 \frac{kg}{month} * \frac{\$0.47}{kg} = \$490,968.48$$

D. Flocculation

The slow stirring or gentle agitation to aggregate the destabilized particles and form a rapid settling floc.

$$\text{Floc Produced} = \frac{167.57 \frac{mg}{l} * 156 \frac{g}{mol}}{594 \frac{g}{mol}} = 44.0 \frac{mg}{l}$$

Floc Produced Per month,

=

$$\left(44.0 \frac{mg}{l}\right) * (54.9 MGD) * \left(\frac{10^6 gal}{1 day}\right) * \left(\frac{1 kg}{10^6 mg}\right) * \left(\frac{3.785 L}{1 gal}\right) * \left(\frac{30 day}{1 month}\right) = 274291.38 \frac{kg}{month}$$

The flocculation chamber is a necessary part of the water treatment for the water to reduce its turbulence for its flow to the sedimentation tank. The flocculation segment of the treatment will be divided into three separate chambers for the reduction of turbulence. For the design criteria, the length of the chamber and the depth will be kept the same as the baffles that will be providing mixing will need to have the necessary space to provide the uniform mixing required. For alum and iron salts

Θ is typically 15 to 30 minT **theta is a min of 30 min preferably higher**

G is typically 20 to 75/sec

GT is typically 50,000 to 100,000 GT

$$Q = 54.9 MGD$$

$$G_1 = 75 s^{-1}, G_2 = 40 s^{-1}, G_3 = 20 s^{-1}$$

$$\Theta = 30 min$$

$$L = D; D = 4.0 m$$

$$V_{total} = 54.9 * \left(\frac{10^6 gal}{1 day}\right) * 30 min * \left(\frac{3.785 L}{1 gal}\right) * \left(\frac{1 m^3}{1000 L}\right) * \frac{1 hr}{60 min} * \frac{1 day}{24 hr} = 4329.1 m^3 \cong 4400 m^3$$

The total volume for the flocculation tanks is calculated with the use of the flow rate and

the detention time. Now, the volume for each tank will be calculated. The number of flocculation

tanks will be equal to the number of rapid mixing tanks that will be used in the tank to make sure

there is an even amount of coagulant in each batch of water being treated. **decide number of floc basins to**

$$V_{tank} = \frac{V_{total}}{\# Tanks} = \frac{4400 m^3}{10} = 440 m^3 \quad \text{match the sed tanks}$$

The volume for each tank will now be divided into three sections that will help reduce the

too many floc basins

turbulence in the water for the floc to remain suspended until the floc reach the sedimentation tank.

$$V_{\text{tank section}} = \frac{V_{\text{tank}}}{3} = \frac{440m^3}{3} = 146.6 \cong 147 m^3$$

$$V_{\text{tank section}} = L * W * D \rightarrow V_{\text{tank}} = W * D^2 \rightarrow W = \sqrt{\frac{V_{\text{tank section}}}{D^2}}$$

$$W = 8.5 m$$

The tank dimension for each section will be as follows.

$$L = 4.5 m; W = 8.5 m; D = 4 m$$

The full flocculation tank dimensions will be as follows. The length of the full flocculation tank will be three times the length of the section since it is divided into three sections.

$$L = 13.5 m; W = 8.5; D = 4m$$

For each section of the flocculation section, there will be different mixing gradients that will be used. The power for each section is calculated below.

$$P = G^2 * V * \mu$$

Section 1

$$(75 s^{-1})^2 * 147 m^3 * \left(1.002 * 10^{-3} \frac{N*s}{m^2}\right) * \frac{1 Watt}{1 \frac{N*s}{m^2}} * \frac{1kW}{1000 Watt} = 0.828 kW$$

Section 2

$$(40 s^{-1})^2 * 147 m^3 * \left(1.002 * 10^{-3} \frac{N*s}{m^2}\right) * \frac{1 Watt}{1 \frac{N*s}{m^2}} * \frac{1kW}{1000 Watt} = 0.236 kW$$

Section 3

$$(20 s^{-1})^2 * 147 m^3 * \left(1.002 * 10^{-3} \frac{N*s}{m^2}\right) * \frac{1 Watt}{1 \frac{N*s}{m^2}} * \frac{1kW}{1000 Watt} = 0.059 kW$$

$$\text{Total Power Per Tank} = 1.12 kw$$

$$\text{Total Power} = \text{Total Power Per Tank} * 10 = 11.23 kW$$

$$\text{Cost per month} = 11.23 kW * \frac{\$0.057}{kWh} * \frac{24hr}{1day} * \frac{30days}{1 month} = \$460.92$$

E. Sedimentation-

The physical water treatment process of allowing particles in suspension in water to settle out of the suspension under the effect of gravity. The sedimentation tank will get the flow of water and contain the suspended solids for them to settle. The water will enter the sedimentation at the inlet zone continuing into the settling zone where the suspended solids will settle to the

base. The water will then, at that point, continue through the outlet zone while the suspended solids, which are now floc, will settle furthermore go to the sludge zone. The important plan rules for the sedimentation tank will be as follows. Each flocculation basin will be followed by a sedimentation chamber that will provide settling for the incoming floc. The design criteria for each tank will be calculated below.

$$\begin{aligned}
 Q &= 54.9 \text{ MGD} \\
 OFR &= 1000 \text{ gal/ft}^2 \text{ day} * \frac{3.785 \text{ L}}{1 \text{ gallon}} * \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right) * \frac{3.28 \text{ ft}}{1 \text{ meter}} * \frac{3.38 \text{ ft}}{1 \text{ meter}} = \\
 A &= \frac{Q}{OFR} = \frac{54.9 \text{ MGD} * \frac{3.785 \text{ L}}{1 \text{ gallon}} * \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right)}{40 \left(\frac{\text{m}^3}{\text{m}^2 \text{ day}} \right)} = 5194.9 \text{ m}^2 \\
 \text{Area per tank} &= \frac{5194.9 \text{ m}^2}{10} = 519.5 \text{ m}^2 \quad \text{ten is way too many for this flow} \\
 \text{Diameter per tank} &= \sqrt{\frac{5194.9 \text{ m}^2 (4)}{\pi}} = 25.71 \text{ m} = D \\
 V_{total} &= 54.9 * \left(\frac{10^6 \text{ gal}}{1 \text{ day}} \right) * \left(\frac{3.785 \text{ L}}{1 \text{ gal}} \right) * \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right) * 6 \text{ hr} * \frac{1 \text{ day}}{24 \text{ hr}} = 51949.13 \text{ m}^3 \quad \text{rectangular units are used for water} \\
 \text{Depth} &= \frac{V_{total}}{\text{Total Area}} = \frac{51949.13 \text{ m}^3}{5195 \text{ m}^2} = 10 \text{ m} \\
 AS &= 4w^2 = \sqrt{\frac{5194.9 \text{ m}^2}{4}} = w = 36 \text{ m}; L(4)(36) = 144 \text{ m} \\
 V_{per \text{ tank}} &= \frac{51949.13 \text{ m}^3}{10} = 5194.91 \text{ m}^3
 \end{aligned}$$

The dimensions for the sedimentation tanks will be 25.7 meters in diameter and 10 meters in depth.

F. Filtration

Filtration is the process that removes suspension in water, this removal is taken place by multiple mechanisms of filtration which are; mechanical screening, sedimentation, flocculation, interception, and impaction. There are three types of granular medium filtration which is depth, pressure, and slow sand filtration. For treatment purposes, we'll focus on depth (gravity) filtration, where we have slow sand filtration which only uses sand for filtration purposes. This process causes too much labor because of excessive dumping of sand. Whereas rapid sand will be useful due to its tight pores to capture remaining sediments in the water. Also, the rapid sand design is multi-media utilizing both sand and carbon for filtration purposes.

The number of filters can be determined by the following equation below.

$$N = 0.0195 * Q^{0.5}$$

$$N = 0.0195(54.9 * \left(\frac{10^6 \text{ gal}}{1 \text{ day}}\right) * \left(\frac{3.785 \text{ L}}{1 \text{ gal}}\right) * \left(\frac{1 \text{ m}^3}{1000 \text{ L}}\right)) = 8.96 \cong 9 \text{ filters} \quad \text{ok}$$

The total amount of filters calculated was 9 filters, however, the use of **10 filters** will be necessary for backwash purposes when one filter goes offline. It's also beneficial to use an even number of tanks for filtration. Regarding calculation, we will continue to use 9 filters for accuracy. The flow rate for a rapid sand filter is designed to criteria that are standardized by TAC to be 2 GPM per square foot for the optimal flow for the process of filtration.

$$A_{\text{total Filters}} = \frac{Q}{FR}$$

$$A_{\text{total Filters}} = \frac{54.9 * 10^6 \frac{\text{gal}}{\text{d}}}{(2 \frac{\text{gal}}{\text{min} * \text{ft}^2}) (\frac{1440 \text{ min}}{1 \text{ day}}) (\frac{10.76 \text{ ft}^2}{1 \text{ m}^2})} = 1771.6 \text{ m}^2$$

$$D = 6 \text{ m} \quad \frac{L}{W} = 1.3$$

$$A = L * 1.3 * W \quad A = W^2 * 1.3$$

$$W = \sqrt{\frac{A}{1.3}} = \sqrt{\frac{130.17 \text{ m}^2}{1.3}} = 10.1 \text{ m}$$

$$L = 1.3W \quad (1.3)(10.1) = 13.13 \text{ m}$$

Next, the total amount of water needed for the backwash needs to be calculated. The formula and the calculations are displayed below:

*Backwash = time of wash * filter area * rise of backwash*

$$(10 \text{ min}) * (12610.24 \text{ ft}^2) * 24 \frac{\text{in}}{\text{min} * \text{ft}} * \frac{1 \text{ ft}}{12 \text{ in}} = 252204.8 \text{ ft}^3 = 7141.64 \text{ m}^3$$

$$\% \text{ of backwash} = \frac{7141.64 \text{ m}^3}{54.9 * 10^6 \text{ m}^2} * 100 = 0.013\%$$

G. Disinfection-

Disinfection is the last method used in a water treatment plant; it is designed to eliminate pathogenic microorganisms that are remaining in treated water. If pathogens remain in the water it causes water-borne diseases that if consumed it can lead to severe illness and even death.

Chlorine disinfection is the most widely used form of disinfectant; more subtle forms of disinfection technology include ozonation and ultraviolet (UV) radiation.

The disinfection and storing process requires the total amount of chlorine needed to treat the inflow of water which is calculated to determine the flow rate. The hydraulic retention time is 15 minutes. The L:W ratio= 10:1 and the depth is 5-15feet; the first step in clarifying the

dimensions of the storage tank is to calculate the volume of the flow rate with a detention time of 15 minutes.

$$Q = 54.9 \text{ MGD}$$

$$\Theta = 15 \text{ minutes}$$

$$V_{total} = 54.9 * \left(\frac{10^6 \text{ gal}}{1 \text{ day}} \right) * 15 \text{ min} * \left(\frac{3.785 \text{ L}}{1 \text{ gal}} \right) * \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right) * \frac{1 \text{ hr}}{60 \text{ min}} * \frac{1 \text{ day}}{24 \text{ hr}} = 2164.54 \text{ m}^3$$

Next, we determine the volume per tank with a total of 7 tanks being utilized, so that the disinfection process will happen equally, and all pathogenic organisms will be eliminated. Then determine L and W to design the proper storage tanks.

$$V \text{ per tank} = \frac{2164.54 \text{ m}^3}{7 \text{ tanks}} = 309.2 \text{ m}^3$$

$$\frac{L}{W} = 10 \text{ D} = 3 \text{ m}$$

$$V = L * W * D = 10W^2D$$

$$W = \sqrt{\frac{V}{10D}} = \sqrt{\frac{309.22 \text{ m}^3}{7 \text{ tanks}}} = 3.2 \text{ m}$$

$$309.22 \text{ m}^3 = L * (3.2) * (3) = 10(3.2)^2 3$$

$$L = 32 \text{ m } W = 3.2 \text{ m } D = 3 \text{ m}$$

This method was first used over a century ago and is still used today. Chlorination is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source. It is a very popular method of water disinfection that has been used for many years. It has been shown to be effective for killing bacteria and viruses. Although chlorination does have some drawbacks, it continues to be the most popular, dependable, and cost-effective method of water disinfection

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“Texas Administrative Code.” *Texas Administrative Code*,
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**OUTCOME “1” SPECIFIC ASSIGNMENTS
USED TO ASSESS THE OUTCOME IN**

**CVEG 4053
TRANSPORTATION ENGINEERING DESIGN**

**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4053: TRANSPORTATION ENGINEERING DESIGN
FALL 2019**

Instructor: Dr. Judy A. Perkins

Title of Assignment

HOMEWORK ASSIGNMENT #4 - PARKING

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
x	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
x	mathematics

Brief justification of the suitability of assignment for the outcome

This parking assignment requires the students to use their understanding of topics related parking studies, parking analysis, and parking design In order to develop solutions to the questions.

ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2019

Homework Assignment #4 - Parking

Given: 29 October 2019

Due: 5 November 2019 NLT 8:05am

Total point value is (40-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
 - Measure Program Learning Outcome ABET Criterion 3 (5) - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
1. This is a group assignment.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - Name and roster number of each group member
 - Given Date of Assignment
 - Due Date of Assignment

Parking Design and Analysis

1. Read the following - Read Chapter Section 4.7, 4.8 and Chapter Section 15.5
2. Review Parking Hand-Outs (if needed)
3. When designing an on-street parking facility, what is the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet? (5-points)
4. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (5-points)
5. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels. (10-points)

6. What are the parking operations entrance considerations that your team is expected to use? (5-points)
7. Given an available area that is 500 feet (long) by 400 feet (width) and the data listed below, design a suitable parking lot layout that maximizes the use of a 90-degree parking angle. Provide an AutoCAD drawing to scale of your parking layout that includes at a minimum (1) total number of parking spaces/stalls, (2) required minimum number of accessible spaces needed using the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for Building and Facilities, (3) dimensions throughout the layout, (4) north arrow, (5) scale, (6) title block, and (6) appropriate labels. (15-points)
 - a. Stall width = 8.5 feet
 - b. Stall length = 18 feet
 - c. Aisle width = 24 feet
 - d. Aisle + row width = $24 + 18 + 18 = 60$ feet
 - e. Allow 25 feet at each row end for traffic circulation
 - f. Number of aisles = $400 \text{ feet} / 60 \text{ feet} = 6.67$

TOTAL PARKING SPACES PROVIDED	REQUIRED MINIMUM NUMBER OF ACCESSIBLE SPACES
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
More than 1,000	20 plus one for each 100 over 1,000

GRADING SCHEME FOR ASSIGNMENT
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2019

Homework Assignment #4 - Parking (Solution)

Given: 29 October 2019

Due: 5 November 2019 NLT 8:05am

Total point value is (40-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
 - Measure Program Learning Outcome ABET Criterion 3 (5) - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
1. This is a group assignment.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - Name and roster number of each group member
 - Given Date of Assignment
 - Due Date of Assignment

Parking Design and Analysis

1. Read the following - Read Chapter Section 4.7, 4.8 and Chapter Section 15.5
2. Review Parking Hand-Outs (if needed)
3. When designing an on-street parking facility, what is the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet? (5-points)

$$N = L/22 = 500/22 = 22.7 \sim 23 \text{ spaces}$$

4. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (5-points)

78% - 96%, average 90%

5. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels. (10-points)
6. What are the parking operations entrance considerations that your team is expected to use? (5-points)
 - **Entrance Considerations**
 - a. **Locate as far from the roadway, an intersection, and conflicting points as possible.**
 - b. **Multiple entrances may ease access and reduce restriction on adjacent roadways.**
 - c. **Place mid-block.**
 - d. **Local ordinances and codes can restrict the number of entrances**
7. Given an available area that is 500 feet (long) by 400 feet (width) and the data listed below, design a suitable parking lot layout that maximizes the use of a 90-degree parking angle. Provide an AutoCAD drawing to scale of your parking layout that includes at a minimum (1) total number of parking spaces/stalls, (2) required minimum number of accessible spaces needed using the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for Building and Facilities, (3) dimensions throughout the layout, (4) north arrow, (5) scale, (6) title block, and (6) appropriate labels. (15-points)
 - g. Stall width = 8.5 feet
 - h. Stall length = 18 feet
 - i. Aisle width = 24 feet
 - j. Aisle + row width = $24 + 18 + 18 = 60$ feet
 - k. Allow 25 feet at each row end for traffic circulation
 - l. Number of aisles = $400 \text{ feet} / 60 \text{ feet} = 6.67$

There can be 6 aisles with 2 rows per aisle

Number of spaces per row = $[500 \text{ ft} - (2)(25 \text{ ft})] / (8.5 \text{ ft/space}) = 52$

Total number of spaces = $(6 \text{ aisles})(2 \text{ rows/aisle})(52 \text{ spaces/row}) = 624 \text{ spaces}$

Minimum handicap spaces needed = $(2\%) (624) = 12.48 \sim 13 \text{ spaces}$

ADAAG Minimum Parking Space Requirements

TOTAL PARKING SPACES PROVIDED	REQUIRED MINIMUM NUMBER OF ACCESSIBLE SPACES
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
More than 1,000	20 plus one for each 100 over 1,000

Prairie View A&M University
Roy G. Perry College of Engineering
Homework Assignment #4

Parking ✓



32.5
40

CVEG 4053 P01 Transportation Engineering Design

Cameron Lavergne #14 ✓

Austin Allen #1 ✓

Daniel Doyle #7 ✓

Date Given:

29 October 2019 ✓

Due Date:

5 November 2019 NLT 8:05am ✓

Submitted To:

Dr. Judy Perkins

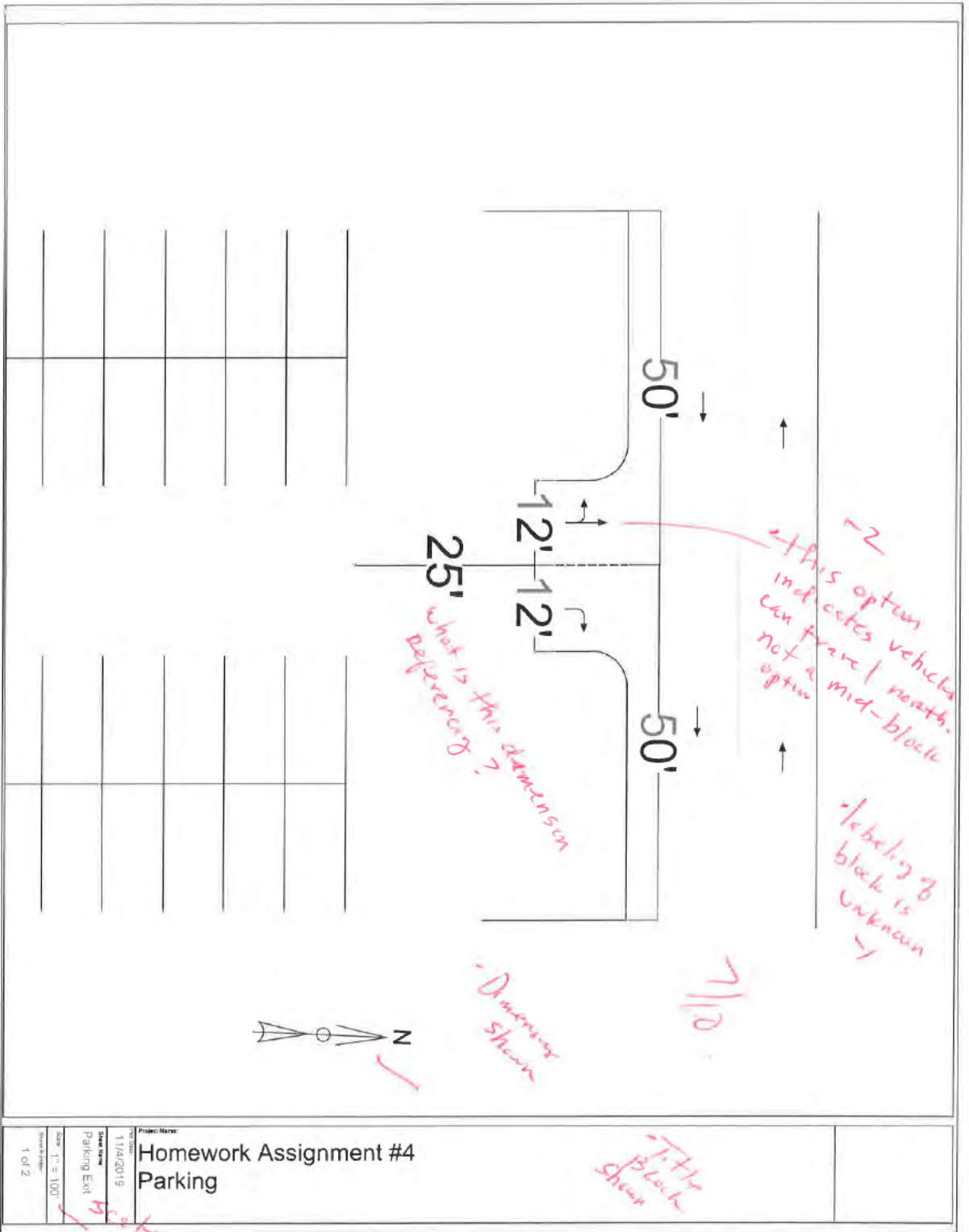
3. When designing an on-street parking facility, what is the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet?

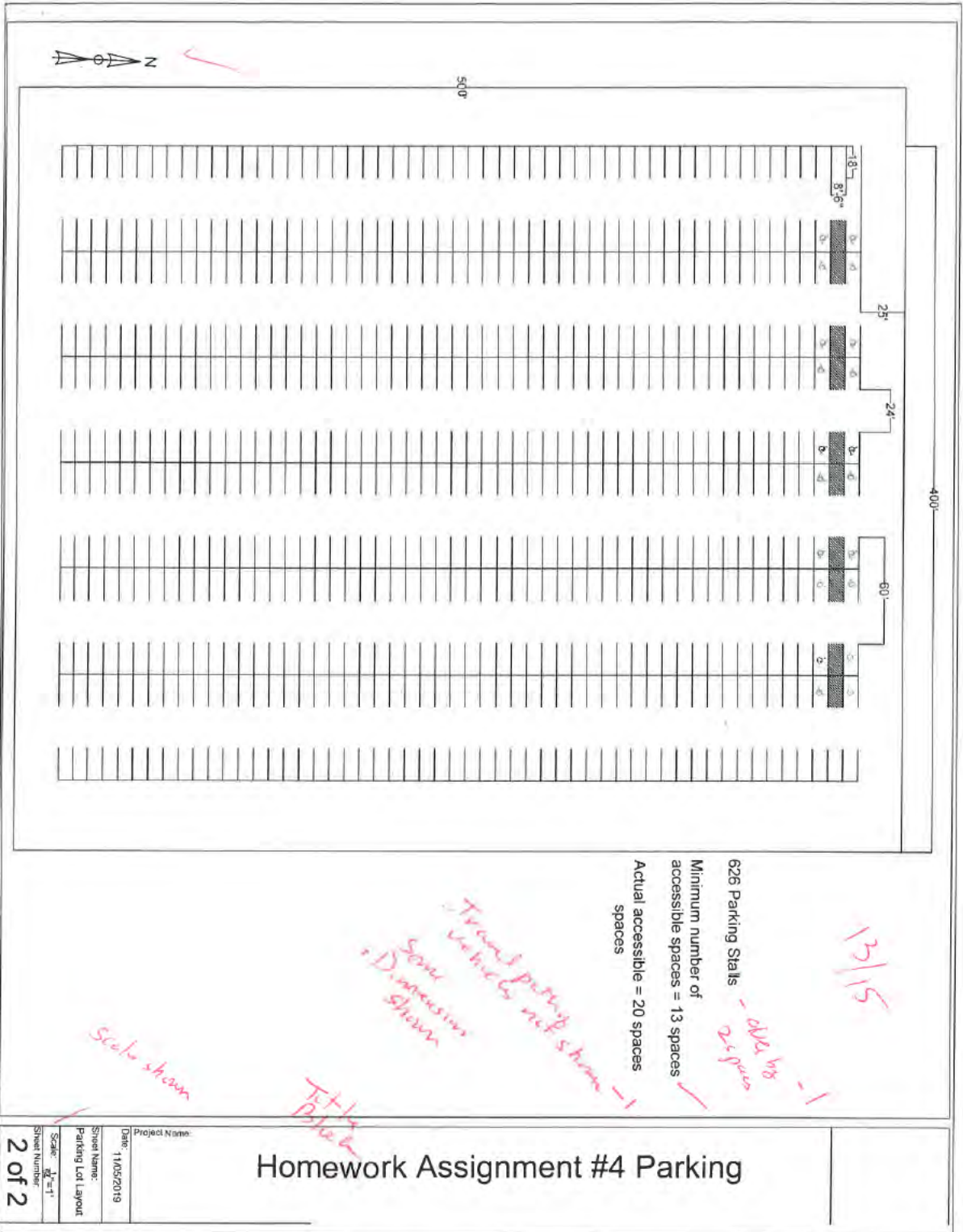
Using the equation for angle of inclination at zero degrees: $N = \frac{L}{22}$, where L is curb length in feet, and N is the number of spaces. Using a curb length of 500 feet, the number of spaces is 22.72 which is rounded to 23 parking spaces.

4. When using the parking space hour supply equation, you must take into account the efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking?

The efficiency factors for curb parking, during highest demand, can be from 78% to 96%. The average efficiency factor used to address curb parking would be

87%.





Homework Assignment #4 Parking

Prairie View A&M University
College of Engineering
Civil & Environmental Department



32.5
40

Homework Assignment #4
Parking

CVEG 4053 - P02 – Transportation Engineering Design
Fall 2019

Francisco Najera - #12

Merchae Dargins - #6

Precious Kalu - #10

Jacolby Terry - #16

Assigned: 29 October 2019

Due: 5 November 2019 NLT 2:05pm

3.) Given: 500 ft curb length
Find: N of spaces

5/5

Round up

Approach: $N = \frac{500 \text{ ft}}{22} = 22.73 \rightarrow \underline{22 \text{ Spaces}}$

4.) 78 percent - 96 percent
 2.5/5
 average is? - 8.5

6.) - Locate as far from the roadway, an intersection, and conflicting points as possible.

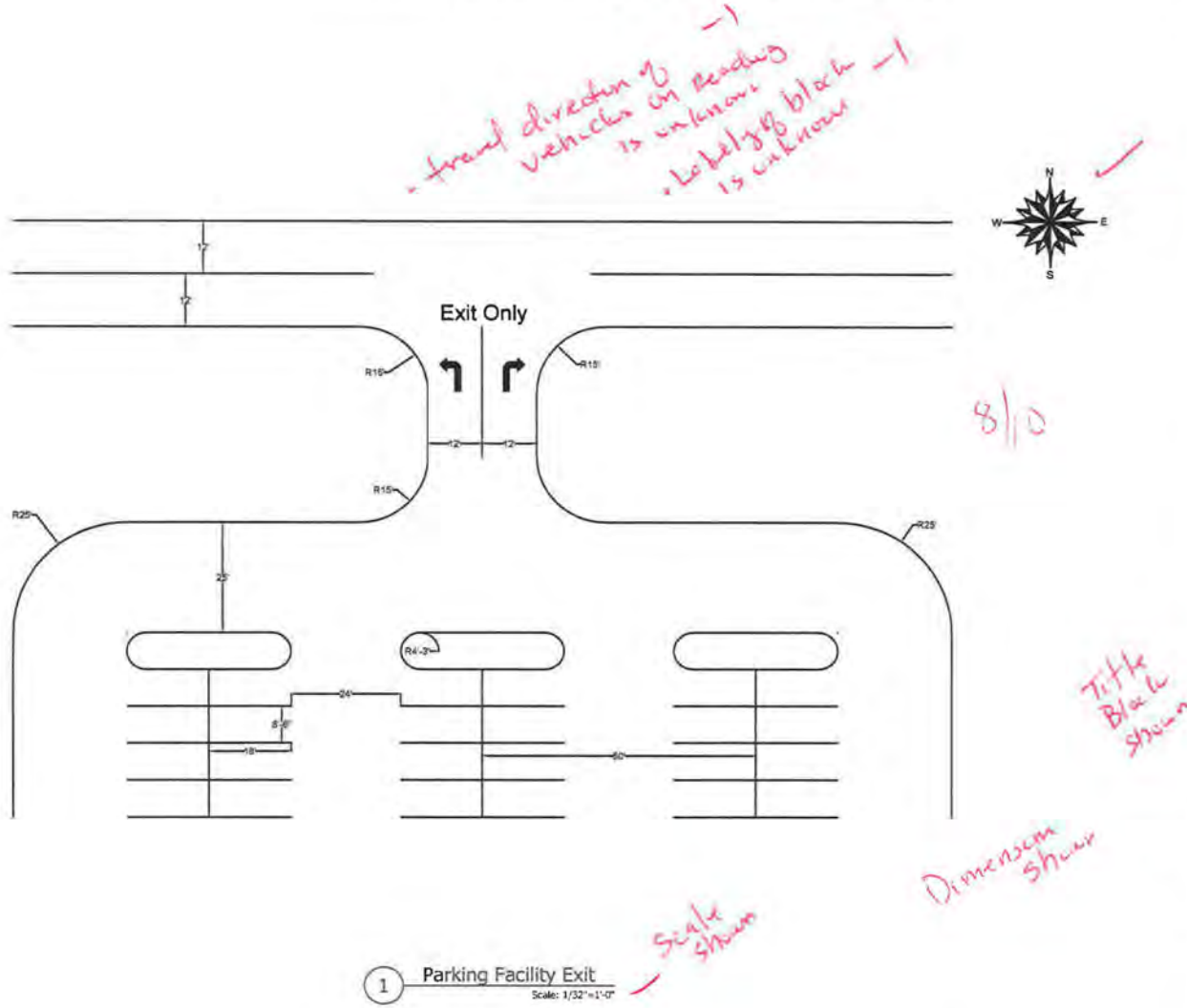
- Multiple entrances may ease access and reduce restrictions on adjacent roadways.

- Place mid-block when possible

✓ 5/5

- Local ordinances and codes can restrict the number of entrances.

PRODUCED BY AN AUTODESK STUDENT VERSION



PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

TRANSPORTERS INC.

Homework Assignment #4
Question #5

Date: 10/30/2019
Drawn by: FN
Checked by: JT, MD, PK

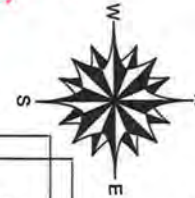
Parking
Facility
Exit

C-1

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Total Number Parking Spaces/Stalls: 620 *of 6 by 4 spaces - 1*
Total Minimum Required Accessible Spaces: 13



TRANSPORTERS INC.

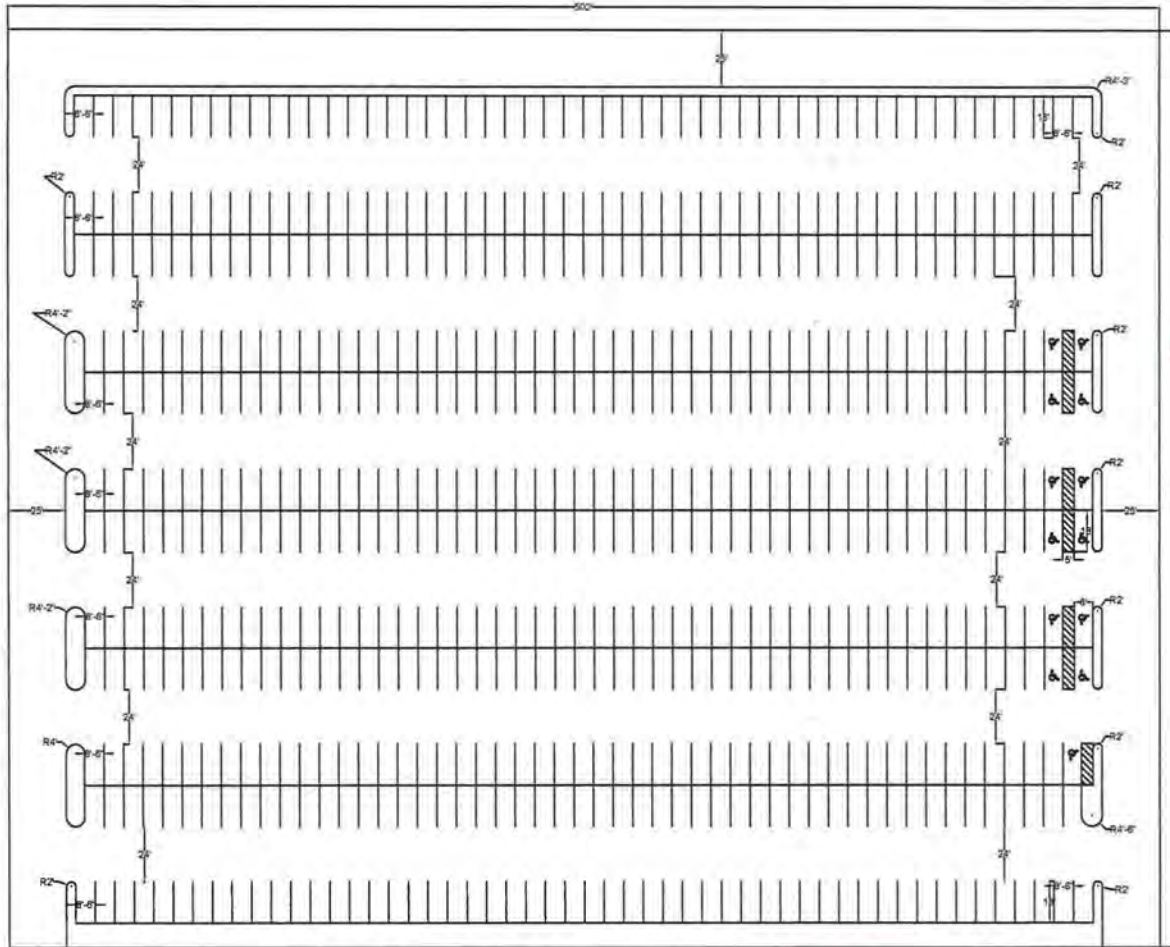
Homework Assignment #4
Question #7

Date: 10/30/2019
Drawn by: FN
Checked by: JT, MD, PK

Proposed
Parking
Layout

C-2

PRODUCED BY AN AUTODESK STUDENT VERSION



1 Proposed Parking Layout
Scale: 1/8"=1'-0"
PRODUCED BY AN AUTODESK STUDENT VERSION

Travel path of vehicle not shown

13/15

Title block

dimensions shown

scale shown

CVEG 4053-P01- Transportation Engineering Design

Fall 2019

Homework Assignment #4

Parking

Given: 29 October 2019

Due: 5 November 2019 NLT 8:05am



Joshua Mason- #15

Justin Jones- #12

Aspen'que Ridgley- #19

Late - 10

Submission Past
The 8:05am Time

16.5
40

ok, typed is preferred
for consistency

3) Given: • Angle of Inclination = 0° (parallel)
• Corb Length $L = 500$ feet

Find: Number of Spaces (N) required

Approach:

$$N = L/22$$

↳ equation for # of spaces
with 0° angle of inclination

$$= 500/22 \\ = 22.73$$

$$\approx 23 \text{ spaces required}$$

✓
5/5

Problem 4

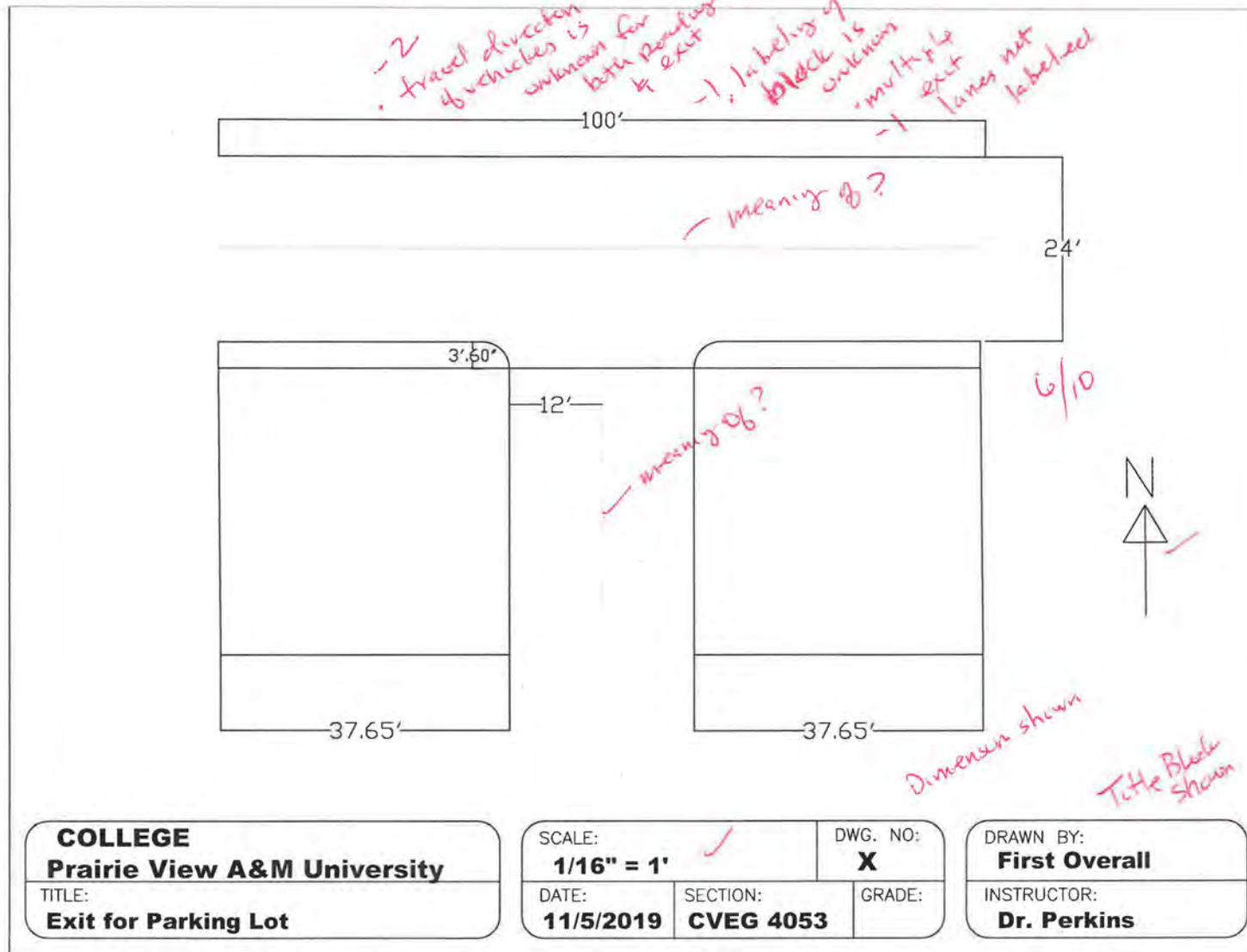
Problem/Given:

When using the parking space hour supply equation you must take into account efficiency of the facility during the highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking.

Find: The average efficiency factor that you must use if you are addressing curb parking. -2.5

Approach: The efficiency factors used during curb parking is 78% - 96%. ✓

This is the range $\frac{+2.5}{5}$



Problem 4

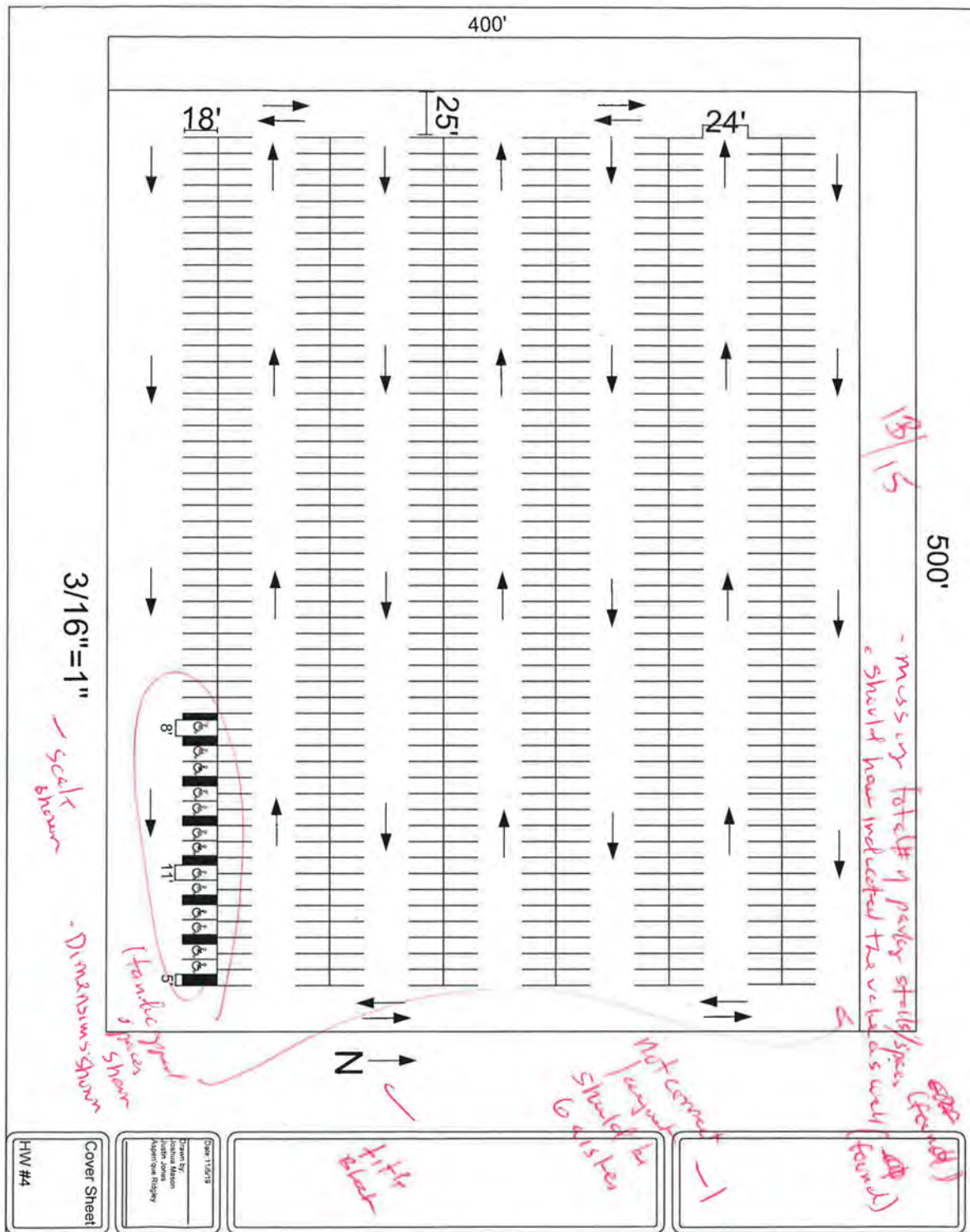
Problem / Given:

What are the parking operations entrance considerations that your team is expected to use?

Find: Parking Operation entrance considerations.

Approach: Based on my team scope of work the parking operation entrance considerations that we are expected to use include: right-turn only lane at the main entrance, at grade channelizations at intersection and a shoulder to accommodate the right turns.

0/5
This response is
more suited for the
Park-N-Ride Facility
DESIGN



Total # of parking stalls = 632 ⁻¹ over by 8 spec/stalls

Requires minimum # of accessible handicap spaces = 13

Prairie View A&M University
Roy G. Perry College of Engineering
Department of Civil & Environmental Engineering



29.25
40

CVEG 4053: Transportation Engineering Design

Fall 2019

Section P02

Homework Assignment #4

Parking

Marion Hall #7

Jarvis Hawkins #8

Frida Rubi #13

Breeland Walker #17

Date Assigned: October 29, 2019

Due Date: November 5, 2019 NLT 2:05pm

Submitted to: Dr. Perkins

Problem 3

Dr. Perkins

Given

angle of inclination is zero

curb length is 500 ft.

Find

Number of spaces required

Approach

$$N = \frac{L}{22}$$

$$N = \frac{500}{22} \Rightarrow$$

23 spaces

✓
5/5

Dr. Perkins

Number 4

Given

Parking space hourly equation

Find

average efficiency factor that you must use if you are addressing curb parking

Approach

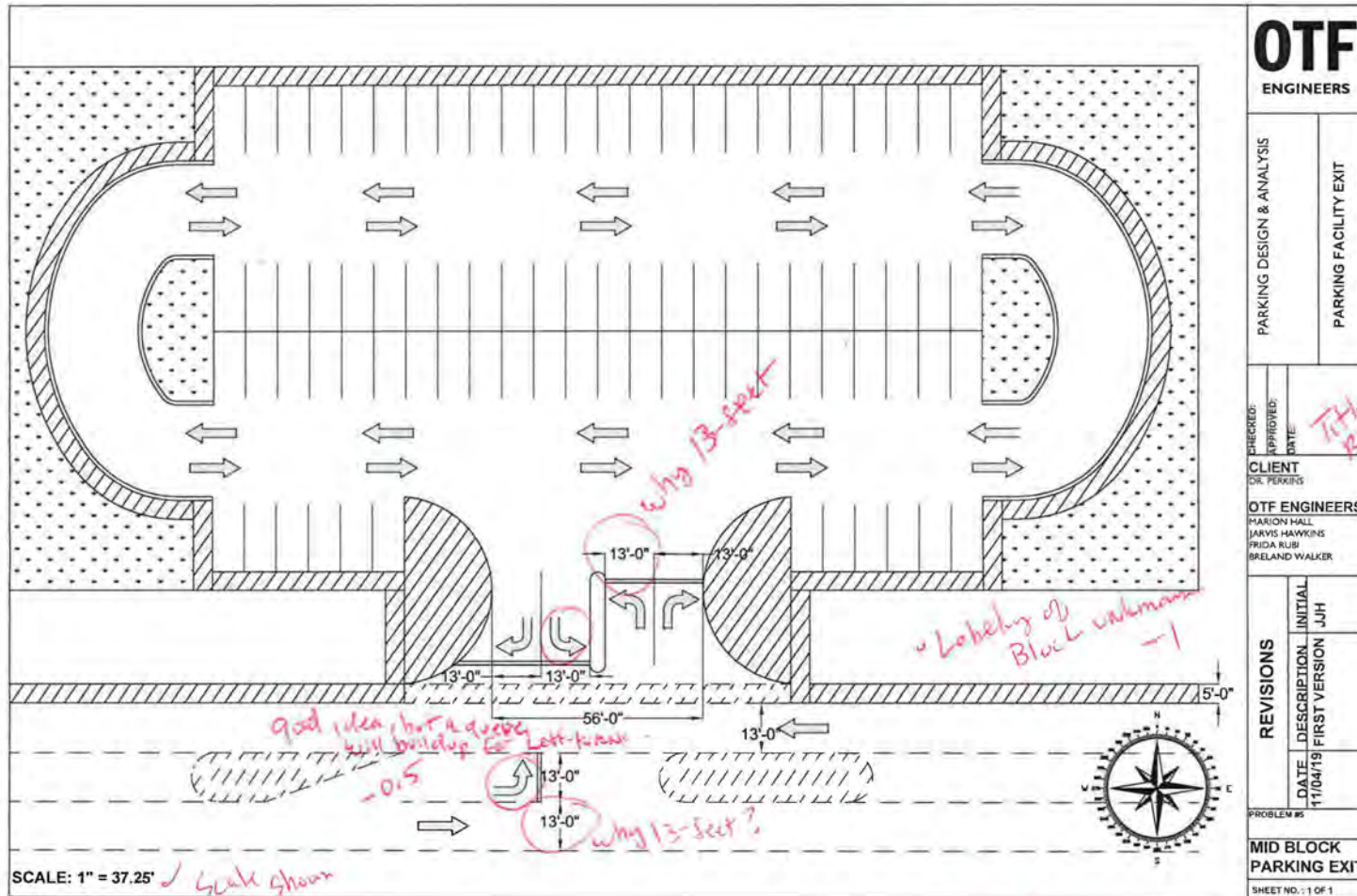
The average efficiency factor ^{-2.5} that has to be used during curb parking is

78 Percent to 96 Percent

^{-12.5/5}

this is the range

8.5/10



OTF
ENGINEERS

PARKING DESIGN & ANALYSIS

PARKING FACILITY EXIT

CHECKED:
APPROVED:
DATE:

Tilly Block

CLIENT
DR. PERKINS

OTF ENGINEERS
MARION HALL
JAKVIS HAWKINS
FRIDA RUBI
BRELAND WALKER

REVISIONS

DATE	DESCRIPTION	INITIAL
11/04/19	FIRST VERSION	JH

PROBLEM #5

MID BLOCK
PARKING EXIT

SHEET NO. 1 OF 1

Dimensions shown

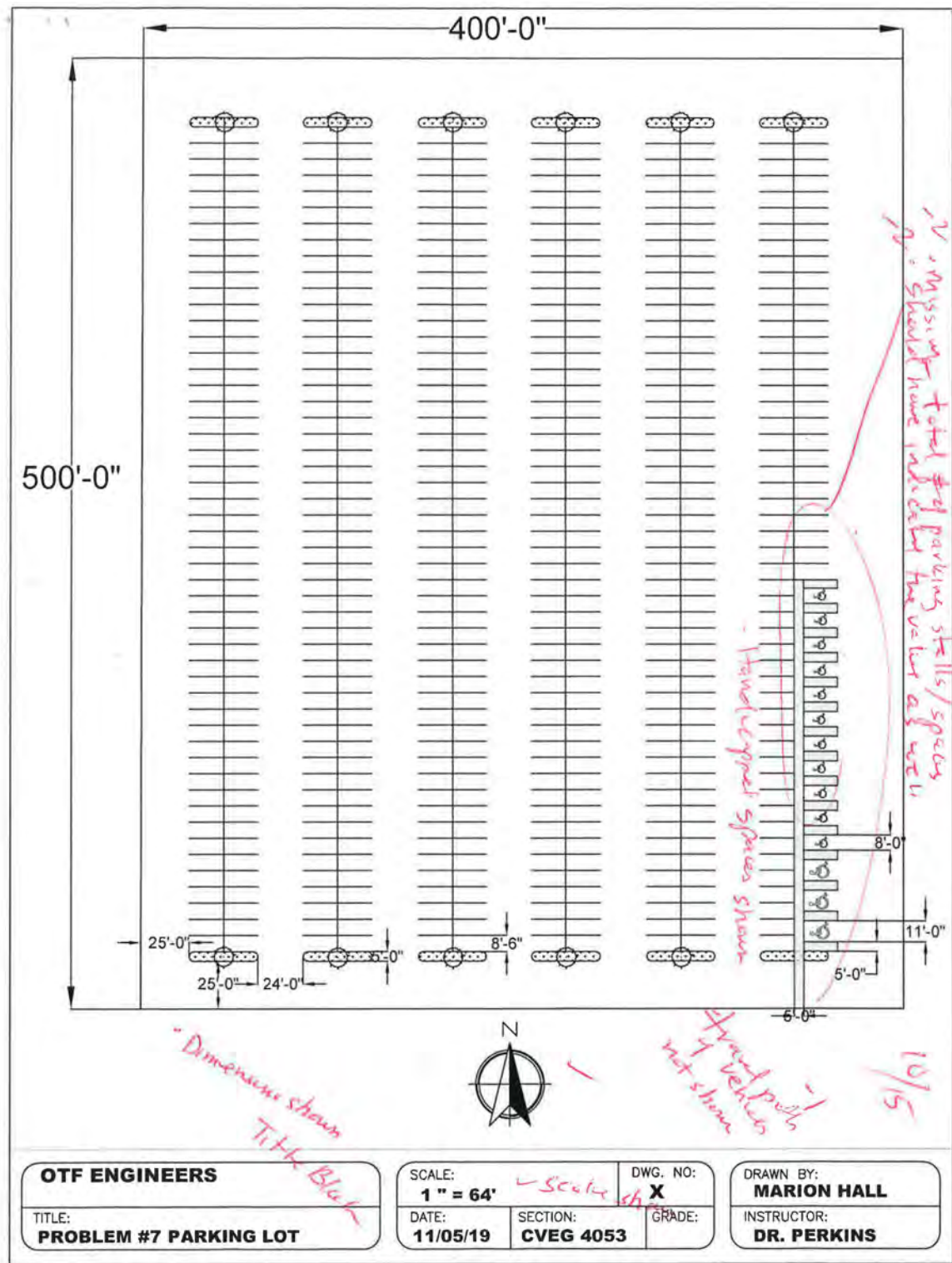
6. What are the parking operations entrances consideration that your team is expected to use?

The parking operations entrance consideration that my team has the idea to use are the following

- +1 1. Use multiple Entrances to make for easier access and reduce the overall traffic and chance of accident. -0.25
- +1.25 2. There will mid blocks whenever possible ^ Restriction on adjacent parking
- +1 3. Use location far from the roadway and conflicting points ^ intersection -0.25

1. missing - 1.25

3.25
5



**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4053: TRANSPORTATION ENGINEERING DESIGN
FALL 2019**

Instructor: Dr. Judy A. Perkins

Title of Assignment

HOMEWORK ASSIGNMENT #5 - CHAPTERS 7, 8, and 10

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of the suitability of assignment for the outcome

Homework Assignment #5 requires the students to respond to questions regarding intersection design, intersection controls, and capacity and level of service at signalized intersections. By doing so, the student will be able to demonstration applying the principles of engineering to solving complex engineering problems.

FALL 2019
ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2019

Homework Assignment #5 - Chapters 7, 8, and 10

Given: 19 November 2019

Due: 19 November 2019 NLT 9:20am

Total point value is (40-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
 - Measure Program Learning Outcome ABET Criterion 3 (5) - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
1. This is a group assignment. The responses should be typed and each problem will need to start a new page.
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 - Assignment Cover Page:
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 - Course number, section and name
 - Name and roster number of each group member
 - Given Date of Assignment
 - Due Date of Assignment

Chapter 7 - Intersection Design

1. Problem #7-4 (5-points)
2. Problem #7-5 (5-points)
3. Problem #7-6 (5-points)

Chapter 8 - Intersection Control

1. Problem #8-1 (5-points)
2. Problem #8-5 (15-points)

Chapter 10 - Capacity and Level of Service at Signalized Intersections

1. Define permitted turning movements (2.5-points)
2. Define protected turns (2.5-points)

GRADING SCHEME FOR ASSIGNMENT

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2019

Homework Assignment #5 - Chapters 7, 8, and 10 (Solution)

Given: 19 November 2019

Due: 19 November 2019 NLT 9:20am

Total point value is (40-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
 - Measure Program Learning Outcome ABET Criterion 3 (5) - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
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 - Due Date of Assignment

Chapter 7 - Intersection Design

1. Problem #7-4 (5-points)

What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

Roundabouts, as opposed to other types of traffic circles, have yield control is used on the approaches, and the roundabout design speed typically does not exceed 30 miles per hour. Conflicting traffic movements are separated by pavement markings or channelizing islands such that vehicles are given detailed guidance as to proper place within the roundabout. Parking is prohibited within the roundabout to maximize capacity.

2. Problem #7-5 (5-points)

What are the main functions of channelization at an at-grade intersection?

Channelization is intended to separate conflicting traffic movements into defined paths to facilitate the safe and orderly movements of both vehicles and pedestrians. This can accomplish many things, including:

- Direct the paths of vehicles so that not more than two paths cross at any one point
- Control the merging, diverging, or crossing angle of vehicles
- Decrease vehicle wander and the area of conflict among vehicles by reducing the amount of paved area
- Provide a clear indication of the proper path for different movements
- Give priority to the predominant movements
- Provide pedestrian refuge
- Provide separate storage lanes for turning vehicles, thereby creating space away from the path of through vehicles for turning vehicles to wait
- Provide space for traffic control devices so that they can be readily seen
- Control prohibited turns
- Separate different traffic movements at signalized intersections with multiple-phase signals
- Restrict the speeds of vehicles

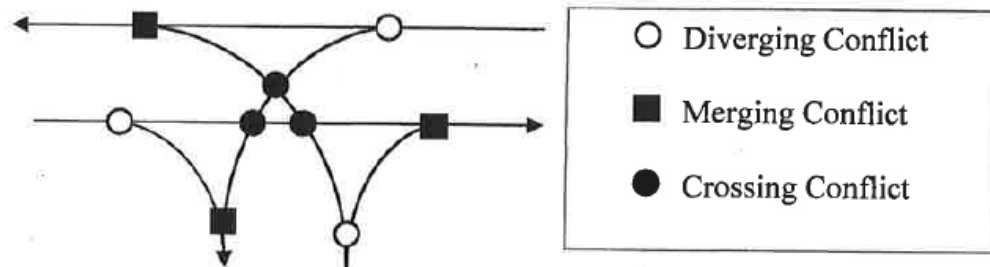
3. Problem #7-6 (5-points)

Discuss the fundamental general principles that should be used in designing a channelized at-grade intersection.

There are several fundamental principles considered in channelized intersection design. Regarding guidance to the motorist, motorists should not be required to make more than one decision at a time. Merging and weaving areas should be as long as possible, but other areas of conflict between vehicles should be reduced to a minimum. Crossing traffic streams that do not weave or merge should intersect at 90° , although a range of 60° - 120° is acceptable; adequate sight distance is provided regardless of angle. Sharp reverse curves and turning paths greater than 90° should be avoided. Separate space should be provided for turning vehicles so that they do not interfere with the movement of through vehicles. Prohibited turning movements should be blocked with channelized islands wherever possible. Finally, the location of essential traffic control devices should be considered in the design process.

1. Problem #8-1 (5-points)

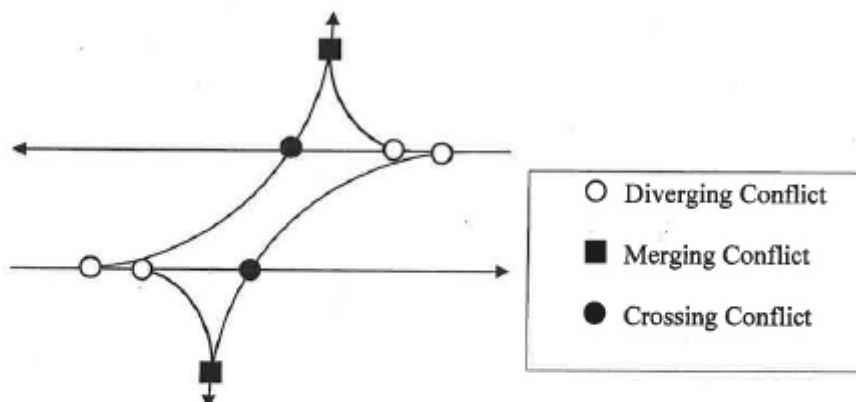
Using an appropriate diagram, identify all the possible conflict points at an unsignalized T intersection.



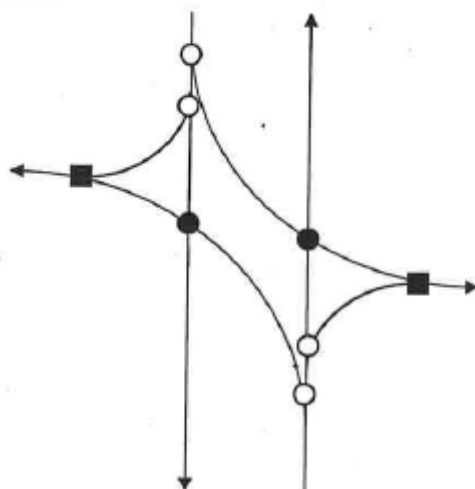
2. Problem #8-5 (15-points)

Using appropriate diagrams, determine the possible conflict points on a four-leg signalized intersection for a two-phase system. Assume no turn on red.

Phase 1:



Phase 2:



Capacity and Level of Service at Signalized Intersections

1. Define permitted turning movements (2.5-points)

Are those made within gaps of an opposing traffic stream or through a conflicting pedestrian flow. For example, when a right turn is made while pedestrians are crossing a conflicting crosswalk, the right turn is a permitted turning movement. Similarly, when a left turn is made between two consecutive vehicles of the opposing traffic stream, the left turn is a permitted turn. The suitability of permitted turns at a given intersection depend on the geometric characteristics of the intersection, the turning volume, and the opposing volume. These movements would be shown a green ball on the signal.

2. Define protected turns (2.5-points)

Are those turns protected from any conflicts with vehicles in an opposing stream or pedestrians on a conflicting crosswalk. A permitted turn takes more time than a similar protected turn and will use more of the available green time. Protected turns would be shown a green arrow on the relevant signal head.

CVEG 4053-P01- Transportation Engineering Design

Fall 2019

Homework Assignment #5

Chapter 7, 8, and 10

Given: 19 November 2019

Due: 19 November 2019 NLT 9:20am



38.62
A0

Cameron Lavergne- #14

Austin Allen- #1

Daniel Doyle- #7

Chapter 7 - Intersection Design

1. Problem #7-4

What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

Key defining characteristics of a roundabout are:

- yield control at each approach
- separation of conflict traffic movements by making pavement markings or raised islands
- Geometric characteristics of the central island that typically allow travel speeds of less than 30 mi/hr
- Parking not usually allowed within the circulating roadway.

5/5

2. Problem #7-5

What are the main functions of channelization at an at-grade intersection?

AASHTO defines channelization as the separation of conflicting traffic movements into definite paths of travel by traffic islands or pavement markings to facilitate safe movement of pedestrians and vehicles.

The main functions of channelization at any grade are:

- Direct paths of vehicles so that not more than 2 paths cross at the same point.
- Supervise the merge, diverge, and intersect angle of vehicles.
- Decrease vehicle wander and the conflict area amount vehicles by reducing paved area.
- Provide clear indication of the proper path for different movements
- Give priority to predominant movements
- Provide storage lanes for turning vehicles thereby creating space away from the path for turning vehicles to wait
- Space for traffic control devices so they can be seen
- Control prohibited turns
- Separate different traffic movements at signalized intersections with multiple phase signals
- Restrict speed of vehicles

Control
- 0.23

MISSING PROVIDE PEDESTRIAN REFUGE - 0.45

4.32
5

3. Problem #7-6

Discuss the fundamental general principle that should be used in designing a channelized at grade intersection?

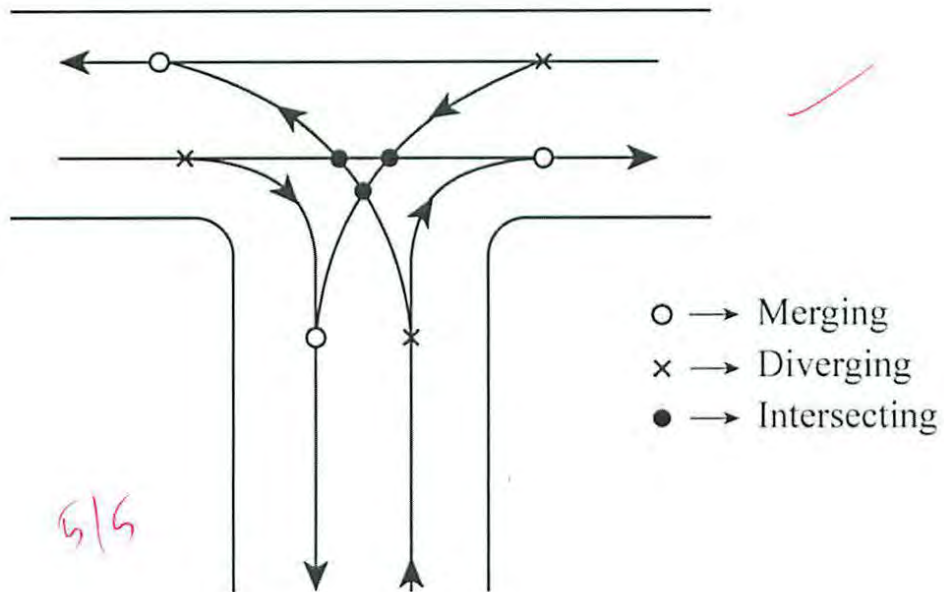
The general principles that should be used in designing a channelized intersection are going to be discussed below. The first principle is that motorists should not be required to make more than one decision at a time. Also reverse curves and turning paths that are greater than 90 degrees should be avoided. Merging and weaving areas should be as long as possible but other areas of conflict between vehicles should be reduced to a minimum. Crossing traffic streams that do not weave or merge should intersect at 90 degrees although a range of 60 to 120 degrees is acceptable. The intersecting angles of merging streams should be such that adequate sight distance is provided. Refuge areas for turning vehicles should not interfere with the movement of vehicles. Prohibited turns should be physically blocked. Decisions on the location of essential traffic control devices should be a component of the design process.

4.3
5

Chapter 8 - Intersection Control

1. Problem # 8-1

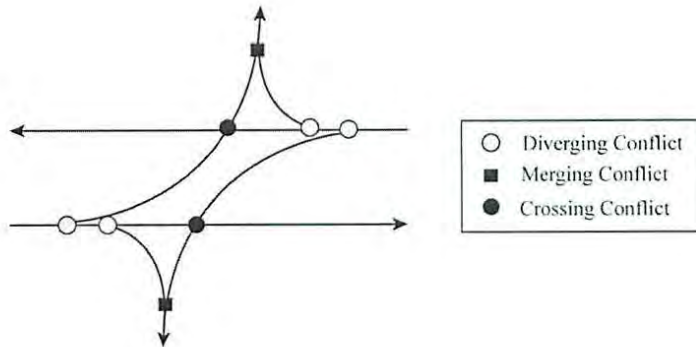
Using an appropriate diagram, identify all the possible conflict points at an unsignalized T intersection.



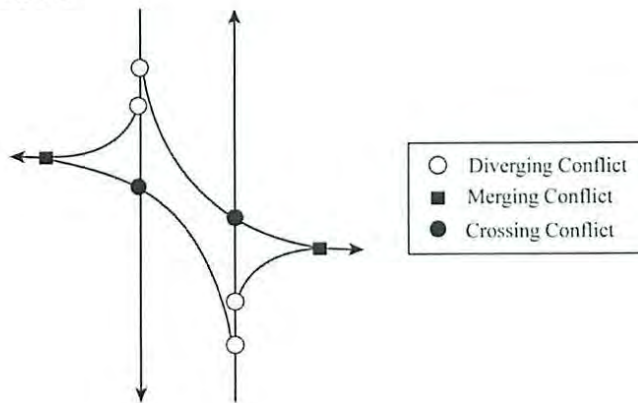
2. Problem #8-5

Using appropriate diagrams, determine the possible conflict points on a four-leg signalized intersection for a two-phase system. Assume no turn on red.

Phase 1



Phase 2



15
15

Chapter 10- Capacity and Level of Service at Signalized Intersections

1. Define permitted turning movements

Permitted turning movements are those made within gaps of an opposing traffic stream or through a conflicting pedestrian flow and should yield to conflicting traffic and pedestrian movements ✓

2-5
2-5

2. Define protected turns

Turns that are protected from any conflict with vehicles in an opposing stream or pedestrians on a conflicting crosswalk.

✓
r/s
r/s

Prairie View A&M University
College of Engineering
Civil & Environmental Department



Homework Assignment #5 ✓
Chapters 7, 8, 10

35.63
✓
40

✓
CVEG 4053 - P02 – Transportation Engineering Design
Fall 2019 ✓

Francisco Najera - #12 ✓

Merchae Dargins - #6 ✓

Precious Kalu - #10 ✓

Jacolby Terry - #15 ✓

Assigned: November 19, 2019

Due: November 19, 2019 NLT 3:45pm

6/19/2019 for
ole

Chapter 7 – Intersection Design

#7-4 What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

- Yield control at each approach.
- Separation of conflict traffic movements by making pavement marking or raised islands.
- Geometric characteristics of the central island that typically allow travel speeds of less than 48 km/h.
- Parking is not allowed within the circulating roadway.

5/5

#7-5 What are the main functions of channelization at an at-grade intersection?

- To direct the paths of vehicles so that not more than two paths cross at any one point.
- To control the merging, diverging, or crossing angle of vehicles.
- To decrease vehicle wander and the area of conflict amount vehicles by reducing the amount of paved area.
- To provide a clear indication of the proper path for different movements.
- To give priority to the predominant movements.
- To provide pedestrian refuge.
- To provide separate storage lanes for turning vehicles, thereby creating space away from the path of through vehicles for turning vehicles to wait.
- To provide space for traffic control devices so that they can be readily seen.
- To control prohibited turns.
- To separate different traffic movements at signalized intersections with multiple-phase signals.
- To restrict the speeds of vehicles.

5/5

#7-6 Discuss the fundamental general principles that should be used in designing a channelized at-grade intersection.

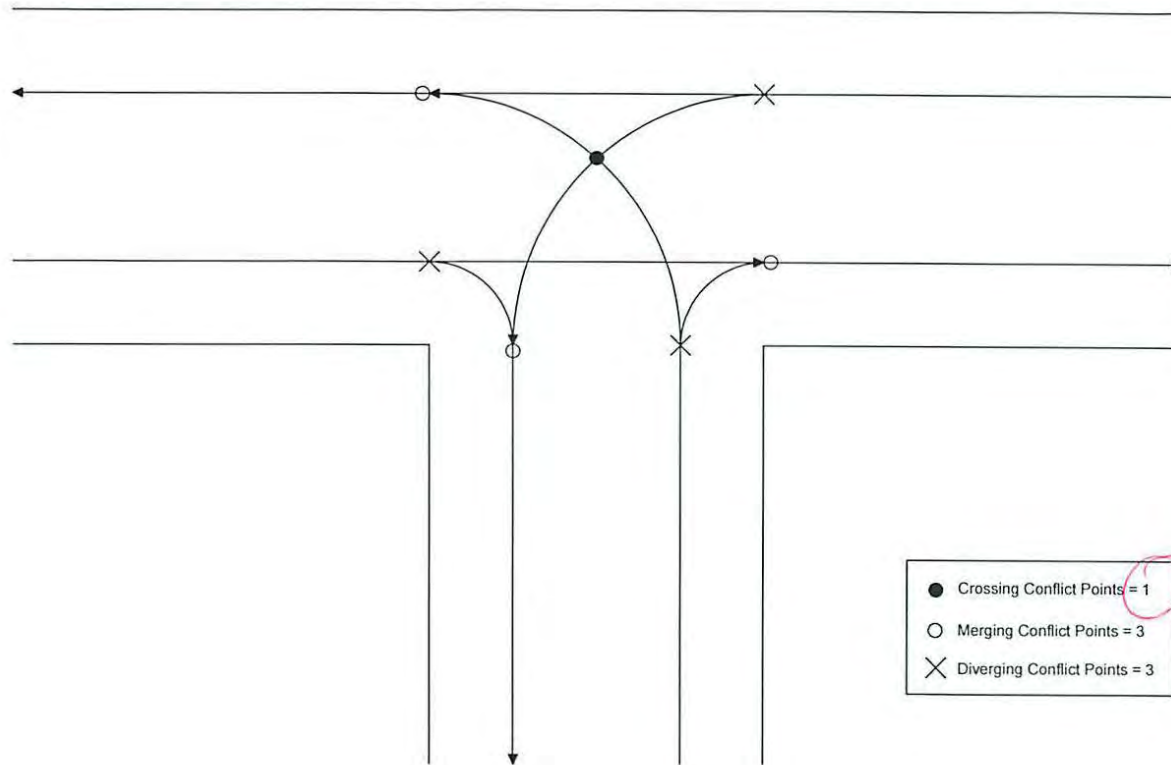
- Motorists should not be required to make more than one decision at a time. ✓ 1
- Sharp reverse curves and turning paths greater than 90 degrees should be avoided. ✓ 4
- Merging and weaving areas should be as long as possible, but other areas of conflict between vehicles should be reduced to a minimum. ✓ 2
- Crossing traffic streams that do not weave or merge should intersect at 90 degrees, although a range of 60 to 120 degrees is acceptable. ✓ 3
- The intersecting angle of merging streams should be such that adequate sight distance is provided.
- Refuge areas for turning vehicles should not interfere with the movement of through vehicles. *no movements*
- Prohibited turns should be physically blocked wherever possible. ✓ 6
- Decisions on the location of essential traffic control devices should be a component of the design process. ✓ 7

4.3
5

Chapter 8 - Intersection Control

Problem #8.1

Possible Conflict Points at an Unsignalized T Intersection

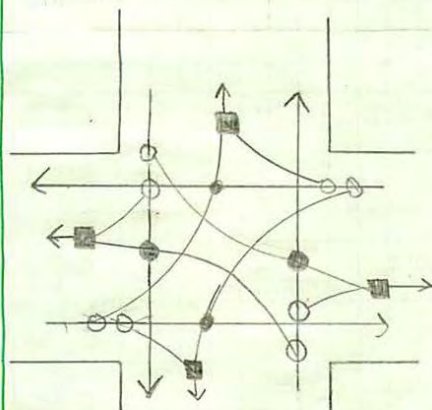


$$\frac{3 \cdot 33}{5}$$

Scale: $\frac{3}{32}" = 1'-0"$

Missing
2 crossing
conflict
points

8-5) Using appropriate diagrams, determine the possible conflict points on a four-leg-signalized intersection for a two phase system. Assume no turn on red.



○ Diverging Conflict
 ■ Merging Conflict
 ● Crossing Conflict

15
 15

Conflict	Number of conflict points
Merging Conflict	4
Diverging conflict	8
Crossing Conflict	4

Chapter 10 - Capacity and Level of service at Signalized Intersections

1. Define permitted turning movements.

Permitted turning movements that are made with within gaps. For example, these turns requires drivers to make turns by yielding to opposing traffic.

of an opposing traffic stream or a conflicting pedestrian flow

Should yield to conflicting traffic & pedestrian movements

$$\frac{1.5}{2.5}$$

2. Define Protected Turns.

Protected turns are secured and protected from conflicts with opposing traffic, these movements can be protected with a traffic signal to prevent the number of conflict points at an intersection.

-1

or
pedestrians
on a
conflicting
crosswalk

1.5
2.5

CVEG 4053-P01- Transportation Engineering Design

Fall 2019

Homework Assignment #5

Chapter 7, 8, and 10

Given: 19 November 2019

Due: 19 November 2019 NLT 9:20am

20.71
40



Joshua Mason- #15

Justin Jones- #12

Aspen'que Ridgley- #19

Chapter 7 – Intersection Design

1. (7-4)

What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

- Yield control at each approach
- Separation of conflicting traffic movements through channelization, by pavement markings or raised islands
- Geometric characteristics of the central island that typically allow travel speeds of less than 48 km/h
- Parking not usually allowed within the circulating roadway

5/5

2. (7-5)

What are the main functions of channelization at an at – grade intersection?

- Direct the paths of vehicles so that not more than two paths cross at any one point
- Control the merging, diverting, or crossing angle of vehicles
- Decrease vehicle wander and the area of conflict among vehicles by reducing the amount of paved area
- Provide a clear indication of the proper path for different movements
- Give priority to the predominant movements
- Provide pedestrian refuge
- Provide separate storage lanes for turning vehicles, thereby creating space away from the path of through vehicles for turning vehicles to wait
- Provide space for traffic control devices so that they can be readily seen
- Control prohibited turns
- Separate different traffic movements at signalized intersections with multiple – phase signals
- Restrict the speeds of vehicles

5/5

3. (7-6)

Discuss the fundamental general principles that should be used in designing a channelized at – grade intersection.

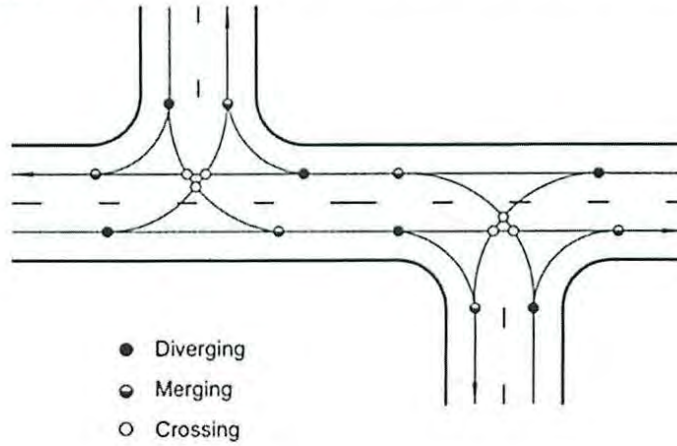
- When delving into the fundamental general principles used, the main focus is portrayed onto the merging and weaving areas in association with crossing traffic and streams. Things like the refuge areas for turning vehicles should not interfere with the movement of through vehicles along with prohibited turns being physically blocked wherever possible at all times provide insight on some of the fundamental general principles.

0.71
/5

Chapter 8- Intersection Control

1. (8-1)

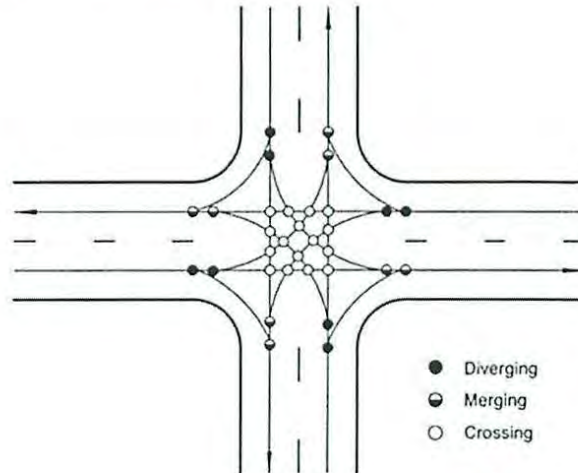
Using an appropriate diagram, identify all possible conflict points at an unsignalized T intersection.



9/5

2. (8-5)

Using appropriate diagrams, determine the possible conflict points on a four – leg signalized intersection for a two-phase system. Assume no turn on red.



10
~~10~~
15

Chapter 10 – Capacity and Level of Service at Signalized Intersections

1.

Define permitted turning movements.

- Permitted turning movements are those made within gaps of an opposing traffic stream or through a conflicting pedestrian flow and should yield to conflicting traffic and pedestrian movements.

2.5
2.5

2.

Define protected turns.

- Protected turns are those turns protected from any conflicts with vehicles in an opposing stream or pedestrians on a conflicting crosswalk.

✓ 2.5 / 2.5

Prairie View A&M University
Roy G. Perry College of Engineering
Department of Civil & Environmental Engineering



35.1
40

CVEG 4053: Transportation Engineering Design

Fall 2019

Section P02

Homework Assignment #5

Parking

Marion Hall #7

Jarvis Hawkins #8

Frida Rubi #13

Date Assigned: November 19, 2019

Due Date: November 19, 2019 NLT 3:45pm

Submitted to: Dr. Perkins

Chapter 7- Intersection Design 7-4)

Question: What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

- Yield control at each approach
- Separation of conflicting traffic movements through channelization, by pavement markings or raised islands
- Geometric characteristics of the central island that typically allow travel speeds of less than 48 km/h
- Parking not usually allowed within the circulating roadway

5/5

7-5)

Question: What are the main functions of channelization at an at – grade intersection?

- Direct the paths of vehicles so that not more than two paths cross at any one point
- Control the merging, diverting, or crossing angle of vehicles
- Decrease vehicle wander and the area of conflict among vehicles by reducing the amount of paved area
- Provide a clear indication of the proper path for different movements
- Give priority to the predominant movements
- Provide pedestrian refuge
- Provide separate storage lanes for turning vehicles, thereby creating space away from the path of through vehicles for turning vehicles to wait
- Provide space for traffic control devices so that they can be readily seen
- Control prohibited turns
- Separate different traffic movements at signalized intersections with multiple – phase signals
- Restrict the speeds of vehicles

5/5

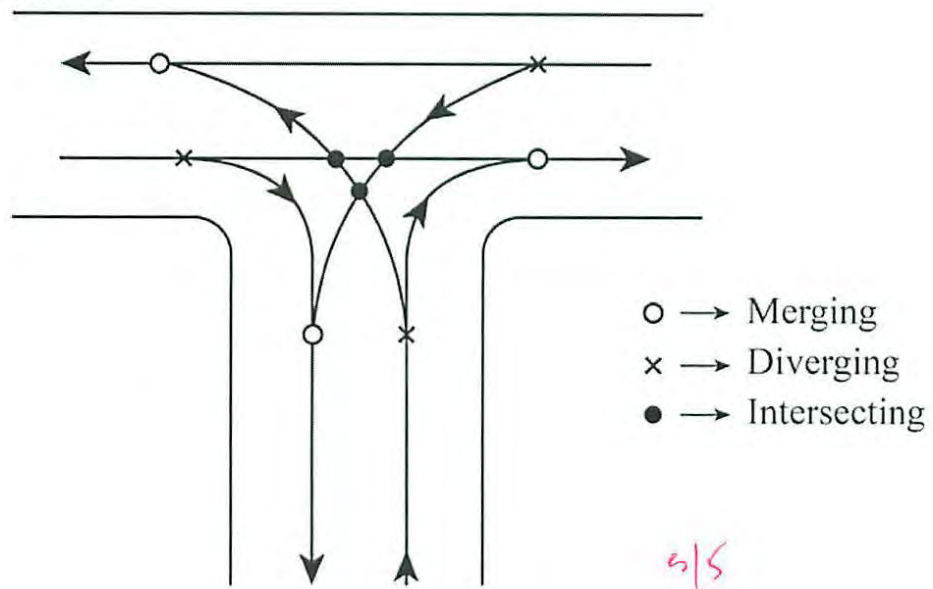
7-6)

Question: Discuss the fundamental general principles that should be used in designing a channelized at – grade intersection.

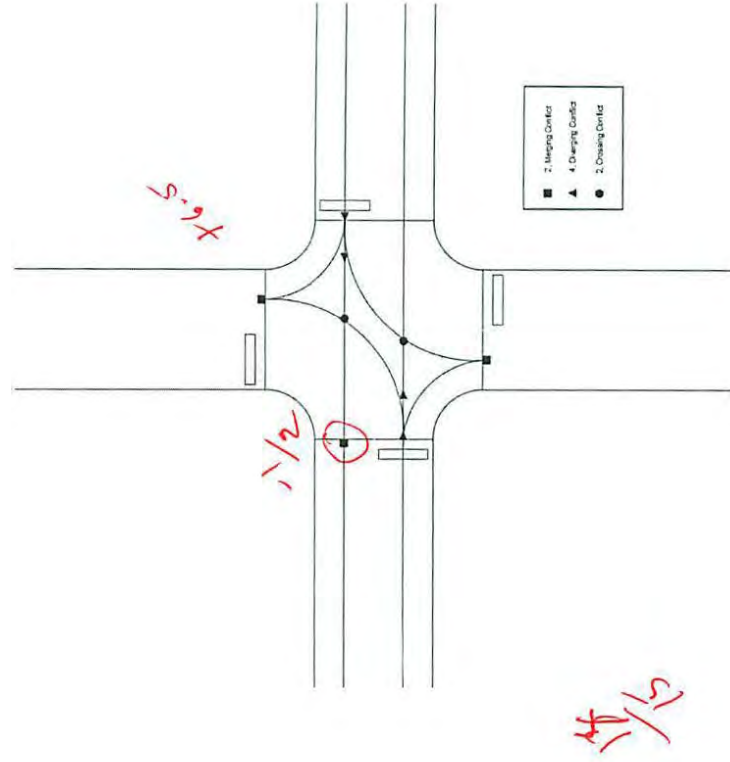
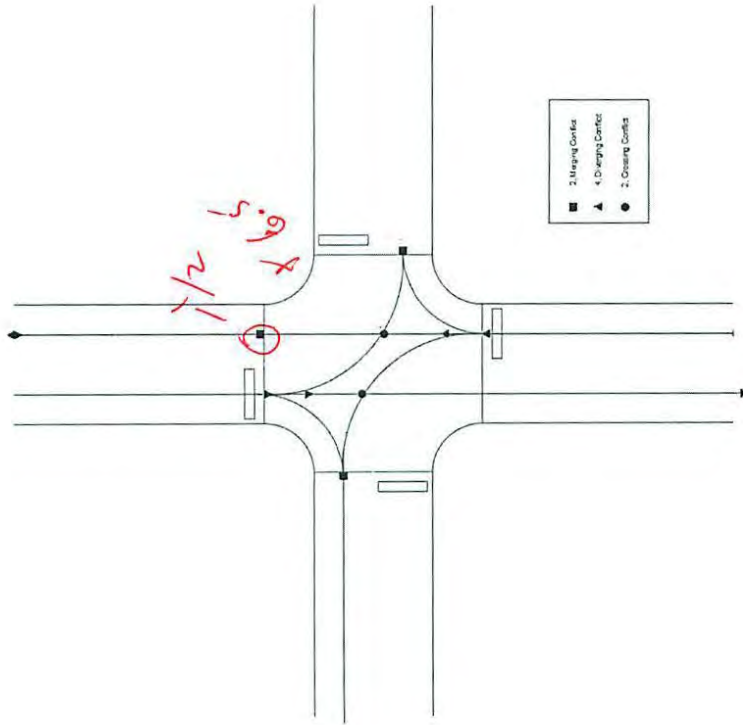
The main focus for general principles used in designing a channelized would be the merging and weaving areas that are associated with crossing of traffic and streams; while avoiding reverse curbs and turning paths that are greater than 90 degrees. A refuge area for turning vehicles should not interfere with the movement of vehicles. Also prohibited turns should be physically blocked. Placement of traffic control devices are vital part of the design process

2.1
5

Problem 8.1



Problem 8.5



Chapter 10- Capacity and Level of service at Signalized Intersection

Question: Define permitted turning movements.

Permitted turning movements are those made within gaps of an opposing traffic stream or through a conflicting pedestrian flow and should yield to conflicting traffic and pedestrian movements.

2/5
1/2/5

2) Question: Define protected turns

Protected turns are turns protected from any conflicts with vehicles in an opposing stream or pedestrians on a conflicting crosswalk.

✓
2.5
2.5

**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4053: TRANSPORTATION ENGINEERING DESIGN
FALL 2020**

Instructor: Dr. Judy A. Perkins

Title of Assignment

HOMEWORK ASSIGNMENT #4 - Intersection Design and Control

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of the suitability of assignment for the outcome

Homework Assignment #4 requires the students to respond to questions regarding intersection design, intersection controls, and capacity and level of service at signalized intersections. By doing so, the student will be able to demonstration applying the principles of engineering to solving complex engineering problems.

ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2020

Homework Assignment #4 – Intersection Design and Control

Given: 5 November 2020

Due: 5 November 2020 NLT 9pm CST

Total point value is (100-points)

- Measuring ABET Criterion 3. Student Outcome 1 - An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - You must type the question/problem and your response to the question/problem.
 - Each question/problem will need to start a new page.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment
 3. Convert the assignment requirements into a single PDF and upload the file into your group's Dropbox folder.

Chapter 7 - Intersection Design

1. Problem #7-4 (25-points)
2. Problem #7-5 (25-points)
3. Problem #7-6 (25-points)

Chapter 8 - Intersection Control

1. Problem #8-1 (25-points)

GRADING SCHEME FOR ASSIGNMENT
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2020

Homework Assignment #4 – Intersection Design and Control - Solution

Given: 5 November 2020

Due: 5 November 2020 NLT 9pm

Total point value is (100-points)

- Measuring ABET Criterion 3. Student Outcome 1 - An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - You must type the question/problem and your response to the question/problem.
 - Each question/problem will need to start a new page.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
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 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment
 3. Convert the assignment requirements into a single PDF and upload the file into your group's Dropbox folder.

Chapter 7 - Intersection Design

4. Problem #7-4

What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

Roundabouts, as opposed to other types of traffic circles, have yield control is used on the approaches, and the roundabout design speed typically does not exceed 30 miles per hour. Conflicting traffic movements are separated by pavement markings or channelizing islands such that vehicles are given detailed guidance as to proper place within the roundabout. Parking is prohibited within the roundabout to maximize capacity.

5. Problem #7-5

What are the main functions of channelization at an at-grade intersection?

Channelization is intended to separate conflicting traffic movements into defined paths to facilitate the safe and orderly movements of both vehicles and pedestrians. This can accomplish many things, including:

- Direct the paths of vehicles so that not more than two paths cross at any one point
- Control the merging, diverging, or crossing angle of vehicles
- Decrease vehicle wander and the area of conflict among vehicles by reducing the amount of paved area
- Provide a clear indication of the proper path for different movements
- Give priority to the predominant movements
- Provide pedestrian refuge
- Provide separate storage lanes for turning vehicles, thereby creating space away from the path of through vehicles for turning vehicles to wait
- Provide space for traffic control devices so that they can be readily seen
- Control prohibited turns
- Separate different traffic movements at signalized intersections with multiple-phase signals
- Restrict the speeds of vehicles

6. Problem #7-6

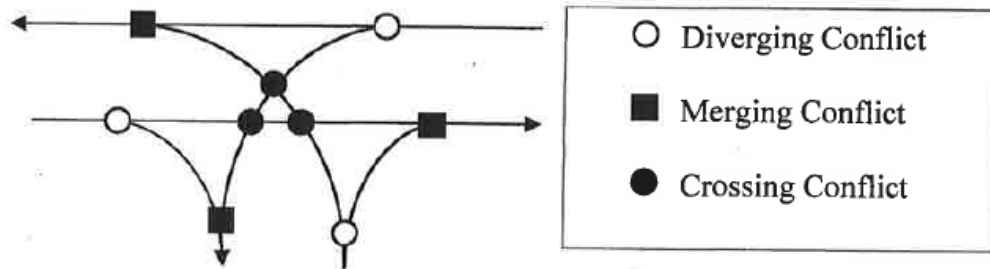
Discuss the fundamental general principles that should be used in designing a channelized at-grade intersection.

There are several fundamental principles considered in channelized intersection design. Regarding guidance to the motorist, motorists should not be required to make more than one decision at a time. Merging and weaving areas should be as long as possible, but other areas of conflict between vehicles should be reduced to a minimum. Crossing traffic streams that do not weave or merge should intersect at 90°, although a range of 60-120° is acceptable; adequate sight distance is provided regardless of angle. Sharp reverse curves and turning paths greater than 90° should be avoided. Separate space should be provided for turning vehicles so that they do not interfere with the movement of through vehicles. Prohibited turning movements should be blocked with channelized islands wherever possible. Finally, the location of essential traffic control devices should be considered in the design process.

Chapter 8 - Intersection Control

1. Problem #8-1

Using an appropriate diagram, identify all the possible conflict points at an unsignalized T intersection.



**CIVIL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**



*Grades
pending*
97

FALL 2020

**CVEG 4053 TRANSPORTATION
ENGINEERING DESIGN P01**

Homework Assignment #4 – Intersection Design and Control

Given: November 5, 2020

Due: November 5, 2020

Submitted on: November 5, 2020

Submitted by: Group 1A Engineering

Devan-Addison Turner

Alex Martinez

Problem #7-4) What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

Key defining characteristics of roundabouts that distinguish them from other traffic circles are:

- Yield control at each approach.
- Pavement markings or raised islands that allow separation of conflict traffic movements.
- Reduces the travel speed of the vehicle to less than 30 mi/h.
- Parking is not allowed within the circulating roadway.



23.75

Problem #7-6) Discuss the fundamental general principles that should be used in designing a channelized at-grade intersection.

The fundamental general principles used in designing a channelized at-grade intersection are:

- Drivers should not be required to make more than one decision at a time.
- Merging and weaving areas should be as long as possible
- Other areas of conflict between vehicles should be reduced to a minimum
- An intersection of 90 degrees should be at crossing traffic streams that do not weave or merge, although 60-120 degrees is accepted.
- Proper sight distance is provided regardless of angle.
- Sharp reverse curves and turning paths greater than 90 degrees should be avoided.
- Separate space should be provided for turning vehicles so that they do not interfere with the movement of through vehicles.
- Allowable turning movements should be blocked with channelized islands whenever possible.
- Location of essential traffic control devices should be considered in the design process.

23.75

Problem #7-5) What are the main functions of channelization at an at-grade intersection?

The main functions of channelization at an at-grade intersection are:

- Provides a speed limit for the vehicles
- Manage prohibited turns
- Divide the flow of traffic at signalized crossings by use of multiple-phase lanes
- To provide the right amount of space for traffic control devices at the intersections
- To provide service lanes for the turning vehicles and repairing vehicles
- To facilitate the pedestrian for shelter
- To provide precedence for the main movements of vehicle
- To provide clear sign for various actions of the vehicles
- To get rid of the conflict area of vehicles with the help of reduced paved areas
- To look over merge, diverge, and intersect angle of vehicles
- To check vehicles travel path so that the number of intersections is not more than the paths at any point.

Please provide chapter 9 reference
23.75

Problem #8-1) Using an appropriate diagram, identify all the possible conflict points at an unsignalized T intersection.

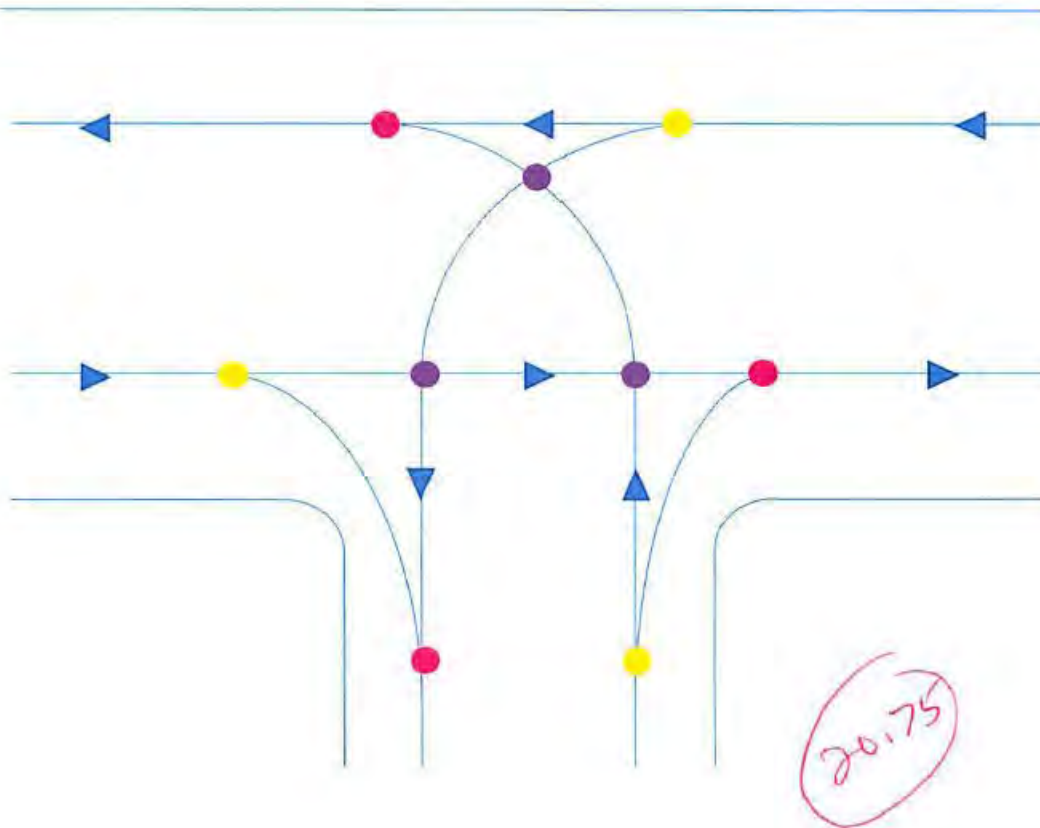
The figure below shows the conflict points for merging, crossing, and diverging.

The yellow dots represent the three conflict points when diverging.

The pink dots represent the three conflict points when merging.

The purple dots represent the three conflict points when crossing.

*Number of
each - 3*



Re: CVEG 4053 - Z01 Group 1A Engineering Updated HW 4 with Reference

Perkins, Judy <juperkins@pvamu.edu>

Sun 11/15/2020 11:00 AM

To: Devan Addison-Turner <daddisonturner@student.pvamu.edu>

Cc: Alex T Martinez <amartinez69@student.pvamu.edu>; Perkins, Judy <juperkins@pvamu.edu>

Good morning and thanks.

Judy A. Perkins, Ph.D., PE
Interim Department Head for Civil & Environmental Engineering
Professor and TAMUS Regents Professor
Prairie View A&M University
Department of Civil & Environmental Engineering
P.O. Box 519, Mail Stop 2510
Prairie View, Texas 77446-4249
Voice (Main Office): 936-261-1665
Voice (Direct): 936-261-1655
Fax: 936-261-1662
Email: juperkins@pvamu.edu

From: Devan Addison-Turner <daddisonturner@student.pvamu.edu>

Sent: Saturday, November 14, 2020 7:43 PM

To: Perkins, Judy <juperkins@pvamu.edu>

Cc: Alex T Martinez <amartinez69@student.pvamu.edu>

Subject: CVEG 4053 - Z01 Group 1A Engineering Updated HW 4 with Reference

Good evening Dr. Perkins,

Group 1A Engineering has uploaded the updated homework #4 with the reference utilized for problem 7-5 into Dropbox as instructed to receive our final grade for the assignment. Thank you.

Kind regards,

Devan Addison-Turner

**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4053: TRANSPORTATION ENGINEERING DESIGN
FALL 2020**

Instructor: Dr. Judy A. Perkins

Title of Assignment

**HOMEWORK ASSIGNMENT #5 –
PARKING ANALYSIS AND DESIGN**

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
x	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
x	mathematics

Brief justification of the suitability of assignment for the outcome

This parking assignment requires the students to use their understanding of topics related parking studies, parking analysis, and parking design In order to develop solutions to the questions.

ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2020

Homework Assignment #5 – Parking Analysis and Design

Given: 19 November 2020 (Updated)

Due: 25 November 2020 NLT 5pm

Total point value is (100-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - Use the format - Given, Find, Approach, and Blocking of Answers - when solving Problem #1
 - Place the responses to each problem on this document. Feel free to write on the back of the page.
 - The response to **Problem #4** will need to be drawn on 8.5-inch by 11-inch paper and attached to this document.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment
 3. Upload this assignment as a single PDF to your Group's Dropbox

Parking Analysis

1. When designing an on-street parking facility, the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet will be _____. (10-points)
2. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (10-points)
3. What are the parking operations entrance considerations that your team is expected to use? (10-points)

Parking Design

1. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels. (70-points)

GRADING SCHEME FOR ASSIGNMENT
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4053 – Transportation Engineering Design
Fall 2020

Homework Assignment #5 – Parking Analysis and Design - Solution

Given: 19 November 2020

Due: 25 November 2020 NLT 5pm

Total point value is (100-points)

- Measure Program Learning Outcome ABET Criterion 3 (1) - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - Use the format - Given, Find, Approach, and Blocking of Answers - when solving Problem #1
 - Place the responses to each problem on this document. Feel free to write on the back of the page.
 - The response to Problem #4 will need to be drawn on 8.5-inch by 11-inch paper and attached to this document.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment
 3. Upload this assignment as a single PDF to your Group's Dropbox

Parking Analysis

1. When designing an on-street parking facility, the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet will be _____. (10-points)

$$N = L/22 = 500/22 = 22.7 \sim 23 \text{ spaces}$$

2. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (10-points)

78% - 96%, average 90%

3. What are the parking operations entrance considerations that your team is expected to use? (10-points)

- **Entrance Considerations**
 - a. **Locate as far from the roadway, an intersection, and conflicting points as possible.**
 - b. **Multiple entrances may ease access and reduce restriction on adjacent roadways.**
 - c. **Place mid-block.**
 - d. **Local ordinances and codes can restrict the number of entrances**

Parking Design

1. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels. (70-points)

OPEN-END RESPONSE

**CIVIL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**



87.5
100

FALL 2020

**CVEG 4053 TRANSPORTATION ENGINEERING
DESIGN – ZO1 ✓**

**Homework Assignment #5 – Parking Analysis and
Design ✓**

Given: November 19, 2020 ✓

Due: November 25, 2020 ✓

GROUP #5 – M.E.S. ENGINEERING GROUP

Milton Cruz ✓

Erik Smith ✓

Sydney Jones ✓

Problem # 1

Given: Curb Length = 500 ft

Angle of Inclination = zero (0)

Find: the number of spaces

Approach: $N = \frac{L}{22}$ (Figure 15.33)

where, N = Number of spaces

L = curb length

Answer:

$$N = \frac{L}{22}$$

$$= \frac{500 \text{ ft}}{22}$$

$$\therefore \boxed{N = 23 \text{ spaces}}$$

(10)

Problem #2

When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking?

10
The efficiency factor for curb parking ranges from 78% to 96% with the average efficiency factor used being 90%.

10

Problem #3

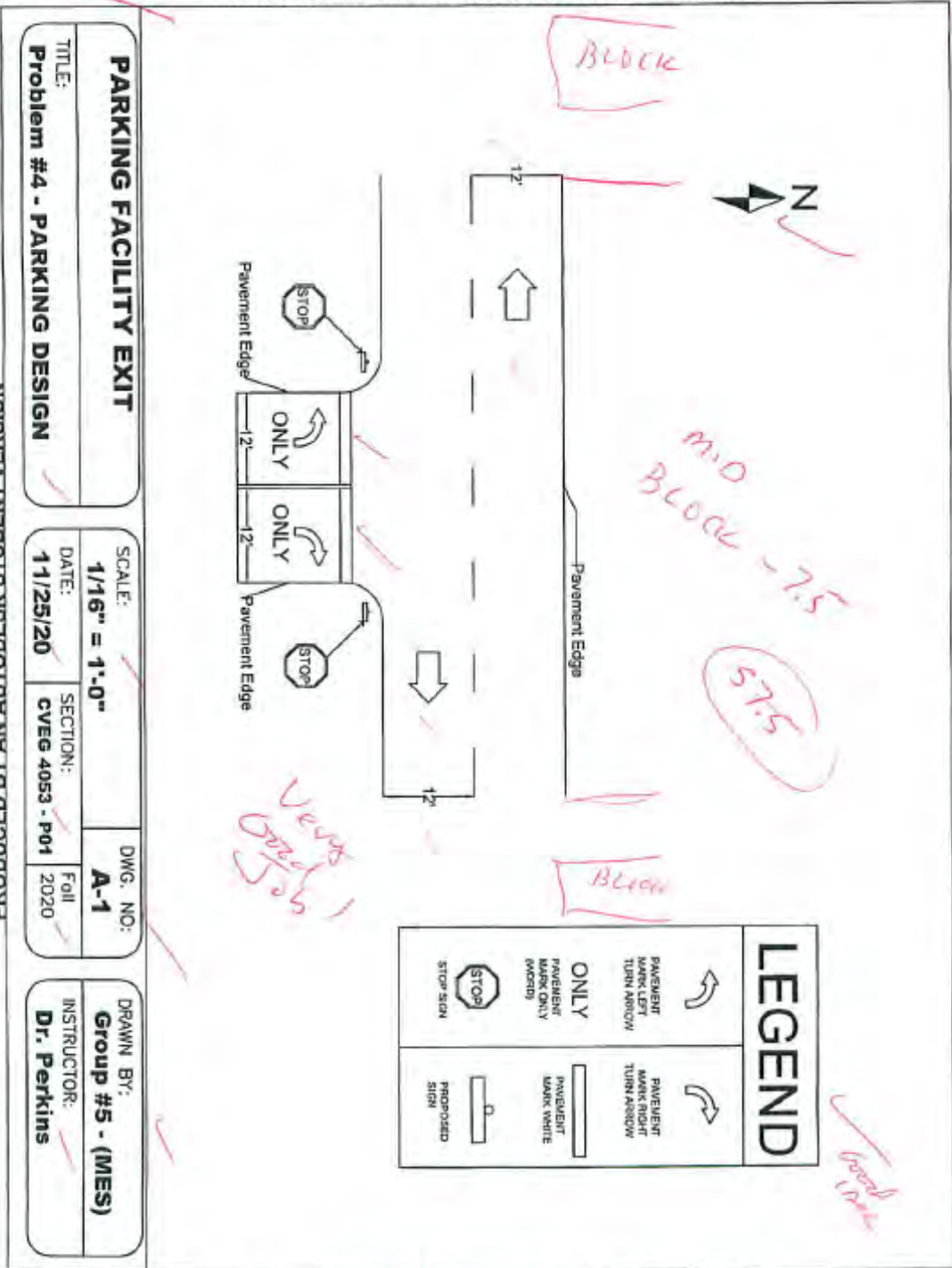
10

What are the parking operations entrance considerations that your team is expected to use?

The parking operations entrance considerations that our team is expected to use are as follows:

- Locate as far from the roadway, an intersection, and conflicting points as possible.
- Multiple entrances may ease access and reduce restriction on adjacent roadways.
- Place mid-block when possible.
- Local ordinances and codes can restrict the number of entrances.

10



ASSIGNMENTS FOR OUTCOME 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematics.

**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4302: TRANSPORTATION ENGINEERING DESIGN
FALL 2021**

Instructor: Dr. Judy A. Perkins

Title of Assignment

HOMEWORK ASSIGNMENT #4 - Intersection Design and Control

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of the suitability of assignment for the outcome

Homework Assignment #4 requires the students to respond to questions regarding intersection design, intersection controls, and capacity and level of service at signalized intersections. By doing so, the student will be able to demonstration applying the principles of engineering to solving complex engineering problems.

ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4302 – Transportation Engineering Design
Fall 2021

Homework Assignment #4 – Intersection Design and Control
Given: 18 November 2021

Due: 23 November 2021 NLT 8:05am CST

Total point value is (100-points)

- **Measuring ABET Criterion 3. Student Outcome 1** - An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - You must type the question/problem and your response to the question/problem.
 - Each question/problem will need to start a new page.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment

Chapter 7 - Intersection Design

1. Problem #7-4 (25-points)
2. Problem #7-5 (25-points)
3. Problem #7-6 (25-points)

Chapter 8 - Intersection Control

1. Problem #8-1 (25-points)

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4302 P01 – Transportation Engineering Design
Fall 2021

Homework Assignment #4 – Intersection Design and Control

Given: 18 November 2021

Due: 23 November 2021

Paige Hines, Nyja Kennedy, Mouni Yamba, Armando Gomez, Jonathon Warrior

Problems 7-4

What are the key defining characteristics of roundabouts that distinguish them from other traffic circles?

The roundabouts have distinguishing characteristics that separate them from the other circular intersections. The characteristics for the roundabouts are as follows:

- Yield control at each approach
- Separation of conflicting traffic movements through channelization, by pavement markings or raised islands
- Geometric characteristics of the central island that typically allow travel speeds of less than 30mi/h
- Parking not usually allowed within the circulating roadway

25

Problem 7-5

What are the main functions of channelization at an at-grade intersection?

The main functions of channelization at an at-grade intersection are as follow;

- Direct the paths of vehicles so that not more than two paths cross at any one point
- Control the merging, diverging, or crossing angle of vehicles
- Decrease vehicle wander and the area of conflict among vehicles by reducing the amount of paved area.
- Provide a clear indication of the proper path for different movement
- Give priority to the predominant movement
- Provide pedestrian refuge
- Provide separation storage lanes for turning vehicles, thereby crating space awasy from the path of through vehicles for turning vehicles to wait
- Provide space for traffic control devices so that they can be readily seen
- Control prohibited turns
- Separate different traffic movement at a signalized intersection with multiple-phases signals
- Restrict the speeds of vehicles

25

Problem 7-6

Discuss the fundamental general principles that should be used in designing a channelized at-grade intersection.

The fundamental principles that govern the designing a channelized at-grade intersection are as follows:

- Motorists should not be required to make more than one decision at a time
- Sharp reverse curves and turning paths greater than 90 degrees should be avoided
- Merging and weaving areas should be as long as possible, but other areas of conflict between vehicles should be reduced to a minimum
- Crossing traffic streams that do not weave or merge should intersect at 90 degrees, although a range of 60 to 120 degrees is acceptable
- The intersecting angle of merging streams should be such that adequate sight distance is provided
- Refuge areas for turning vehicles should not interfere with the movement of through vehicles
- Prohibited turns should be physically blocked wherever possible
- Decisions on the location of essential traffic control devices should be a component of the design process

25

Problem 8-1

Using an appropriate diagram, identify all the possible conflict points at an unsignalized T intersection.

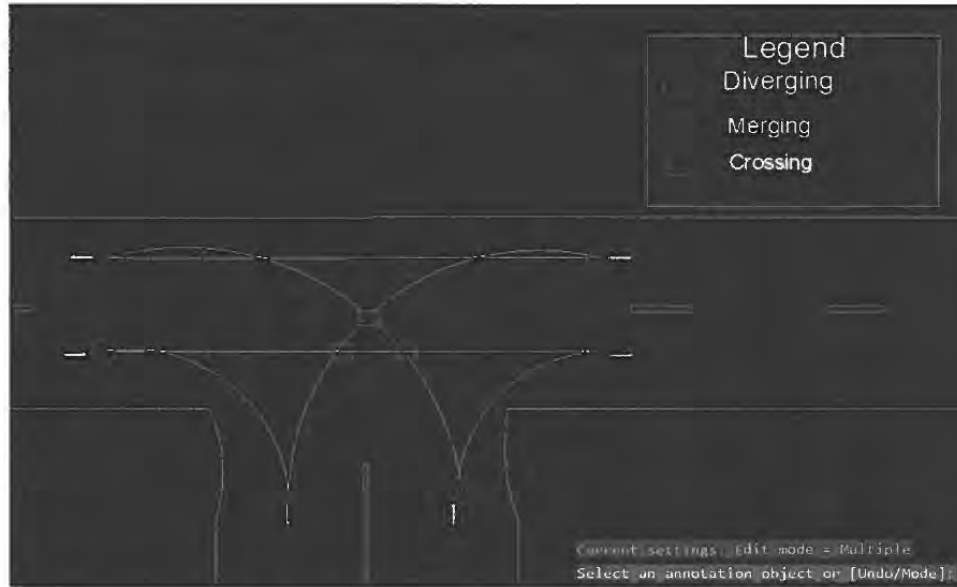


Figure 01: T Intersection Conflicts

There are three types of conflicts which are merging, diverging, and crossing. The total number of conflicting points at the T intersection denoted on figure 01 are nine.

- Diverging – 3
- Merging – 3
- Crossing – 3

✓ (25)

**CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
CVEG 4302: TRANSPORTATION ENGINEERING DESIGN
FALL 2021**

Instructor: Dr. Judy A. Perkins

Title of Assignment

**HOMEWORK ASSIGNMENT #5 –
PARKING ANALYSIS AND DESIGN**

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
x	involves wide-ranging or conflicting technical issues,
x	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
x	includes many component parts or sub-problems
	involves multiple disciplines
x	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
x	engineering
	science
x	mathematics

Brief justification of the suitability of assignment for the outcome

This parking assignment requires the students to use their understanding of topics related parking studies, parking analysis, and parking design In order to develop solutions to the questions.

ASSIGNMENT STATEMENT/QUESTIONS
Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

CVEG 4302 – Transportation Engineering Design
Fall 2021

Homework Assignment #5 – Parking Analysis and Design
Given: 23 November 2021

Due: 30 November 2021 NLT 8:05am CST

Total point value is (100-points)

- **Measuring ABET Criterion 3. Student Outcome 1** - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
1. This is a group assignment.
 - Use the format - Given, Find, Approach, and Blocking of Answers - when solving Problem #1
 - Place the responses to each problem on this document. Feel free to write on the back of the page.
 - The response to **Problem #4** will need to be drawn on 8.5-inch by 11-inch paper and attached to this document.
 2. Your assignment submission will need to include a single cover page that follows the format shown below:
 - Assignment Cover Page:
 - **Complete** title of assignment
 - Course number, section and name
 - First Name and Last Name of each group member
 - Given Date of Assignment
 - Due Date of Assignment

Parking Analysis

1. When designing an on-street parking facility, the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet will be _____. (10-points)
2. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (10-points)
3. What are the parking operations entrance considerations that your team is expected to use? (10-points)

Parking Design

4. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels. (70-points)

LATE 8:50 AM

-10 pts

Department of Civil & Environmental Engineering
Prairie View A&M University



67/100

**CVEG 4302 P01 Transportation Engineering
Design**

Fall 2021

Homework Assignment #5 on
"Parking Analysis and Design"

Given on
November 23, 2021

Submitted by
Sanjay Tillmurt ✓
Autumn Carter ✓
Darrell Patterson ✓
Omar Rafey ✓

On
November 30, 2021

To

Dr. Judy Perkins
Transportation Engineering Design Instructor
CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT
TRANSPORTATION ENGINEERING DESIGN

Parking Analysis

1. When designing an on-street parking facility, the number of spaces required when the angle of inclination is zero (0) degrees and the curb length is 500 feet will be _____.
(10-points)

Given: Curb Length, $L = 500$ ft
Angle of Inclination = 0° (Parallel)
On Street Parking Facility

Find: # of Spaces, N

Approach:

As seen in Fig. 1, the number of spaces required when the angle of inclination is zero (0°) is:

$$N = \frac{L}{22} = \frac{500 \text{ ft}}{22} = 22.73 \text{ spaces} \approx \boxed{23 \text{ Parking Spaces}}$$

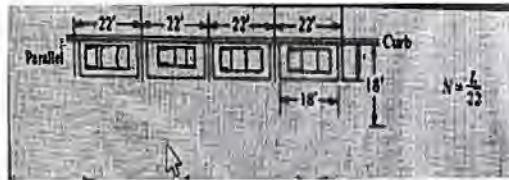


Figure 1 – Street Space Used for Parallel Configuration

2. When using the parking space hour supply equation, you must take into account efficiency of the facility during its highest demand period. What is the average efficiency factor that you must use if you are addressing curb parking? (10-points)

The parking supply estimation calculation is expressed as

$$S = f \sum_{j=1}^M t_j$$

Simply stated: $S = f \cdot t_{\text{ave/space}} \cdot M$ where:

S = practical number of space-hours of supply for a specific period

M = number of parking spaces available

t_j = total length of time in hours when the j -th space can be legally parked on during the specific period.

f = efficiency factor to consider the time lost during turnovers

Efficiency Factor Table- f

Parking Facility	Percentage	Average Percentage
Curb Parking	78-96	90
Surface Lots	75-92	85
Garages	75-92	80

When addressing curb parking the average efficiency factor will be 90%.

710

3. What are the **parking operations entrance** considerations that your team is expected to use? (10-points)

Our team was tasked with designing a 30° parking lot. So, for our lot we are expected to consider: (1) the stall and aisle dimensions and make sure they're compatible with the type of operation planned for the facility, (2) the width, length of stalls, width of aisles, and radius of turns, and (3) seeing if we can get to incorporate a module into our parking arrangement. In Figure 2 below, the 30° parking lot has a module incorporated with one direction of traffic flow. There is a 10-foot width between parking stalls on each side of the aisle.

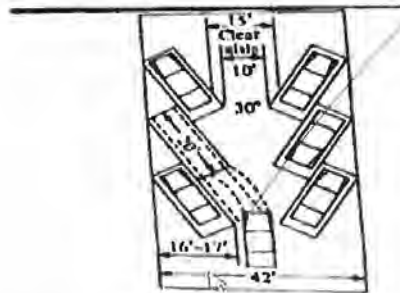
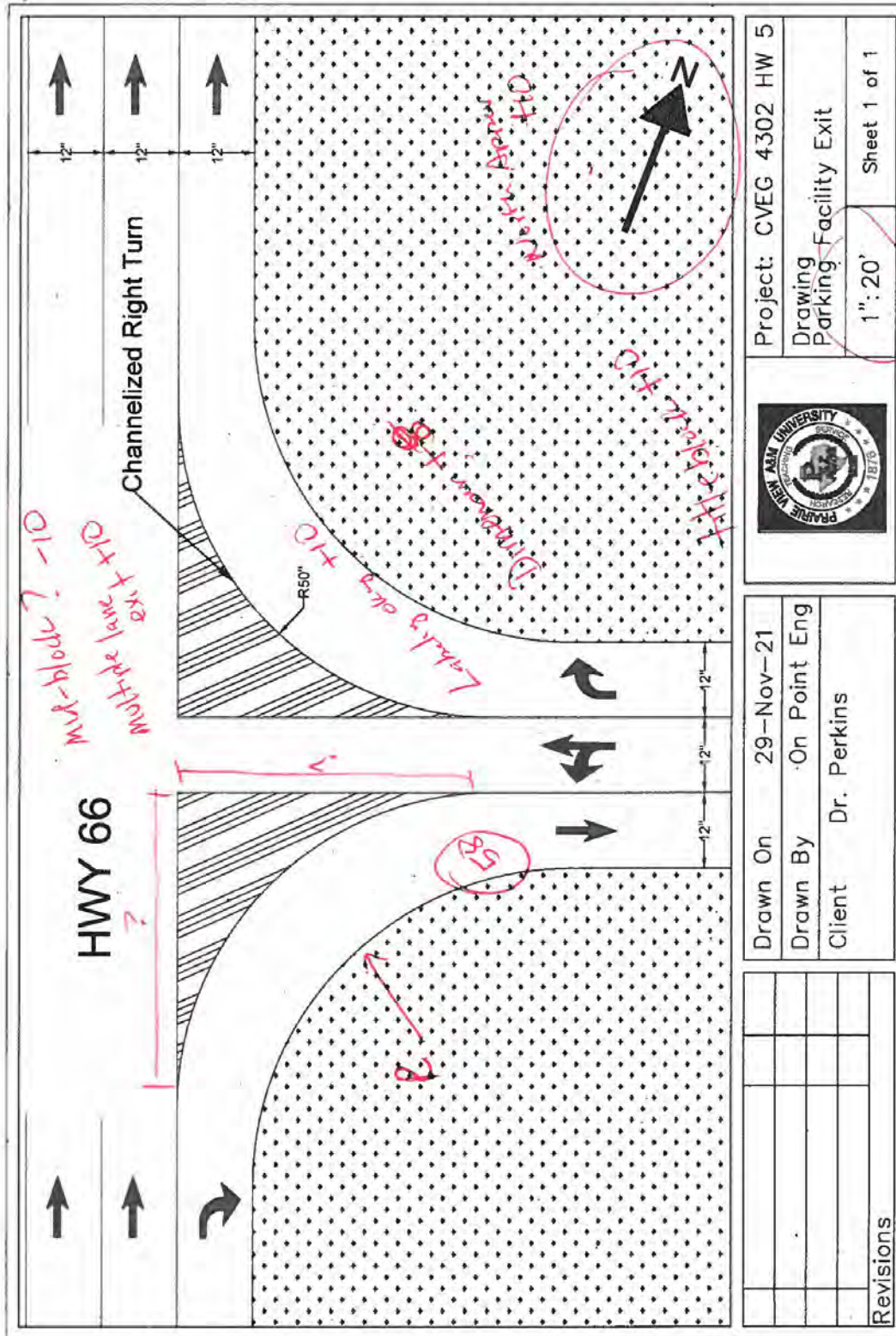


Figure 2 - Parking Stall Layout

Parking Design

4. Provide an AutoCAD drawing to scale of a parking facility **exit** that must adhere to the following: (a) multiple exit lanes to help right turning vehicles avoid waiting for left turning vehicles and (b) placement at mid-block. Also, include at a minimum (1) dimensions

throughout the drawing, (2) north arrow, (3) scale, (4) title block, and (5) appropriate labels.
(70-points)



**OUTCOME “1” SPECIFIC ASSIGNMENTS
USED TO ASSESS THE OUTCOME IN**

**CVEG 4063
WATER RESOURCES ENGINEERING**

**CIVIL & ENVIRONMENTAL ENGINEERING
DEPARTMENT
OUTCOME SPECIFIC ASSIGNMENT
COVER SHEET**

WATER RESOURCES ENGINEERING

SPRING 2020

Instructor: Dr. Iftekhar Ahmed, P.E.

Title of Assignment

Homework #5: Reservoir Routing with EXCEL Applications

Outcome Measured Using this Assignment

Outcome 1

Ability to identify, formulate, and solve *complex engineering problems* (CEPs) by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

A complex engineering problem in hydrology is to route inflow hydrograph through a reservoir to derive the outflow hydrograph and identify the peak attenuation for flood control downriver from the reservoir-dam system. In this problem, students are faced with the challenge of solving a situation with two unknowns (storage and outflow at a future time step) with only one available equation. Students learn to create an auxiliary chart relating the unknown variables to solve the otherwise complex problem.

CVEG 4063: Water Resources Engineering
Spring 2020
Homework #5 (Reservoir Routing by Storage Indication Method)
One Problem in Hydrology (Reservoir Routing using M.S. EXCEL)

ABET Student Outcome #1 Assessment Tool
**(Complex problem with two unknown variables and one available equation;
Requires the creation of a Chart relating the unknown variables to solve the
problem)**

Assigned: Thursday, February 13, 2020
Due: Thursday, February 20, 2020 (12:30 PM, in class, in person)

Start Early!!

SHOW SAMPLE CALCULATIONS WITH UNITS ON ENGINEERING PAPER

Reservoir Routing:

***Textbook Problem #3-49 (200 points possible) – Route the
Total Hydrograph (TH) mentioned in the book starting from
time = 0 day**

Set up Excel Spreadsheets (2 required tables) with Formula coded in the cells;
**Everybody will be required to submit their individual, independent Excel work for
this HW.**

Use U.S. unit system as stated in the book; Show all numbers with 2 decimal places in Excel.

Use $\Delta h = 1$ foot (head increment);

Use $\Delta t = 12$ hour or 0.5 days, per the given Inflow Hydrograph's time increment;

Hard copy deliverables:

1. (Printout) Two required tables: a) Storage-Outflow table, b) Routing table
2. (Printout) Plot of both Storage-Outflow Curves on the same Excel grid;
3. (Printout) Plot Inflow and Outflow Hydrographs on the same Excel grid; Report
the peak flow attenuation and time to peak of the peak outflow or discharge.
4. Sample Hand Calculations sheet (engineering paper)

E-file deliverables:

Full EXCEL work file of both required tables (formula coded in cells) and all labelled plots as requested above. **WAIT FOR INSTRUCTION TO SUBMIT THE E-FILE.**



COLLEGE OF ENGINEERING
PRAIRIE VIEW A&M UNIVERSITY
PRAIRIE VIEW, TEXAS 77446



CVEG 4063 (P01): WATER RESOURCES ENGINEERING

Dr. I. Ahmed

SPRING 2020

HOMEWORK COVER SHEET

NAME Pera Zaldívar

HOMEWORK ASSIGNMENT # 5

PROBLEM #s 3-49

DUE DATE: 2/20/2020 DATE SUBMITTED 2/20/2020

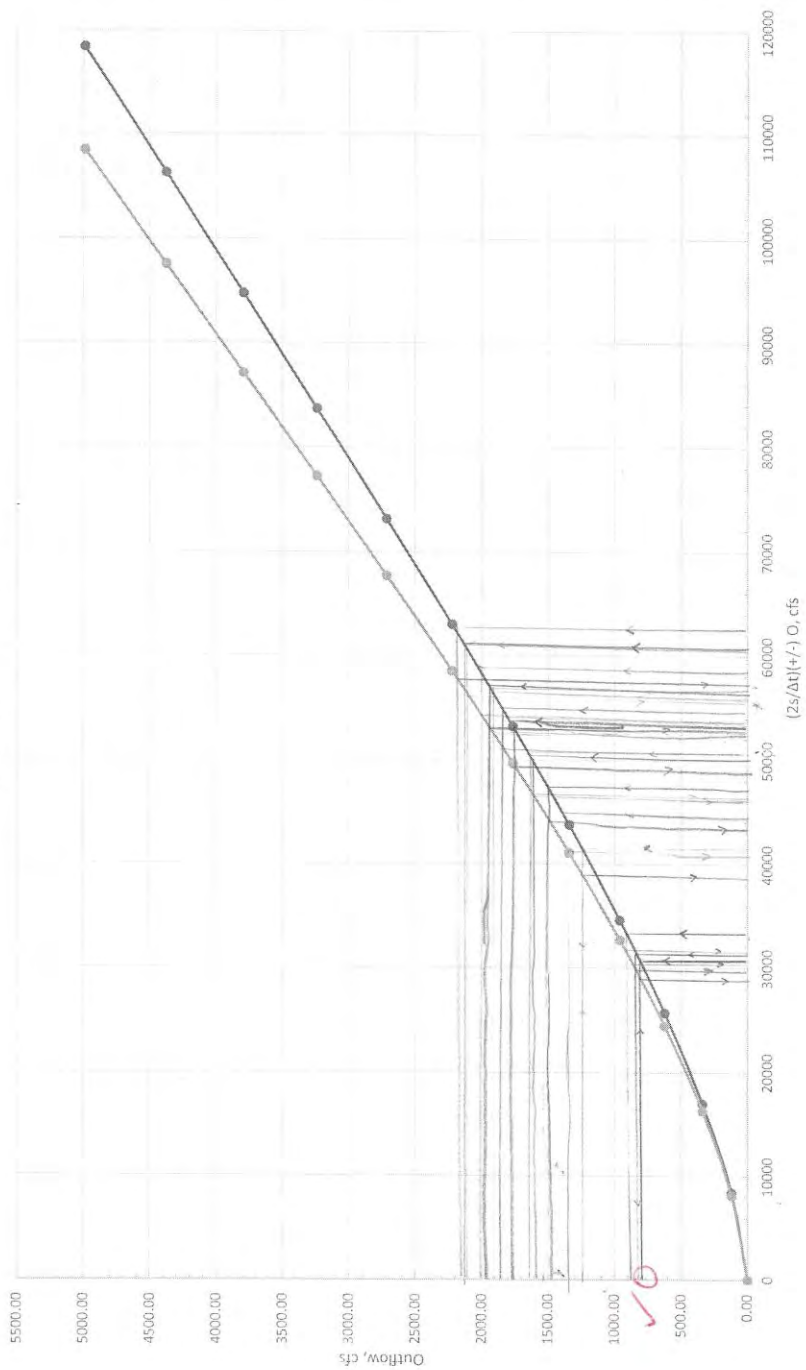
Elevation (ft)	Head Above Crest (ft)	Outflow (cfs)	Reservoir Area (acre)	Δs (ac-ft)	Cumulative Storage (ac-ft)	(sfd)	(2s/ Δt)+O (cfs)	(2s/ Δt)-O (cfs)
1000	0	0.00	4100	0	0	0	0	0
1001	1	120.00	4112	4106	4106	2073.74	8414.95	8174.95
1002	2	339.41	4148	4130	8236	4159.60	16977.80	16298.97
1003	3	623.54	4208	4178	12414	6269.70	25702.33	24455.25
1004	4	960.00	4292	4250	16664	8416.16	34624.65	32704.65
1005	5	1341.64	4400	4346	21010	10611.11	43786.09	41102.80
1006	6	1763.63	4532	4466	25476	12866.67	53230.30	49703.03
1007	7	2222.43	4688	4610	30086	15194.95	63002.23	58557.37
1008	8	2715.29	4868	4778	34864	17608.08	73147.61	67717.03
1009	9	3240.00	5072	4970	39834	20118.18	83712.73	77232.73
1010	10	3794.73	5300	5186	45020	22737.37	94744.23	87154.76
1011	11	4377.94	5552	5426	50446	25477.78	106289.06	97533.17
1012	12	4988.31	5828	5690	56136	28351.52	118394.37	108417.75

Excel:

Missing legend on O-S
chart

-10

Storage Outflow Curves



Legend

STORAGE OUTFLOW TABLE CALCULATIONS

OUTFLOW:

$$Q = 120 h^{3/2} \text{ (cfs)}$$

$$12(1)^{3/2} = \boxed{120 \text{ cfs}}$$

RESERVOIR AREA:

$$A = 4100 + 12 h^2 \text{ (acres)}$$

at $h=1$

$$4100 + 12(1)^2 = \boxed{4112 \text{ acre}}$$

 ΔS :

$$\frac{4100 + 4112}{2} (\text{acre}) \times (1 \text{ ft}) = \boxed{4106 \text{ ac-ft}}$$

Cumulative storage:

for ac-ft

$$0 + 4106 = \boxed{4106 \text{ ac-ft}}$$

$$4106 + 4130 = \boxed{8236 \text{ ac-ft}}$$

for sfd

$$4106 \text{ ac-ft} \times \frac{1 \text{ sfd}}{1.98 \text{ ac-ft}} = \boxed{2073.74 \text{ sfd}}$$

 $(2s/\Delta t) + 0$:

$$\frac{2(4112)}{0.5} + 120 = \boxed{8414.95 \text{ cfs}}$$

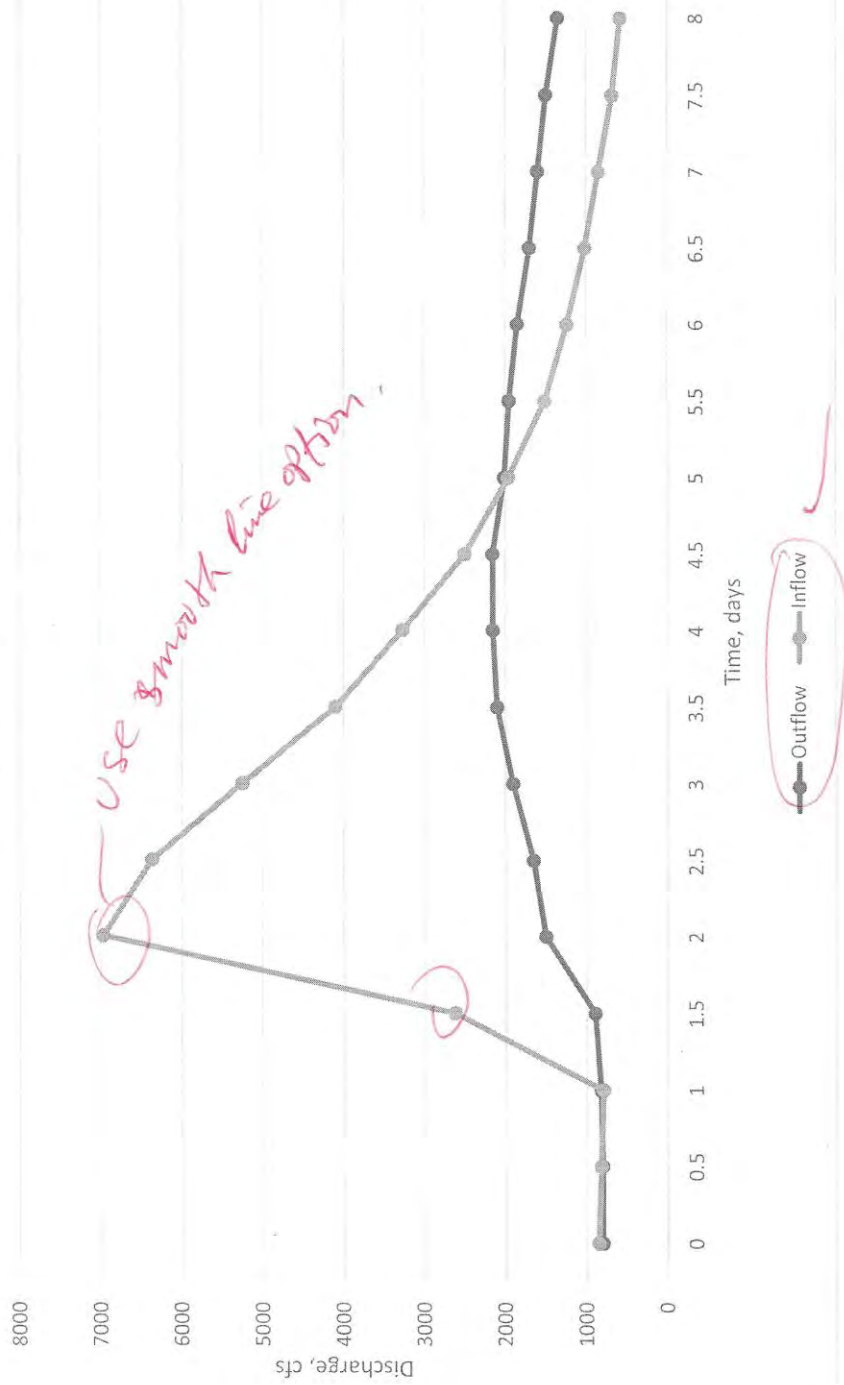
 $(2s/\Delta t) - 0$:

$$\frac{2(4112)}{0.5} - 120 = \boxed{8174.95 \text{ cfs}}$$

Index	Time	Inflow, I	$(2s/\Delta t)-O$	$(2s/\Delta t)+O$	Outflow, O
(i)	(days)	(cfs)	(cfs)	(cfs)	(cfs)
1	0	850	28,500		800
2	0.5	820	29800	30,170	801
3	1	790	30500	31,410	820
4	1.5	2620	31500	33,910	890
5	2	6970	38500	41,090	1500
6	2.5	6370	46100	51,840	1650
6	3	5250	52000	57,720	1900
7	3.5	4100	55000	61,350	2100
8	4	3270	55500	62,370	2150
9	4.5	2500	54000	61,270	2155
10	5	1960	53500	58,460	2010
11	5.5	1510	52500	56,970	1950
12	6	1240	51000	55,250	1850
13	6.5	1020	48500	53,260	1700
14	7	850	45900	50,370	1600
15	7.5	680	43500	47,430	1500
16	8	580	41000	44,760	1350

~2,500 cfs
-10

Inflow and Outflow Hydrograph



Peter Zaldivar

ROUTING TABLE:

$$\frac{2S}{\Delta t} + 0$$

$$\begin{matrix} 850 & + & 820 & + & 28,500 & = & 30,170 \\ (04) & & (05) & & (04) & & \end{matrix}$$

inflow peak = 6970 cfs
outflow peak = 2155 cfs

Attenuation

$$6970 \text{ cfs} - 2155 \text{ cfs} = 4815 \text{ cfs}$$

delayed 2.5 days

**CIVIL & ENVIRONMENTAL ENGINEERING
DEPARTMENT
OUTCOME SPECIFIC ASSIGNMENT
COVER SHEET**

WATER RESOURCES ENGINEERING

SPRING 2020

Instructor: Dr. Iftekhar Ahmed, P.E.

Title of Assignment

**Homework 9:
Specific Energy and Gradually Varied Flow
Concepts in Open Channel Flow**

Outcome Measured Using this Assignment

Outcome 1
Ability to identify, formulate, and solve *complex engineering problems* (CEPs)
by applying principles of engineering, science, and mathematics

**Brief Description of the suitability of this assignment for the
outcome**

A comprehensive treatment of specific energy and gradually varied concept in open channel flow is the highlight of the course. In that spirit, students learned how to determine the downstream flow depth under various upstream flow conditions namely, super- and sub-critical flows. In the process, they were introduced to the specific energy diagram that must be in sync with the profile diagram. Some excelled at it and some did not take the exercise seriously enough and left out such diagrams (critical to follow the solution on paper) from the equation. Here is a good sample work from the class of 19 students.

CVEG 4063: Water Resources Engineering
Spring 2020
Homework #9
Open Channel Hydraulics

Assigned: Tuesday, April 7, 2020

Due: Thursday, April 16, 2020 (by Midnight, Via E-mail, No Exceptions)

You may start submitting from Wednesday Night, April 15, 2020

Start Early!!

SHOW COMPLETE HYDRAULICS CALCULATIONS WITH FORMULAE and UNITS;

Additional Instructions:

Must provide Top View, Cross Section, Profile and Specific Energy diagrams next to each other as explained during lectures. Make sure you show detailed information on these so they are in sync. Thus, the drawings cannot be sloppy. NO PARTIAL CREDIT WITHOUT LABELLED PROFILE AND SPECIFIC ENERGY DRAWINGS.

Check for Choke at downstream ends for all applicable problems. In case of a Choke, downstream flow depth goes to critical depth; Must re-calculate the adjusted upstream flow depth.

Provide sketch of hydraulic jump or any other situation as requested in the problem statements.

Textbook Problems:

7-24

7-25

7-30

7-36

7-53

7-55

7-61

LATE SUBMISSIONS ARE NOT ACCEPTED

Tre Von Rogers

HW #9

7-24

$$Q = 200 \text{ cfs}$$

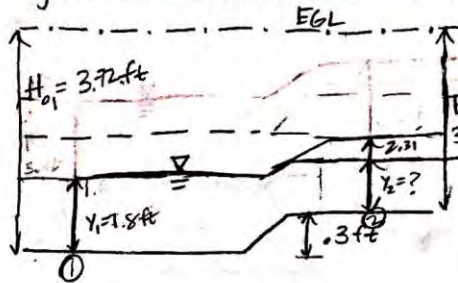
$$y_1 = 1.8 \text{ ft}$$

$$b_1 = 10 \text{ ft}$$

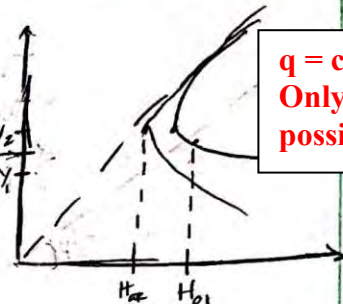
$$\Delta z = 0.3 \text{ ft}$$

$$b_2 = 10 \text{ ft}$$

$$y_2 = ?$$



Water Surface Profile



Specific Energy Diagram

**q = constant;
Only 1 curve is possible**

$$1) q = \frac{Q}{b} \Rightarrow \frac{(200 \text{ cfs})}{10 \text{ ft}} = 20 \text{ cfs/ft}$$

$$2) y_c = \sqrt[3]{\frac{q^2}{g}} = \sqrt[3]{\frac{(20 \text{ cfs/ft})^2}{(32.2 \text{ ft/s}^2)}} = 2.31 \text{ ft}$$

$$y_1 < y_c$$

$\therefore$ Supercritical

$$3) H_{01} = y_1 + \frac{V_1^2}{2g} \rightarrow y_1 + \frac{(q/y_1)^2}{2g}$$

$$H_{01} = (1.8 \text{ ft}) + \frac{(20 \text{ cfs/ft})^2}{2(32.2 \text{ ft/s}^2)(1.8 \text{ ft})} = 3.72 \text{ ft}$$

$$H_{01} - \Delta z = H_{02}$$

$$\rightarrow (3.72 \text{ ft}) - (0.3 \text{ ft}) = 3.42 \text{ ft} = H_{02}$$



$$H_{0(\min)} = \frac{3}{2} y_c \rightarrow \frac{3}{2} (2.31 \text{ ft}) = 3.46 \text{ ft}$$

$$H_{02} < H_{0(\min)}$$

$\therefore$ CHOKE @ sec. 2

$$y_2 = y_c$$

**CHOKE test
was done at
Section 2**

$$H_{01} = H_{02} + \Delta z = (3.46 \text{ ft}) + (0.3)$$

$$3.76 \text{ ft}$$

$$3.76 \text{ ft} = y_1 + \frac{V_1^2}{2g} \rightarrow y_1 + \frac{(q/y_1)^2}{2g}$$

$$3.76 \text{ ft} = y_1 + \frac{(20 \text{ cfs/ft})^2}{2(32.2 \text{ ft/s}^2)y_1^2}$$

Adjusted

$$y_1 = 2.64 \text{ ft} \quad y_2 = 2.31 \text{ ft} \quad y_c = 2.31 \text{ ft}$$

**y(2) = y(c) due to Choke
condition at Section 2;
Profile drawing shows
this situation at Section 2
as it should.**

Tre'Von Rogers

HW #9

7-25

$Q = 300 \text{ cfs}$

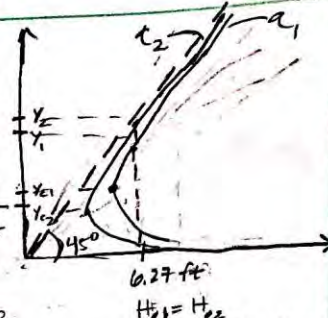
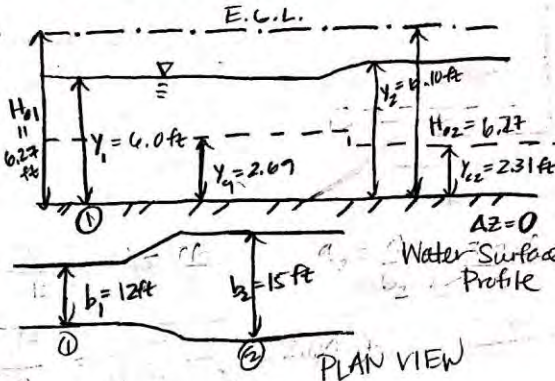
$y_1 = 6.0 \text{ ft}$

$b_1 = 12 \text{ ft}$

$\Delta z = 0 \text{ ft}$

$b_2 = 15 \text{ ft}$

$y_2 = ?$



$y_1 > y_c$ $\therefore$ subcritical flow

① $q_1 = \frac{Q}{b_1} = \frac{300 \text{ cfs}}{12 \text{ ft}} = 25 \frac{\text{cfs}}{\text{ft}}$ ② $q_2 = \frac{Q}{b_2} = \frac{300 \text{ cfs}}{15 \text{ ft}} = 20 \frac{\text{cfs}}{\text{ft}}$

$q_1 > q_2$

③ $y_{c1} = \sqrt[3]{\frac{q_1^2}{g}} = \sqrt[3]{\frac{(25 \frac{\text{cfs}}{\text{ft}})^2}{32.2 \frac{\text{ft}}{\text{s}^2}}} = 2.67 \text{ ft}$ ④ $y_{c2} = \sqrt[3]{\frac{q_2^2}{g}} = \sqrt[3]{\frac{(20 \frac{\text{cfs}}{\text{ft}})^2}{32.2 \frac{\text{ft}}{\text{s}^2}}} = 2.31 \text{ ft}$ $y_{c1} > y_{c2}$

$y_1 > y_{c1} > y_{c2}$

⑤ $H_{01} - \Delta z = H_{02} \rightarrow H_{01} = H_{02}$

$H_{01} = y_1 + \frac{(q_1)^2}{2g(y_1)^3} = 6.0 \text{ ft} + \frac{(25 \frac{\text{cfs}}{\text{ft}})^2}{2(32.2 \frac{\text{ft}}{\text{s}^2})(6.0 \text{ ft})^3} = 6.27 \text{ ft} = H_{01} = H_{02}$

⑥ $H_{02} = y_2 + \frac{(q_2)^2}{2g(y_2)^3} = 6.27 \text{ ft} = \left(y_2 + \frac{(20 \frac{\text{cfs}}{\text{ft}})^2}{2(32.2 \frac{\text{ft}}{\text{s}^2}) y_2^3} \right)$ ⑦ $y_2^3 - 6.27 y_2^2 + 6.21 = 0$ $y_2 < y_2 < y_1 - 2$

$y_2 = 6.10 \text{ ft}$

⑦ CHOKE ?? $\rightarrow$ NO CHOKE

$H_{02(\text{min})} = \frac{3}{2} y_c \rightarrow \frac{3}{2} (2.31) = 3.465 \text{ ft}$
 $H_{02} = 6.27 \text{ ft} > H_{02(\text{min})} = 3.465 \text{ ft}$

Tre'Von Rogers

HW #9

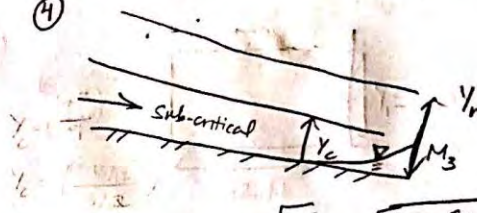
$b = \frac{7-61}{12}$ ft-wide rectangular channel

$$Q = 345 \text{ cfs}$$

$$y_n = 5 \text{ ft}$$

specific section $y_1 = 2 \text{ ft}$

(4)



$$q = \frac{Q}{b} = \frac{345 \text{ cfs}}{12 \text{ ft}} = 28.75 \text{ cfs/ft}$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} = \sqrt[3]{\frac{(28.75 \text{ ft}^2/\text{s})^2}{(32.2 \text{ ft/s}^2)}} = 2.95 \text{ ft}$$

$$(1) y_n > y_c \rightarrow 5 \text{ ft} > 2.95 \text{ ft}$$

$\therefore$ Mild Slope

$$(2) y_1 < y_c \rightarrow 2 \text{ ft} < 2.95$$

$\therefore$ Supercritical

(3) $\frac{1}{2}$ supercritical
its Zone 3

M-3 $\therefore$ depth increases

Part (4) should have included the use of the governing differential equation for gradually varied open channel flow to determine the M-3 curve in the figure provided above.

$$(5) n = .020 \text{ what is channel slope?}$$

$$S_o = ?$$

$$\frac{Q}{A} = \frac{1.49}{n} A R^{2/3} S_o^{1/2}$$

$$\frac{345}{(12)(5)} = \frac{1.49}{.020} (11)^{2/3} S_o^{1/2}$$

$$S_o = .12$$

$$P = y + \frac{b}{2} \rightarrow 5 \text{ ft} + \frac{12 \text{ ft}}{2} = 11 \text{ ft}$$

$$(6) S_f = \left(\frac{nv}{1.49 R^{2/3}} \right)^2 \rightarrow \left(\frac{(0.020)(11.375 \text{ ft/s})}{1.49 (11.375)^{2/3}} \right)^2$$

$$S_f = .053$$

Bed slope S_o and friction slope S_f calculations are incorrect. Student failed to note that, to calculate bed slope, the normal depth is always used in Manning's equation; and to calculate friction slope, a depth other than the normal depth is used in Manning's equation. Flow area and wetted perimeter should differ for the two calculations.

**CIVIL & ENVIRONMENTAL ENGINEERING
DEPARTMENT
OUTCOME SPECIFIC ASSIGNMENT
COVER SHEET**

WATER RESOURCES ENGINEERING

SPRING 2021

Instructor: Dr. Iftekhar Ahmed, P.E.

Title of Assignment

Homework #4: Reservoir Routing with EXCEL Applications

Outcome Measured Using this Assignment

Outcome 1

Ability to identify, formulate, and solve *complex engineering problems* (CEPs) by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

A complex engineering problem in hydrology is to route inflow hydrograph through a reservoir to derive the outflow hydrograph and identify the peak attenuation for flood control downriver from the reservoir-dam system. In this problem, students are faced with the challenge of solving a situation with two unknowns (storage and outflow at a future time step) with only one available equation. Students learn to create an auxiliary chart relating the unknown variables to solve the otherwise complex problem.

Spring 2021

MS EXCEL Homework #5 (Reservoir Routing by Storage Indication Method)
One Problem in Hydrology (Reservoir Routing using M.S. EXCEL)

ABET Student Outcome #1 Assessment Tool

(Complex problem with two unknown variables and one available equation;
Requires the creation of a Chart relating the unknown variables to solve the problem)

Assigned: Thursday, March 11, 2021

Due: Monday, March 22, 2021 (11:59 PM, via E-mail to Dr. Ahmed)

Late Submissions will not be accepted

Start Early!!

SHOW ALL POSSIBLE SAMPLE CALCULATIONS WITH UNITS ON ENGINEERING OR RULED PAPER

Reservoir Routing:

***Textbook Problem #3-53 (200 points possible) – Route the Total Hydrograph (TH) mentioned in the book starting from time = 0 day**

Set up Excel Spreadsheets (2 required tables) with Formula coded in the cells;
Everybody is required to submit their individual, independent Excel file for this HW.

Use S.I. unit system as stated in the book. There is no “sfd” volume unit in S.I. system.
Show all numbers with 3 decimal places in Excel.

Use $\Delta h = 0.5$ m (head increment);

Use $\Delta t = 12$ hour or 0.5 days, per the given Inflow Hydrograph’s time increment;

Deliverables: All in One Excel File plus 1 PDF file of Sample Calculations: Be sure to use Formula in Excel where needed. I should see formula when I go to computation cells in your individual Excel file

1. Two required tables: a) Storage-Outflow table, b) Routing table
2. Plot of both Storage-Outflow Curves **on the same Excel grid;**
3. Plot Inflow and Outflow Hydrographs **on the same Excel grid;** Report the peak flow attenuation and time to peak of the peak outflow or discharge.
4. Sample Hand Calculations sheet (PDF) – **Separate PDF Sheet in the same E-mail.**

***1 hectare = 10,000 square meter**

This is an Individual HW. Plagiarism (submitting each other’s work) will be handled per University Guidelines.

Hines, Paige

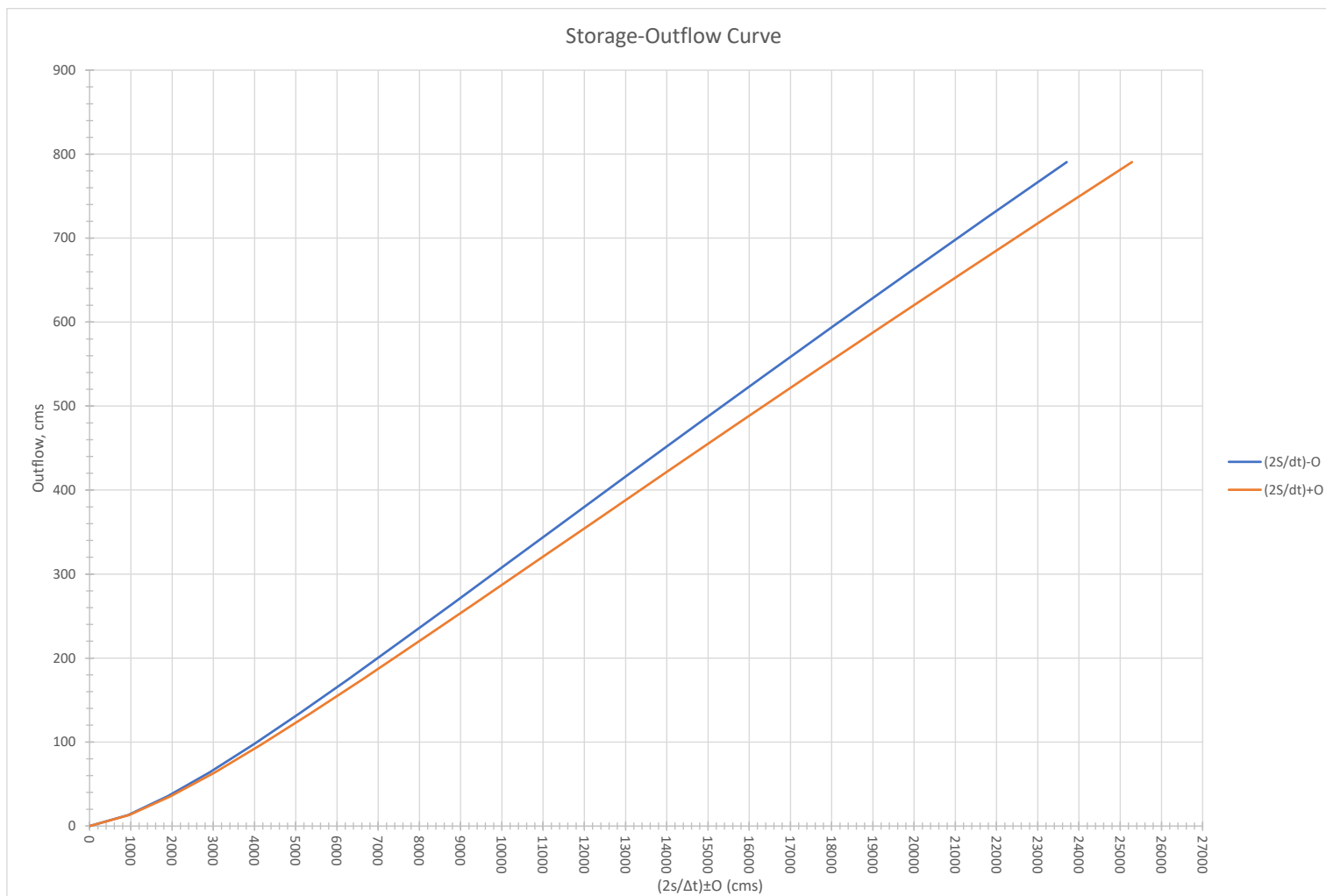
Spring 2021

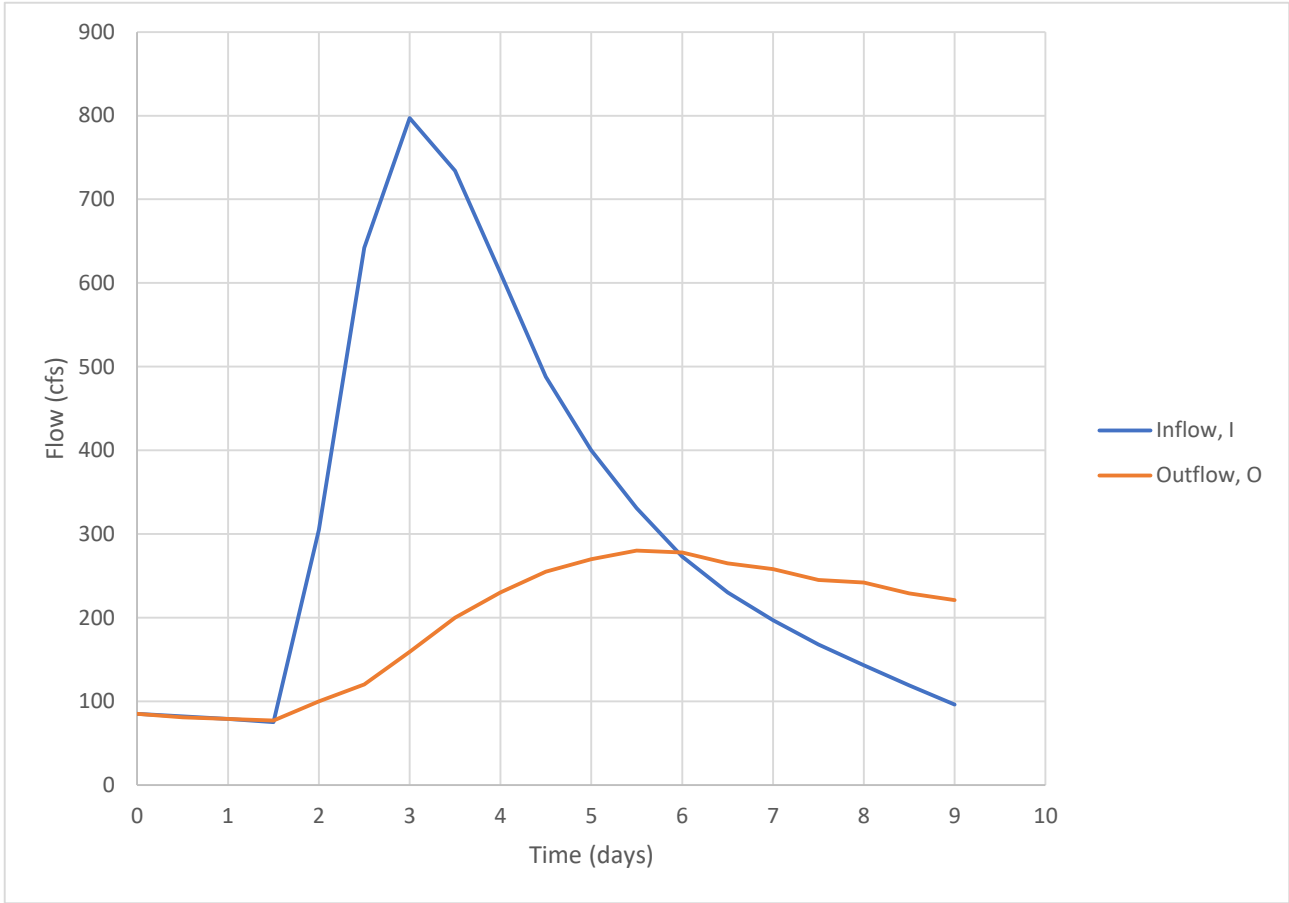
CVEG 4063

HW-4

Peak outflow occurs at Day 6.**Score: 190/200****Data Tabulation**

Index	Elevation	Head above crest, h	Outflow, O	Reservoir area		Δs	Cumulative Storage, S	$(2s/\Delta t)+O$	$(2s/\Delta t)-O$
	(m)	(m)	(cms)	(ha)	(m ²)	(m ³)	(m ³)	(cms)	(cms)
1	100.0	0	0.000	4000.000	40000000.000	0.000	0.000	0.000	0.000
2	100.5	0.5	12.994	4163.228	41632282.306	20408070.577	20408070.577	957.812	931.824
3	101.0	1.0	35.500	4375.000	43750000.000	21345570.577	41753641.153	1968.539	1897.539
4	101.5	1.5	63.909	4610.015	46100153.713	22462538.428	64216179.581	3036.880	2909.062
5	102.0	2.0	96.989	4861.524	48615237.662	23678847.844	87895027.425	4166.203	3972.225
6	102.5	2.5	134.042	5126.054	51260541.569	24968944.808	112863972.233	5359.226	5091.142
7	103.0	3.0	174.604	5401.447	54014473.071	26318753.660	139182725.893	6618.249	6269.041
8	103.5	3.5	218.337	5686.215	56862148.937	27719155.502	166901881.395	7945.276	7508.602
9	104.0	4.0	264.981	5979.262	59792618.662	29163691.900	196065573.294	9342.091	8812.129
10	104.5	4.5	314.330	6279.745	62797450.650	30647517.328	226713090.622	10810.307	10181.646
11	105.0	5.0	366.214	6586.993	65869931.152	32166845.451	258879936.073	12351.396	11618.968
12	105.5	5.5	420.489	6900.457	69004574.260	33718626.353	292598562.426	13966.718	13125.741
13	106.0	6.0	477.032	7219.680	72196804.325	35300344.646	327898907.073	15657.537	14703.473
14	106.5	6.5	535.738	7544.274	75442740.558	36909886.221	364808793.293	17425.034	16353.558
15	107.0	7.0	596.514	7873.905	78739045.492	38545446.512	403354239.806	19270.321	18077.294
16	107.5	7.5	659.276	8208.282	82082815.086	40205465.145	443559704.950	21194.447	19875.896
17	108.0	8.0	723.950	8547.150	85471496.995	41888578.020	485448282.971	23198.408	21750.507
18	108.5	8.5	790.471	8890.283	88902828.443	43593581.360	529041864.330	25283.150	23702.208





ASSIGNMENTS FOR ABET OUTCOME 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

DEPARTMENT OF

CIVIL & ENVIRONMENTAL ENGINEERING

OUTCOME SPECIFIC ASSIGNMENT

COVER SHEET

CVEG 4303

Water Resources Engineering

Spring 2022

Instructor: Dr. Emmanuel U. Nzewi, PE

Title of Assignment

- 1] Design Project 01 – Stormwater Management in a Small Watershed**
- 2] Design Project 02 – Water Distribution System Design**

Outcome Measured Using this Assignment

ABET Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

These are open-ended water resources design projects

Project 01 – Given watershed map, and applicable data, use Rational Method to determine design flow rates. Also design an open channel for stormwater management

[Project description provided]

Project 02 – Design analysis of a water distribution system (using Hardy Cross Method) including water pressure adequacy, for an assigned area (residential or commercial) given applicable water demand information [Project description provided]

Project 01

Rational Method

Application:

**Stormwater Sewer
Design Peak Flows
in a Small
Watershed**



Department of Civil & Environmental Engineering

CVEG 4303 PO1

WATER RESOURCES ENGINEERING

SPRING 2022

Dr. Ngweni

REVISED: 04/19/2022

RATIONAL METHOD APPLICATION: STORMWATER SEWER DESIGN PEAK FLOWS IN A SMALL WATERSHED

PROJECT DETAILS POSTED IN CANVAS

This project involves the determination of the peak runoff flowrates for stormwater sewer design in a small catchment. Students will be required to work in groups. Students may consult the Instructor for help and for project clarification.

PROJECT OVERVIEW

CVEG 4303 student groups are charged with the design of a drainage system for a watershed at the Harris County, TX location shown in the accompanying map. The scale of the map (with 2-foot contour lines) is noted (see map). Land use practices have been identified – see the accompanying land use practices table.

The primary task is to generate engineering information necessary for determining the size the sewers. This information should be presented in a tabular format. The Rational Method will be implemented in the determination of peak runoff flowrates at drainage inlets (manholes). The system to be designed should adequate for a 5-, 10- or 25-year rainfall event. The actual return period of the design storm event will be specified for each student group. The pertinent Intensity-Duration-Frequency (IDF) curve data/graphs have been supplied in the Appendix.

Group	Location	Watershed Sub-areas	Design Return Period [Years]	Minimum t_c [minutes]	Slope []	Channel flow Velocity [ft/s]
	Harris County Region I	A (left of ditch) & C	25	20.0	Based on ground elevation. Circular pipe	3.0
	Harris County Region II	B (right of ditch+A024) & C	10	17.0	Based on ground elevation. Circular pipe	4.0
	Harris County Region III	A (left of ditch) & C	5	10.0	Based on ground elevation. Circular pipe	3.5
	Harris County Region II	B (right of ditch+A024) & C	25	14.0	Based on ground elevation. Circular pipe	3.0
	Harris County Region I	A (left of ditch) & C	5	18.0	Based on ground elevation. Circular pipe	4.0
	Harris County Region III	B (right of ditch+A024) & C	10	11.0	Based on ground elevation. Circular pipe	2.0

REQUIREMENTS

1	Determine the areas [acres] using two clearly defined methods. Provide, in tabular format, a comparison of your results. The 2 alternative area determination methods are necessary for ensuring the accuracy (consistency) of area calculations. The <i>Triangular Method</i> must be one of the methods used.
2	Determine an appropriate (hydraulic) length [ft] for each sub-watershed. This is the length for the calculation of time of overland flow travel (used for t_c determination). <u>Tabulate the results.</u>
3	Calculate the average slope of each sub-watershed. Assume that the length [ft] used in design calculations is a straight line from the farthest point in the catchment to the outlet in each sub-watershed. <u>Tabulate the results.</u>
4	Calculate the time for overland flow travel using the <u>Kirpich</u> formula. Perform the checks to show your values are reasonable. Use Figure 16.7 (textbook-Gupta) to determine a ballpark estimate. Tabulate and compare the results.
5	Determine the runoff coefficients for each sub-watershed (based on land use for each sub-area). <u>Tabulate the results.</u>
6	For the design storm return period (based on Group assignment): a) Calculate the peak discharge from <u>each</u> sub-watershed. b) Calculate the peak flow that will be used to size each segment of the storm sewer line – identify the sewer segments and manholes (drainage inlets) by numbering them appropriately on the map c) Present a schematic of the storm sewer layout on your area. Provide a separate, properly annotated, map. d) Provide a table with the required details for the sewer system design.

EACH GROUP WILL SUBMIT A BOUND REPORT (WITH MAPS) AND EACH MEMBER WILL SUBMIT 2 POWERPOINT SLIDES DESCRIBING THE PROJECT COMPONENT IN WHICH THEY WERE LEAD.

ADDITIONAL PROJECT INSTRUCTIONS

STUDENT DESIGNATIONS: STUDENT 1 – GROUP LEADER [SUBMITS REPORT FOR GROUP]

TASK NO.	DESCRIPTION OF REQUIREMENT	LEAD** STUDENT
1	Determine an appropriate length [ft] for each sub-watershed. Please state any assumptions you have made in determining this value. Indicate the path designated for this watershed linear measure on the map (drawing) you were provided by the instructor.	STUDENT1
2	Calculate the average slope [] of each sub-watershed. Assume that the length to be used is the straight line distance to the farthest point in the catchment (from the outlet in each sub-catchment. This distance (length [ft]) was determined in #1. Slope = [maximum elevation – minimum elevation]/[sub-watershed length].	STUDENT2
3	Calculate the time of concentration using the Kirpich formula for overland flow segment of travel time.	STUDENT2
4	Determine the Runoff Coefficient (C) for each sub-watershed (The value of C depends on the land use determined for each sub-watershed section.) Consult appropriate references to obtain appropriate values of C and specify your references. See the Appendix for tables of C values.	STUDENT3
5	For each sub-catchment, calculate the peak runoff rate [cfs] using the Rational Method	STUDENT3
6	Compute the peak flowrate that would be used in the design of each segment of the storm sewer <u>system</u> as runoff is channeled (routed) toward the outlet of the system.	STUDENT1
7	For the peak flow in 6 , design a lined trapezoidal concrete channel for the purple segment (see map) using the discharge at the outlet of sub-watershed C061 and the slope of the storm sewer segment along sub-watershed C061.	STUDENT1
8	Provide a sketch of your storm drainage system including the location of the open channel.	STUDENT1

****LEAD STUDENT = STUDENT HAVING PRIMARY RESPONSIBILITY FOR COMPLETING TASK [FOR PROJECT GRADE DETERMINATION]**

LAND USE PRACTICES

A Sub-watersheds are **West** of Hammond Ditch **B** sub-watersheds are **East** of Hammond Ditch

Sub-Watershed	Land Use
A011	30% grassed; 70% commercial
A012	20% Gravel trailer park; 80% business
A013	Office buildings with paved areas
A021	30 % residential (sparse); 70% lawn with dense soil
A022	Pasture with 10% woodland
A023	70% soy bean field with grassed swale
A024	Grassed area with pond
C061	90% grassed area; rest is soy bean field. (Location of future detention pond)
B031	50% lawn with dense soil, 50% residential
B032	30% Residential; 70% playground
B033	20% Residential; 80% playground
B034	Apartment complexes
B041	Light Commercial
B042	40% grassed lawn; 60% commercial development
B043	Primary school area
B044	Commercial development

APPENDIX I

IDF CURVES

Atlas 14 IDF Curves

Assistance with NOAA Atlas 14 Updates to the Harris County Flood Control District Policy Criteria & Procedure Manual (PCPM)

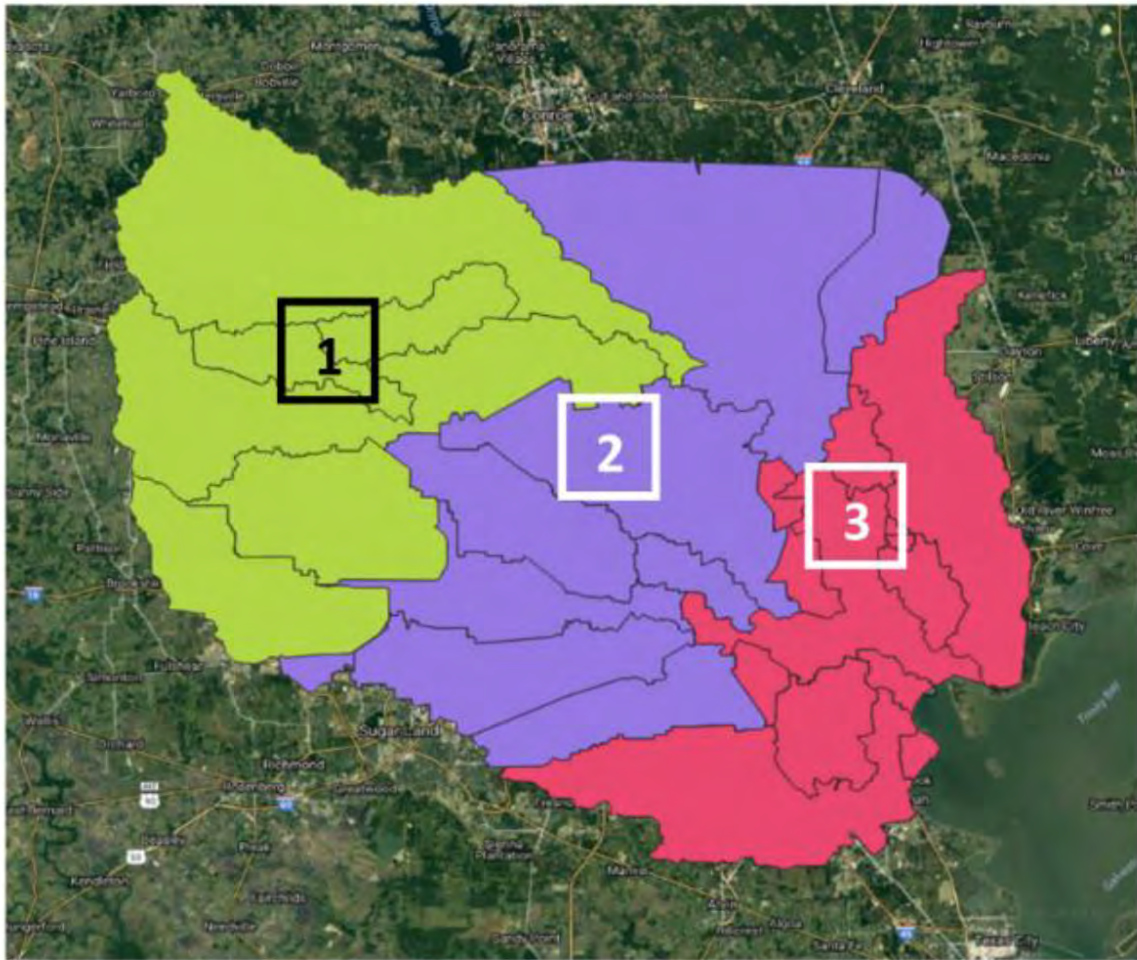


Figure 1. Harris County Regional Watersheds

$$I = \frac{b}{(t_c + d)^e}$$

Equation 1. IDF Relationship Equation

where:

I = design rainfall intensity (inches/hour)

t_c = time of concentration (minutes)

e , b and d = coefficients based on rainfall frequency-duration curves

Table 1. Updated Rainfall IDF Coefficients for Harris County

Coefficient	50 % AEP	20 % AEP	10 % AEP	4 % AEP	2 % AEP	1 % AEP	0.2 % AEP
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
<i>Region 1</i>							
e	0.7372	0.7058	0.6819	0.6446	0.6170	0.5870	0.5111
b (in.)	48.27	51.78	54.26	54.97	54.84	53.93	50.89
d (min.)	9.30	8.19	7.44	6.27	5.45	4.53	2.69
<i>Region 2</i>							
e	0.7263	0.7051	0.6752	0.6397	0.6166	0.5857	0.5129
b (in.)	47.25	54.09	55.26	56.72	57.94	56.68	54.26
d (min.)	8.94	8.34	7.30	6.12	5.47	4.46	2.72
<i>Region 3</i>							
e	0.7244	0.6900	0.6623	0.6294	0.6096	0.5797	0.5196
b (in.)	48.35	52.32	54.68	57.79	61.00	60.66	62.17
d (min.)	9.07	7.88	6.96	5.89	5.46	4.44	2.95

AEP - annual exceedance probability

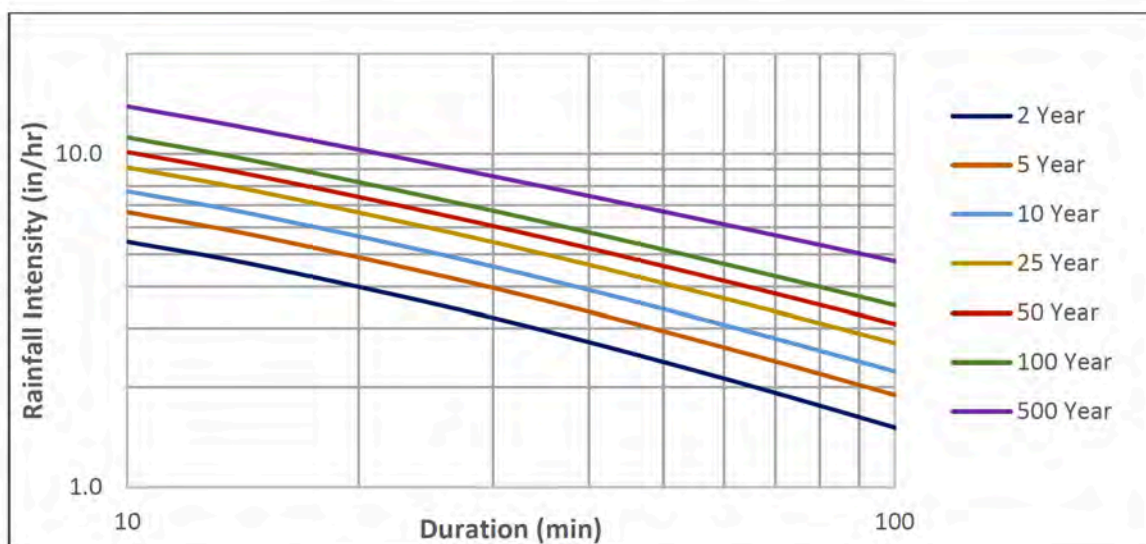


Figure 3. Region 1 Updated IDF Curves, 2-year through 500-year

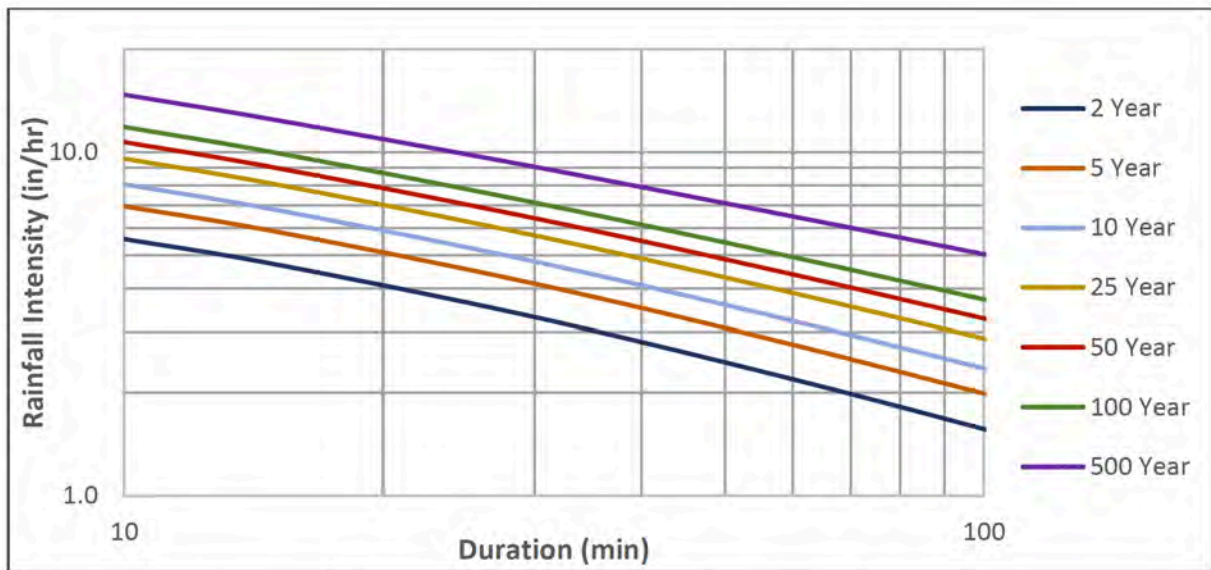


Figure 4. Region 2 Updated IDF Curves, 2-year through 500-year

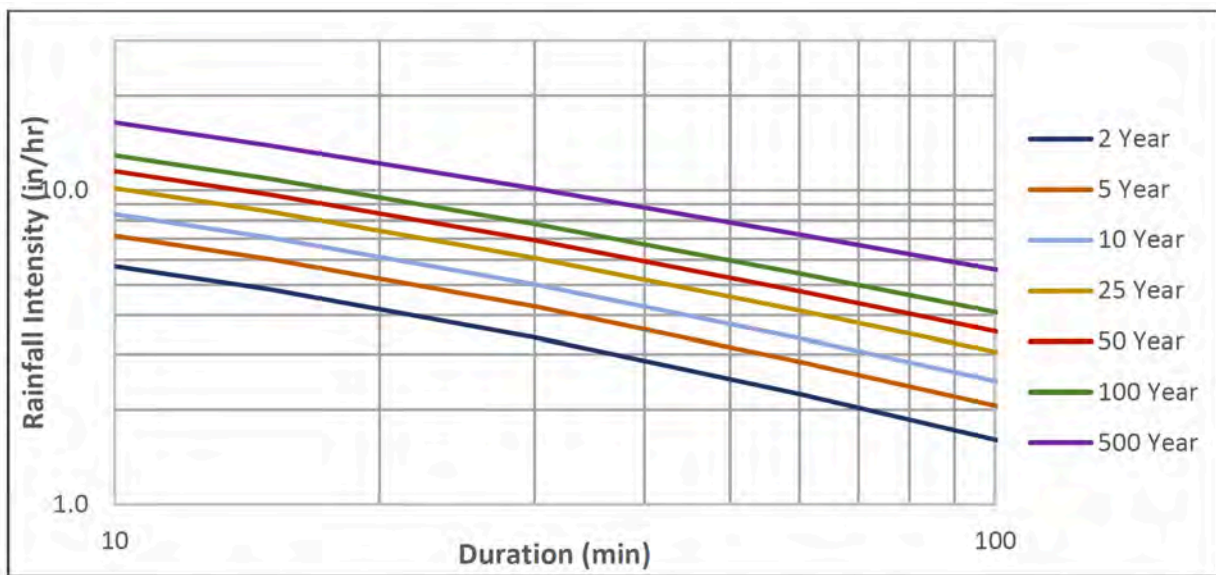


Figure 5. Region 3 Updated IDF Curves, 2-year through 500-year

APPENDIX II

RUNOFF COEFFICIENTS (SAMPLE)

RUNOFF COEFFICIENT, C

[HYDRAULIC DESIGN MANUAL, TXDOT, 2019)

Table 4-10: Runoff Coefficients for Urban Watersheds

Type of drainage area	Runoff coefficient
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.30-0.70
Residential:	
Single-family areas	0.30-0.50
Multi-units, detached	0.40-0.60
Multi-units, attached	0.60-0.75
Suburban	0.35-0.40
Apartment dwelling areas	0.30-0.70
Industrial:	
Light areas	0.30-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.30-0.40
Railroad yards	0.30-0.40
Unimproved areas:	
Sand or sandy loam soil, 0-3%	0.15-0.20
Sand or sandy loam soil, 3-5%	0.20-0.25
Black or loessial soil, 0-3%	0.18-0.25
Black or loessial soil, 3-5%	0.25-0.30
Black or loessial soil, > 5%	0.70-0.80
Deep sand area	0.05-0.15
Steep grassed slopes	0.70
Lawns:	
Sandy soil, flat 2%	0.05-0.10
Sandy soil, average 2-7%	0.10-0.15
Sandy soil, steep 7%	0.15-0.20
Heavy soil, flat 2%	0.13-0.17
Heavy soil, average 2-7%	0.18-0.22

RUNOFF COEFFICIENT, C

[HYDRAULIC DESIGN MANUAL, TXDOT, 2019]

Table 4-10: Runoff Coefficients for Urban Watersheds

Type of drainage area	Runoff coefficient
Heavy soil, steep 7%	0.25-0.35
Streets:	
Asphaltic	0.85-0.95
Concrete	0.90-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.95
Roofs	0.75-0.95

Table 4-11: Runoff Coefficients for Rural Watersheds

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	0.08-0.14 Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water; clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainageways steep and small, no marshes	0.08-0.10 Well-defined system of small drainageways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes
Table 4-11 note: The total runoff coefficient based on the 4 runoff components is $C = C_r + C_i + C_v + C_s$				

RUNOFF COEFFICIENT, C FOR RETURN PERIODS

Description of area	Runoff Coefficient (C)			
	Up to 10 yr Frequency		25 yr Frequency	
	minimum	maximum	minimum	maximum
Business:				
Downtown areas	0.75	0.95	0.83	1.00
Neighborhood areas	0.50	0.70	0.55	0.77
Residential areas:				
Single family	0.30	0.50	0.33	0.55
Multiple units, detached	0.40	0.60	0.44	0.66
Multiple units, attached	0.60	0.75	0.66	0.83
Residential, suburban	0.25	0.40	0.28	0.44
Apartment dwelling areas	0.50	0.70	0.55	0.77
Industrial areas:				
Light	0.50	0.80	0.55	0.88
Heavy	0.60	0.90	0.66	0.99
Parks, cemeteries	0.10	0.25	0.11	0.28
Playgrounds	0.20	0.35	0.22	0.39
Railroad yards	0.20	0.40	0.22	0.44
Unimproved areas	0.10	0.30	0.11	0.33

Character of Surface	Up to 10 yr Frequency		25 yr Frequency	
	Minimum	Maximum	Minimum	Maximum
Pavement:				
Asphalt	0.70	0.95	0.77	1.00
Concrete	0.80	0.95	0.88	1.00
Brick	0.70	0.85	0.77	0.94
Roofs	0.70	0.95	0.77	1.00
Lawns, sandy soil:			0.00	0.00
Flat (2 %)	0.05	0.10	0.06	0.11
Average (2 - 7 %)	0.10	0.15	0.11	0.17
Steep (7% or more)	0.15	0.20	0.17	0.22
Lawns, heavy soil:			0.00	0.00
Flat (2 %)	0.13	0.17	0.14	0.19
Average (2 - 7 %)	0.18	0.22	0.20	0.24
Steep (7% or more)	0.25	0.35	0.28	0.39

Compiled from data obtained from "Design and Construction of Sanitary and Storm Sewers" (1969) ASCE and WPCF, pp 50-51

RUNOFF COEFFICIENT, C

(GUPTA, 2017 – PAGE 714)

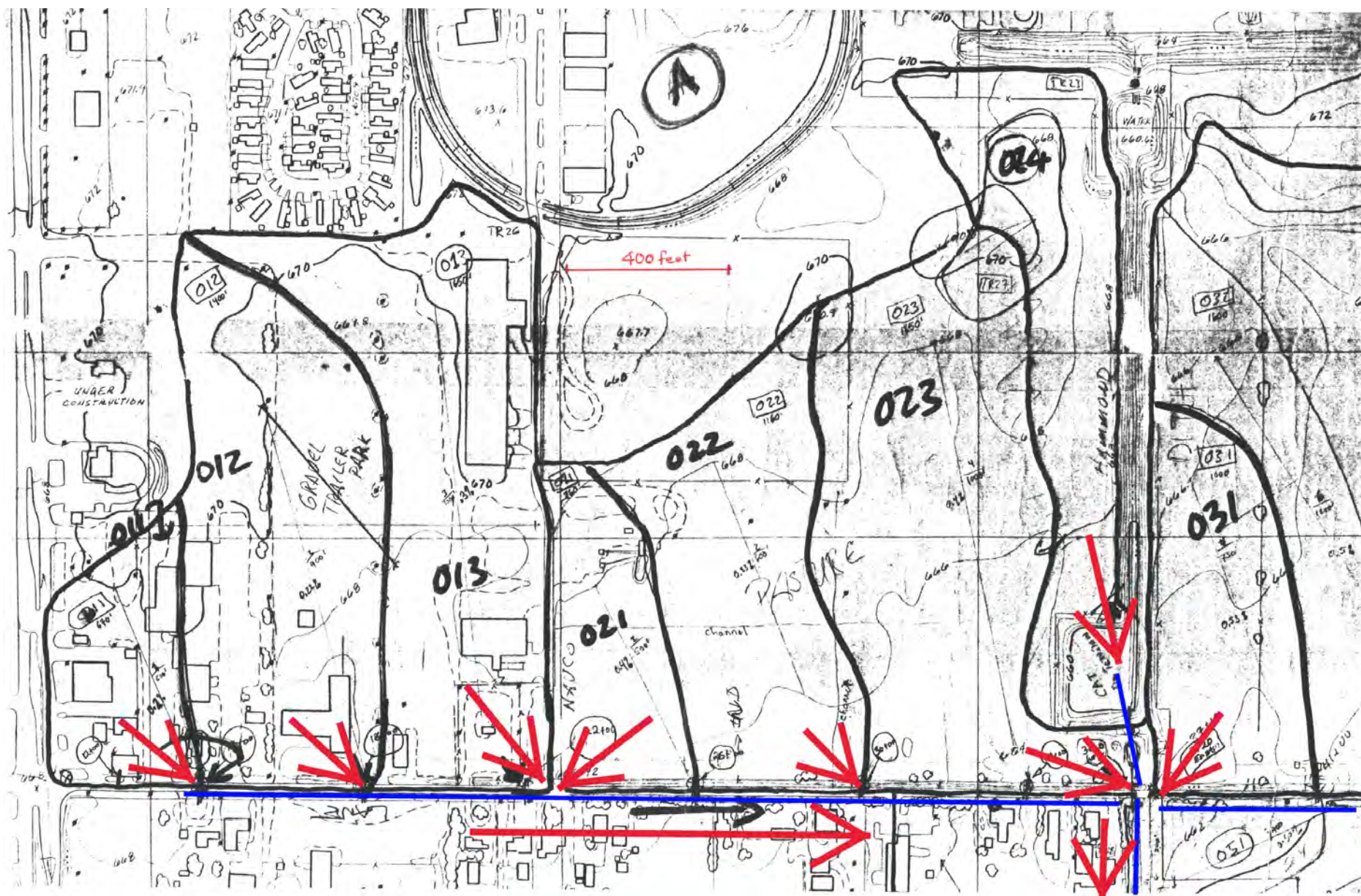
Table 16.5 Rational Runoff Coefficient

Urban Catchments			
General Description	C	Surface	C
City	0.7–0.9	Asphalt paving	0.7–0.9
Suburban business	0.5–0.7	Roofs	0.7–0.9
Industrial	0.5–0.9	Lawn heavy soil	
		>7° slope	0.25–0.35
Residential multiunits	0.6–0.7	2–7°	0.18–0.22
Housing estates	0.4–0.6	<2°	0.13–0.17
Bungalows	0.3–0.5	Lawn sandy soil	
		>7°	0.15–0.2
Parks, cemeteries	0.1–0.3	2–7°	0.10–0.15
		<2°	0.05–0.10
Rural Catchments (less than 10 km ²)			
Ground Cover	Basic Factor	Corrections: Add or Subtract	
Bare surface	0.40	Slope < 5%: –0.05	
Grassland	0.35	Slope > 10%: +0.05	
Cultivated land	0.30	Recurrence interval < 20 yr: –0.05	
Timber	0.18	Recurrence interval > 50 yr: +0.05	
		Mean annual precipitation < 600 mm: –0.03	
		Mean annual precipitation > 900 mm: +0.03	
Source: Stephenson (1981).			

APPENDIX III

PROJECT MAPS

SMALL HARRIS COUNTY WATERSHED







**Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department**

6

H



CVEG 4303: Water Resources

Section: P01

Title: Watershed Analysis and Design

Submitted By: Armando Gomez, Allyssa Reynolds

Submitted To: Dr. Nzewi

Due Date: April 28, 2022 – 1:00PM

Prairie View A&M University
Department Of Civil & Environmental Engineering

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Letter of Transmittal

Dr. Nzewi
Professor of Civil & Environmental Engineering
C.L. Wilson Engineering Building
Prairie View, Texas, 77446

April 27, 2022

Dear Dr. Nzewi,

Good

We submit the proposed report titled "Watershed Analysis and Design," as a fulfillment of the required design project for the Water Resource Engineering course.

The purpose of this report is to successfully analyze and design a watershed and trapezoidal channel providing the necessary parameters to showcase the knowledge and efficacy of the course. Components such as finding the runoff coefficient and time of concentration, and the analysis of a Harris County watershed in Region III, have all been observed and designed adequately. The following report reflects how the watershed was analyzed, and how the trapezoidal channel was designed.

Please review our report, and provide all constructive feedback. If there are any questions, please contact the Team Lead, Allyssa Reynolds, via email at areynolds18@pvamu.edu, or by phone at (314)-677-7306. We hope this report is sufficient in providing all of the necessary data and design.

Sincerely,

Allyssa Reynolds & Armando Gomez

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You forgot to number
the pages

1 Abstract

The objective of this project was to analyze Harris County watershed, develop a drainage system network to the left of Hammond ditch, and to design a lined concrete trapezoidal channel based on the drainage system analysis. Data such as the land use for each watershed, direction of flow, elevation of the land site, and boundary of each watershed have all been provided by the client.

2 Introduction

R&G Engineering Firm was contracted by Dr. Nzewi of Prairie View A&M University to analyze the Harris County Region III watershed, and to design a lined concrete trapezoidal channel based on the analysis. The design included the calculations for runoff coefficient, time of concentration, rainfall intensity, and subsequent peak runoff rates. A drainage system-network was also developed to create the channel. This drainage system will be able to ~~withstand a~~ 10-year rainfall event, and is located to the left of Hammond ditch. *drain*

3 Data Presentation

3.1.0 Task 1

For the first task, our team had to establish an adequate length for each sub-watershed. Our client provided a known length, and the team was able to convert the known length in feet to inches. In this project, 2 inches were equivalent to 400 feet. By breaking this conversion further, $\frac{1}{2}$ inches were equivalent to 100 feet. The length would represent where the farthest droplet of water would travel and was determined by measuring the distance between the highest and lowest elevation closest to the runoff pipe. The following table represents the lengths found for each sub-watershed:

Sub-Watershed	Length (ft)
A024	1375
B031	1000
B032	1560
B033	1500
B034	1600
B041	1100
B042	1500
B043	600
B044	1800
C061	1000

Table 1.0: Sub-watershed Lengths, L

3.1.1 Task 2

For the second task, our team had to calculate the average slope of each sub-watershed. The following equation was utilized to find the slope:

$$\text{Slope, } S = \frac{\text{Elevation}_{\text{maximum}} - \text{Elevation}_{\text{minimum}}}{\text{Sub-watershed Length}}, \text{ Equation 1}$$

All equations were provided from the client, and the sub-watershed length was determined in the previous task, task 1. The following table represents each slope for each sub-watershed:

Sub-Watershed	Change in Elevation (ft)	Length (ft)	Slope
A024	10	1375	0.0073
B031	2	1000	0.0020
B032	2	1560	0.0013
B033	10	1500	0.0067
B034	6	1600	0.0038
B041	4	1100	0.0036
B042	6	1500	0.0040
B043	2	600	0.0033
B044	8	1800	0.0044
C061	2	1000	0.0020

Table 2.0: Slope, S, for each Sub-watershed

3.1.2 Task 3

For the third task, our team determined the time of concentration. This is the overland flow segment of travel time, the time it takes for a droplet of water to travel from the farthest point of the catchment to the pipe. The time of concentration was calculated by using the Kirpich formula. This equation can be found below:

$$t_c = \frac{0.0078L^{0.77}}{S^{0.385}}, \text{ Equation 2}$$

The length, L, was determined from task 1, and the slope, S, was determined from task 2. All other values are constants due to English units being utilized.

The following table represents the time of concentration for each sub-watershed:

Sub-Watershed	Length, L (ft)	Slope (S)	t_c (min)
A024	1375	0.0073	13.55
B031	1000	0.0020	17.43
B032	1560	0.0013	29.12
B033	1500	0.0067	14.98
B034	1600	0.0038	19.65
B041	1100	0.0036	14.90
B042	1500	0.0040	18.23
B043	600	0.0033	9.66
B044	1800	0.0044	20.15
C061	1000	0.0020	17.43

Table 3.0: Time of Concentration, t_c , for each Sub-watershed

3.1.3 Task 4

For the fourth task, our team determined the runoff coefficient, C, for every sub-watershed. The client provided the land use for each sub-watershed and various sources to determine C. Thus, we were able to determine the runoff coefficient for each sub-watershed. The following table represents this data:

keep to 2 decimal places
Good detail!

Sub-Watershed	Runoff Coefficient (C)	General Description (Handout)
A024	0.300	High C_r + High C_i + Normal C_v + Normal C_s
B031	0.28 0.280	Lawns, Heavy Soil Single Family
B032	0.32 0.320	Single Family Playground
B033	0.300	Single Family Playground
B034	0.600	Apartment Dwelling Area
B041	0.68 0.675	Light Industrial
B042	0.420	Lawns, Flat Neighborhood area
B043	0.600	Neighborhood area
B044	0.600	Neighborhood area
C061	0.345	Grassland

Table 4.0: Runoff Coefficient, C, for each Sub-watershed

The watershed to the left of Hammond ditch was determined to be an urban and suburban area. The area South of Hammond ditch was determined to be rural due to its land use. These assumptions allowed the team to determine the runoff coefficients effectively. Averages for each range of the runoff coefficients were obtained and used as C.

3.1.4 Task 5

For the fifth task, the peak runoff rate was determined for each sub-catchment by utilizing the Rational Method. Since the client wanted us to use the Rational Method, the following assumptions were made:

1. The area of the analyzed catchment is less than 200 acres.
2. Rainfall intensity is uniform during a storm.
3. Rainfall is distributed uniformly across the drainage area.

With these assumptions, we were able to complete the Rational Method:

1. Determine the area of each sub-watershed, and verify that the area is less than 200 acres.
 - a. Area was calculated using two methods to ensure validity of results. Methods included the triangular and square method.
 - b. Square method can be found in Appendix A.
2. Determine the time of concentration for each sub-watershed.
3. Determine rainfall intensity based on each time of concentration.
4. Solve for the peak runoff rate.

The following equation was utilized to find the peak runoff rate:

$$Q = CIA, \text{ Equation 3}$$

The equation for runoff coefficient is as follows:

$$C = \frac{\sum a_i \cdot c_i}{\sum a}, \text{ Equation 4}$$

The equation for rainfall intensity was provided by the client. This equation is located below:

$$I = \frac{b}{(t_c + d)^e}, \text{ Equation 5}$$

Where b , in. = 54.68, d , min. = 6.96, and $e = 0.6623$. These values were obtained by utilizing the updated rainfall coefficient table. This table is located in Appendix B under Figure 1.

The following table represents the peak runoff rate for each sub-watershed:

Sub-Watershed	C	t_c (min)	Intensity, I (in/hr)	Area, A (ac)	Flow, Q (cfs)
A024	0.300	13.55	5.26	8.82	13.93
B031	0.280	17.43	4.20	4.99	6.13
B032	0.320	29.12	5.17	22.10	35.39
B033	0.300	14.98	4.50	7.93	10.99
B034	0.600	19.65	4.37	11.31	18.18
B041	0.675	14.90	4.16	7.00	11.73
B042	0.420	18.23	4.28	4.50	7.77
B043	0.600	9.66	3.66	2.00	2.99
B044	0.600	20.15	3.78	16.25	27.36
C061	0.345	17.43	6.51	13.75	38.65

Table 5.0: Peak Runoff Rate, Q, for each Sub-watershed

3.1.5 Task 6

For the sixth task, we determined the peak flow rate that was used to design the segment of the storm sewer system, also named the drainage system-network. This was calculated by utilizing the segment that held the largest time of concentration value. To determine the maximum time of concentration, though, the travel time for each pipe was found. The client provided the velocity, 2 feet/s, and the length of each pipe was determined by the team. The following equation represents this:

$$\frac{\text{Length of Pipe, ft}}{\text{Velocity, ft/s}} \cdot \frac{60 \text{ s}}{1 \text{ min}}, \text{ Equation 6}$$

The time of travel was converted into minutes to provide uniformity of dimensions. The following table represents the peak flow rate determined:

Excellent detail

Sub-Watershed	Length (ft)	Travel Time (min)	Time of Concentration (min)
061->G	0	0.000	17.43
031->A->G	1100	9.17	26.59
024->I->A->G	1325	11.04	40.17
032->B->A->G	1500	12.50	27.48
033->C->B->A->G	1900	15.83	35.48
034->D->C->B->A->G	2700	22.50	37.40
041->D->C->B->A->G	2700	22.50	40.73
042->E->D->C->B->A->G	3500	29.17	38.83

043->F->E->D->C->B->A->G	3700	30.83	50.98
044->F->E->D->C->B->A->G	3700	30.83	48.26

Table 6.0: Peak Runoff Rate, Q, for the Storm Sewer System

The peak flow rate that would be used for the design of the watershed using equations 3 - 5 as follows:

$$C = \frac{\sum a_i \cdot c_i}{\sum a}$$

$$C = 42.59 / 98.65$$

$$C = 0.432$$

$$I = \frac{b}{(t_c + d)^e}$$

$$I = 54.68 / (50.98 + 6.96)^{0.6623}$$

$$I = 3.6582$$

$$A_{\text{SumTotal}} = 98.65 \text{ Acres}$$

$$Q = CIA$$

$$Q = 0.432 * 3.6582 * 98.65$$

$$Q = 156 \text{ cfs}$$

3.1.6 Task 7

For the seventh task, we designed a concrete-lined trapezoidal channel using the peak flow from Task 6. The discharge at each outlet of the sub-watershed C061 and the slope of the storm sewer segment along sub-watershed C061 was utilized. Several equations were used to determine the appropriate design, including the Manning's equation. Through the trial-and-error method, the design was developed and provided.

To begin the design, the area of the channel was determined to be: 22.61 ft^2 . The following equation was utilized:

$$\text{Area, } A = by + zy^2, \text{ Equation 7}$$

Where bottom width, $b = 10$, depth of the channel, $y = 1.8$, and side slope, $z = 1.6$.

Since b and y were determined, the perimeter of the channel and channel top width, T , were found to be 16.79 ft and 15.76 ft by utilizing the following two equations:

$$\text{Perimeter, } P = b + 2y\sqrt{(1 + z^2)}, \text{ Equation 8}$$

$$T = b + 2zy, \text{ Equation 9}$$

Next, the hydraulic radius, R, was determined to be 1.50 ft. The following equation was used:

$$R = \frac{A}{P}, \text{ Equation 10}$$

Next, the hydraulic depth was determined to be 1.43 ft by utilizing the following:

$$D = \frac{A}{T}, \text{ Equation 11}$$

Next, the channel flow rate was determined to be 164.52 cfs by using the following equation:

$$Q = \frac{1.486}{n} AR^{2/3} \sqrt{S}, \text{ Equation 12}$$

Where Manning's roughness coefficient, $n = 0.012$, and land slope, $S = 0.0020$.

Note, n value of 0.012 is sufficient for pipes with a max diameter of 35 inches.

Finally, the freeboard for the channel was determined to be 1.66 ft. This was found using the following equation:

$$u = \sqrt{cy}, \text{ Equation 13}$$

Where freeboard coefficient, $c = 1.53$.

Although the freeboard for the channel was found to be 1.66, the value was rounded to the next whole number, 2 ft. If this channel were to be designed within Harris County, it would be more economical and feasible to obtain a freeboard of 2 ft rather than 1.66 ft.

The following table provides the channel characteristics:

Channel Flow Rate, Q, cfs	164.52
Channel Side Slope, z	1.6
Channel Bottom Width, b, ft	10.0
Depth of Channel, y, ft	1.8
Channel Freeboard, u, ft	2.0
Channel Velocity, ft/s	2.0

Table 7.0: Design Channel Characteristics

3.1.7 Task 8

For the seventh task, we sketched the drainage system design and provided the location of the open channel.

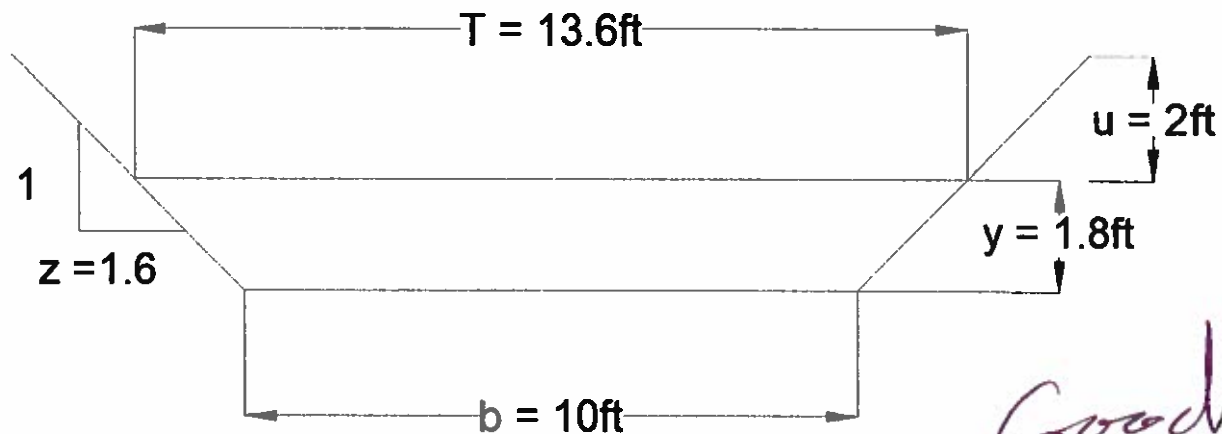


Figure 1.0: Drainage Channel

4 Conclusion

The objective of the project was to analyze the Harris County Region III watershed and to design a lined concrete trapezoidal channel based on the analysis. By completing eight tasks, the design was able to be developed appropriately. The flow used to design the channel was 156 cfs. The channel characteristics included a bottom width of 10 feet, a depth of 1.8 feet, and a slide slope of 1.6. With these dimensions, the channel has a flow capacity of 164.52 cfs. This is above the needed flow rate of 156 cfs, and thus verifies that the channel is adequate. Recommendations include utilizing a Water Resources Engineering software to develop the design, as this would aid in understanding the project better.

References

1. Gupta, Ram S. *Hydrology & Hydraulic Systems.* , 2017. Print.

Appendix A

Raw Calculations

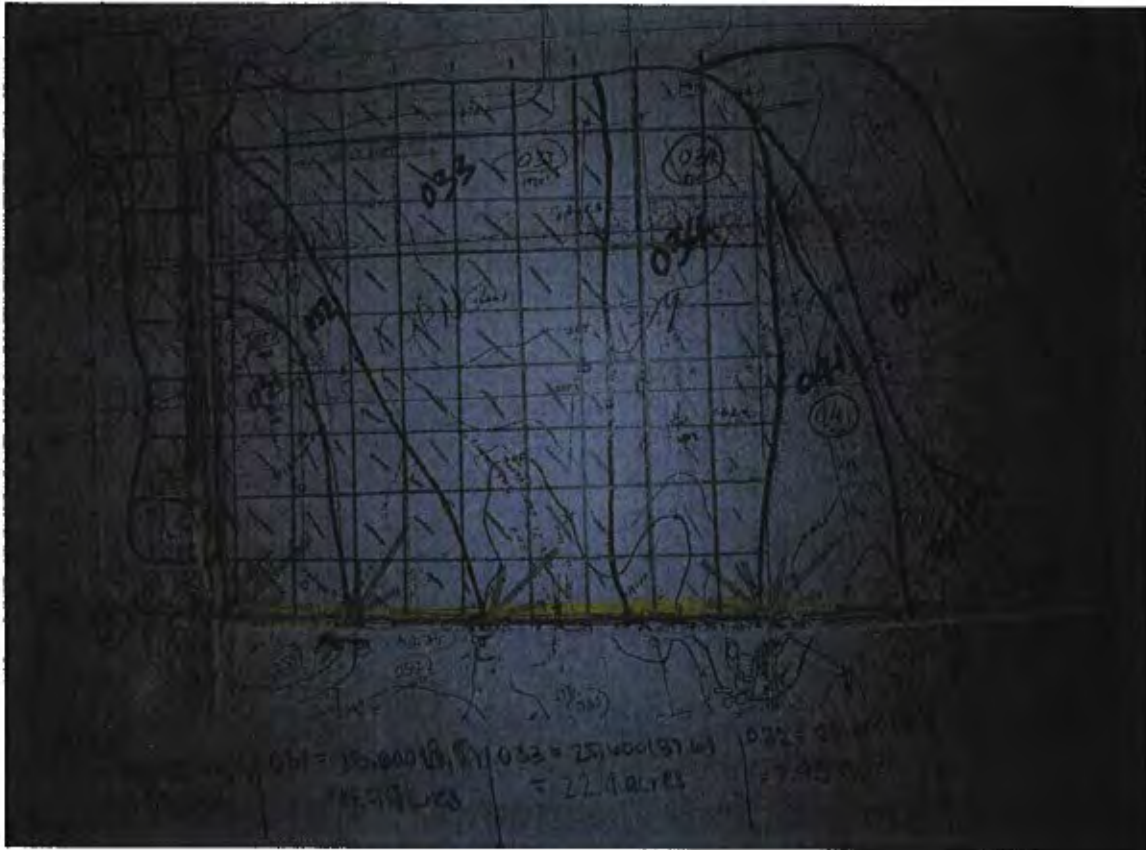


Figure 1.0: Area Calculations reflect calculations of the area via the squares method for sub-sheds 024-034.

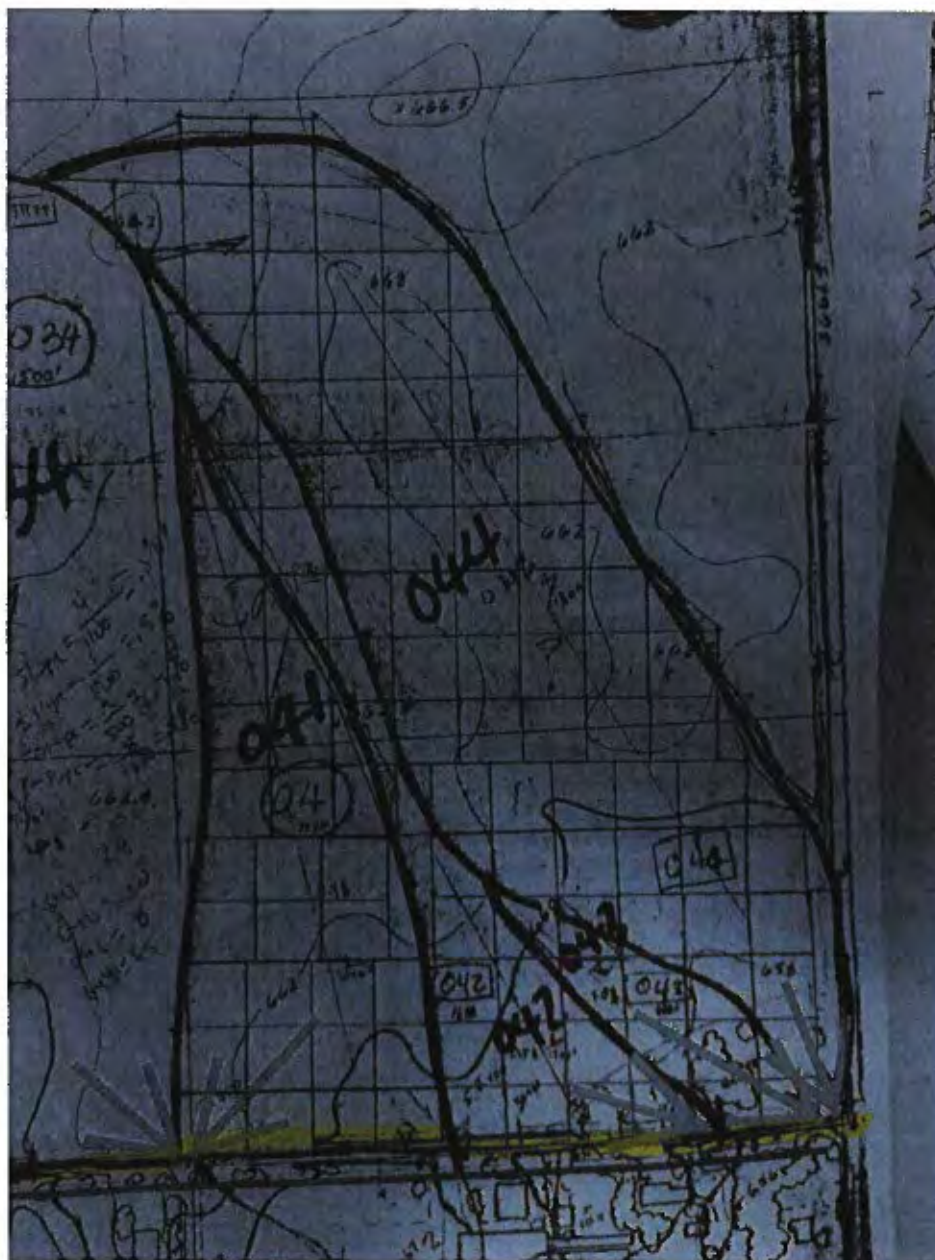


Figure 2.0: Area Calculations reflect calculations of the area via the squares method for sub-sheds 041-044.



Figure 3.0: Area Calculations reflect calculations of the area via the squares method for sub-sheds 061 .

Appendix B

Tables and Figures Used

Table 1. Updated Rainfall IDF Coefficients for Harris County							
	50 % AEP 1-Year	50 % AEP 5-Year	10 % AEP 10-Year	4 % AEP 25-Year	2 % AEP 50-Year	1 % AEP 100-Year	0.2 % AEP 500-Year
Region 1							
C	0.7372	0.7058	0.6819	0.6446	0.6170	0.5870	0.5111
3.0-in	48.27	51.78	54.26	54.97	54.84	53.93	50.89
2.0-in	9.30	8.19	7.44	6.27	5.45	4.53	2.69
Region 2							
C	0.7263	0.7051	0.6752	0.6397	0.6166	0.5857	0.5129
3.0-in	47.25	54.09	55.26	56.72	57.94	56.68	54.26
2.0-in	8.94	8.34	7.30	6.12	5.47	4.46	2.72
Region 3							
C	0.7244	0.6900	0.6623	0.6294	0.6096	0.5797	0.5196
3.0-in	48.35	52.32	54.68	57.79	61.00	60.66	62.17
2.0-in	9.07	7.88	6.96	5.89	5.46	4.44	2.95

Figure 1.0: Rational Runoff Coefficient reflects the runoff coefficient used for the analysis

Rational Runoff Coefficient			
Urban Catchments			
General Description	C	Surface	C
City	0.7-0.9	Asphalt paving	0.7-0.9
Water front buildings	0.5-0.7	Roofs	0.7-0.9
Lawns	0.5-0.9	Lawn heavy soil	
		>7° slope	0.25-0.35
Shaded shrublands	0.6-0.7	2-7°	0.18-0.22
Moist grasslands	0.4-0.6	<2°	0.13-0.17
Barren soils	0.3-0.5	Lawn sandy soil	
		>7°	0.15-0.2
Gravel, concrete	0.1-0.3	2-7°	0.10-0.15
		<2°	0.05-0.10
Rural Catchments (less than 10 km ²)			
Ground Cover	Basic Factor	Corrections: Add or Subtract	
Asphalt	0.40	Slope < 5%: -0.05	
Grassland	0.35	Slope > 10%: +0.05	
City rural land	0.30	Recurrence interval < 24 yr: -0.05	
Timber	0.18	Recurrence interval > 50 yr: +0.05	
		Mean annual precipitation < 600 mm: -0.03	
		Mean annual precipitation > 900 mm: +0.03	
Source: Froehner (1963)			

Figure 2.0: Rational Runoff Coefficient reflects the runoff coefficient used for the analysis.

Rational Runoff Coefficient	
Surface	Runoff Coefficient
Asphalt	0.80-0.90
Concrete	0.65-0.80
Gravel	0.50-0.75
Grass	0.35-0.40
Grass with trees	0.30-0.35
Forest	0.30-0.35
Forest with trees	0.20-0.30
Forest with trees	0.10-0.25
Forest with trees	0.30-0.40
Forest with trees	0.30-0.40
Forest with trees	0.15-0.20
Forest with trees	0.20-0.25
Forest with trees	0.18-0.25
Forest with trees	0.25-0.30
Forest with trees	0.70-0.80
Forest with trees	0.05-0.15
Forest with trees	0.70
Forest with trees	0.05-0.10
Forest with trees	0.10-0.15
Forest with trees	0.15-0.20
Forest with trees	0.15-0.20
Forest with trees	0.15-0.20

Figure 3.0: Rational Runoff Coefficient reflects the runoff coefficient used for the analysis.

Runoff Coefficient		Runoff Coefficient		
		0.15-0.35		
		0.55-0.95		
		0.50-0.95		
		0.70-0.85		
		0.75-0.95		
		0.75-0.95		

Table 4-11: Runoff Coefficients for Rural Watersheds

Watershed Characteristics	Extreme	High	Normal	Low
Rolling, hilly, with average slopes of 10-30%	0.25-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.15-0.20 Rolling, with average slopes of 5-10%	0.05-0.14 Relatively flat land with average slopes of 0-5%
Soil type: clay - C ₁	0.12-0.16 No effective soil cover, either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal, well drained high or medium textured soils, sandy loams	0.04-0.06 Sandy sand or other soil that takes up water readily, very light, well drained soils
Soil type: sand - C ₂	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Open to fair, clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.04-0.06 Fair to good, about 50% of area in good grassland or woodland, not more than 10% of area in cultivated crops	0.04-0.06 Good to excellent, about 90% of drainage area in good grassland, woodland, or equivalent cover
Soil type: silt - C ₃	0.12-0.16 Moderate surface roughness, low soil stability, drainage poor, steep and shallow slopes	0.08-0.10 Well defined system of small channels, no ponds or swamps	0.04-0.06 Normal, moderate surface roughness, drainage good, no ponds or swamps	0.04-0.06 Good surface roughness, drainage system not poorly developed, large floodplain area, large number of ponds or swamps

Figure 4.0: Rational Runoff Coefficient reflects the runoff coefficient used for the analysis.

RATIONAL RUNOFF COEFFICIENTS FOR DIFFERENT SURFACES				
Type of Surface	Frequency		Frequency	
	Minimum	Maximum	Minimum	Maximum
Asphalt	0.75	0.95	0.88	1.00
Concrete	0.80	0.90	0.85	0.97
Gravel	0.30	0.50	0.33	0.55
Gravel with detached	0.40	0.60	0.44	0.66
Gravel with attached	0.60	0.75	0.66	0.83
Gravel with detached	0.25	0.40	0.28	0.44
Gravel with attached	0.50	0.70	0.55	0.77
Gravel with gravel	0.50	0.80	0.55	0.80
Gravel with gravel	0.60	0.80	0.66	0.96
Gravel with gravel	0.10	0.25	0.11	0.28
Gravel with gravel	0.20	0.35	0.22	0.36
Gravel with gravel	0.20	0.40	0.22	0.44
Gravel with gravel	0.10	0.30	0.11	0.33

Type of Surface	5 to 10 yr Frequency		25 yr Frequency	
	Minimum	Maximum	Minimum	Maximum
Asphalt	0.70	0.95	0.77	1.00
Concrete	0.80	0.95	0.88	1.00
Gravel	0.70	0.85	0.77	0.94
Gravel with gravel	0.70	0.85	0.77	1.00
Gravel with gravel	0.05	0.10	0.06	0.00
Gravel with gravel	0.10	0.15	0.11	0.11
Gravel with gravel	0.15	0.20	0.17	0.17
Gravel with gravel	0.15	0.20	0.17	0.22
Gravel with gravel	0.15	0.17	0.14	0.00
Gravel with gravel	0.15	0.22	0.20	0.19
Gravel with gravel	0.25	0.35	0.28	0.24
Gravel with gravel				0.39

Figure 5.0: Rational Runoff Coefficient reflects the runoff coefficient used for the analysis.

**OUTCOME “1” SPECIFIC ASSIGNMENTS
USED TO ASSESS THE OUTCOME IN**

**CVEG 4482
SENIOR DESIGN & PROFESSIONALISM II**

Senior Design is a group project. Students received the scores for the Final Report, which included sections devoted to solving complex engineering problems (criterion 1), apply engineering design to produce solutions (criterion 2), communicate effectively by presentations (criterion 3), and recognize ethical and professional responsibilities and make informed judgments considering impact in global, economic, and environmental contexts (criterion 4). Assessment items related to criteria and the scores for assessment of items were based on the average of the individual evaluations of assignment and final report addressing these criteria.

OUTCOME SPECIFIC ASSIGNMENTS USED TO ASSESS OUTCOME

ASSIGNMENTS FOR OUTCOME “1”

An ability to identify, formulate, and solve **complex** engineering problems by applying principles of engineering, science, and mathematics

**CIVIL & ENVIRONMENTAL ENGINEERING
DEPARTMENT
OUTCOME SPECIFIC ASSIGNMENT
COVER SHEET**

SENIOR DESIGN AND PROFESSIONALISM II

Instructor: Dr. Radha

Title of Assignment

Senior Design Final Report

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

The final report contained project scope and statement of the various components that make-up the assigned project. This assessment report contains the cover page, tables of contents and the team make-up and tasks. The students also submitted a set of blue prints covering the main areas of the project.

INSTRUCTOR COMMENTS:

1. Project Report is used for the assessment.
 - Format and organization was satisfactory.
 - There was consistency and completeness among the sections of the report, drawings and figures were appropriate and included in the report.
 - All areas structural, geotechnical, transportation, water resources and environmental are covered.
 - However, students need to improve the writing skills.
 - The presentation of technical aspects, methods of analyzing and solving complex problems needs improvement.
2. See attachment student project samples for details.
3. There was willingness and motivation to perform solving complex problems to the fullest potential.
4. Grade:
 - Score was 71 for 100. Good level of performance; a quality product was turned in at the end of the semester; further improvement is needed.

**Some Sample pages
of final Report are
provided in the
following pages**

ABOVE AVERAGE



Sterling Engineering
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Houston, Texas 77001
281-661-8875

April 23, 2020

Department of Civil and Environmental Engineering
P O Box 519, Mail Stop 2510
Prairie View A&M University
Prairie View, TX 77446

Dear Dr. Radha and Mr. Gant:

Please find attached the final technical report from Sterling Engineering. The report contains the specifications for the Commercial Master Plan at the intersection of FM 2020 and Success Road. If there are any questions feel free to contact us at 512-661-8875 or ericakeltner@gmail.com.

Yours truly,

Erica Keltner
Team Lead

Samuel Fisher
Civil Engineer

Francisco Najera
Civil Engineer

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Roy G. Perry College of Engineering

Civil & Environmental Engineering Department



CVEG 4482.P01

Senior Design and Professionalism II

Dr. R. Radhakrishnan, Ph.D., P.E, F. ASCE

Mr. Johnny Gant, P.E.

Technical Report for Commercial Master Plan

Assigned on: January 30, 2020

Submitted on: April 23, 2020

Submitted by: Sterling Engineering

Samuel Fisher

Erica Keltner

Francisco Najera

Abstract

This report provides the technical details of Sterling Engineering's Commercial Master Plan at the intersection of FM 2020 and Success Road. The plan includes:

- Northeast Corner: Walmart (275,000 sqft)
- Northwest Corner: CVS (15,000 sqft), Car Wash (55,000 sqft)
- Southeast Corner: USPS (9,500 sqft), 24 Hour Fitness (67,250 sqft), Exxon Mobil (44,000 sqft)
- Southwest corner: Walgreens (25,000 sqft), Wells Fargo (35,000 sqft), Shipley's Donuts (4,500 sqft)

The buildings have all been raised by twelve inches of fill dirt and include a stormwater drainage system that flows out to the City of Houston's stormwater sewer. The stormwater drainage system has 40" diameter HDPE pipes leading to a detention pond, one on each corner.

The access to the shopping center is by two 3-lane roads, FM 2020 and Success Road. The intersection is fully signalized and equipped with inductive loop vehicle detection.

This plan includes a canopy over the gas pumps for the Exxon Mobil Gas Station. The gas station canopy is 125 feet long and 30 feet wide with ten 15 foot columns. It includes galvanized steel joists and sheet metal for roofing, as well as aluminum fascia. The columns are W8 x 35 and the beams are W12 x 65.

The water system has been designed to remove all impurities and material in the raw water coming into the plant, so that when it leaves the plant it is safe for the public's consumption. The wastewater system has been designed to remove contaminants from the wastewater and convert it into an effluent that can be returned to the water cycle with minimum impact on the environment, or directly reused.

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Introduction

The purpose of this report is to provide technical details of Sterling Engineering's Commercial Master Plan at the intersection of FM 2020 and Success Road. It includes details on the traffic, transportation, water resources, environmental, structural, and geotechnical aspects of the design. The Plan includes detailed calculations and explanations covering each design segment.

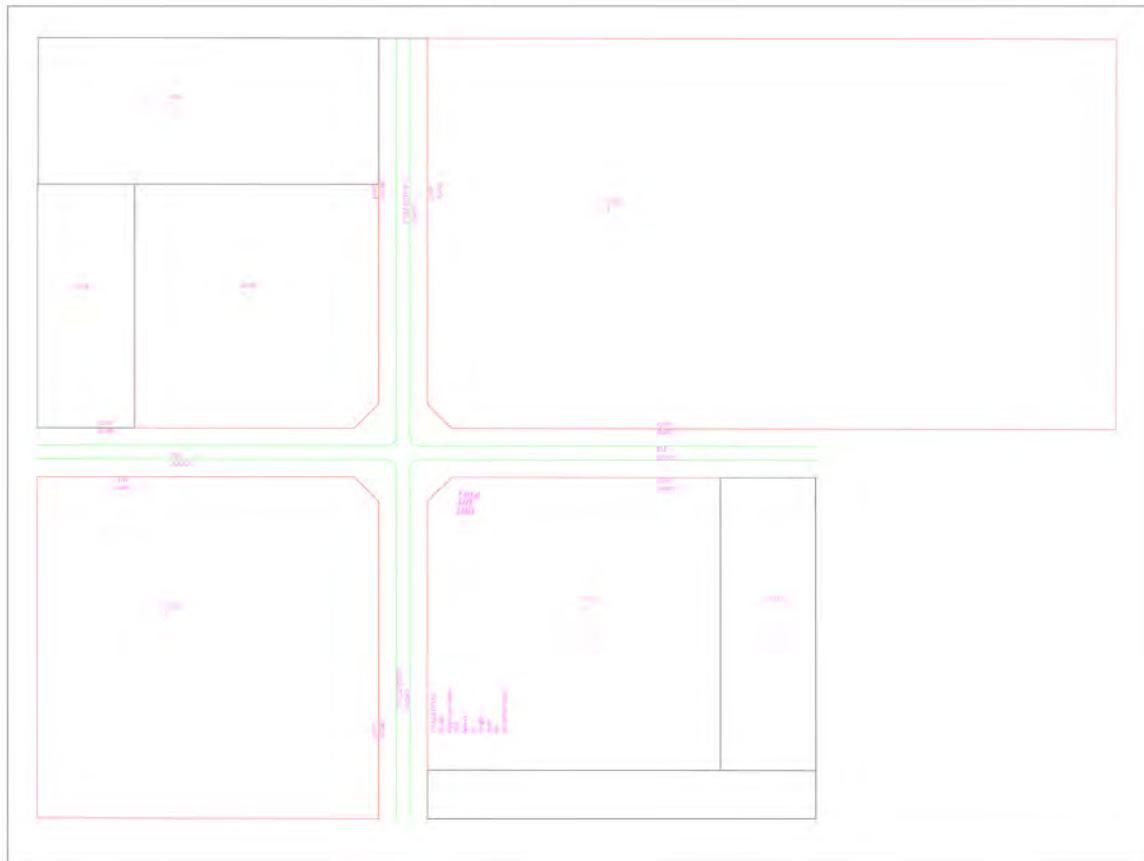


Figure 1 Existing Conditions



Objectives

After finishing this project, the engineers from Sterling Engineering will be able to:

- Traffic and Transportation
 - Use the Trip Generation Manual to determine the traffic demand
 - Design a fully actuated traffic signal with left and right turn lanes
 - Determine the best fit vehicle detection system
 - Create a layout of a parking lot including stripping, stormwater inlets, curbs, driveways, number of parking stalls, including handicap accessible
- Water Resources
 - Design detention ponds
 - Create stormwater system including inlets, pipe routing, and sheet flow
 - Calculate reservoir routing
 - Create inflow and outflow hydrographs
- Structural and Geotechnical
 - Design foundations for traffic signal poles and parking lot lighting
 - Create a soil boring profile
 - Design a general foundation plan 
 - Design a gas station canopy
- Environmental
 - Design a water treatment schematic
 - Design a wastewater treatment schematic

Chapter 1. Geotechnical

For this plan, the ground level began at zero elevation and a soil boring report was provided. The buildings were raised to a required 12 inches and foundations were designed for traffic signals, light poles, and the gas station canopy.

1.1 Soil Boring Profile

The Table 1.1.1 below shows the characteristics of the soils for the boring log B-2 (Appendix C). It shows the Standard Penetration Test, SPT, blow count of the last 12 inches of each boring log at the different depth given.

Table 1.1.1 Soil Characteristics

Depth (ft)	SPT Blow Count	Soil Consistency	Soil Type	Soil Color
3	9	Stiff	silty sand (SM)	Brown
5	14	Stiff	silty sand (SM)	Brown
7	7	Medium	Sandy Lean Clay (CL)	Brown
13	11	Stiff	Sandy Lean Clay (CL)	Brown
15	13	Stiff	Silty Clayey Sand (SC-SM)	tan
16	Water Table			
29	23	Very Stiff	Sandy Silt (ML)	Tan and gray
34	10	Stiff	Sandy Lean Clay (CL)	tan
49	40	Hard	Clayey Sand (SC)	Gray and Grayish tan
64	33	Hard	Clayey Sand (SC)	Gray and Grayish tan

The boring logs contained the direct characteristics of several layers of soil. The thickness of the soil layers and soil colors varied as well. The types of soil were primarily silty sand (SM), sandy lean clay (CL) and clayey sand (SC) based on Table 1.1.2: Soil Classification Chart by Unified Soil Classification (USC) System (ASTM D 2487). Table 1.1.2 was referenced from the textbook (Liu et. al 17).

Table 1.1.2. Soil Classification Chart by Unified Soil Classification System (ASTM D 2487)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A				Soil Classification		
				Group Symbol	Group Name ^B	
Coarse-grained soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean gravels: Less than 5% fines ^C	$C_u \geq 4$ and $1 \leq C_c \leq 3^E$	GW	Well-graded gravel ^F	
		Gravels with fines: More than 12% fines ^C	$C_u < 4$ and/or $1 > C_c > 3^E$	GP	Poorly graded gravel ^F	
			Fines classify as ML or MH	GM	Silty gravel ^{F,G,H}	
			Fines classify as CL or CH	GC	Clayey gravel ^{F,G,H}	
			$C_u \geq 6$ and $1 \leq C_c \leq 3^E$	SW	Well-graded sand ^I	
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean sands: Less than 5% fines ^D	$C_u < 6$ and/or $C_c < 1$ or $C_c > 3^E$	SP	Poorly graded sand ^I	
		Sands with fines: More than 12% fines ^D	Fines classify as ML or MH	SM	Silty sand ^{G,H,I}	
			Fines classify as CL or CH	SC	Clayey sand ^{G,H,I}	
			$PI > 7$ and plots on or above "A" line ^J	CL	Lean clay ^{K,L,M}	
			$PI < 4$ plots below "A" line ^J	ML	Silt ^{K,L,M}	
Fine-grained soils: 50% or more passes the No. 200 sieve	Silts and clays: Liquid limit less than 50	Inorganic	Liquid limit—oven dried < 0.75	OL	Organic clay ^{K,L,M,N}	
		Organic	Liquid limit—not dried		Organic silt ^{K,L,M,O}	
	Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay ^{K,L,M}	
			PI plots below "A" line	MH	Elastic silt ^{K,L,M}	
			Liquid limit—oven dried < 0.75	OH	Organic clay ^{K,L,M,P}	
		Organic	Liquid limit—not dried		Organic silt ^{K,L,M,Q}	
				PT	Peat	
		Highly organic soils		Primarily organic matter, dark in color, and organic color		

^ABased on the material passing the 3-in. (75-mm) sieve.

^BIf field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^CGravels with 5 to 12% fines require dual symbols:
GW-GM, well-graded gravel with silt
GW-GC, well-graded gravel with clay
GP-GM, poorly graded gravel with silt
GP-GC, poorly graded gravel with clay

^DSands with 5 to 12% fines require dual symbols:
SW-SM, well-graded sand with silt
SW-SC, well-graded sand with clay
SP-SM, poorly graded sand with silt
SP-SC, poorly graded sand with clay

^E $C_u = D_{60}/D_{10}$, $C_c = (D_{30})^2/(D_{10} \times D_{60})$

^FIf soil contains $\geq 15\%$ sand, add "with sand" to group name.

^GIf fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

^HIf fines are organic, add "with organic fines" to group name.

^IIf soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^JIf Atterberg limits plot in hatched area, soil is a CL-ML silty clay.

^KIf soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^LIf soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.

^MIf soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.

^ABased on the material passing the 3-in. (75-mm) sieve.

^BIf field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^CGravels with 5 to 12% fines require dual symbols:

GW-GM, well-graded gravel with silt

GW-GC, well-graded gravel with clay

GP-GM, poorly graded gravel with silt

GP-GC, poorly graded gravel with clay

^DSands with 5 to 12% fines require dual symbols:

SW-SM, well-graded sand with silt

SW-SC, well-graded sand with clay

SP-SM, poorly graded sand with silt

SP-SC, poorly graded sand with clay

$$C_u = D_{60}/D_{10}, C_c = (D_{30})^2/(D_{10} \times D_{60})$$

^EIf soil contains $\geq 15\%$ sand, add "with sand" to group name.

^FIf soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^GIf fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

^HIf fines are organic, add "with organic fines" to group name.

^IIf soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^JIf Atterberg limits plot in hatched area, soil is a CL-ML silty clay.

^KIf soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^LIf soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.

^MIf soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.

The soil consistencies were determined using Table 1.1.3 (from Terzaghi and Peck, 1967) based on the SPT blow-counts. Based on the SPT blow count, it can be seen that the soil profile of boring B-2 at depth of 3ft and 5 ft the soil is stiff. At 7ft the soil is medium, at 13ft and 15ft the soil is stiff again. At 29 ft the soil is very stiff, at 34ft is stiff and at ft 49 and 64 the soil is hard.

Table 1.1.3 Approximate Values of C_u , SPT, & Soil Consistency

Soil Consistency	SPT N (See Note)	S_u (psf)
Very Soft	< 2	< 250
Soft	2 - 4	250 - 500
Medium	4 - 8	500 - 1000
Stiff	8 - 15	1000 - 2000
Very Stiff	15 - 30	2000 - 4000
Hard	> 30	> 4000

The Table 1.1.4 below shows the percentage of moisture, liquid and plastic limits, plasticity index, percent passing, American Association of State Highway and Transportation Officials, AASHTO, classification from table 1.1.5 (Liu et. al 13) and USC classification from Table 1.1.2.

Table 1.1.4 Soil Properties

Cu (psf) (approx)	Moisture (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 200	AASHTO Classification	USC Classification
1143	10	-	-	-	-	-	-
1857	13	17	16	1	71	A-4	SM (silty sand)
875	21	-	-	-	-	-	-
1428	20	-	-	-	-	-	-
1714	19	76	24	52	64	A-7-6	CH (fat clay)
3067	23	-	-	-	-	-	-
1286	24	-	-	-	-	-	-
4000	32	-	-	-	-	-	-
4000	19	-	-	-	-	-	-

Table 1.1.5 Classification of Soils by AASHTO

General Classification	Granular Materials (35% or less passing 0.075 mm) <i>~ 200 sieve</i>							Silt-Clay Materials (more than 35% passing 0.075 mm)				
	A-1 <i>Good material</i>			A-2				<i>Not Good material</i> A-5		A-6	A-7	
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6	
Sieve analysis: <u>Percent passing:</u>												
2.00 mm (No. 10)	50 max.	—	—	—	—	—	—	—	—	—	—	
0.425 mm (No. 40)	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—	
0.075 mm (No. 200)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.	
Characteristics of fraction passing 0.425 mm (No. 40):												
Liquid limit	—	—	—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	
Plasticity index	6 max.	—	NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min. ¹	
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils		
General ratings as subgrade	Excellent to good						Fair to poor					

¹Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

Source: Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Part I, Specifications, 30th ed., AASHTO, 2010.

Table 1.1.5 was used to classify the soil according to AASHTO. With the data provided it was determined that two types of soil classifications were on the samples collected, A-4 and A-7-6

In order to determine the ultimate bearing capacity the Table 1.1.6 below was used to determine the angle of internal friction of the soil and the dry unit weight. The internal angle of friction was 32.6° and the unit weight, 16.4 kN/m^3 (104.4 lb/ft^3).

Table 1.1.6 Relationship among relative density, penetration resistance, dry unit weight, and angle of internal friction of cohesionless soils

Descriptive Relative Density	Relative Density **	Standard Penetration Resistance N_1 (see Note) *	Static Cone Resistance q_c	Angle of Internal Friction ϕ	Dry Unit Weight
	%	blows/foot	tsf or kgf/cm^2	degrees	KN/m^3
Very Loose	< 15	< 4	< 50	< 30	< 14
Loose	15 - 35	4 - 10	50 - 100	30 - 32	14 - 16
Medium Dense	35 - 65	10 - 30	100 - 150	32 - 35	16 - 18
Dense	65 - 85	30 - 50	150 - 200	35 - 38	18 - 20
Very Dense	85 - 100	> 50	> 200	> 38	> 20

* N_1 = N -value corrected to an effective vertical overburden pressure of 1.0 tsf or 100 kPa

** Freshly deposited, normally consolidated sand

Note: As originally proposed, this correlation used the uncorrected SPT blowcount, N_1 . However, hammers delivering 60% of the theoretical energy have been the most commonly used hammers for SPT tests, and it seems likely that the data on which the correlation was based was obtained primarily from tests with such hammers. It therefore seems logical to use $N_{1,60}$ with this correlation, and it is the recommendation of this report that this be done.

The footing calculation results were determined to find the worst footing for foundation design and settlement considerations.

The ultimate bearing capacity for a shallow, square footing was found from the equation:

$$q_{ult} = 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma$$

C = cohesion of soil

N_c, N_q, N_γ = Terzaghi's bearing capacity factors

γ = effective unit weight of soil above the base of the foundation.

D_f = Depth of footing

B = width of square footing

The cohesion of soil is already known and all of Terzahai's bearing capacity factors were taken from Table 1.1.7 (Liu et. al 155) where the angle of internal friction was 32.6°.

Table 1.1.7. Relationship between Bearing Capacity Factors and angle of internal friction

ϕ°	N_c	N_q	N_γ
0	5.14	1.00	0.00
2	5.63	1.20	0.01
4	6.19	1.43	0.04
6	6.81	1.72	0.11
8	7.53	2.06	0.21
10	8.34	2.47	0.37
12	9.28	2.97	0.60
14	10.37	3.59	0.92
16	11.63	4.34	1.37
18	13.10	5.26	2.00
20	14.83	6.40	2.87
22	16.88	7.82	4.07
24	19.32	9.60	5.72
26	22.25	11.85	8.00
28	25.80	14.72	11.19
30	30.14	18.40	15.67
32	35.49	23.18	22.02
34	42.16	29.44	31.15
36	50.59	37.75	44.43
38	61.35	48.93	64.08
40	75.32	64.20	93.69
42	93.71	85.38	139.32
44	118.37	115.31	211.41
46	152.10	158.51	329.74
48	199.27	222.31	526.47
50	266.89	319.07	873.89

Therefore,

$$q_u = 1.3 * 1857 * 33.35 + 104.4 * 5 * 25.06 + .04 * 104.4 * B * 24.76$$

$$q_u = 103585.929 + 1033.98B$$

Since the load that needs to be supported by the foundation is 130801bs. And a factor of safety of 3 was used,

$$q_{allow} = \frac{q_u}{FS}$$

$$q_{allow} = \frac{q_u}{3}$$

$$q_{allow} = \frac{103585.929 + 1033.98B}{3}$$

$$q_{allow} = 34528.64 + 344.66B$$

Now,

$$Q = q_{allow}B^2$$

$$13080 = (34528.64 + 344.66B)B^2$$

$$0 = 344.66B^3 + 34528.64B^2 - 13080$$

$$B = 7.4 \text{ in} \sim 1 \text{ ft}$$

Thus the side of the square footing should be 1 foot wide. Further footing sizing is discussed in Chapter 1.4 Gas Station Canopy Foundation.



$$q_u = 34528.64 + 1033.98B$$

$$q_u = 34528.64 + 1033.98(1)$$

$$q_u = 35562.62 \frac{\text{pounds}}{\text{square foot}}$$

1.2 Grading

Fill was found by first using the land use chart to get the building descriptions and square footage. There were a total of nine buildings which were; Walmart (275,000 sq.ft), CVS (15,000 sq.ft), U.S. Post Office (9,500 sq.ft), Wells Fargo Bank (35,000 sq.ft), Car Wash (55,000 sq.ft),

Exxon Mobil Gas (44,000 sq.ft), Shipleys Donuts (4,500 sq.ft), and 24-Hour Fitness (67,250 sq.ft). The summation of the square footage was taken, then multiplied by the 1 ft lift. After the volume of fill was found in cubic feet it was then converted to cubic yards to find the final cost of earthwork. A 25 cu.yd off-highway dump truck was used for the hauling of material and it cost \$3.17 per cubic yard. Table 1.2.1 below shows how the cost of fill was calculated. There was no cut because the elevation was assumed to be zero.

Table 1.2.1 Cost of Fill

Building Description	Square Footage
Walmart	275,000
CVS	15,000
Walgreens	25,000
US Post Office	9,500
Wells Fargo Bank w/10,000 sq.ft. lease office space	35,000
Car Wash	55,000
Exxon Mobil Gas (10 pumps)	44,000
Shipleys Doughnuts	4,500
24-Hour Fitness	67,250
Total Square Footage =	530,250
12 Inch Lift = 1 foot lift	530,250
1 YD ³ = 27 FT ³	19,638
25 CY off-highway dump truck \$3.17/CY	\$62,255
Total Cost of Hauling Material =	\$62,255

1.3 Light Pole Foundation

According to Harris County, Figure 1.3.1 below shows the standard foundation design for a 25ft to 30ft parking light pole. The diameter of the foundation will be 2.5 ft and have a depth of 7 ft. It will use #4 reinforced bars and it will #3 ties at 12in o.c.

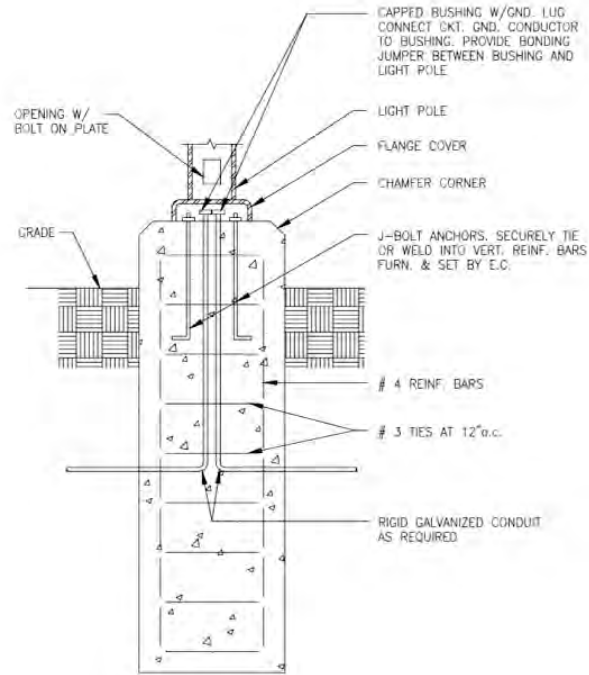


Figure 1.3.1-Standard foundation for a 25' to 30' high parking lot light.

1.4 Signal Pole Foundation

The traffic signal pole foundation was designed using the Harris County Engineering Department Strain Pole Assembly Details for 100 MPH Wind Zones. Figure 1.4.1 was used to determine the span wire design load (lbs.) with a span length of 90ft and 4 number of signal heads and using a sag of 8ft. The design load was determined to be 3500 lbs. Therefore according to the standards it will require a 34ft height pole. The strain pole assembly and elevation are shown in Figure 1.4.2.

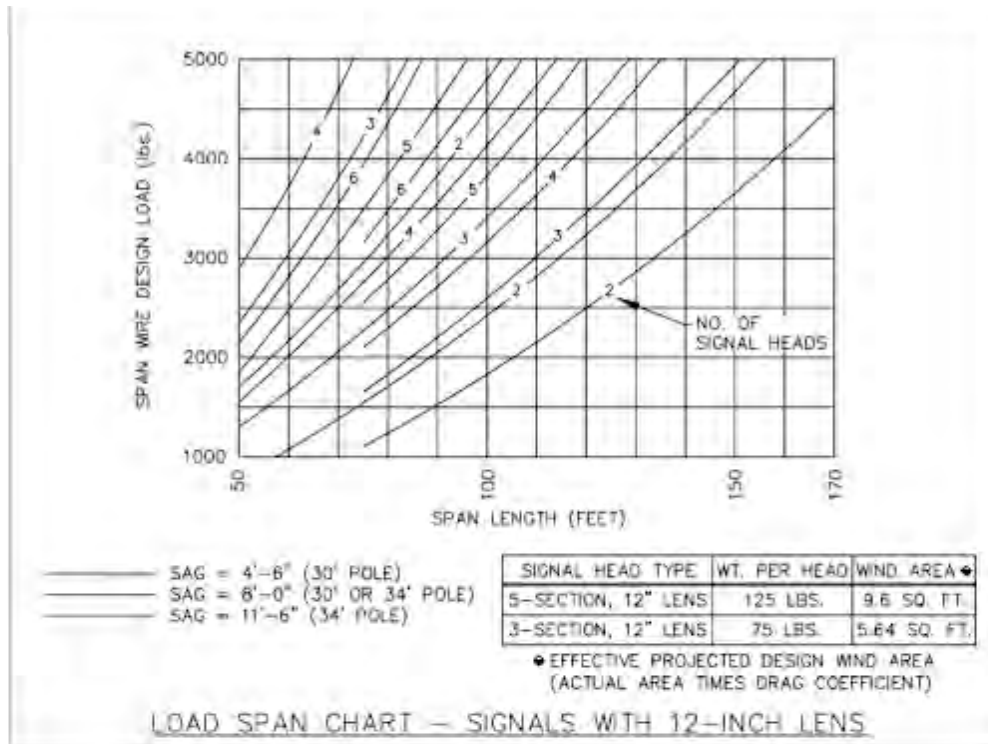


Figure 1.4.1 - Load Span Chart

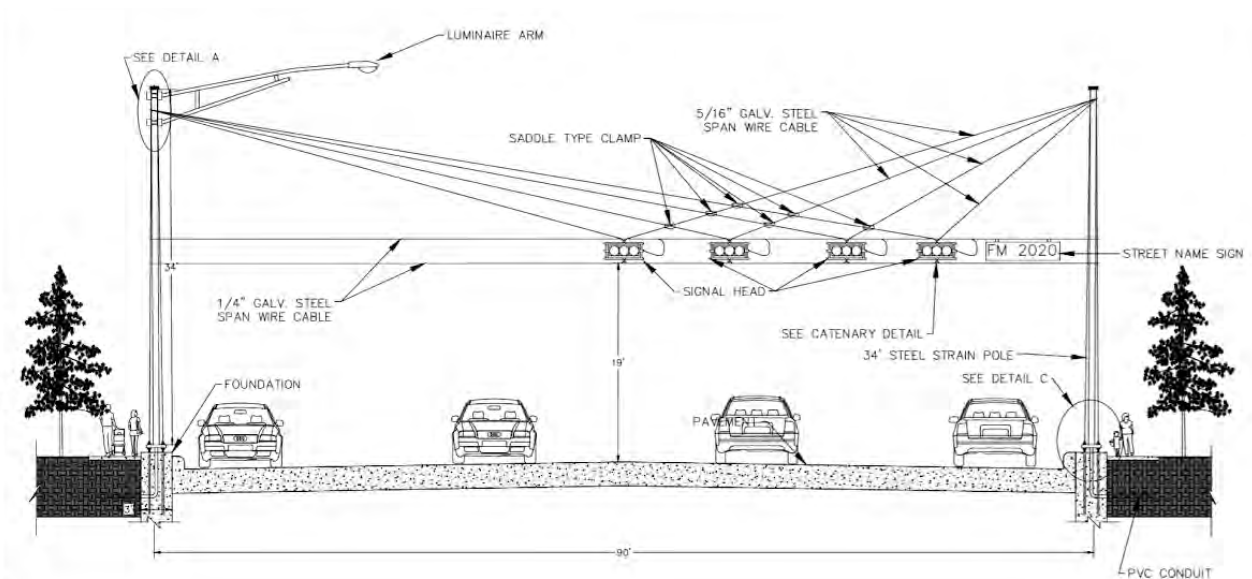


Figure. 1.4.2 - Strain Pole Assembly and Elevation

Table 1.4.1 gives us the design criteria for the foundation depending on the height of the pole. Since the pole is 34ft high, the foundation type that's going to be used is number 10036.

Table 1.4.1 Strain Pole Foundation Design Table

FOUNDATION TYPE	DRILL SHAFT DIAMETER	REINFORCING STEEL			DRILL SHAFT DIAMETER	ANCHOR BOLT DESIGN			FOUNDATION DESIGN LOAD			TYPICAL APPLICATION
		VERTICAL BARS	ADDITIONAL VERTICAL BARS	SPIRAL & PITCH		ANCHOR BOLT DIAMETER	F _y	BOLT CIRCLE DIAMETER	MOMENT	SHEAR	TORQUE	
DESCRIPTION	IN.				FT.	IN.	KSI	IN.	K-FT	KIPS	K-FT.	
10030	30"	8-#9	8-#9x7'-6"	#3@9"	16'-0"	2 1/4"	55	19"	184	7	0	CLAMP-ON MAST ARM ASSEMBLY, 30' STRAIN POLE WITH OR WITHOUT LUMINAIRE
10036	36"	8-#10	8-#10x8'-0"	#3@9"	14'-0"	2 1/4"	55	21"	236	8	0	CLAMP-ON MAST ARM ASSEMBLY, 34' STRAIN POLE WITH OR WITHOUT LUMINAIRE
									133	5	104	

The table shows a drill shaft diameter of 36in. For the reinforcement steel, the vertical bars will be eight #10 and and for the spiral reinforcement it will be #9 at 9 inches. It will have a depth of 14 ft. as shown in Figure 1.4.3 below.

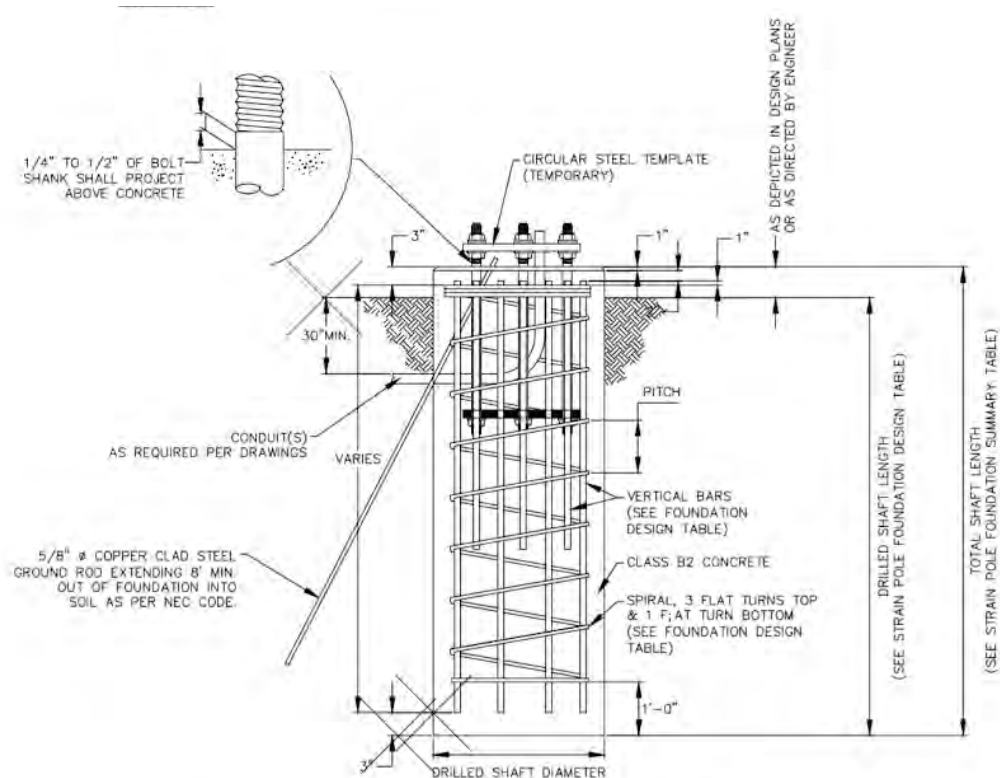


Figure 1.4.3 - Strain Pole Foundation

1.5 Gas Station Canopy Foundation

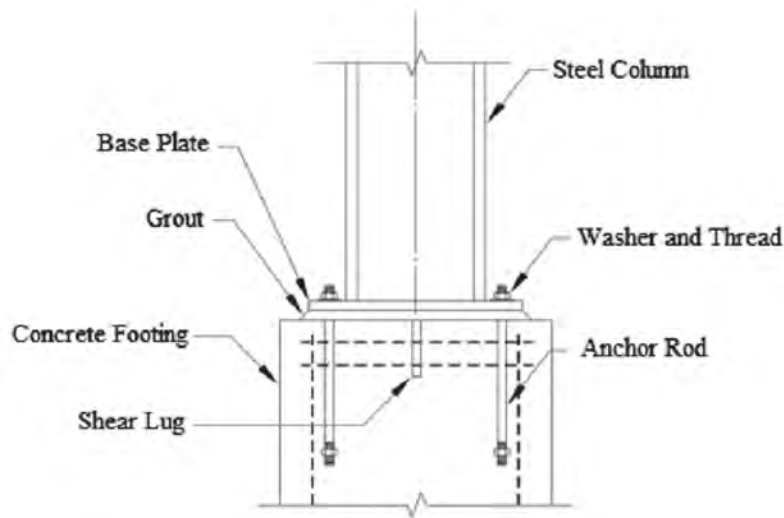


Figure 1.5.1 Components of a Steel Column Base

The Gas Station Canopy Foundation layout is approximated in Figure 1.5.1. First, the concrete footing was designed followed by the steel base plate. The concrete footing was square with grade 60 steel used for the reinforcement. Standard weight concrete, 150 pounds per cubic foot, with a compressive strength of 3000 pounds per square inch was used for the footings. An assumed footing thickness of 18 inches was used to begin the calculations. The width of the footing was determined in the geotechnical design (Ch1.1) to be 1 foot and the depth of the overburden soil to be 3 feet.

The allowable bearing capacity, q_{allow} , must be found from the ultimate bearing capacity (calculated in Ch1.1):

$$q_{allow} = \frac{q_u}{FS}$$

$$q_{allow} = \frac{q_u}{3}$$

$$q_{allow} = \frac{35562.62}{3}$$

$$q_{allow} = 11854.21$$

Using the allowable bearing capacity, the area of the foot was calculated:

$$A_{footing} = \frac{\text{Loading}}{q_a - w_{footing} - w_{soil}}$$

$$A_{footing} = \frac{13077}{11854 - (150) - (114 * 3)} = 1.15 \text{ square feet}$$

Where $A_{footing}$ = area of the footing

$w_{footing}$ = weight of the concrete footing

w_{soil} = weight of the overburden soil

The width of the footing was then calculated by taking the square root of 1.15 square feet and was 1.07 feet. Rounding up to one half foot increments gave the width as 1.5 feet (area of 2.25 square feet). Since this was larger than that calculated in the geotechnical design, the larger value of 1.5 feet was used.

The assumed thickness of the footings (18 inches) were tested for two-way (punching) shear and one-way. For the two-way shear, the theoretical effective depth, d , must be lower than the assumed value. The assumed value of the effective depth was the height minus 3 inches of clear cover or 15 inches.

The equation required calculating the perimeter of the shear, b_o , and the shear force for two-way, V_{u2} .

$$b_o = 4 * (d + w_{column})$$

$$b_o = 4 * (15 + 8) = 92 \text{ inches}$$

Where w_{column} = width of the column

$$V_{u2} = A_{footing} - q_u(d + w_{column})^2$$

$$V_{u2} = (2.25 - \left(\frac{4 + 8}{12}\right)^2) * 35562$$

$$V_{u2} = 44453 \text{ pounds}$$

With the perimeter of the shear and the shear force, the first theoretical effective depth was calculated.

$$d = \frac{V_{u2}}{\phi 4 \lambda \sqrt{f'_c} b_o}$$

$$d = \frac{44453}{0.75 * 4 * 1 \sqrt{3000} * 4 * 12} = 5.64 \text{ inches}$$

The resulting value, 5.64 inches was lower than the assumed value of 15 inches, meaning the two-way shear was in an acceptable range.

For the one-way shear the theoretical effective depth must be lower than the assumed value again. The shear force for one-way shear was needed.

$$V_{u1} = w_{footing} q_u \left(\frac{w_{footing}}{2} - \frac{w_{column}}{2} \right)$$

$$V_{u1} = 1 * 35562 \left(\frac{1.5}{2} - \frac{8/12}{2} \right)$$

$$V_{u1} = 14818 \text{ pounds}$$

With the shear force of the one one-way shear, the theoretical effective depth was calculated.

$$d = \frac{V_u}{\phi 2\sqrt{f'_c} w_{footing}}$$

$$d = \frac{14818}{0.75 * 2\sqrt{3000} * 1 * 12} = 10.02 \text{ inches}$$

Again, the value of the theoretical effective depth is less than the assumed depth, so the one-way shear is acceptable.

With both shears found acceptable, sizing the reinforcing steel and determining the development length remained. The reinforcement sizing was found using R_n to find ρ , the ratio of reinforcement in a section.

$$R_n = \frac{M_u}{\phi b d^2}$$

Where the ultimate moment, M_u , was found using Staad Pro to be 4403 kips. This allowed the R_n to be calculated:

$$R_n = \frac{4403}{0.9 * 18 * 18^2} = 0.84 \frac{\text{pounds}}{\text{square inch}}$$

Once R_n was known, Table 1.5.1 relating R_n to the ratio of reinforcement in a section was used from *Design of Reinforced Concrete* (McCormac 606).

Table 1.5.1 Relating R_n to the ratio of reinforcement in a section

	ρ	$\frac{M_u}{\phi b d^2}$	ρ	$\frac{M_u}{\phi b d^2}$	ρ	$\frac{M_u}{\phi b d^2}$	ρ	$\frac{M_u}{\phi b d^2}$
ρ_{min} for temp. and shrinkage	0.0018	105.7	0.0048	271.7	0.0078	424.9	0.0108	565.4
	0.0019	111.5	0.0049	277.0	0.0079	429.8	0.0109	569.9
	0.0020	117.2	0.0050	282.3	0.0080	434.7	0.0110	574.3
	0.0021	122.9	0.0051	287.6	0.0081	439.5	0.0111	578.8
	0.0022	128.6	0.0052	292.9	0.0082	444.4	0.0112	582.3
	0.0023	134.3	0.0053	298.1	0.0083	449.2	0.0113	587.6
	0.0024	139.9	0.0054	303.4	0.0084	454.0	0.0114	592.0
	0.0025	145.6	0.0055	308.6	0.0085	458.8	0.0115	596.4
	0.0026	151.2	0.0056	313.8	0.0086	463.6	0.0116	600.7
	0.0027	156.9	0.0057	319.0	0.0087	468.4	0.0117	605.1
	0.0028	162.5	0.0058	324.2	0.0088	473.2	0.0118	609.4
	0.0029	168.1	0.0059	329.4	0.0089	477.9	0.0119	613.7
	0.0030	173.7	0.0060	334.5	0.0090	482.6	0.0120	618.0
	0.0031	179.2	0.0061	339.7	0.0091	487.4	0.0121	622.3
ρ_{min} for flexure	0.0032	184.8	0.0062	344.8	0.0092	492.1	0.0122	626.6
	0.0033	190.3	0.0063	349.9	0.0093	496.8	0.0123	630.9
	0.0034	195.8	0.0064	355.0	0.0094	501.4	0.0124	635.1
	0.0035	201.3	0.0065	360.1	0.0095	506.1	0.0125	639.4
	0.0036	206.8	0.0066	365.2	0.0096	510.7	0.0126	643.6
	0.0037	212.3	0.0067	370.2	0.0097	515.4	0.0127	647.8
	0.0038	217.8	0.0068	375.3	0.0098	520.0	0.0128	652.0
	0.0039	223.2	0.0069	380.3	0.0099	524.6	0.0129	656.2
	0.0040	228.7	0.0070	385.3	0.0100	529.2	0.0130	660.9
	0.0041	234.1	0.0071	390.3	0.0101	533.8	0.0131	664.5
	0.0042	239.5	0.0072	395.3	0.0102	538.3	0.0132	668.6
	0.0043	244.9	0.0073	400.3	0.0103	542.9	0.0133	672.8
	0.0044	250.3	0.0074	405.2	0.0104	547.4	0.0134	676.9
	0.0045	255.7	0.0075	410.2	0.0105	551.9	0.0135	681.0
	0.0046	261.0	0.0076	415.1	0.0106	556.4	0.0136	685.0
	0.0047	266.4	0.0077	420.0	0.0107	560.9		

The value of the ratio of reinforcement in a section was found to be less than 0.0018. The ratio of reinforcement must meet minimum requirements of:

$$\rho = \frac{200}{f_y} \text{ or } \frac{3\sqrt{f'_c}}{f_y}$$

$$\rho = \frac{200}{60000} \text{ or } \frac{3\sqrt{3000}}{60000} = 0.0033 \text{ or } 0.00274$$

The largest of the three numbers, 0.0033, controlled the ratio. The area of steel reinforcement, A_s , can be found using ρ .

$$A_s = \rho w_{footing} d$$

$$A_s = 0.0033 * 42 * 15 = 2.079 \text{ square inches}$$

Using Table 1.5.2, three number 8 bars were chosen (McCormac 596) for both directions in the footing at 6 inch spacing.

Table 1.5.2 Area of Groups of Bars, in^2

Number of Bars	Bar Size Designation										
	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
2	0.22	0.39	0.61	0.88	1.20	1.57	2.00	2.54	3.12	4.50	8.00
3	0.33	0.59	0.92	1.33	1.80	2.36	3.00	3.81	4.68	6.75	12.00
4	0.44	0.79	1.23	1.77	2.41	3.14	4.00	5.08	6.24	9.00	16.00
5	0.55	0.98	1.53	2.21	3.01	3.93	5.00	6.35	7.80	11.25	20.00
6	0.66	1.18	1.84	2.65	3.61	4.71	6.00	7.62	9.36	13.50	24.00
7	0.77	1.37	2.15	3.09	4.21	5.50	7.00	8.89	10.92	15.75	28.00
8	0.88	1.57	2.45	3.53	4.81	6.28	8.00	10.16	12.48	18.00	32.00
9	0.99	1.77	2.76	3.98	5.41	7.07	9.00	11.43	14.04	20.25	36.00
10	1.10	1.96	3.07	4.42	6.01	7.85	10.00	12.70	15.60	22.50	40.00
11	1.21	2.16	3.37	4.86	6.61	8.64	11.00	13.97	17.16	24.75	44.00
12	1.33	2.36	3.68	5.30	7.22	9.42	12.00	15.24	18.72	27.00	48.00

The final parameter to determine was the development length. It was found using the following equation.

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{f_y}{\lambda \sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s}{c_b + K_{tr}} \frac{1}{d_b}$$

Where: l_d/d_b = development length in bar diameters

ψ_t = reinforcement location factor

ψ_e = coating factor

ψ_s = reinforcement size factor

λ = lightweight aggregate concrete factor

c_b = spacing or cover dimension

K_{tr} = transverse reinforcement index

Most of the factors involved in the development length were found in Table 1.5.3 (ACI Code, Section 25.4.2.4). The reinforcement location factor falls under other reinforcement or 1.0. There is no coating, so the coating factor is also 1.0. Since the reinforcement bars are size 8, the reinforcement size factor is 1.0. Normal weight concrete is used, so the lightweight aggregate concrete factor is 1.0. For the spacing or cover dimension, the shortest distance is from the reinforcing bar to the edge of the concrete - 1.5 inches. The transverse reinforcement index is calculated below:

$$K_{tr} = \frac{40A_{tr}}{sn}$$

$$K_{tr} = \frac{40 * 3}{6 * 3} = 6.67$$

Where A_{tr} = area of transverse reinforcements

s = center to center spacing

n = number of bars

Table 1.5.3: ACI Code, Section 25.4.2.4

(1) ψ_t = reinforcement location factor	
Horizontal reinforcement so placed that more than 12 in. of fresh concrete is cast in the member below the development length or splice	1.3
Other reinforcement	1.0
(2) ψ_e = coating factor	
Epoxy-coated or zinc and epoxy dual-coated reinforcement with cover less than $3d_b$, or clear spacing less than $6d_b$	1.5
Epoxy-coated or zinc and epoxy dual-coated reinforcement for all other conditions	1.2
Uncoated and zinc-coated (galvanized) reinforcement	1.0
However, the product of $\psi_t\psi_e$ need not be taken as greater than 1.7.	
(3) ψ_s = reinforcement size factor	
No. 6 and smaller bars and deformed wires	0.8
No. 7 and larger bars	1.0
In SI units	
No. 19 and smaller bars and deformed wires	0.8
No. 22 and larger bars	1.0
(4) λ (lambda) = lightweight aggregate concrete factor	
When lightweight aggregate concrete is used, λ shall not exceed	0.75
However, when f_{ct} is specified, λ shall be permitted to be taken as $\frac{f_{ct}}{6.7\sqrt{f_{cm}}}$, where f_{cm} is the measured average compressive strength of concrete (ACI Code, Section 19.2.4.3).	
It's $\frac{f_{ct}}{0.56\sqrt{f_{cm}}}$ in SI.	
But not greater than	1.0
When normal-weight concrete is used	1.0
(5) c_b = spacing or cover dimension, in.	
Use the smaller of either the distance from the center of the bar or wire to the nearest concrete surface, or one-half the center-to-center spacing of the bars or wires being developed.	

With all of the factors known, the development length was calculated.

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{6000}{1.0\sqrt{3000}} \frac{1.0 * 1.0 * 1.0}{\frac{1.5 + 6.67}{1.0}} = 1.01 \text{ diameters}$$

The development length of 1.01 diameters was rounded up to 1.25 diameters or 1.25 inches.

Next, the base plate's dimensions were calculated. The nominal bearing capacity with a resistance factor, ΦP_p , must exceed the concentrated axial load, P_u which equals 13.08 kips for this design.

$$P_u = 13.08 \text{ kips} \leq \phi P_p$$

Using the nominal bearing capacity equation, the bearing area of the base plate was determined.

$$\phi P_p = \phi 0.85 f'_c A_1 \sqrt{\frac{A_2}{A_1}}$$

Where f'_c = compressive strength of concrete

A_1 = bearing area of base plate

A_2 = full area of support for base plate

$$13080 = 0.65 * 0.85 * 3000 * A_1 \sqrt{\frac{324}{A_1}}$$

$$A_1 = 0.19 \text{ square inches}$$

The bearing area is 0.19 inches, but still had to be greater than or equal to the following equation:

$$1.7 f'_c A_1$$

$$13080 = 1.7(3000)A_1$$

$$A_1 = 2.56 \text{ square inches}$$

The bearing area of 2.56 square inches controlled, but the area of the plate had to be greater than or equal to the size of the 8 inch by 8 inch column or 64 square inches. Therefore, the area of the

plate was 64 square inches or 8 inch by 8 inch. Next, the thickness of the plate was determined by the following equation from AISC's Steel Construction Manual:

$$t \geq l \sqrt{\frac{2P_u}{0.90f_y B^2}}$$

Where: t = thickness of the plate

l = the larger of m or n

B = width of plate

The ℓ from the equation is the larger of m or n where

$$m = \frac{B - 0.95d}{2} = \frac{8 - 0.95 * 8}{2} = 0.2$$

$$n = \frac{B - 0.8b_f}{2} = \frac{8 - 0.8 * 8}{2} = 0.8$$

Where: d = depth of beam

bf = base of beam's flange

Since 0.8 was the largest, it was used to determine the thickness of the steel:

$$t \geq 0.8 \sqrt{\frac{2 * 13080}{0.90 * 3000 * 8^2}} = 0.31 \text{ inches}$$

The thickness was 0.31 but was rounded up to 0.5 inches.

Chapter 2. Structural

The gas station canopy is 125 feet long and 30 feet wide with ten 15 foot columns. It includes galvanized steel joists and sheet metal for roofing, as well as aluminum fascia. The basic outline is shown in Figure 2.0.

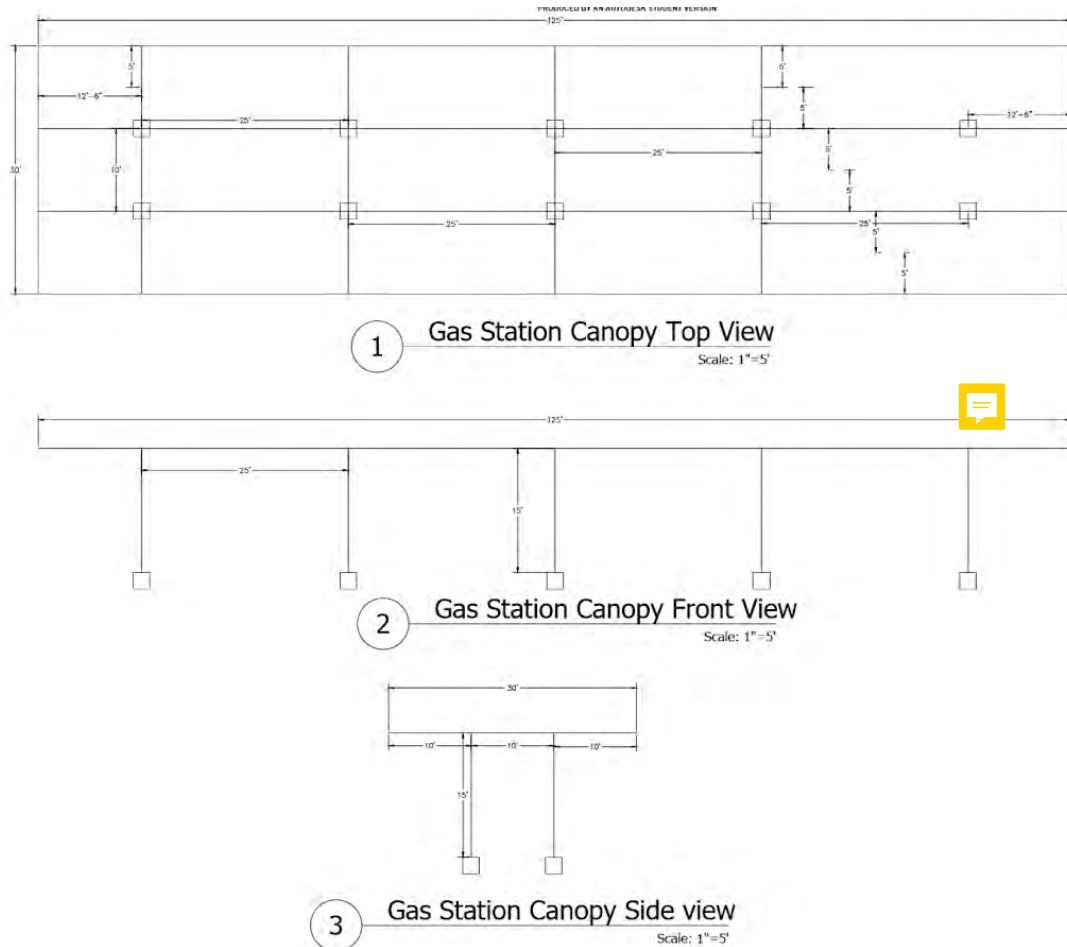


Figure 2.0 Gas Station Canopy

2.1 Canopy Loading

The canopy had three load types - live load, dead load, and wind load. The live and dead loads were distributed along the beams as shown in Figure 2.1.1. The twelve center panels delivered

their load in one direction and were calculated as a one-way loading system. The six exterior panels transferred their load in two directions and were calculated as two-way loading systems. Since the canopy's columns are interior to part of the roofing, concentrated loads were used to account for the loading exterior to the columns.

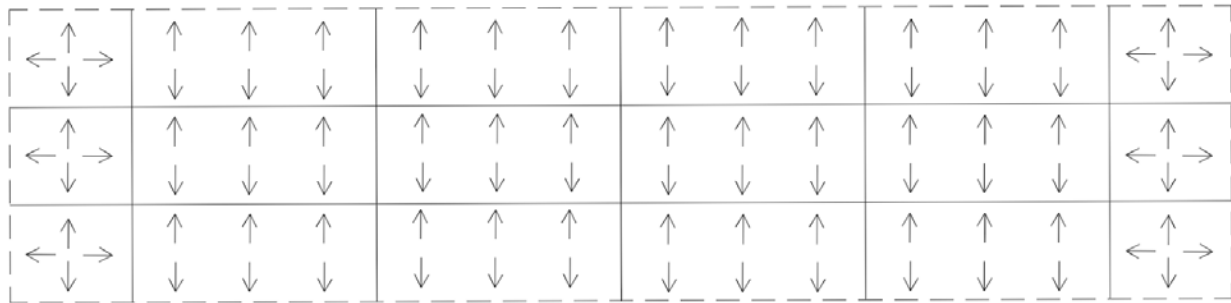


Figure 2.1.1 Distribution of Loads on Canopy

The live load used for this project was the ASCE 7-10 standard live load for roofs - 20 pound per square foot. The load was distributed as shown in the Staad Pro Model in Figure 2.1.2.

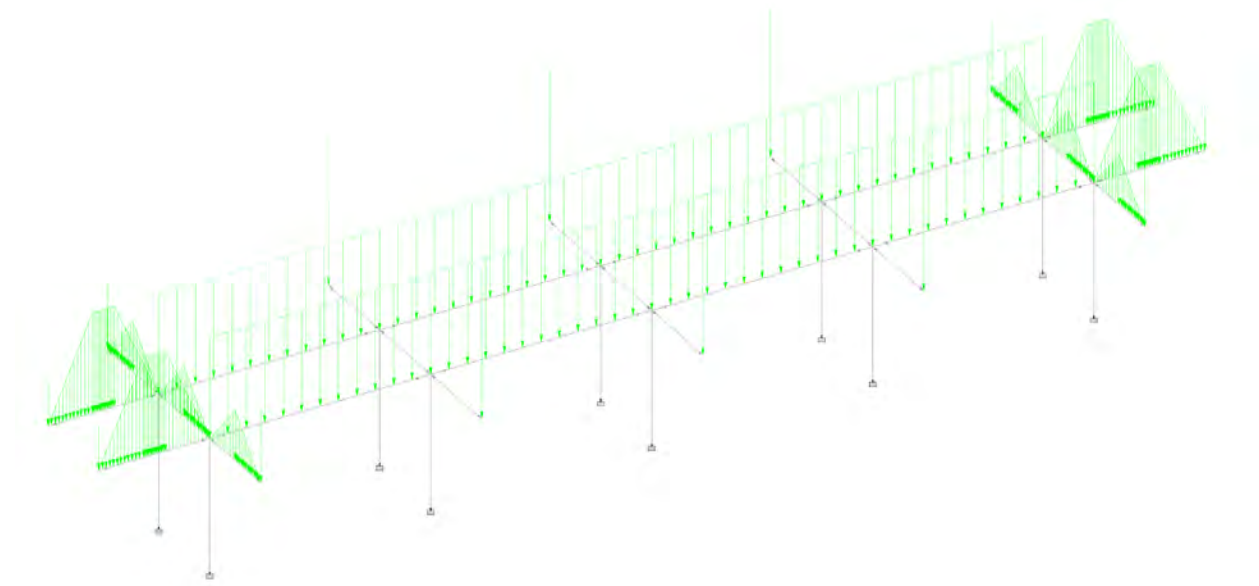


Figure 2.1.2 Live Loading Distribution

The dead load included the self-weight of the beam and columns and the roofing. The roofing dead load was calculated from the weight of materials shown below in Table 2.1.1.

Table 2.1.1 Roofing Dead Loads

Description of Load	Weight
Roofing - Metal decking	3 psf
Roofing - Rigid insulation	2 psf
Roofing - Mechanical and electrical	7 psf
Roofing - Joists & girders	5 psf
Roofing - Suspended ceiling	2 psf
Fascia - Aluminum Siding	1 psf
	20 psf

The dead load was distributed as shown in Figure 2.1.3. The figure does not show the self-weight of the columns and beams.

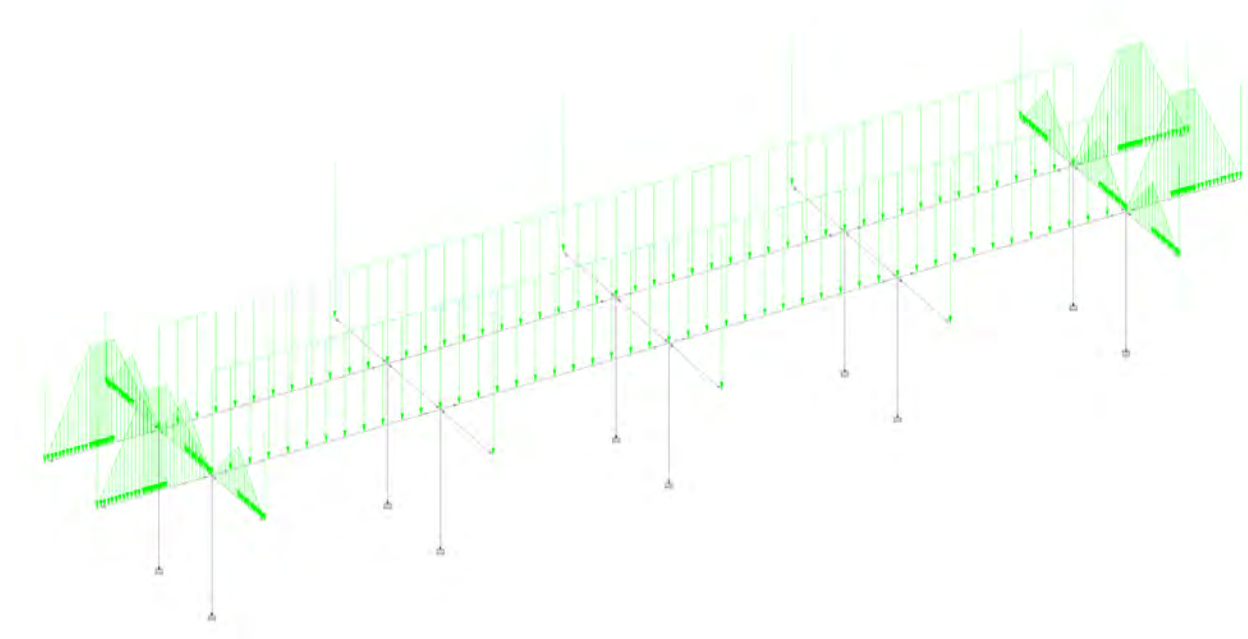


Figure 2.1.3 Dead Loading Distribution

The wind load was determined using ASCE 7-10, Chapter 30: Wind Loads—Components and Cladding. Within chapter 30, there are six parts. Each part is used to calculate the wind load for different types of buildings. For this project Chapter 30 part 5 was used. The figure 2.1.4 below shows the steps to take to calculate the wind load or open buildings.



Table 30.8-1 Steps to Determine C&C Wind Loads for Open Buildings
Step 1: Determine risk category, see Table 1.5-1 Step 2: Determine the basic wind speed, V, for applicable risk category, see Figure 26.5-1A, B, or C Step 3: Determine wind load parameters: ➤ Wind directionality factor, K_d, see Section 26.6 and Table 26.6-1 ➤ Exposure category B, C, or D, see Section 26.7 ➤ Topographic factor, K_{zt}, see Section 26.8 and Figure 26.8-1 ➤ Gust-effect factor, G, see Section 26.9 Step 4: Determine velocity pressure exposure coefficient, K_z or K_{hs}, see Table 30.3-1 Step 5: Determine velocity pressure, q_h, Eq. 30.3-1 Step 6: Determine net pressure coefficients, C_{Ns}, for ➤ Monosloped roof, see Fig. 30.8-1 ➤ Pitched roof, see Fig. 30.8-2 ➤ Troughed roof, see Fig. 30.8-3 Step 7: Calculate wind pressure, p, Eq. 30.8-1

Figure 2.1.4 Steps to determine C&C wind loads for Open Buildings

Step 1 is to determine the risk category of the building using the table 1.5-1 on the ASCE 7-10 book. The risk category for the gas station is 3. Step 2, is to determine the basic wind speed, V , for applicable risk category. According to the city of Houston the basic wind speed for a risk category 3 is 150mph. Step 3, wind load parameters were determined. The wind directionality factor, k_{zt} was determined to be 0.85. The exposure category is B. the topographic factor is 1 and the gust-effect, G is 0,05. Step 4, the velocity pressure exposure coefficient k_z was determined to be 0.7. Step 5, the velocity pressure was determined to be 34.76 lb/ft². Step 6, the net pressure coefficient was determined to be 2.4 and -3.3. 8

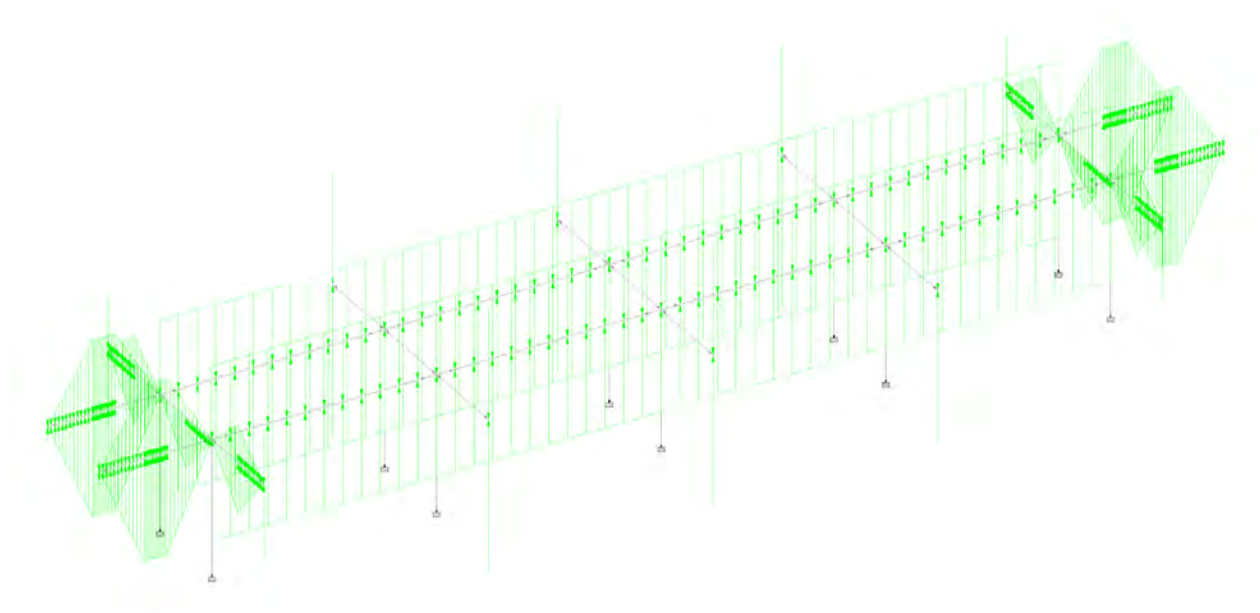


Figure 2.1.4 Wind Loading Distribution

2.2 Canopy Beams

The columns and beams for the canopy framing were determined with the use of Bentley's Staad Pro (a structural analysis and design software) and AISC's Steel Construction Manual. A standard W-shape beam was chosen by designing for the beams with the highest stresses. The following calculations were then completed to prove the chosen beam met the standard requirements for moment strength, shear strength, and deflection.

The first step in the process was to find the required and nominal moment strengths to satisfy the equation:

$$M_u \leq \phi M_n$$

Where M_u = required moment strength

ϕ = resistance factor for bending

M_n = nominal moment strength

Using Staad Pro, the required moment strength was determined to be 50 kips per foot. The nominal moment strength was found by assuming a beam size and then using the Steel Construction Manual to determine if the nominal moment strength of that beam met the requirements. For this design, a W12 x 65 beam was chosen with a nominal moment strength of 285 kip per foot, well exceeding the needed moment. Next, the nominal and required shear strengths were determined. Using Staad Pro, the required shear strength was determined to be 5.24 kips. For a W12 x 65 beam, the nominal shear strength time the resistance factor was 142 kips, again well exceeding the needed amount. With both moment and shear within acceptable parameters, the deflection of the beam was determined. Using Staad Pro, the required deflection was determined to be 0.61 inches. Nominal deflection is determined by the equation:

$$\Delta = \frac{5}{384} * \frac{wL^4}{EI}$$

Where Δ = maximum deflection

w = distributed live load

L = length of beam

E = Modulus of Elasticity

I = moment of inertia

The distributed live load was determined in section to be 0.02 kips per foot or 0.002 kips per inch. The length of the beam in question was 25 foot (300 inches) and the modulus of elasticity of steel 29,000 ksi. The moment of inertia was found to be 533 quartic inches (Steel Construction Manual 1-29). Therefore,

$$\Delta = \frac{5}{384} * \frac{0.002(300^4)}{29000 * 533} = 0.70 \text{ inches}$$

The maximum deflection of 0.70 inches was greater than the actual deflection of 0.61 inches, so the W12 x 65 beam was permissible.

The W12 x 65 beam passed all test calculations for moment strength, shear strength, and deflection.

2.3 Canopy Columns

For the column design, a combination of Staad Pro and the Steel Construction Manual from the American Institute of Steel Construction was used. A standard W-shape column was chosen by designing for the columns with the highest stresses. The following calculations were then completed to prove the chosen column met the standard requirements for compressive strength.

The first step in the process was to find the required and nominal compressive strengths to satisfy the equation:

$$P_u \leq \phi P_n$$

Where P_u = required compressive strength

ϕ = resistance factor

P_n = nominal compressive strength

Using Staad Pro, the required compressive strength was determined to be 13.08 kips. The total column height is 15 feet and the longest unbraced length is 15 feet. With a relatively low compressive strength needed, a W8 x 35 column was chosen to start with. The buckling strength in both the x and y directions must be calculated to determine which direction will control.

$$P_{CR-X} = \frac{\pi^2 EI_x}{(K_x L_x)^2} = \frac{\pi^2 * 29000 * 127}{(0.65 * 15)^2} = 382 \text{ kips}$$

$$P_{CR-Y} = \frac{\pi^2 EI_y}{(K_y L_y)^2} = \frac{\pi^2 * 29000 * 42.6}{(0.65 * 15)^2} = 128 \text{ kips}$$

Where P_{cr} = critical load for buckling

E = elastic modulus of steel

I = moment of inertia

K = effective length factor

L = unbraced length

Since the buckling strength is less in the y direction, y controls. The effective strength was found directly from the Steel Construction Manual to be 261 kips. This is much greater than the required compressive strength, so the W8 x 35 column will work.

Chapter 3. Traffic and Transportation

The traffic and transportation designs are based on the assumption of a 45 mile per hour speed limit.

3.1 Trip Generation

The number of trip ends generated by the land use for this development was determined using the Trip Generation manual from the Institute of Transportation Engineers (7th edition). The results are found in Table 3.1.1, but were limited by the data available in the Trip Generation manual. For example, the 24 Hour Fitness has a gross floor area of 67,000 square feet, but the Trip Generation data was only available up to a 50,000 square foot club. Given these limitations, an estimate of 2762 trip ends are expected for the weekday peak hours in the evening.

Table 3.1.1 Trip Generation

			Variable		Weekday, Peak Hour		Limitations
ITE Code	Store Name	ITE Description	Name	Number	AM	PM	
210	Housing	Single Family Detached Housing	Dwelling Units	250	187	251	
492	24 Hour Fitness	Health and Fitness Club	1000 Sq Feet Gross Floor Area	67	70	200	Information only available up to 50k sq feet
732	US Post Office	United States Post Office	1000 Sq Feet Gross Floor Area	0.9	50	50	
813	Walmart	Free-Standing Discount Superstore	1000 Sq Feet Gross Floor Area	275	675	875	Information only available up to 210k sq feet
853	Exxon Mobil	Convenience Market with Gasoline Pumps	1000 Sq Feet Gross Floor Area	44	200	300	Information only available up to 4.5k sq feet
881	CVS	Pharmacy/Drugstore with Drive-Through Window	1000 Sq Feet Gross Floor Area	15	117	143	
881	Walgreen s	Pharmacy/Drugstore with Drive-Through Window	1000 Sq Feet Gross Floor Area	25	117	143	Information only available up to 15k sq feet
912	Wells Fargo	Drive-in Bank	1000 Sq Feet Gross Floor Area	35	440	750	Information only available up to 14k sq feet
934	Shipleys Donuts	Fast-Food Restaurant with Drive-Through Window	1000 Sq Feet Gross Floor Area	0.45	25	50	Information only available down to 1k sq feet
948	Carwash	Automated Car Wash	Sq Feet	55000			No information available
				Total	1881	2762	

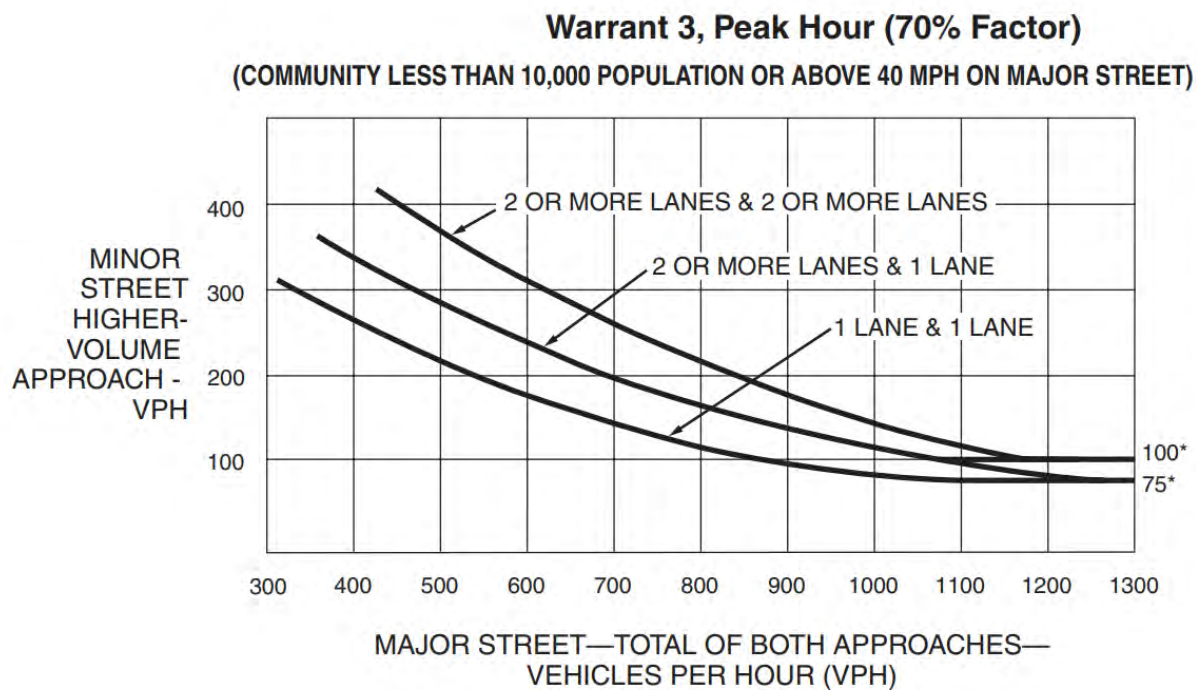
3.2 Number of Lanes

Using the trip generation results, the design volume for both roadways rounds up to three thousand vehicles per hour. Using 1000 vehicles per lane criterion from AASHTO's Geometric

Design of Highways and Streets, the development needs three lanes in each direction for both roadways.

3.3 Signal Warrant Study

A signal warrant study was done for the intersection of FM 2020 and Success Road using the Manual on Uniform Traffic Control Devices (MUTCD). Signalization was justified using Warrant 3, Peak Hour graph which is shown in Figure 3.3.1. This development called for 2 or lanes for both streets, so the top line on the graph was used to determine the minimum requirements. Using the trip generation results, the minor street, Success Road, has approximately 1400 vehicles per hour in one direction and the major street, FM 2020, has approximately 2800 vehicles per hour in both directions. The point of (2800, 1400) is well above the required minimum line.



*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 3.3.1 Warrant 3, Peak Hour

3.4 Pavement Details

The curb below in figure 3.4.1 was designed based off of Harris County Engineering Department standards. From the top of the pavement to the center of the #4 continuous rebar is 4 inches and from the top of the pavement to the top of the curb is 6 inches. The maximum radius that the curve can be is 3 inches.

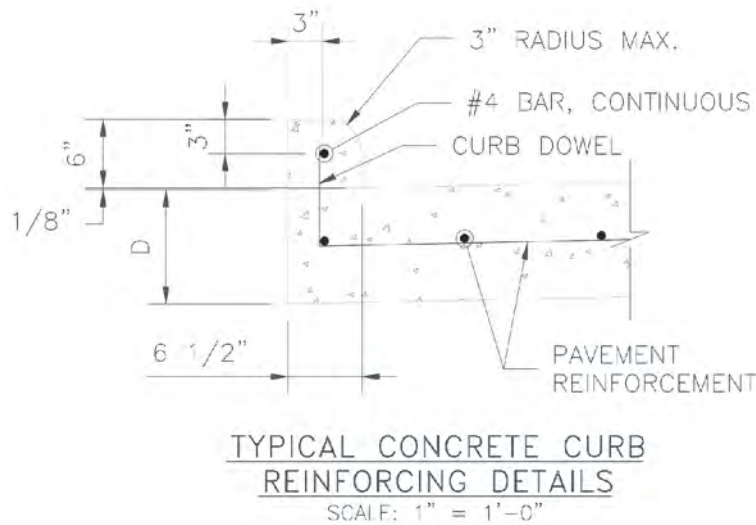


Figure 3.4.1 Concrete Curb

The spacing of longitudinal joints shown in Figure 3.4.3 were placed 12 feet from the front of the curb. The #5 rebars were placed at 18 inches apart from center to center. According to the Harris County Engineering Department the pavement had to be offset 12 inches from the edge of the stabilized subgrade.

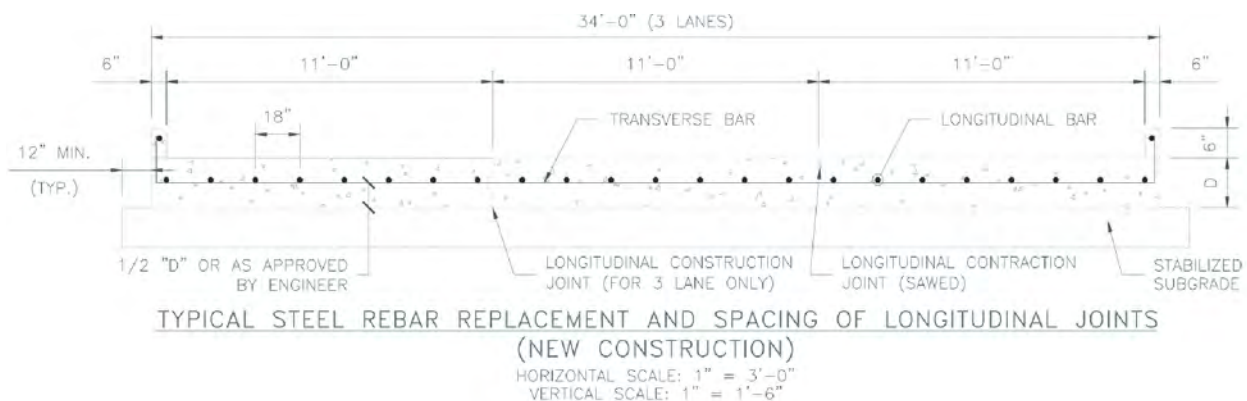


Figure 3.4.3 Longitudinal Joints

The spacing of transverse expansion and contraction joints shown below in Figure 3.4.2 were based off of the Harris County Engineering Department standards. The contraction and expansion joints were spaced every 20 feet in a span of 80 feet. Maximum. The spacing of each #5 bar was 36 inches from center to center.

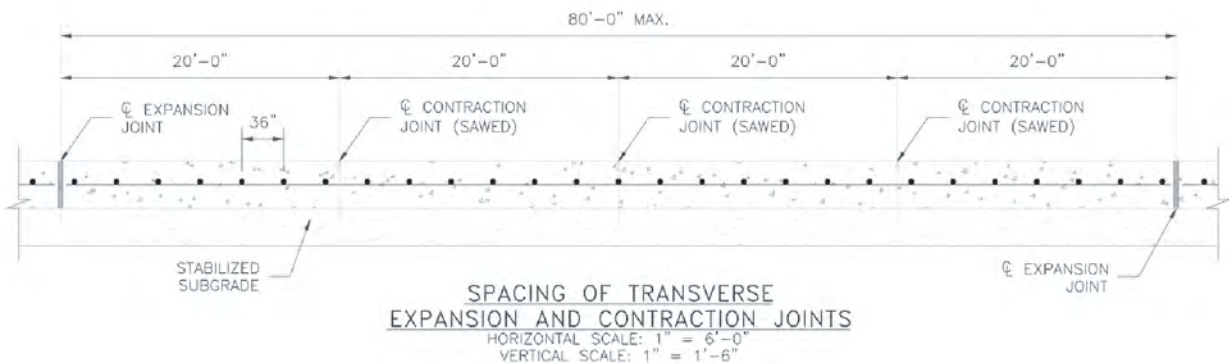


Figure 3.4.2 Expansion and Contraction Joints

The typical thickness of a concrete slab is 10 inches, but the minimum thickness is 6 inches in the city of Houston. For this project we choose to use a 10 inch concrete slab. The base layer is 6 inches thick and the subbase is as needed thickness depending on the conditions of the existing soil. Figure 3.4.4 below shows the layers of the roadway.

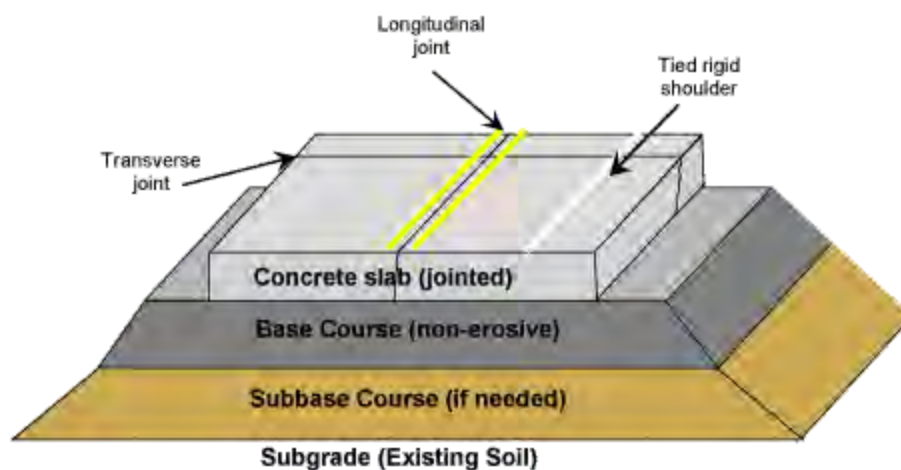


Figure 3.4.4 Layers of The Roadway

3.5 Signalization and Vehicle Detection

The proposed signalization of the intersection of FM 2020 and Success Road is shown in Figure 3.5.1. It includes four LED traffic signals, one for each lane, supported by two poles.

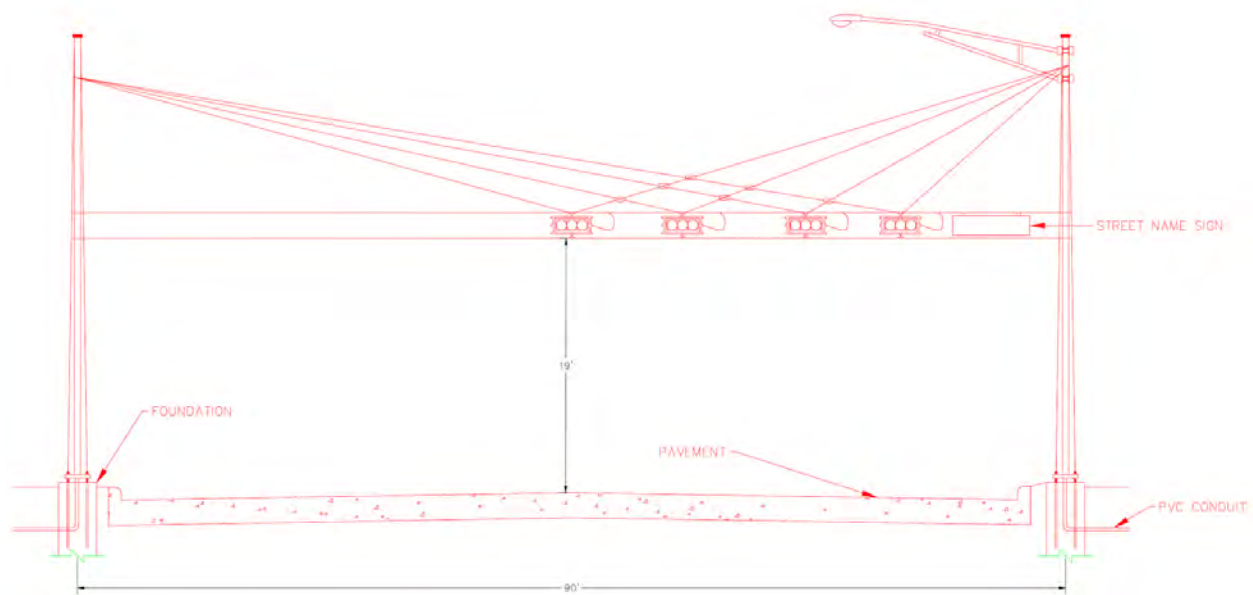


Figure 3.5.1 Signalization

According to the City of Houston's Design Manual, Chapter 15, the City requires the use of inductive loop vehicle detection systems as seen in Figure 3.5.2. The general function is the interruption of the inductance of the electromagnetic loop when a vehicle passes over. The inductive loop detection system has the advantages of being a mature, well understood technology that is insensitive to inclement weather such as rain, fog, and snow as well as having a lower cost than many alternatives. Its disadvantages include: requiring pavement cuts which decreases pavement life and requiring multiple devices to monitor a location.

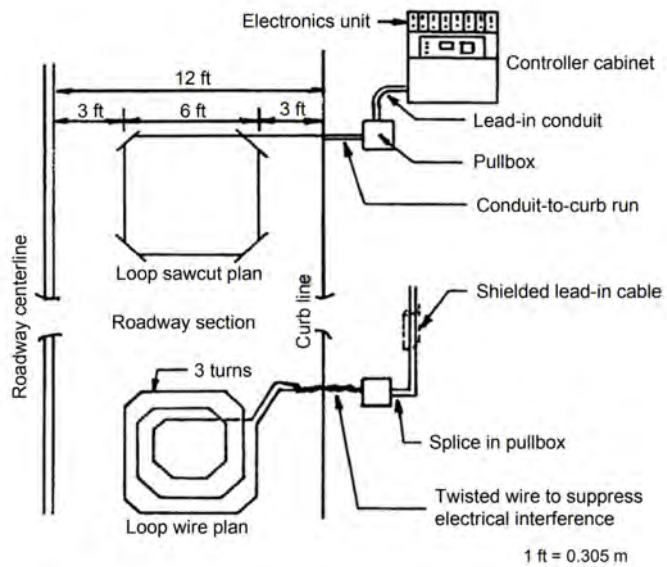


Figure 3.5.2 Principal Components of Inductive Loop Detector

3.6 Roadway Geometry

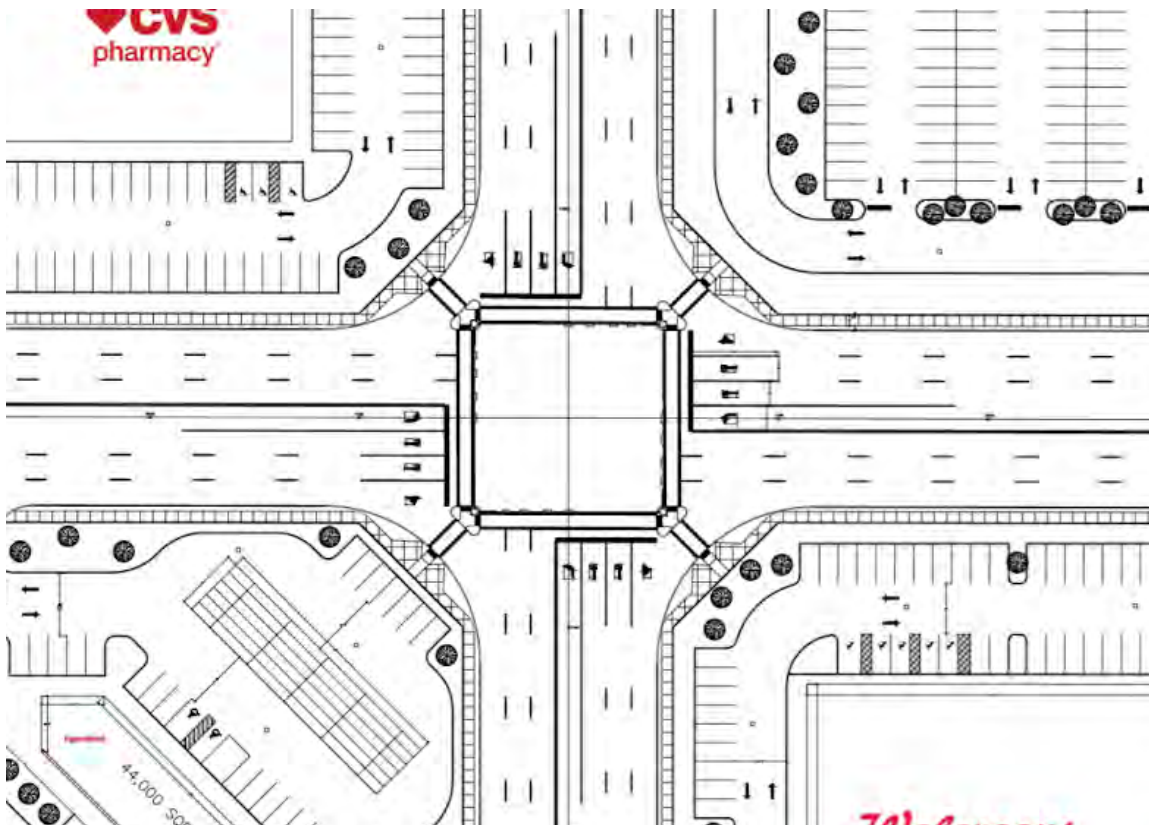


Figure 3.6.1 Roadway Layout

Figure 3.6.1 shows the roadway layout for this project. According to the trip generation the number of lanes on each direction was determined to be 3 lanes. Each direction consists of a left turn and a right turn lane at the intersection. For the left turn lane the storage length had a distance of 100ft. The intersection includes crosswalks. Beyond the intersection, the center lanes become a two way left turn lane.

3.7 Pavement Markings

Markings were placed to divide the lanes and left and right turn arrows were placed to direct traffic. TxDot standard road markings were used to design the roadway. Figure 3.7.1 shows some of the standard details that were used. For example it shows the minimum storage spacing for left turns, the different thickness of the marks, the placements of the raised pavement markers. Also, the markings needed for a continuous medium without a raised barrier.

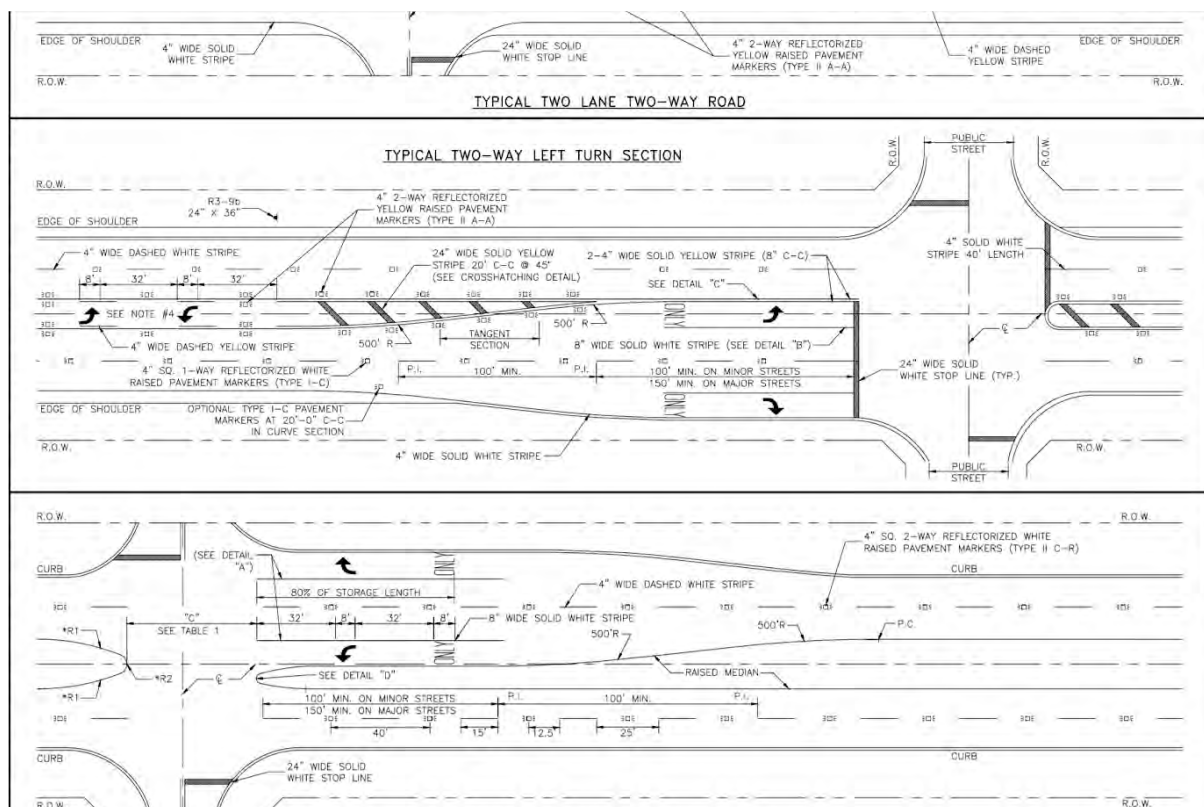


Figure 3.7.1 Harris County Standard Marking details

Figure 3.7.2 shows a close up of the markings of the roadway design. It is shown that the crosswalk has a gap of 6 ft and it is marked by two white lines of 1 ft in thickness. Then, the stop bar is located 4ft away from the crosswalk line and it has a thickness of 2 ft. The markings that separate the lanes start with a solid white 40 ft long then the hash line begins with a 30 ft spacing. Then a 10 ft long white dash followed by a 30 ft spacing again. This design is continued until the end of the roadway.

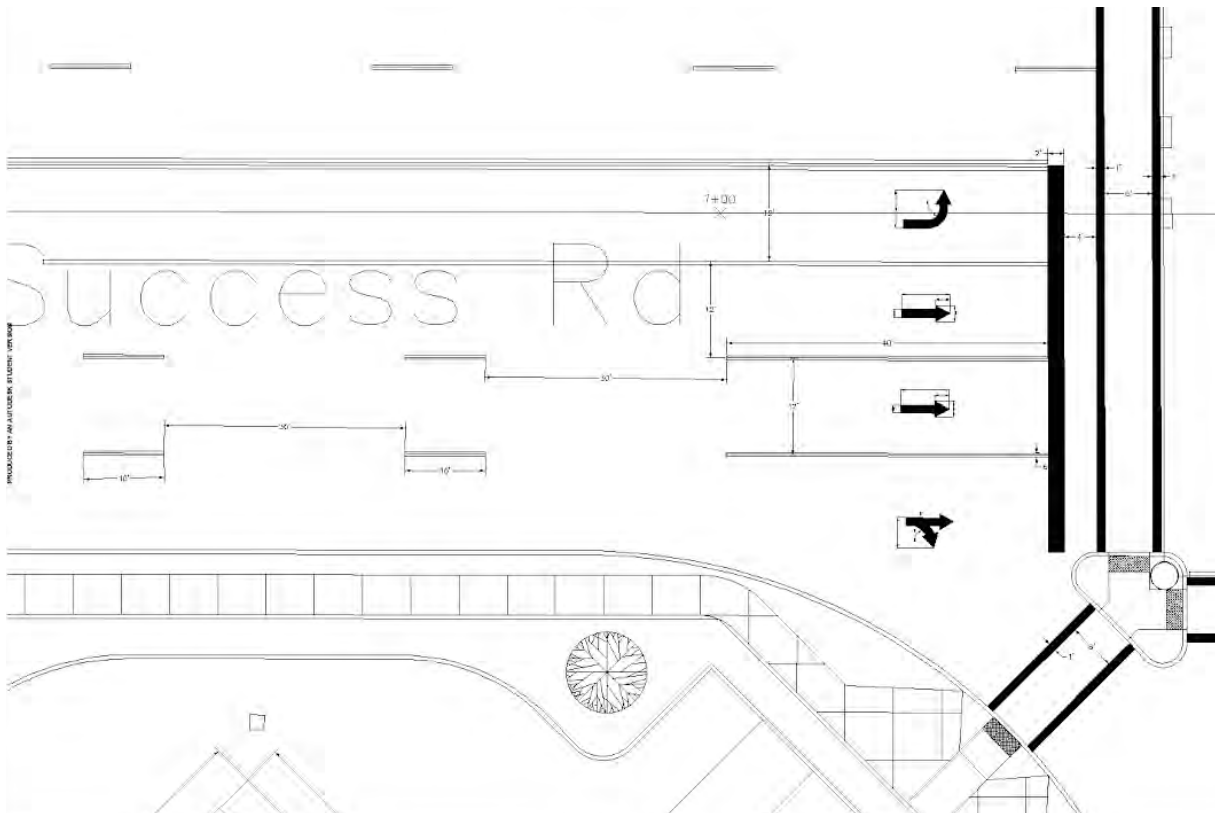


Figure 3.7.2 Example of the markings on Success road

3.8 Parking Lots

Parking lots were designed to accommodate the proper commercial facility. Table 3.8.1 below shows the parking spaces required depending on the square footage of the facility.

Table 3.8.1- Parking requirements based on the area of the facilities.

Building Description	SQFT.	Parking Spaces Required	ADA Parking	ADA Parking Van
Walmart	275,000	1100	21	3
CVS	15,000	60	3	1
Walgreens	25,000	100	4	1
US Post Office	9,500	24	1	1
Wells Fargo Bank w/10000 sf lease office space	35,000	125	5	1
Exxon Mobil Gas (10 pumps)	44,000	30	2	1
Car Wash (entire space cover with concrete)	55,000	35	2	1
Shipleys Doughnuts	4,500	27	2	1
24-Hour Fitness	67,250	337	8	1
Total	530,250	1803	48	11

Figure 3.8.1 below shows the parking lot design for walmart. It has 1100 parking spaces and 21 of those are dedicated for accessible parking. Three of the 21 ADA parking areas are van accessible.



Figure 3.8.1 - Walmart Parking lot

Figure 3.8.2 below shows the parking for Walgreens, Shipley's Doughnuts and Wells Fargo. All the parking areas combined add up to 252 spaces and 11 of those are designed for the ADA Parking and 3 are for van accessible.



Figure 3.8.2 - South East parking Commercial Development.

Figure 3.8.3 below shows the parking lot design for the USPS, Exxon Gas station, and the 24 Hour Fitness. All together there are 391 parking spaces and 11 of these are ADA parkings with 3 being for van access.



Figure 3.8.3 - South West Commercial Development.

Figure 3.8.4 below shows the parking lot design for the carwash and the CVS. The carwash has 35 parking spaces and 2 of them are ADA parkings. The CVS has 60 parking spaces and 3 of them are ADA parkings.

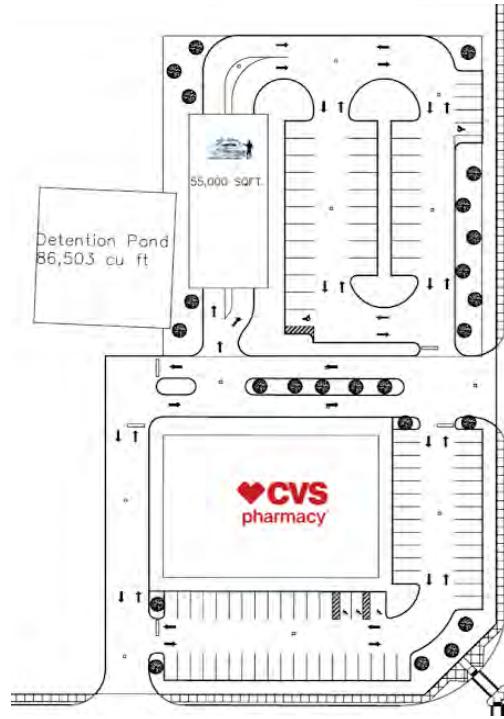


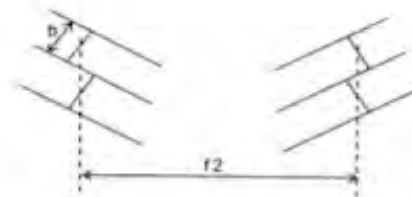
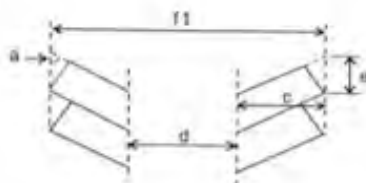
Figure 3.8.4 North West Commercial Development.

After determining the number of parking spaces, Table 3.8.2 , from the city of houston design manual, was used to determine the dimensions of the stalls.

Table 3.8.2 Parking Stall Dimensions

Parking Directions	a	b	c	d	e	Center to Center Width of Two Row Bin with Access Road Between (ft)	
	Parking Angle (Degrees)	Stall Width (ft)	Stall to Curb (ft)	Aisle Width (ft)	Curb Length (ft)	Curb to Curb	Overlap C-C
One-Way	0	7.5	7.5	12.0	21.0	27.0	-
		8.5	8.5	12.0	23.0	29.0	-
		9.0	9.0	12.0	23.0	30.0	-
One-Way	30	7.5	14.0	11.0	15.0	39.0	32.0
		8.5	16.0	11.0	17.0	43.0	36.0
		9.0	16.0	11.0	18.0	43.0	36.0
One Way	45	7.5	14.5	13.0	10.6	42.0	38.0
		8.5	16.5	15.0	12.0	48.0	44.0
		9.0	16.5	15.0	12.7	48.0	44.0
One Way	60	7.5	15.5	15.0	8.7	46.0	43.0
		8.5	18.0	18.0	9.8	54.0	51.0
		9.0	18.0	18.0	10.4	54.0	51.0
Two-Way	60	7.5	15.5	21.0	8.7	52.0	50.0
		8.5	18.0	26.0	9.8	62.0	59.0
		9.0	18.0	26.0	10.4	62.0	59.0
One-Way	75	7.5	16.0	17.0	7.8	49.0	47.0
		8.5	18.5	22.0	8.8	59.0	57.0
		9.0	18.5	22.0	9.3	59.0	57.0
Two-Way	75	7.5	16.0	21.0	7.8	53.0	51.0
		8.5	18.5	26.0	8.8	63.0	61.0
		9.0	18.5	26.0	9.3	63.0	61.0
Two-Way	90	7.5	15.0	21.0	7.5	51.0	-
		8.5	17.5	26.0	8.5	61.0	-
		9.0	17.5	26.0	9.0	61.0	-

- 7.5 feet = Compact size motor vehicles only
- 8.5 and 9.0 feet — Medium or large size motor vehicles



Since the design of the parking lot was based on a two way 90 degree parking lot, the stall width was 9ft and the length was 19ft. The aisle has a dimension of 24ft. For the accessible parking parking spaces, Table 3.8.3, was used to determine the minimum number of accessible parking spaces needed for the design of the commercial development. The table below was obtained from the Americans with Disabilities Act (ADA) web page. Table 3.8.3, was used to determine the minimum number of accessible parking spaces.

Table 3.8.3- Minimum Number of Accessible Parking Spaces

2010 Standards (208.2)

Total Number of Parking Spaces Provided in Parking Facility (per facility)	(Column A) Minimum Number of Accessible Parking Spaces (car and van)	Minimum Number of Van-Accessible Parking Spaces (1 of six accessible spaces)
1 to 25	1	1
26 to 50	2	1
51 to 75	3	1
76 to 100	4	1
101 to 150	5	1
151 to 200	6	1
201 to 300	7	2
301 to 400	8	2
401 to 500	9	2
500 to 1000	2% of total parking provided in each lot or structure	1/6 of Column A*
1001 and over	20 plus 1 for each 100 over 1000	1/6 of Column A*
*one out of every 6 accessible spaces		

Chapter 4. Water Resources

The water resources design consists of stormwater inlets leading to a detention pond that flows out into the City of Houston's stormwater drainage system.

4.1 Detention Pond

The detention pond was designed to hold all of the water that was collected on the property without flowing to any surrounding property. In order to design for the correct volume, the impervious surface had to be accounted for. Impervious surfaces are any surface that do not let any fluids pass through. The area of impervious surface was found by using autocad to find the area of each parking lot and building roofs. Chapter 9 of the City of Houston Design Manual referred to an equation that helped calculate for the detention volume after the area was found.

Total Detention Volume required is calculated as follows:

$$VT = [43,560 \times (0.50 \times AII)]$$

Where VT= Total detention volume (cu.ft)

AII = Impervious surface area(acres)

There is a detention pond in each corner which means there are four detention ponds. Each detention pond is in the shape of a truncated square pyramid. Each pond outflow is through a 24 inch pipe to the city of Houston stormwater system. Figure 4.1.1 below shows the truncated square pyramid detention pond.

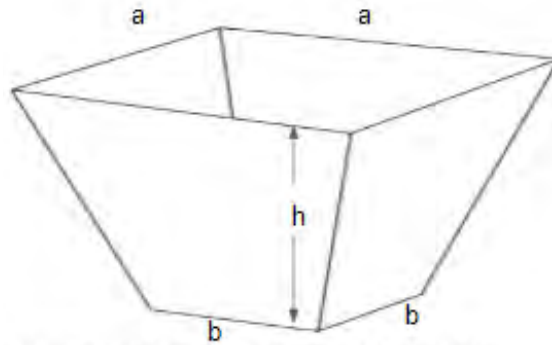


Figure 4.1.1. Truncated Square Pyramid Detention Pond

4.2 Water Flow

The impervious areas of the development were divided into drainage sections as shown in Figure 4.2.1, and inlets were added to the approximate center of each drainage section. Arrows were added to show the direction the water flows within each drainage section.

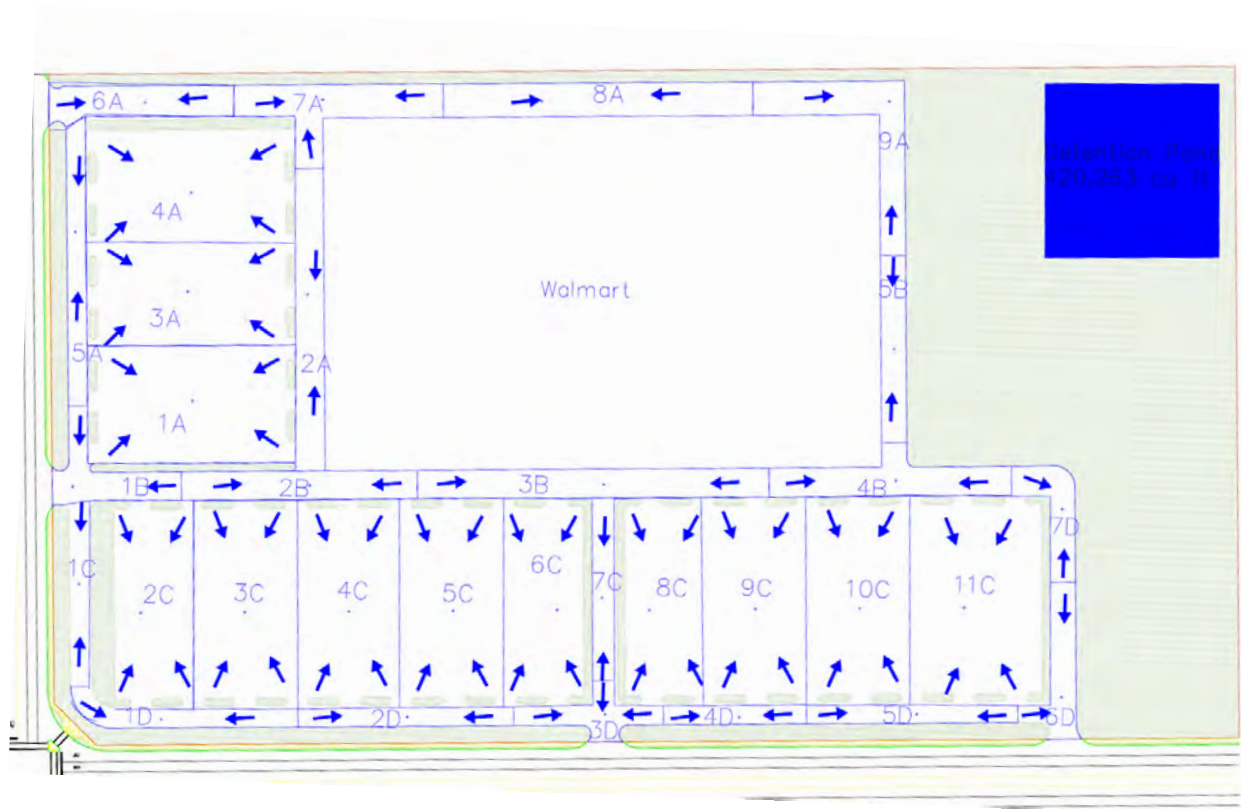


Figure 4.2.1 Water Drainage

4.3 Reservoir Routing

The drainage sections were connected to each other by pipe, as shown in Figure 4.3.1. Four different routes (A, B, C, D) were required to meet the demand. Additional piping was added for roof drainage, near section 9A.

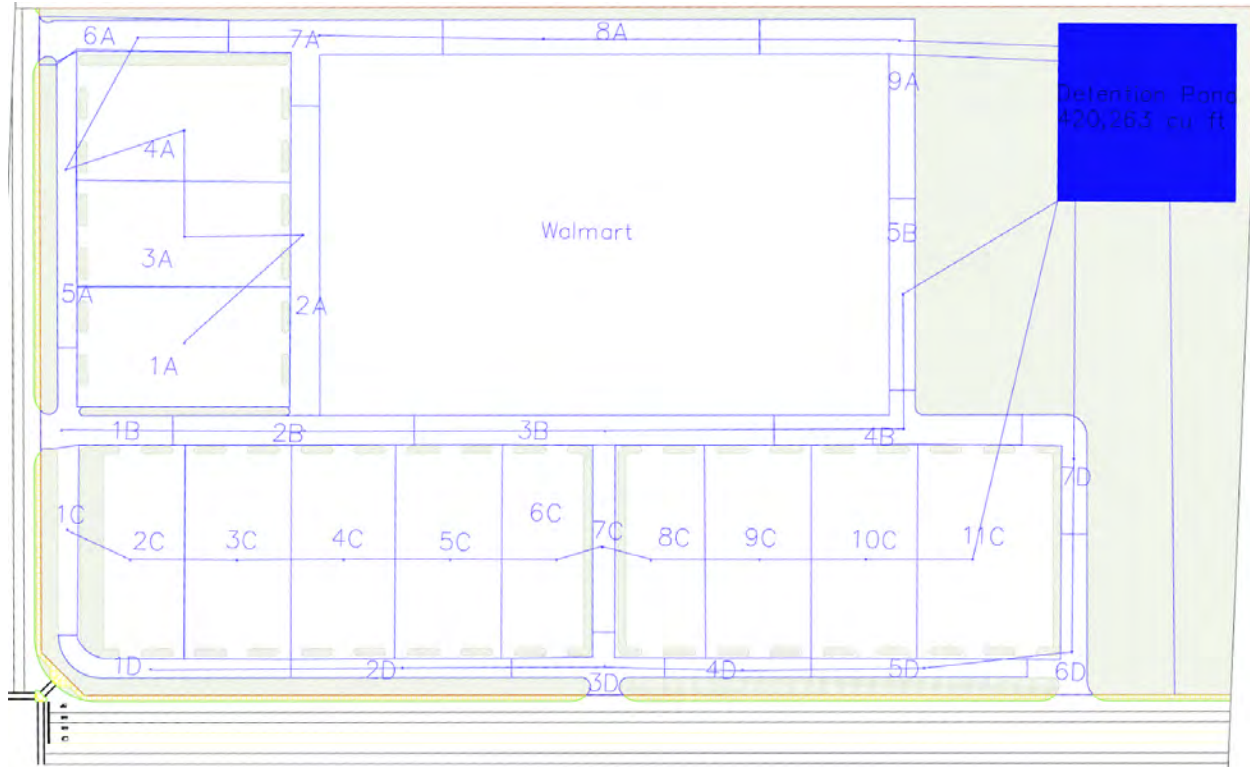


Figure 4.3.1 Drainage Piping

To determine the size of the drainage pipes, the reservoir routing was completed, as shown in Table 4.2.1. The drainage area, length of pipe, and wetted perimeter were all determined from the AutoCAD drawing. The runoff coefficient, time of concentration, and the intensity were determined from the City of Houston's Infrastructure Design Manual, Chapter 9 - Stormwater Design and Water Quality Requirements. The required runoff coefficient for a business district was 0.80. The time of concentration, T_c , was determined from the City of Houston's equation:

$$T_c = 10A^{0.1761} + 15$$

Where A = subarea in acres.

The intensity, I, was determined using the following equation from the City of Houston:

$$I = b / (d + T_c)^e$$

Where b, d, and e are given rainfall frequency parameter for a 100-year storm.

Flow, Q, was determined using the rational equation:

$$Q = CIA$$

Where C = runoff coefficient

I = intensity

A = area.

The diameter of the piping was determined using the Hazen-Williams Nonographs with a roughness coefficient of 140, shown in Appendix A. Velocity, V, was determined using Mannings Equation:

$$V = (1.49/n) * R^{2/3} * S^{1/2}$$

Where n = Mannings coefficient (0.009 for HDPE pipe)

R = hydraulic radius (area/wetted perimeter).

S = slope

Table 4.3.1 Walmart Reservoir Routing

Inlet	Drainage area (acres)	Total Drainage Area (Acres)	Runoff Coeff, C	Time of Concentration, Tc (min)	Intensity, I (in/hr)	Flow, Q (cfs)	Flow (gal/min)	Length of Pipe, L (ft)	Size, D (in)	Mannings Coefficient, n	Wetted Perimeter (ft)	Hydraulic Radius, R (ft)	Slope (%)	Velocity, V (fps)
Roof	4.020	4.020	0.8	27.78	3.23	10.378	4657.83	197.25	39	0.009	2165.00	0.002	0.25	1.26
1A	0.798	0.798	0.8	27.73	3.23	2.061	925.13	186.67		0.009	773.33	0.001	0.27	0.87
2A	0.294	1.092	0.8	27.73	3.23	2.821	1266.11	137.92		0.009	785.67	0.001	0.36	1.24
3A	0.699	1.790	0.8	27.73	3.23	4.626	2076.11	123.92		0.009	738.67	0.002	0.40	1.90
4A	0.860	2.651	0.8	27.73	3.23	6.848	3073.60	145.25		0.009	791.50	0.003	0.34	2.17
5A	0.179	2.829	0.8	27.73	3.23	7.309	3280.60	176.08		0.009	726.33	0.004	0.28	2.18
6A	0.224	3.053	0.8	27.73	3.23	7.888	3540.44	212.17		0.009	535.50	0.006	0.24	2.57
7A	0.273	3.326	0.8	27.73	3.23	8.593	3856.82	261.58		0.009	696.17	0.005	0.19	2.05
8A	0.338	3.665	0.8	27.73	3.23	9.467	4249.31	414.00		0.009	816.50	0.004	0.12	1.57
9A	0.281	3.946	0.8	27.73	3.23	10.195	4575.70	185.33	25	0.009	777.00	0.005	0.27	2.54
1B	0.193	0.193	0.8	25.27	3.39	0.524	235.31	282.42		0.009	525.25	0.000	0.18	0.36
2B	0.218	0.412	0.8	25.27	3.39	1.116	500.86	349.92		0.009	629.50	0.001	0.14	0.47
3B	0.330	0.742	0.8	25.27	3.39	2.010	902.36	348.25		0.009	907.00	0.001	0.14	0.55
4B	0.267	1.009	0.8	25.27	3.39	2.736	1227.79	156.58		0.009	703.50	0.001	0.32	1.19
5B	0.154	1.163	0.8	25.27	3.39	3.152	1414.64	209.83	20	0.009	506.83	0.002	0.24	1.41
1C	0.130	0.130	0.8	28.68	3.17	0.330	147.91	78.75		0.009	486.67	0.000	0.63	0.55
2C	0.000	0.130	0.8	28.68	3.17	0.330	147.93	124.83		0.009	742.50	0.000	0.40	0.33
3C	0.707	0.836	0.8	28.68	3.17	2.123	953.01	123.08		0.009	745.33	0.001	0.41	1.14
4C	0.687	1.523	0.8	28.68	3.17	3.866	1735.34	125.83		0.009	737.67	0.002	0.40	1.69
5C	0.707	2.230	0.8	28.68	3.17	5.660	2540.34	123.00		0.009	744.67	0.003	0.41	2.19
6C	0.598	2.827	0.8	28.68	3.17	7.177	3221.28	54.42		0.009	706.83	0.004	0.92	4.00
7C	0.129	2.957	0.8	28.68	3.17	7.505	3368.46	60.25		0.009	548.50	0.005	0.83	4.64
8C	0.594	3.550	0.8	28.68	3.17	9.012	4044.91	125.33		0.009	703.33	0.005	0.40	3.08
9C	0.702	4.252	0.8	28.68	3.17	10.794	4844.68	124.00		0.009	745.17	0.006	0.40	3.36
10C	0.707	4.960	0.8	28.68	3.17	12.589	5650.57	124.00		0.009	744.17	0.007	0.40	3.72
11C	0.957	5.916	0.8	28.68	3.17	15.018	6740.66	428.17	38	0.009	831.17	0.007	0.12	2.09
1D	0.145	0.145	0.8	24.83	3.42	0.395	177.42	292.33		0.009	600.17	0.000	0.17	0.27
2D	0.129	0.273	0.8	24.83	3.42	0.747	335.26	234.42		0.009	556.00	0.000	0.21	0.48
3D	0.132	0.405	0.8	24.83	3.42	1.109	497.66	159.75		0.009	569.00	0.001	0.31	0.74
4D	0.086	0.492	0.8	24.83	3.42	1.345	603.48	211.42		0.009	386.33	0.001	0.24	0.95
5D	0.125	0.617	0.8	24.83	3.42	1.688	757.45	173.33		0.009	548.67	0.001	0.29	0.96
6D	0.159	0.776	0.8	24.83	3.42	2.123	952.94	224.08		0.009	512.25	0.002	0.22	1.03
7D	0.129	0.905	0.8	24.83	3.42	2.476	1111.45	299.92	20	0.009	413.58	0.002	0.17	1.14

The largest required piping was 39 inches in diameter, which was rounded up to 40 inches in order to standardize the pipes and not require special orders.

4.4 Inflow & Outflow Hydrographs

The inflow hydrograph was determined using the Harris County Flood Control District's Policy, Criterial, and Procedure Manual, section 3.6: Small Watershed Hydrograph Method. The inflow hydrograph in Figure 4.4.1, shows the flow increasing from 0 to 14 hours (50400 seconds) and nearing zero at 28 hours (100800 seconds).

Inflow Hydrograph

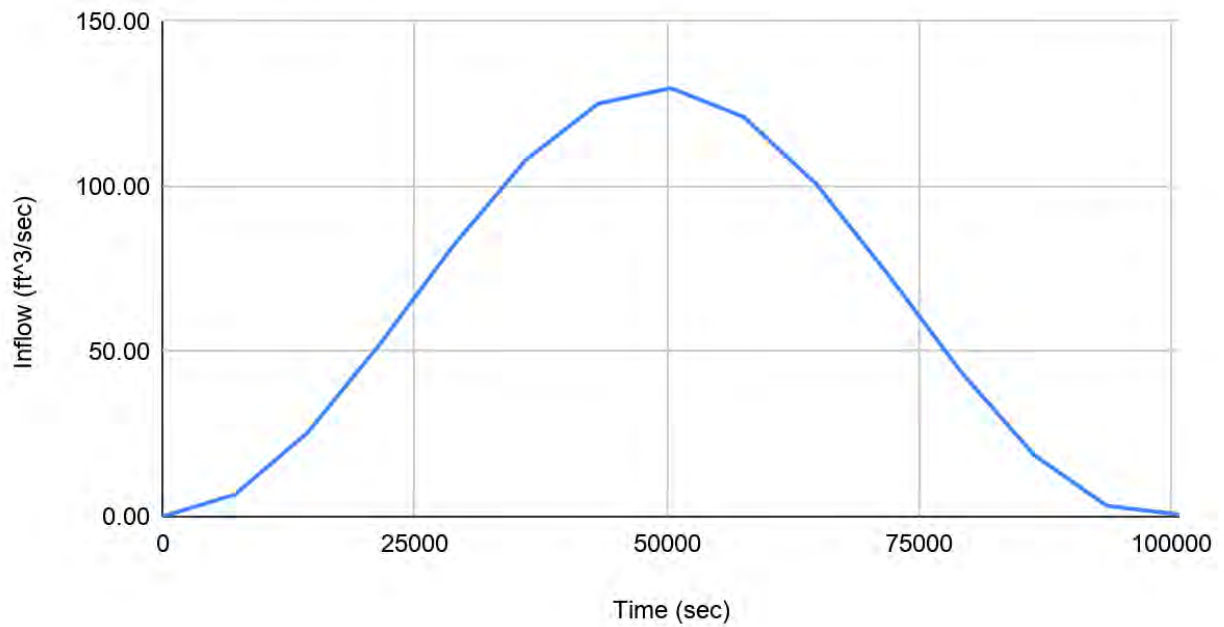


Figure 4.4.1 Inflow Hydrograph

The outflow hydrograph, shown in Figure 4.4.2, slowly increases from zero seconds to 28 hours. The outflow was determined using the Orifice Equation from Harris County Flood Control District's Policy, Criterial, and Procedure Manual, section 6.7: Outflow Structures. The hydrographs are combined into one graph in Figure 4.4.3.

Outflow Hydrograph

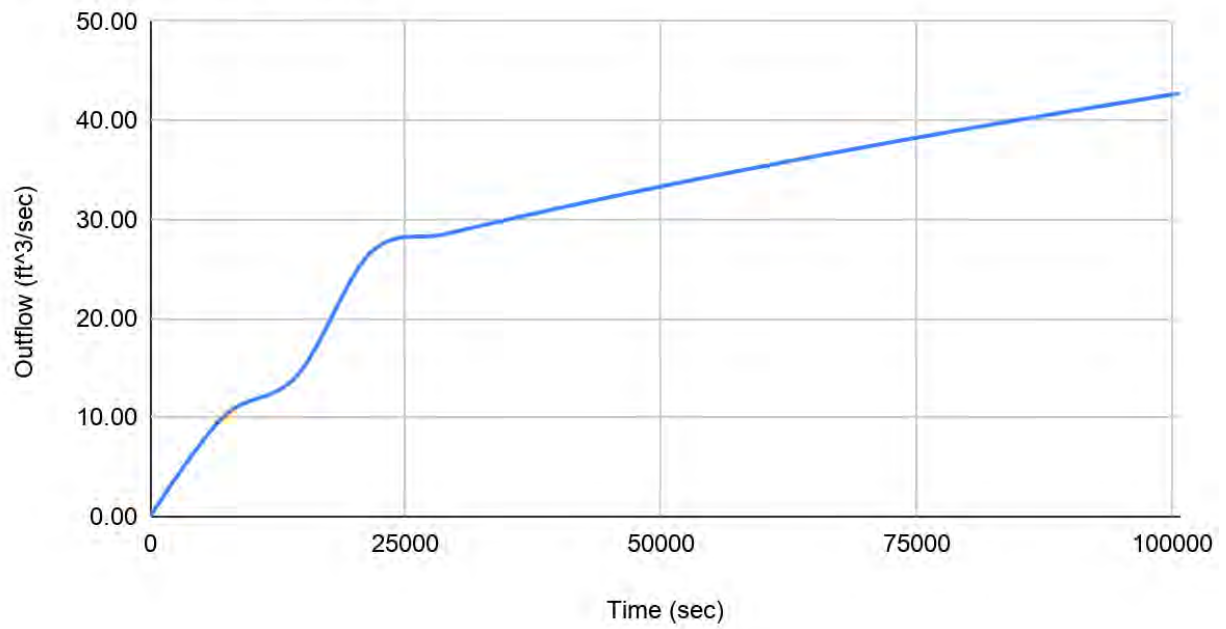


Figure 4.4.2 Outflow Hydrograph

Inflow & Outflow Hydrographs

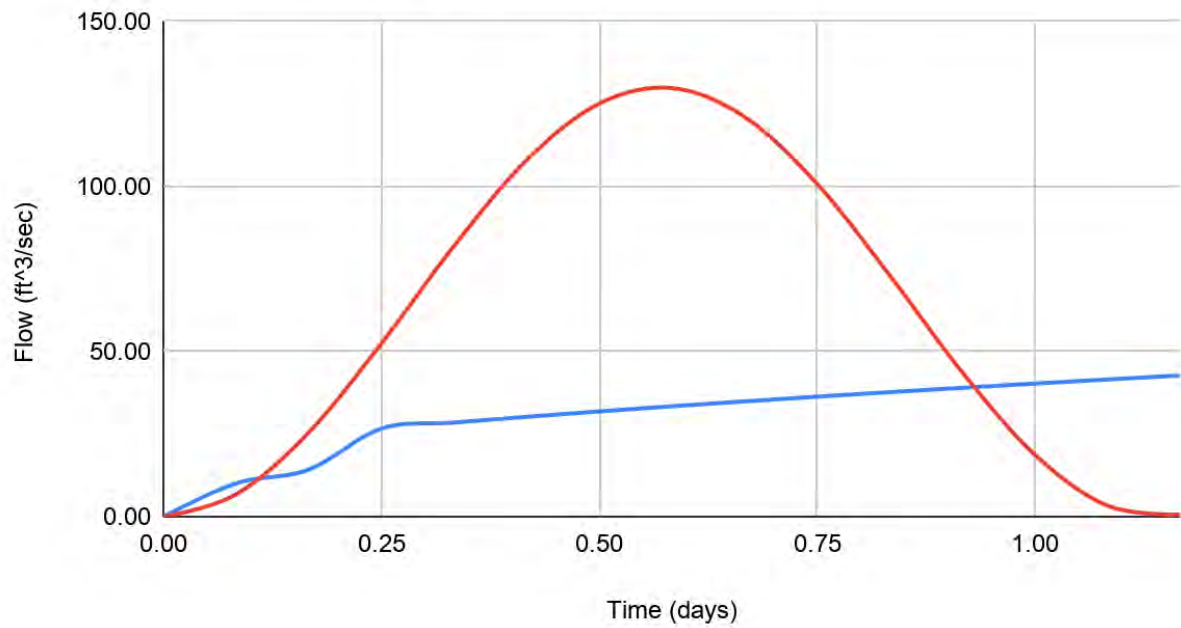


Figure 4.4.3 Inflow & Outflow Hydrographs

Chapter 5. Environmental

5.1 Wastewater Treatment

The principal objective of wastewater treatment is to produce an effluent that can be discharged without causing severe environmental impacts. The processes and operations in water treatment are similarly used for wastewater except for the biological methods. The procedure required for wastewater will depend on the effluent discharge requirements. When treated effluent is to be discharged to an inland stream, complete treatment may be necessary.

There are three different types of treatment identifications; primary, secondary, and advanced. The primary treatment involves sedimentation of solid waste within the water after filtering out large contaminants. The secondary treatment makes use of oxidation to purify wastewater further, and this can be done in one of three ways; biofiltration, aeration, oxidation ponds. The advanced treatment is mostly used for removing phosphates and nitrates from the water supply. Substances like activated carbon and sand are among the most commonly used materials that assist in the process.

Wastewater Treatment plants are designed according to the Texas Administrative Code (TAC) and the Texas Commission of Environmental Quality (TCEQ) standards. A large number of biological process configurations are used, and several combine physical operations and chemical and biological processes with the same unit. Figure 5.1.1 below shows the wastewater treatment schematic.

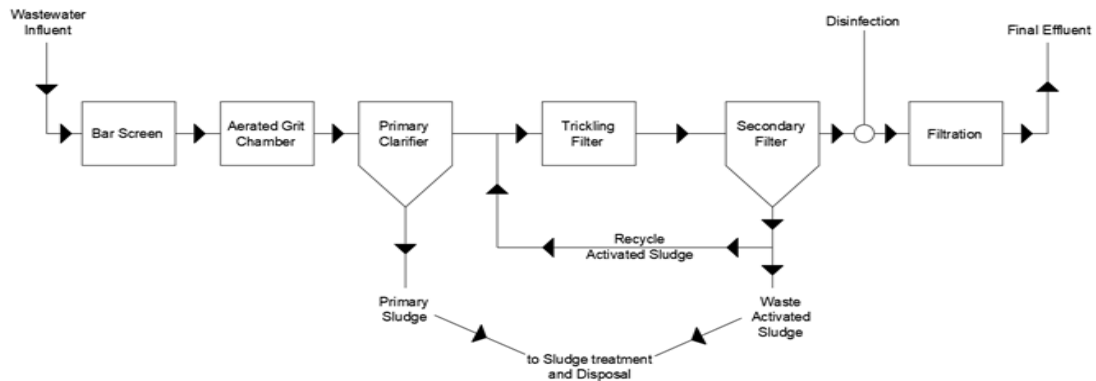


Figure 5.1.1 Wastewater treatment Schematic

5.2 Water Treatment

Before raw water can be distributed, a water treatment process was required to be performed to meet the regulations for drinking water. One such regulation is the Surface Water Treatment Rule (SWTR), a primary drinking water regulation for surface waters and groundwaters under the direct influence of surface water. SWTR requires filtration to decrease the Turbidity to be less than 0.5 NTU in 95% of samples for direct filtration and/or disinfection to remove 99.9% or 99.99% of microorganisms.

The first process that the water goes through is the Pre-treatment that removes materials that can be easily collected from the raw surface water before they damage or clog the pumps and skimmers of primary treatment sedimentation tanks. The next step will be the screening. The raw surface water is strained to remove all large objects carried in the stream, such as rags, sticks, cans, fruit, etc. This is most commonly done with an automated mechanically raked bar screen in modern plants serving large populations, whilst in smaller or less modern plants a manually cleaned screen may be used. After the screening stage, the water receives pre-treatment of disinfection with the use of Chlorine that is mixed into the raw water before it flows into the mixer. Disinfection early in the treatment process reduces the risk of pathogenic organisms contaminating the other treatment basins with removal of these organisms.

The raw water flows into a flash mixer, where lime and soda is added to reduce the hardness. This treatment process is called coagulation and flocculation. Within the coagulation and flocculation treatment process, the removal of turbidity, color, taste, odor, lead and copper occurs.

During the sedimentation stage, water slowly flows through large tanks, commonly called primary sedimentation tanks. The main purpose of the sedimentation stage is the removal of turbidity, suspended and dissolved solids by allowing them the time to settle out of the water into a sludge that can be separately processed.

Majority of municipal plants treat the settled water liquid using filtration and disinfection. The water flows from the Sedimentation Basins into the Filter bed. Filters contain material of graduated size in layers that remove solids from the water. Water is pumped onto the filters, leaving behind suspended matter as it passes downward through the filter. The filter captures solids that are larger than the pores or holes between the grains. Disinfection is achieved by the addition of chlorine. Disinfection and filtration are practiced as required by the Surface Water Treatment Rule; it is the final process before stored in underground Clear-well tanks. Figure 5.12 below shows the water treatment schematic.

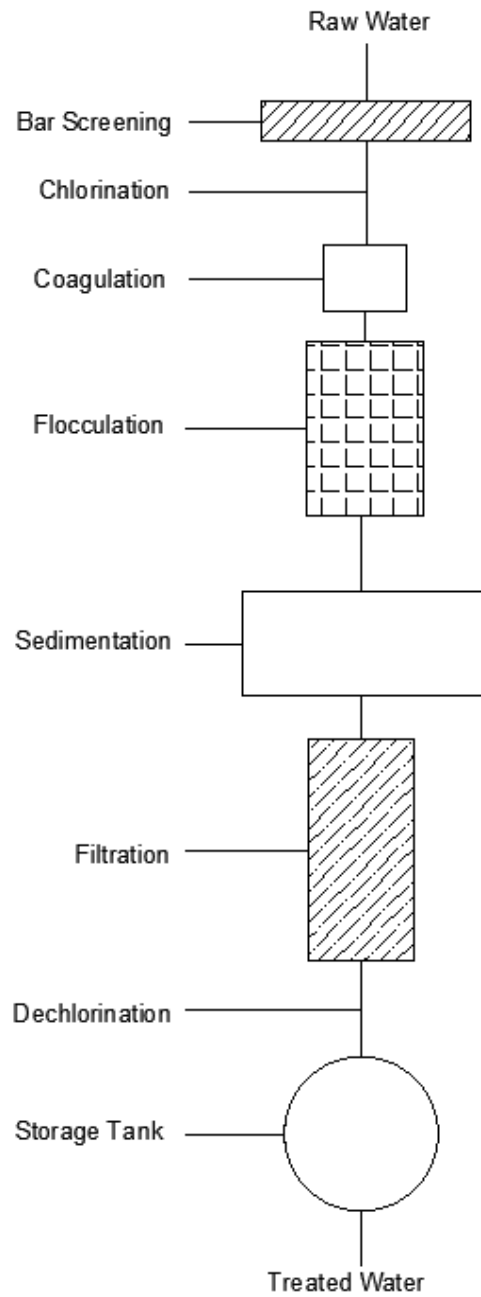


Figure 5.1.2. Water Treatment Schematic

Conclusions and Recommendations

The objectives of this project were to:

- Traffic and Transportation
 - Use the Trip Generation Manual to determine the traffic demand
 - Design a fully actuated traffic signal with left and right turn lanes
 - Determine the best fit vehicle detection system
 - Create a layout of a parking lot including stripping, stormwater inlets, curbs, driveways, number of parking stalls, including handicap accessible
- Water Resources
 - Design detention ponds
 - Create stormwater system including inlets, pipe routing, and sheet flow
 - Calculate reservoir routing
 - Create inflow and outflow hydrographs
- Structural and Geotechnical
 - Design foundations for traffic signal poles and parking lot lighting
 - Create a soil boring profile
 - Design a general foundation plan
 - Design a gas station canopy
- Environmental
 - Design a water treatment schematic
 - Design a wastewater treatment schematic

The Sterling Engineering Team completed this project and fulfilled all the objectives. This was done through research and repetition. The team consisted of three individuals who were required to communicate effectively to reach this goal. This required responsibility on all three team members' parts.

References

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Appendix A: Hazen-Williams Nonographs

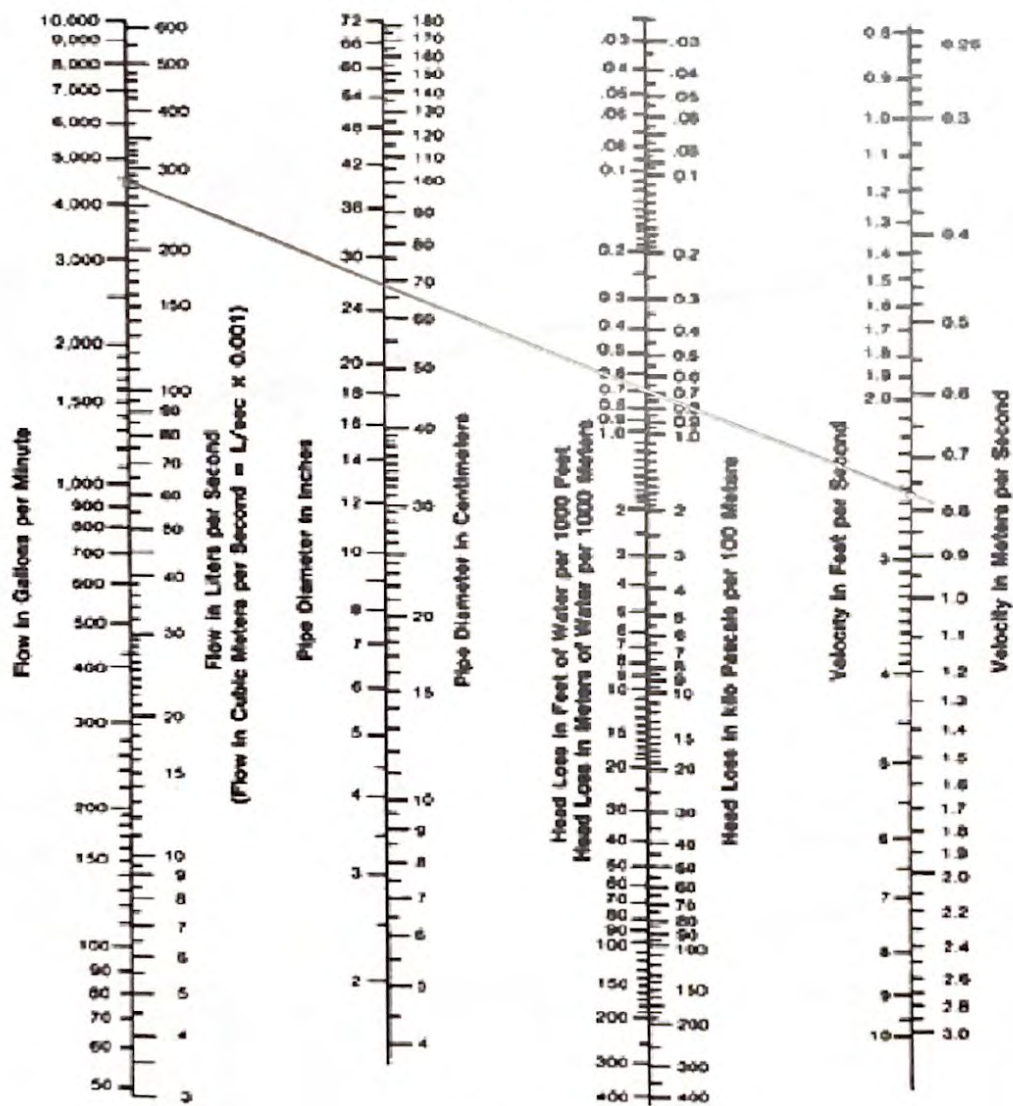
3/31/2020

HazenWilliams.png

walmart

Hazen-Williams Nonograph

English/Metric Units



C=140

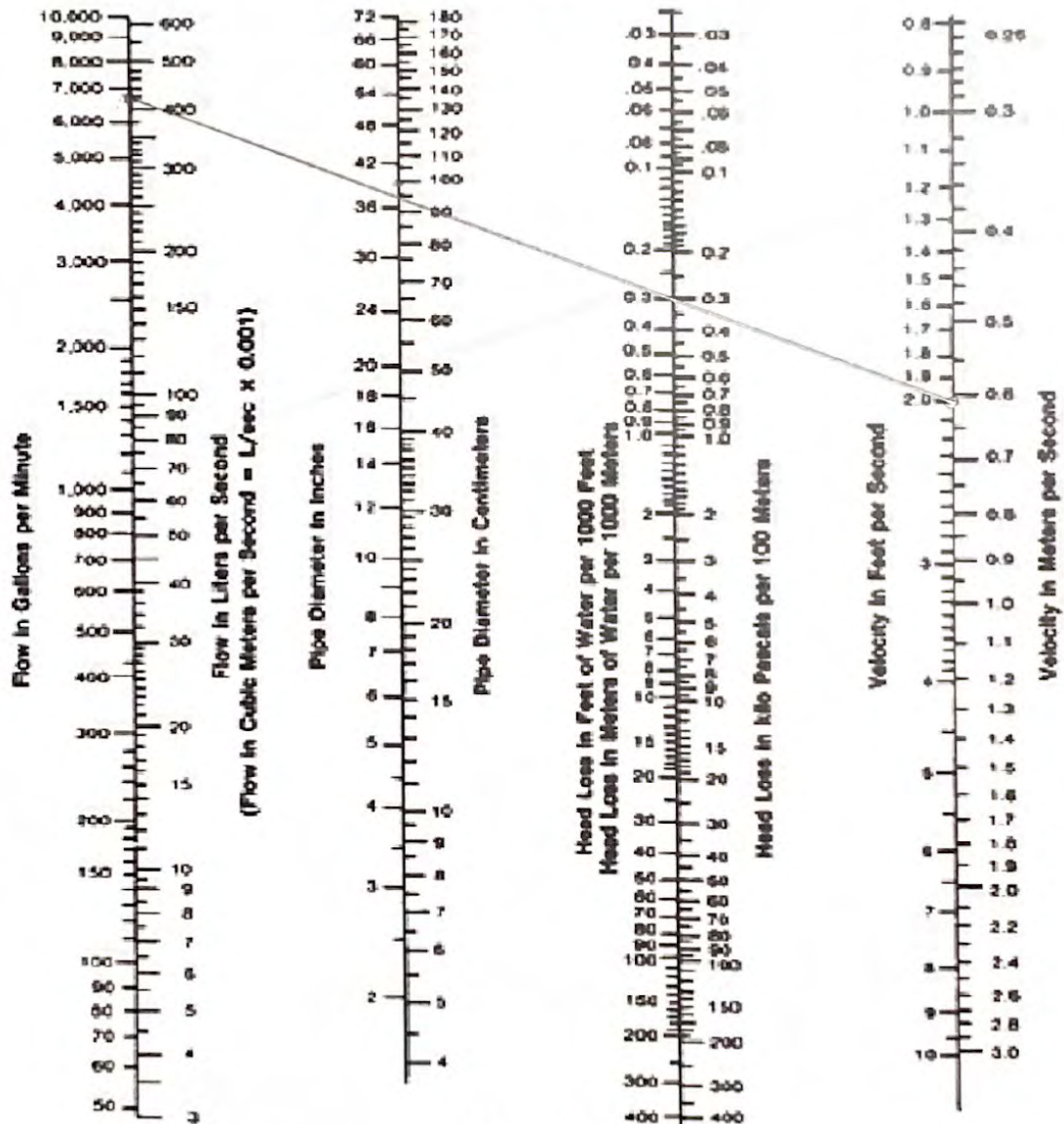
C is a roughness coefficient

9A = 25 in

Hazen-Williams Nonograph

Walmart

English/Metric Units

**C=140**

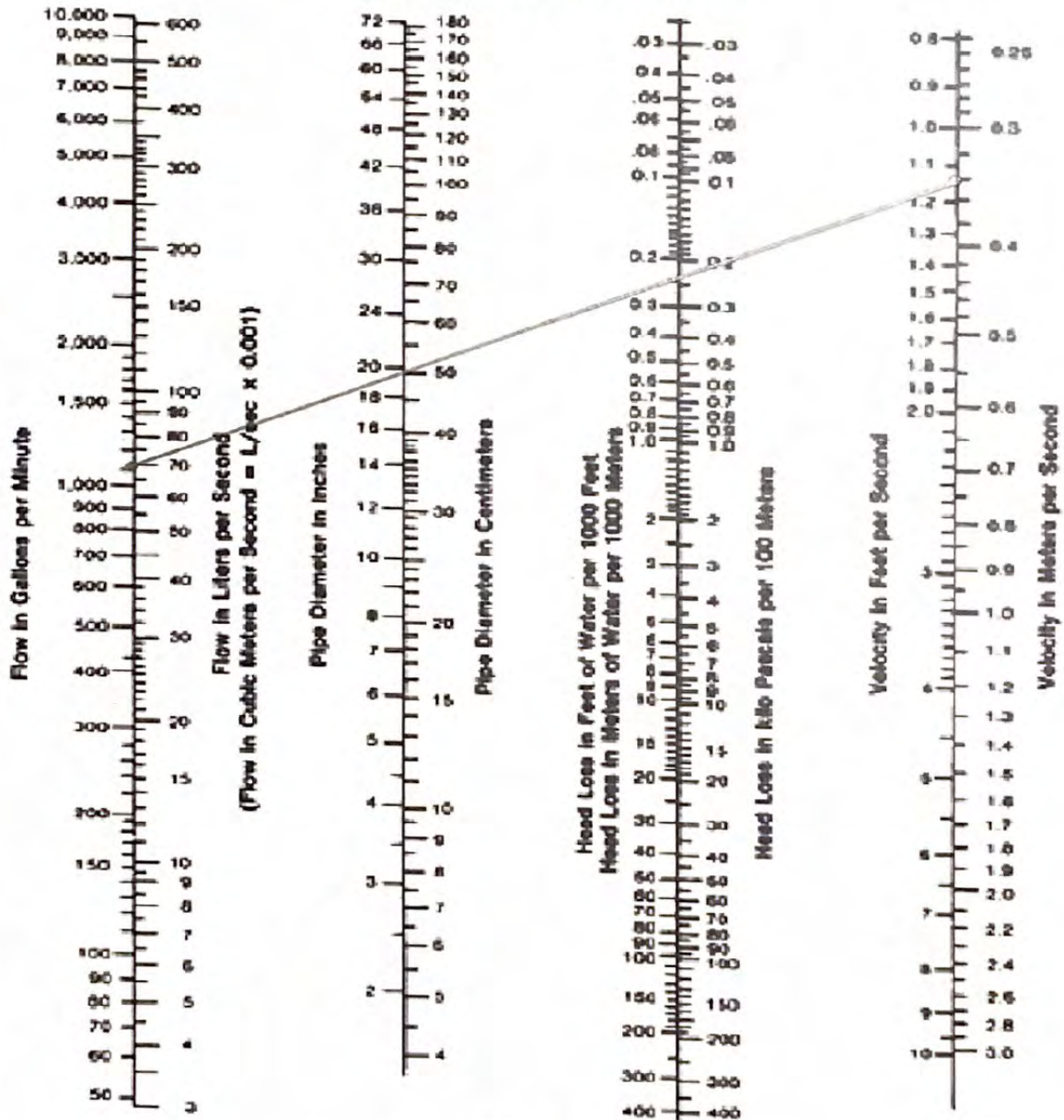
C is a roughness coefficient

11C = 381

Hazen-Williams Nonograph

Walmart

English/Metric Units



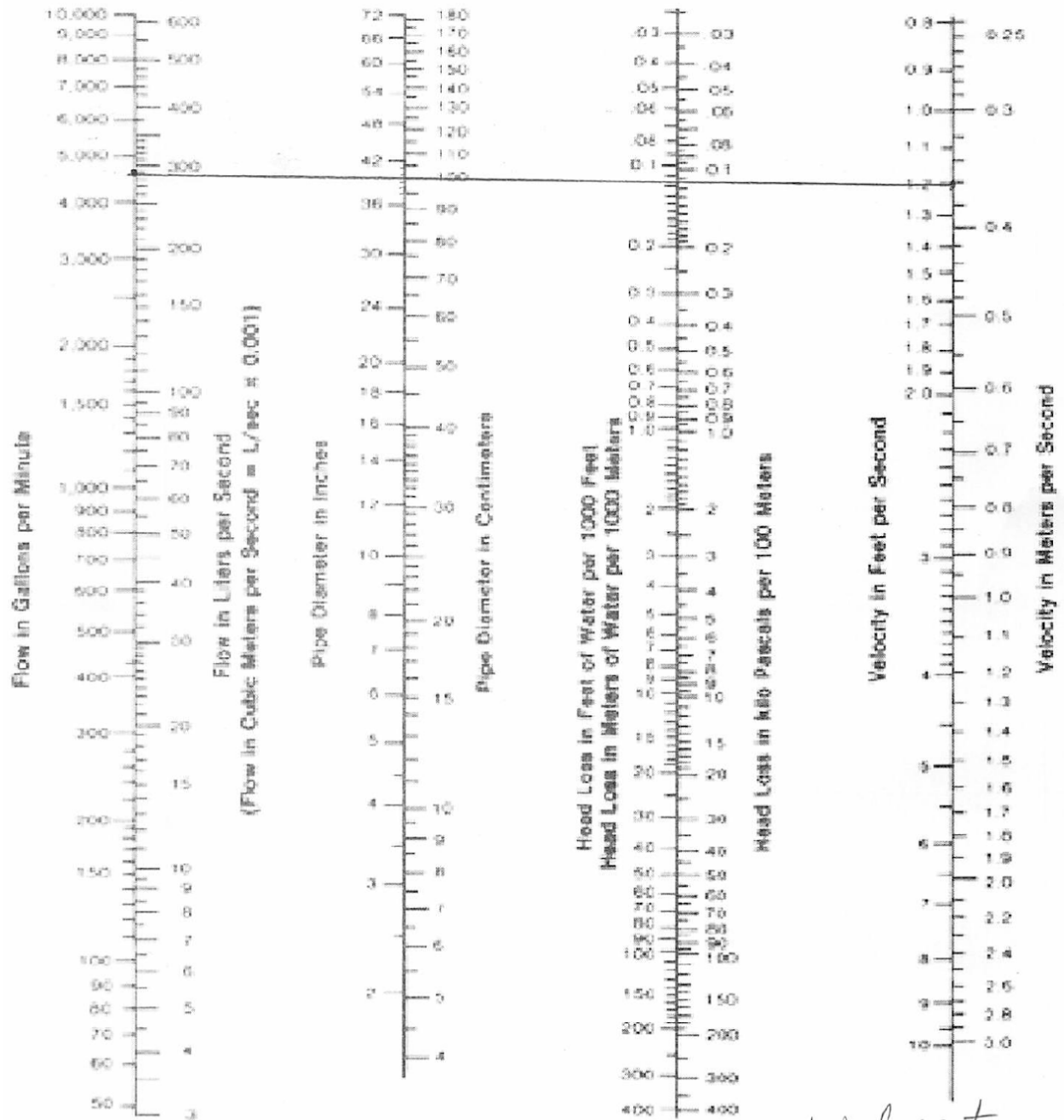
C=140

C is a roughness coefficient

7D=20in

Hazen-Williams Nonograph

English/Metric Units



C=140

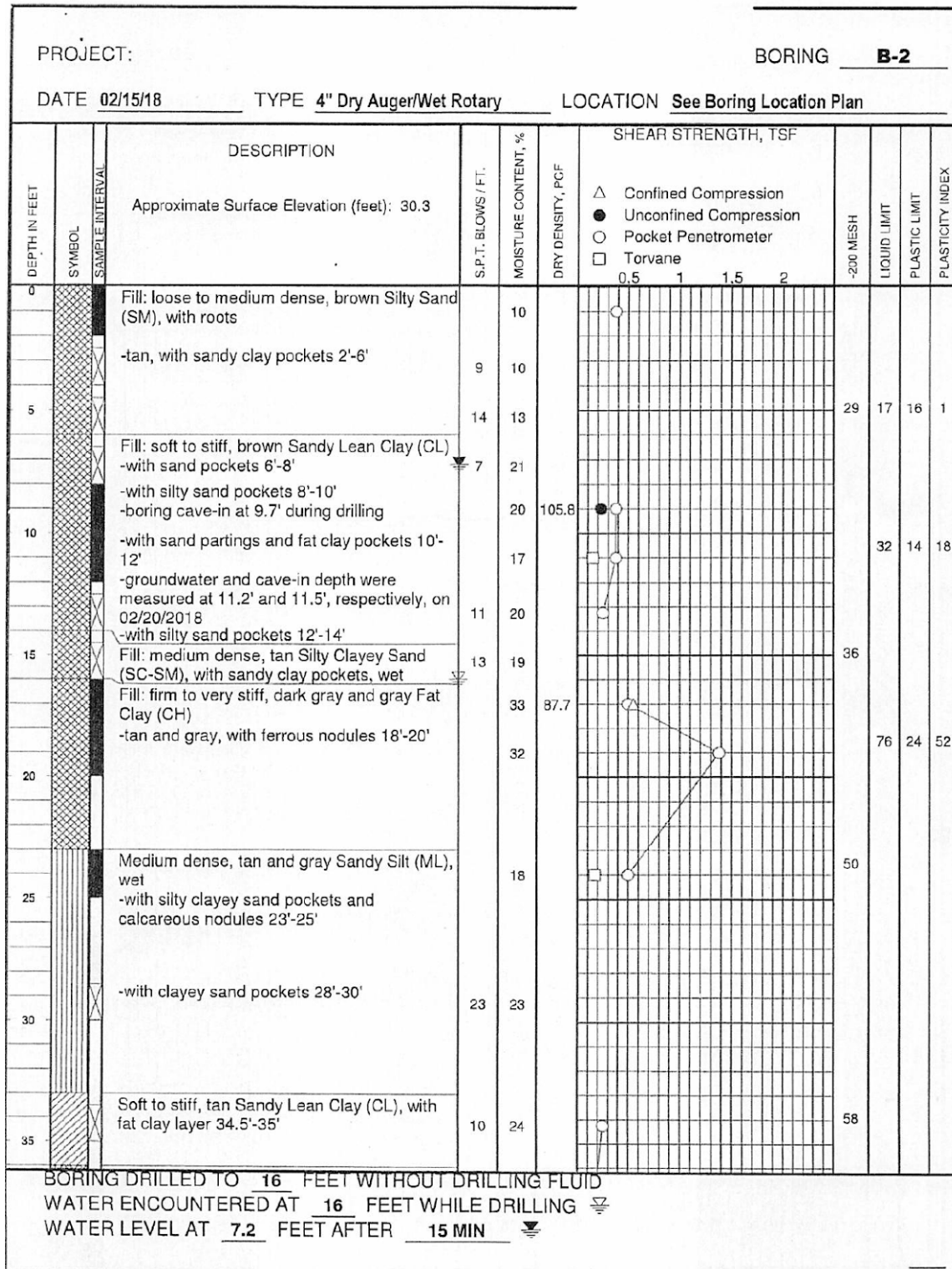
C is a roughness coefficient

Walmart
D=39"

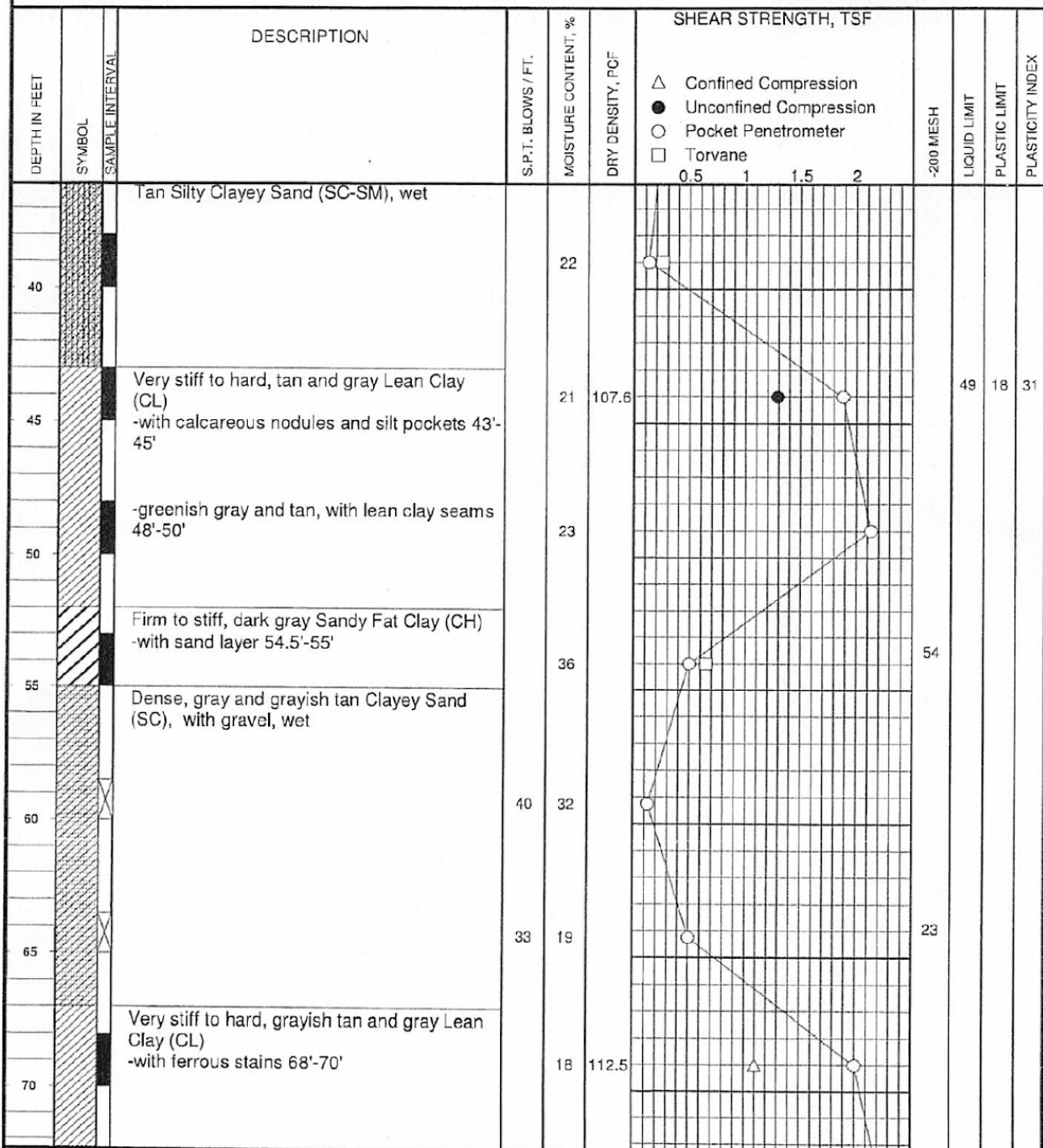
Appendix B: Water Routing Calculations

Time (days)	Time (hrs)	Time (sec)	Time (Δt)	Elevation (ft)	Head above crest (ft)	Outflow (cfs)	Reservoir Area (ac)	Δs (ac-ft)	Cum. Storage (ac-ft)	Cum. Storage (sfd)	($2s/\Delta t$) + O (cfs)	($2s/\Delta t$) - O (cfs)
0.00	0	0	0	0	0.00	0.00	9.66	0.00	0.00	0.00	0.00	0.00
0.08	2	7200	2	1	0.25	10.08	9.66	2.42	2.42	4.78	14.86	-5.30
0.17	4	14400	2	2	0.50	14.25	9.66	4.83	7.25	14.35	28.60	0.09
0.25	6	21600	2	3	1.75	26.67	9.66	16.91	24.15	47.82	74.48	21.15
0.33	8	28800	2	4	2.00	28.51	9.66	19.32	43.47	86.07	114.58	57.56
0.42	10	36000	2	5	2.25	30.24	9.66	21.74	65.21	129.11	159.34	98.87
0.50	12	43200	2	6	2.50	31.87	9.66	24.15	89.36	176.92	208.80	145.05
0.58	14	50400	2	7	2.75	33.43	9.66	26.57	115.92	229.52	262.95	196.09
0.67	16	57600	2	8	3.00	34.92	9.66	28.98	144.90	286.90	321.82	251.99
0.75	18	64800	2	9	3.25	36.34	9.66	31.40	176.30	349.06	385.41	312.72
0.83	20	72000	2	10	3.50	37.71	9.66	33.81	210.11	416.01	453.72	378.29
0.92	22	79200	2	11	3.75	39.04	9.66	36.23	246.33	487.73	526.77	448.70
1.00	24	86400	2	12	4.00	40.32	9.66	38.64	284.97	564.24	604.56	523.92
1.08	26	93600	2	13	4.25	41.56	9.66	41.06	326.03	645.53	687.09	603.97
1.17	28	100800	2	14	4.50	42.76	9.66	43.47	369.50	731.60	774.36	688.84

Appendix C: Soil Boring Report



PROJECT:

BORING **B-2**DATE 02/15/18TYPE 4" Dry Auger/Wet RotaryLOCATION See Boring Location Plan

BORING DRILLED TO 16 FEET WITHOUT DRILLING FLUID
 WATER ENCOUNTERED AT 16 FEET WHILE DRILLING ∇
 WATER LEVEL AT 7.2 FEET AFTER 15 MIN ∇

LOG OF BORING B-6										PAGE 1 OF 2		DATE: 07/14/2017														
1 Basin										BORING TYPE: 4" Dry Auger / Wet Rotary		SURFACE ELEVATION (FT.): 45.51														
DEPTH (ft.)	USC	WATER LEVEL	LOCATION	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	BLOW COUNT				DRY DENSITY (pcf)	UU / UC SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psf)	Natural Moisture Content and Atterberg Limits		MOISTURE CONTENT (%)			ATTERBERG LIMITS (%)			PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°)	OTHER TESTS & REMARKS		
						20	40	60	80					Plastic Limit	Liquid Limit	LL	PL	PI	LL	PL	PI					
0			Northing: 13780536.33 Easting: 3128680.00 Texas State Plane, Feet, Grid	FILL: FAT CLAY WITH SAND (CH), stiff to very stiff, high plasticity, dark gray and gray, moist	P=2.25	▲				98.3	0.55	9.8	0					23	57	17	40	81		2-4' Crumb: 1		
5				-with silty sand pockets, gravel, and ferrous nodules 0'-2'	P=2.0	▲												25								
10				-dark gray and tan 2'-4', with calcareous nodules 2'-6'	P=0.75	▲				90.8	0.39	2.6	5					29	92	32	60	64				
15				dark gray, olive, and tan 4'-6'	P=1.5	▲												31								
20				FILL: SANDY FAT CLAY (CH), firm to stiff, very high plasticity, dark gray, tan, and gray, with slickensides, moist	P=0.75	▲												28								
25				-with calcareous nodules 6'-10'	P=1.25	▲				92.8	0.55	3.4	9					27								
30				-reddish tan and gray 10'-14'	P=1.0	▲												22	54	18	36	83		12'-14' Crumb: 1		
35				-with gravel and calcareous nodules 12'-14'	P=2.75	▲												31								
40				FILL: FAT CLAY WITH SAND (CH), firm to stiff, high plasticity, reddish tan, moist	P=1.5	▲				91.3								32							18'-25' CU: C _u = 560 psf φ = 11.9° C _u = 560 psf φ = 8.4° 21'-22' Crumb: 1	
				-with silty sand pockets, gravel, and ferrous nodules 0'-2'	P=1.25 P=1.0	▲				96.5 89.0	0.29	4.0	14					26 32	62	22	40					
				FILL: FAT CLAY (CH), firm to very stiff, high plasticity, reddish brown, with slickensides, moist	P=1.5	▲				94.0								28								
				-with silt pockets and calcareous gravel 16'-18'		▲																				
				-brown, with calcareous nodules 18'-20'																						
				-reddish tan and gray 20'-21'																						
				-brown, tan, and gray 21'-22'																						
				FILL: SANDY FAT CLAY (CH), firm to stiff, high plasticity, reddish tan, with calcareous nodules, moist																						
				-reddish tan and gray 28'-30'																						
				FILL: FAT CLAY WITH SAND (CH), firm, very high plasticity, olive, gray, and reddish tan, with slickensides, shell, and	P=0.75	▲				90.4	0.27	14.8	19					29	66	25	41	83		38'-40' Double Hydro: 35		

Water Level

Est.: ☒ Measured: ☒ Perched: ☒

Water Observations: Water encountered at 21-ft during drilling; measured water at 19.5-ft after 10-min and 10.2-ft on 07/25/2017.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed (Auer)

Notes:

(1) Wet rotary started at 22-ft.

(2) Boring caved in at 25.9-ft on 07/25/2017.

Key to Abbreviations:

N - SPT Data (blows/ft) T - Torvane

P - Pocket Penetrometer C_u - Undrained Cohesion (tsf)

(tsf) SS - Shear Strength (P/2, tsf)

PLATE A-8

Water Level Est.: ☒ Measured: ☒ Perched: ☒
 Water Observations: Water encountered at 21-ft during drilling; measured water at 19.5-ft after 10-min and 10.2-ft on 07/25/2017.
 Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed (Auger)

Key to Abbreviations:
 N - SPT Data (blows/ft) T - Torvane
 P - Pocket Penetrometer C_u - Undrained Cohesion (tsf)
 (tsf) SS - Shear Strength (P/2, tsf)

Notes:
 (1) Wet rotary started at 22-ft.
 (2) Boring caved in at 25.9-ft on 07/25/2017.

PLATE A-8



Sterling Engineering
1234 Magnificent Dr
Houston, Texas 77001
281-661-8875

April 23, 2020

Department of Civil and Environmental Engineering
P O Box 519, Mail Stop 2510
Prairie View A&M University
Prairie View, TX 77446

Dear Dr. Radha and Mr. Gant:

Please find attached the final technical report from Sterling Engineering. The report contains the specifications for the Commercial Master Plan at the intersection of FM 2020 and Success Road. If there are any questions feel free to contact us at 512-661-8875 or ericakeltner@gmail.com.

Yours truly,

Erica Keltner
Team Lead

Samuel Fisher
Civil Engineer

Francisco Najera
Civil Engineer

**CIVIL & ENVIRONMENTAL ENGINEERING
DEPARTMENT
OUTCOME SPECIFIC ASSIGNMENT
COVER SHEET**

SENIOR DESIGN AND PROFESSIONALISM II

Instructor: Dr. Radha

Title of Assignment

Senior Design Midterm Report

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

The Midterm Report contained project scope and statement of the various components that make-up the assigned project. The report contains the cover page, table of contents and the team make-up and tasks. The students also submitted a set of calculations in the appendix.

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
CVEG 4482 Senior Design and Professionalism II
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

Spring 2021

Instructor: Dr. R. Radha

Title of Assignment

Project Design-Midterm Report

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Check the engineering design characteristics related to this assignment

X	Involves identifying the specific needs to be met by defining/understanding the problem and developing plans for the project to satisfy the need
X	Involves conducting a review of the literature and performing preliminary design by generating alternative ideas/solutions and applying creativity
X	Involves performing detailed engineering design using analysis techniques, equations etc. leading to specification and fabrication/selection of components for system being designed.
	Involves consideration of one or more of the following (Please check those involved in this assignment.)
☒	Public health
☒	Safety and welfare
☒	Global factors
☒	Cultural factors
☒	Social factors
☒	Environmental factors
☒	Economic factors
	Involves fabrication and testing of model or prototype

Brief justification of the suitability of assignment for the outcome

A project is assigned to develop and design a Project with residential subdivision on the site located in Harris County. Report showing subdividing project into tasks, applying analysis techniques to design components during spring 2021 Semester covering civil engineering areas such as structural, geotechnical, transportation, environmental and water resources will be evaluated.

ASSIGNMENT STATEMENT/QUESTIONS :

A project is assigned to develop and design a Project with residential subdivision on the site located in Harris County. Report of spring 2021 Semester covering civil engineering areas such as structural, geotechnical, transportation, environmental and water resources will be assessed.

GRADING SCHEME FOR ASSIGNMENT:

General outline and Report Content

Front page

Course Name

Group Name and Student Name

Title

CONTENTS

- 19) Abstract (3 Pts)
- 20) Table of Contents (1 Pt)
- 21) Introduction (5 points)
- 22) Objectives (3 Points)
- 23) Method and approach to design (2 Pts)
- 24) Materials and properties (2 Pts)
- 25) Step by step description of design calculations (25 pts)
- 26) Alternative solutions (5 pts)
- 27) Summary- Conclusion and Recommendations (10 Pts)
- 28) Results and Sketches (10 Pts)
 - Use of tables, Figures, bar Charts, pictures, photos, etc.
- 29) Reference and Literature Citations (2 Pts)
- 30) Appendices (If Applicable) (2 Pts)
- 31) General Report Layout (3 pts)
- 32) Format consistency, Page numbering (3 Pts)
- 33) Written Communication Skills -Use of English language& Grammar (10 Pts)
- 34) Appropriate Captioning of Tables, Figures and Equations (3 Pts)
- 35) Sequential numbering of Tables, Figures and Equations (3 Pts)
- 36) Practical interpretation of results and findings in relation to Engineering Material Concept, and Industry Applications (8 Pts)

TOTAL = 100 Pts

See below Student Sample for Crit. 1

INSTRUCTOR COMMENTS:

1. Midterm Report:

- **Format and organization was satisfactory.**
- **There was consistency and completeness among the sections of the report, drawings and figures were appropriate and included in the report.**

2. Project: See attachment for project details.

3. There was willingness and motivation to perform design to the fullest potential.

4. Grade:

- **Score was 74 for 100. Good level of performance; a quality product was turned in at the end of the semester.**

**Some Sample pages
of Midterm Report
are provided in the
following pages**

Midterm Report

CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT

PRAIRIE VIEW A&M UNIVERSITY



CVEG 4472 SENIOR DESIGN AND PROFESSIONALISM I

Spring 2021

Senior Design Project: "PVHB Residential"

Submitted by:

Devan Addison Turner

Loriell Campbell

Milton Cruz

Dontevius Robinson

Aspen'Que Ridgley

Frida Rubi

On:

March 23, 2021

To:

Dr. Radha

Letter of Transmittal

Dr. Ramalingam Radhakrishnan

Prairie View A&M University

C.L. Wilson Engineering Building, *Department of Civil & Environmental Engineering*

CVEG 4472 – Senior Design and Professionalism I

Dear Dr. Radhakrishnan,

The following detailed report is in reference to the PVHB Residential at a site in Hockley, Texas along with the project and the requirements that were requested in the spring semester of 2021. With a completion date of March 22, 2021, the purpose of this project was to design and develop a residential area with a three-story office facility, one-story community center/clubhouse, residential homes, and a water & wastewater treatment plant. This is located in Harris County on the north side of FM 290 and east of TX 99. All the information in the report was gathered from every individual within the group. This report provides the major components of the project, showing and explaining the results of the design in detail. If you have any questions or concerns, please do not hesitate to contact our Lead, Loriell Campbell, or Assistant Lead, Dontevius Robinson, through email: lcampbell23@student.pvamu.edu, donterobinson58@student.pvamu.edu.

Sincerely,

Six Figure Engineering

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Introduction

This report is a submission of the final senior design project from Six Figure Engineering during the Fall semester of 2020. The project was structured to focus on every concentration of Civil Engineering for our design which is in Harris County. The project includes multi-civil engineering services for the entire site ranging from structural, parking lot layouts, intersections redesign, drainage requirements, water & wastewater treatment, and other variety of tasks. The given project scope involves a variety of civil engineering applications. Six Figure Engineering has decided to expand its efficiency and divide each member into six divisions. The six divisions consist of Geotechnical Engineering, Structural Engineering, Transportation Engineering, Environmental Engineering (Water Treatment), Environmental Engineering (Wastewater Treatment), and Water Resources Engineering.

Objective

The objective of this capstone project was composed of a multitude of things. We as a firm were given a set of tasks that had to be completed punctually. These tasks included a variety of necessary engineering calculations, along with the designing of certain items. The firm was able to focus on the core essentials needed to produce a valuable result, and through doing so, we as a firm were able to increase our ability to connect and come up with plans suited to achieve the deliverables.

Existing Conditions Layout

Below is the exact site plan provided before design, located on a 168.17-acre lot.

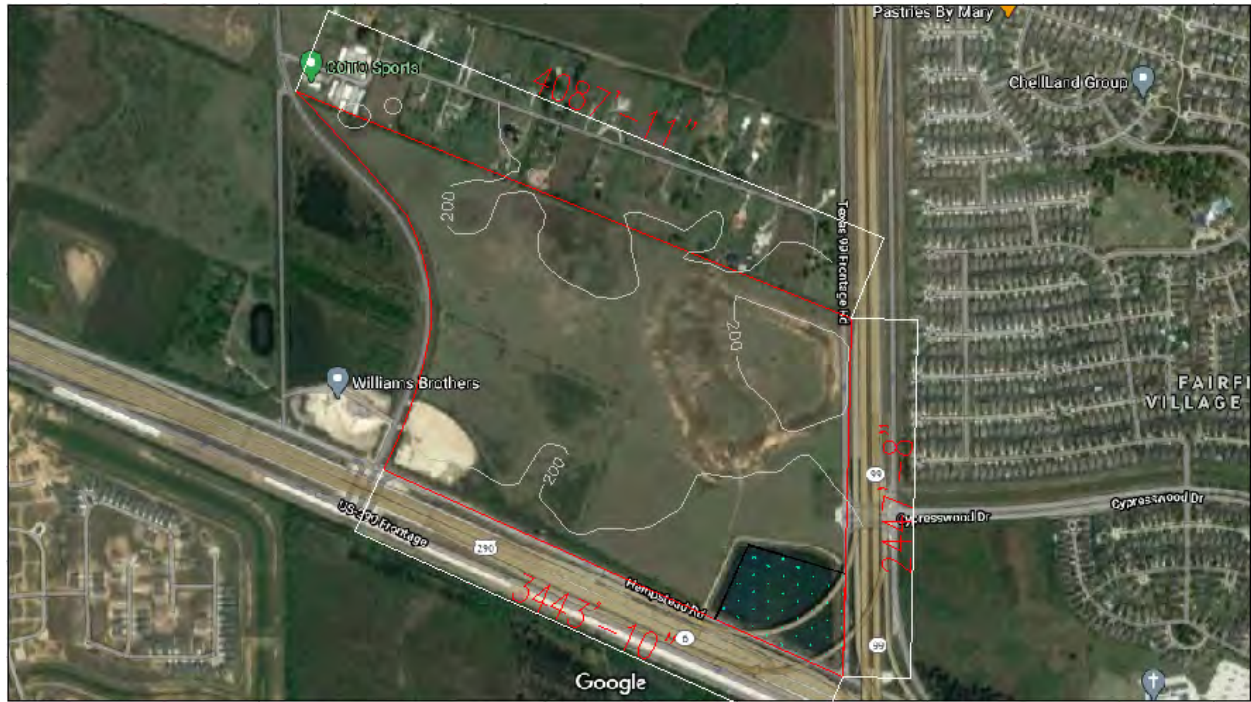


Figure 1. Existing Site Plan

Structural

Subdivision Site Plan Layout Design Calculations

- Total Area of Project Site = 168.17 acres
- Total Area of Project Site = 7,325,485.20 sq.ft
- Existing Lake = 496, 816 sq.ft
- Existing Detention Pond = 496, 816 sq.ft
- Water Treatment Facility = 400,000 sq.ft
- Wastewater Treatment Facility = 300,000 sq.ft
- Community Center Structure (One-Story) = 5,625 sq.ft.
- Community Center Parking Lot = 49,944 sq.ft
- One Residential Structure (Driveway, Backyard, Distance between homes) = 46,352 sq.ft
- 60 Residential Structures = 2,781,120 sq.ft
- Office Structure (Oil & Gas) = 9,600 sq. ft
- Office Structure (Oil & Gas) Parking Lot = 87,402 sq.ft
- New Detention Pond = 1,500,625 sq.ft

Area Used = 5,631,132 sq.ft

Remaining Area = 1,694,353 sq. ft.

Introduction

Steel design is the methodical investigation of the stability, strength, and rigidity of steel structures. Steel can be assembled quickly and efficiently in all seasons. Components are pre-manufactured off-site with minimal on-site labor. A whole frame can be erected in a matter of days rather than weeks, with a corresponding 20% to 40% reduction in construction time relative to on-site construction, depending on a project's scale. Structural steel's lighter weight relative to other framing materials such as concrete enables a smaller, more straightforward foundation. These efficiencies in execution translate to considerable resource efficiencies and economic benefits, including accelerated project schedules, reduced site management costs, and an earlier return on investment.

Steel sections provide an elegant, cost-effective method of spanning long distances. Steel-built buildings are often adaptable, with much potential for alterations to be made over time, extending the life of the structure. When a steel-framed building is demolished, its components can be reused or circulated into the steel industry's closed-loop recycling system for a meltdown and repurposing. Steel can be recycled endlessly without loss of properties. Nothing is wasted; steel saves on the use of natural raw resources since around 30% of today's new steel is already being made from recycled steel.

Objective

Design a 3 Story Oil & Gas Commercial Building to supply electricity and power for a subdivision. The Oil & Gas Company will be ExxonMobil. I am to design 2D Floor Plans via AutoCAD and establish all equipment to be included inside structure. Next, I will create cross-sectional elevations for oil & gas office building. Also, determine official building occupancy with gross area. Water consumption will be computed for supply and energy consumption for electrical and power systems demand. Then I will finalize Dead Loads, Live Loads, and Wind Loads acting on the multi-story structure. After, compute water

consumption based on building occupancy. Following, design Steel Structural components of structure: slabs, beams, columns, footings, and connections. Model structure in STAADPro then analyze results for max bending moment, max shear force, and displacement. Finally, establish costs and expenses for materials, equipment, and construction.

Architectural Features

The International Codes, or I-Codes, are developed and published by the International Code Council (ICC). The I-Codes are adopted by all fifty states, the District of Columbia, and several countries. Each state decides at what level, e.g., state or jurisdiction (municipality, city, etc.), codes are adopted. Additionally, the code year adopted and the authority for introducing local amendments varies. The jurisdictions responsible, at whatever level, have to manage code adoption and implementation. While government entities are focused on their specific jurisdiction and thus familiar with their building code status, it can be difficult for designers who work across jurisdictions to identify the codes in use and where to access them, especially where local amendments are in place.

In addition, this document has been created to provide a quick reference to the code year currently adopted by each state for the International Building Code (IBC) and International Residential Code (IRC). An “X” designation in the table below denotes those states where a specific IBC and or IRC code year has not been adopted and decisions are made at a local level. Each state link leads to a brief overview of the current building (IBC) and residential (IRC) codes being used (and in most cases links to view the codes online for free) and other useful and interesting information. IBC 2012 was used when designing for service loads and other factors that may affect the structural integrity of the structure located in Cypress, TX.



Figure 2. Oil & Gas Company

Structure Type: Business Group B IBC (Section 304) - Business Group B occupancy includes, among others, the use of a building or structure, or a portion thereof, for office professional or service-type transactions, including storage of records and accounts.

Dimensions

Floor Area: $120 \text{ ft} \times 80 \text{ ft} = 9,600 \text{ sq ft}$

Total Area: $9,600 \text{ sq ft} \times 3 \text{ floors} = 28,800 \text{ sq ft}$

Height: 60 ft

Definitions

Dead Loads - A structure's completed weight, usually measured in pounds per square foot, before it goes into service. The floors, walls, roof, columns, stairs, permanent equipment and any fixed decor constitute a static load that normally does not change over the life of the building. Dead loads account for the non-dynamic forces that place continuous and permanent force on a structure.

Live Loads - The dynamic forces from occupancy and intended use. They represent the transient forces that can be moved through the building or act on any particular

structural element. Also measured in psf, these loads include the anticipated weight of people, furniture, appliances, automobiles, moveable equipment and the like.

Wind Loads - Wind loads are randomly applied dynamic loads. The intensity of the wind pressure on the surface of a structure depends on wind velocity, air density, orientation of the structure, area of contact surface, and shape of the structure.

Dead Loads and Pressures

Materials

- lightweight concrete
- gypsum board
- carpet
- tile
- lighting fixtures
- etc.

Note: Still determining x psf and loads for each material throughout entire area structure

Live Loads and Pressures

- Lobby & Reception 1st floor: 100 psf
- Computer Use/Individual offices on the 2nd and 3rd floor: 100 psf each
- Corridors 1st, 2nd floor, and 3rd floor: 100 psf each
- 2 Elevator Machine Rooms: 300 lbs each (Concentrated)
- Server room on 3rd floor: 100 psf each
- Roof Loads (Occupiable with HVAC): 150 psf
- 2 Stairs and 2 exits: 100 psf each
- 1 Kitchen on the 2nd and 3rd floor: 75 psf each
- 2 Restrooms for women and men on all 3 floors: 100 psf each

AutoCAD 2-D Floor Plans

The floor plans of the 3 story Oil & Gas commercial structure are scaled diagrams of a room or building viewed from above. The floor plan depicts the entire building, one floor of a building at a time and single rooms. These include measurements, furniture, appliances, or anything else necessary to the purpose of the plan. Floor plans help design furniture layout, wiring systems, and much more.

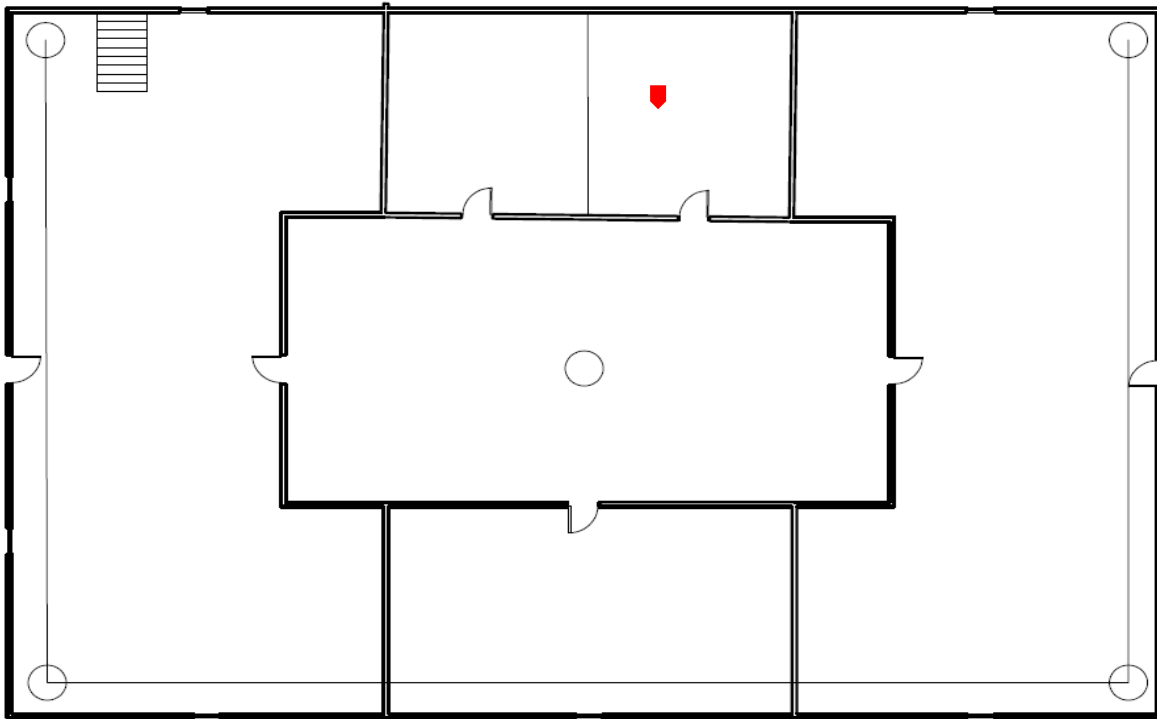


Figure 3. AutoCAD 1st Floor Plan

Mechanical systems will include Elevator, Air-conditioning, Plumbing, Cooling system, Ventilating, and a heating system. **Electrical or power systems** will include circuit breakers, fuses, emergency and standby power, electrical distribution, transformers, and transfer switches. Modern commercial HVAC systems are comprised of either rooftop units

or, air ducts, CO2 sensors, thermostats, fans and dampeners. Some systems may even contain humidifiers and dehumidifiers as well as carbon monoxide detectors.

In order to keep the building comfortable, eliminate allergens and mold and prevent toxic gases from building up in the indoor environment, all of these pieces of equipment must work together. The thermostats must be programmed for the season as well as the time of day and anticipated occupancy levels. The CO2 sensors must detect the amounts of CO2 in the air and trigger the dampeners to open when CO2 levels are too high in order to allow fresh air into the building. The dehumidifiers and/or humidifiers must monitor the moisture in the air and turn on and off in order to maintain ideal humidity levels, and the fans and blowers must operate long enough to circulate the air in the building to prevent stagnation. Keeping all of these components working optically helps keep building occupants comfortable.

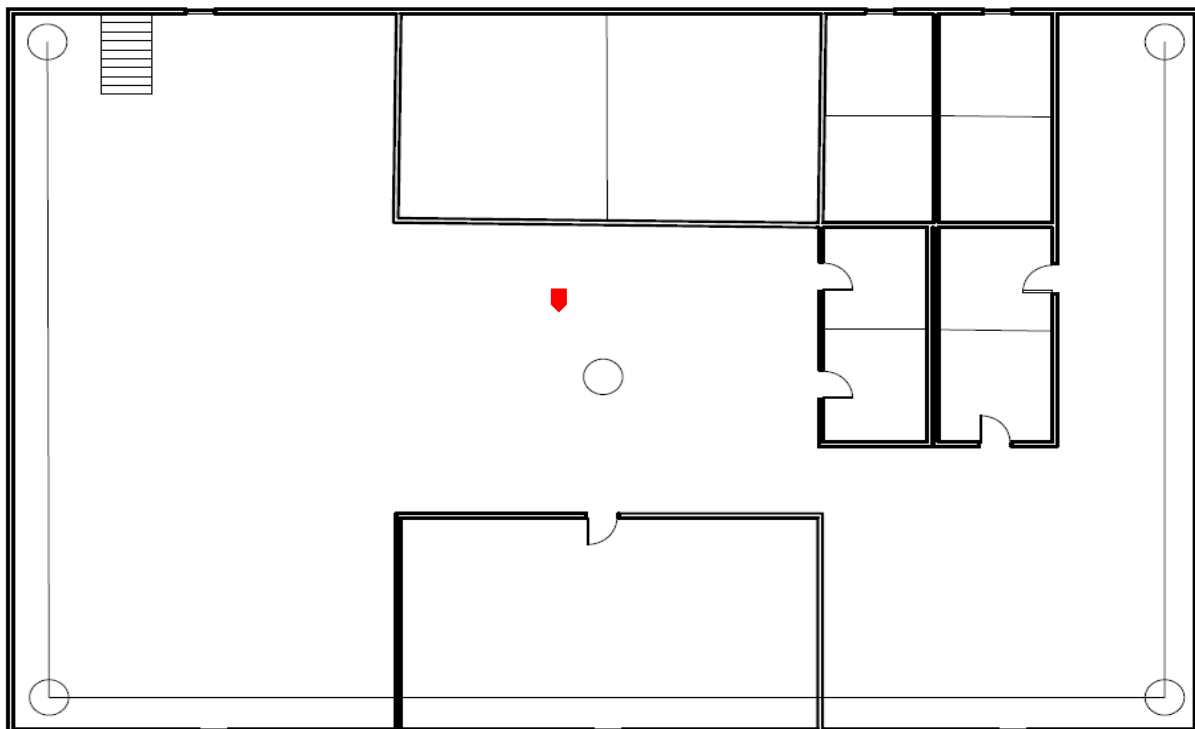


Figure 4. AutoCAD 2nd Floor Plan

Table 1 below displays the office space types for employees who will occupy building area. These are variations for typical office spaces and dimensions associated with each space type.

Table 1. Office Space Types and Dimensions

Space Type	Dimensions(Space Size)
Standard Offices	10' x 15' (150 SF)
Small Offices	12' x 10' (120 SF)
Supervisor Workstation	10' x 10' (100 SF)
Standard Cubicle	8' x 6' (48 SF)

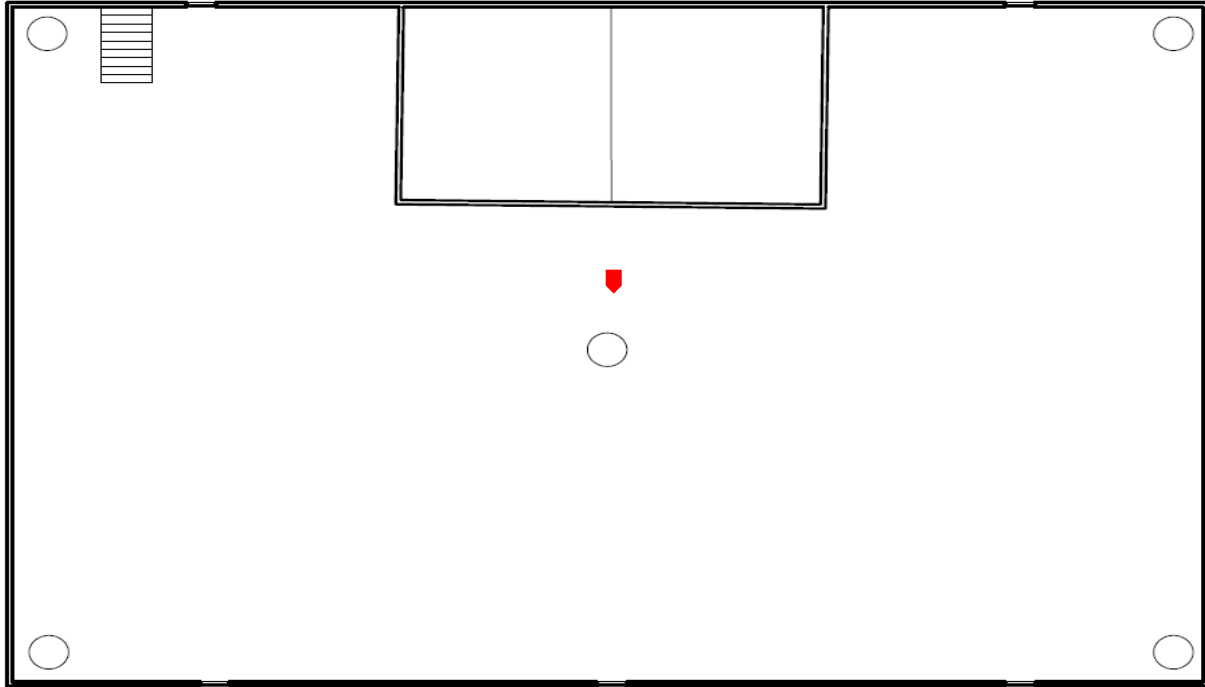


Figure 5. AutoCAD 3rd Floor Plan

Table 2. Typical Maximum Floor Area Allowances Per Occupant

Function of Space	Floor Area in Square Feet Per Occupant*
Assembly Gaming floors (keno, slots, etc)	11 Gross
Assembly without fixed seats Concentrated (chairs only – not fixed) Standing Space Unconcentrated (tables and chairs)	7 Net 5 Net 15 Net
Business areas	100 Gross

Based on Table 2 above from the COMMERCIAL PROPERTY SAFETY REQUIREMENTS: MAXIMUM OCCUPANCY, the Building Occupancy Estimation will be approximately 150 - 180 people.

Plumbing, Pipe Design, and Water Quantity

Referencing the Federal Energy Management; Plumbing and Water Consumption, most buildings have restrooms with plumbing fixtures. Daily water used by plumbing fixture is dependent on the number of occupants in the building. As a reasonable rule of thumb for a typical nine-hour work day, people use between eight and 12 gallons per day in restrooms. The low-end estimate is typical for buildings with water-efficient fixtures. The high-end estimate is more appropriate for buildings with higher water consuming fixtures.

Estimation for the range of water used based on the building occupancy:

LOW ESTIMATED DAILY USE

Daily Use (gal/day) = Average Number Daily of Occupants $\times$ 8 (gal/person)

HIGH ESTIMATED DAILY USE

Daily Use (gal/day) = Average Number Daily of Occupants $\times$ 12 (gal/person)

Approximately 1,800 - 2,160 (gal/day) of water consumed

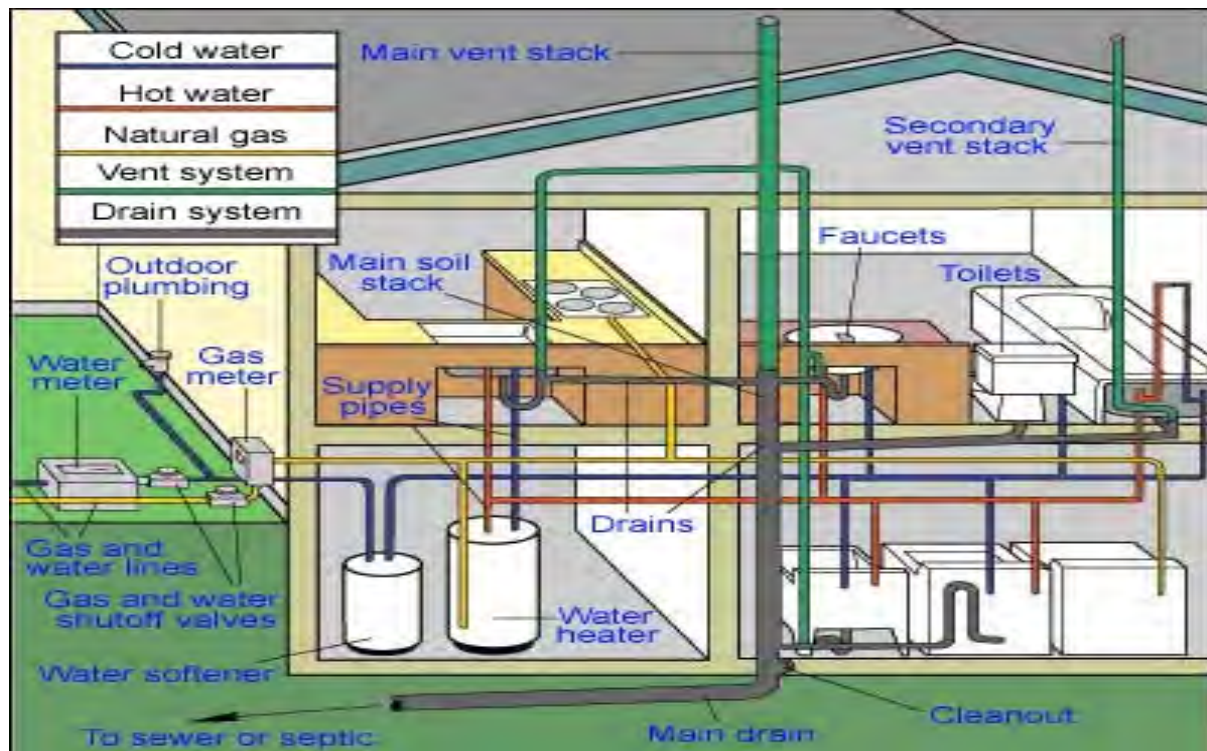


Figure 6. Water and Gas Pipeline System Example 1 for Multi-Story Structure ♥

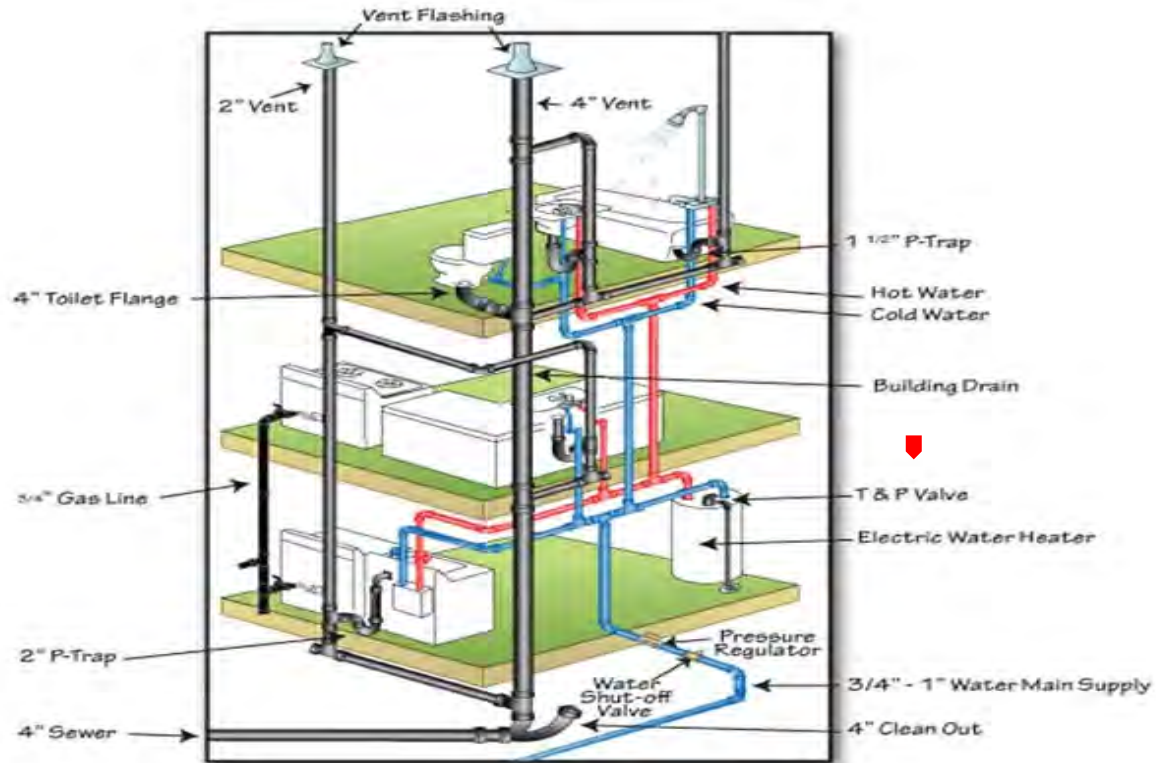


Figure 7. Water and Gas Pipeline System Example 2 for Multi-Story Structure

The pipe diameter for the plumbing design is assumed to be 4 inches. The International Plumbing Code states that the minimum Water pressure for office buildings is 35 psi and a maximum of 80 psi. The more floors within a structure requires higher pressure demand and there must be enough water to supply. Therefore, the 3 story Oil & Gas structure will have a water pressure of 65 psi. The water pressure will come from flush valves, toilets, sinks, drains, urinals, drinking fountains and a Fire/Sprinkler System.

Structural Design References

- American Institute of Steel Construction Steel Construction Manual, 14th Edition, 2010

- Texas State Building Code – Volume I (General Construction), Current Code
- American Society of Civil Engineers Code 7-10
- Structural Engineering Handbook, McGraw-Hill, 4th Edition, 1997
- Structural Steel Design Handbook, Roger B. and Frederick M., McGraw-Hill, 2011
- Senior Design Project Manual 11.20.2009 Edition
- Harris County, TX Municipal Building Codes 2016
- International Master-I-Code-Adoption-Chart-Jan-2020
- Design of Reinforced Concrete Handbook, 10th Edition-1
- International Plumbing Code

Geotechnical

Objective

For this project the task for the geotechnical aspect consisted of the three basic design analysis. The first was for the analysis of the site of construction to determine the soil characteristics for potential issues present and possible solutions that can be made. The analysis of the site was determined with the use of soil boring logs that were provided detailing the different layers and water table information in the area. From the analysis the design of the foundation for the different structures were determined to be fit for their intended use. From the design proposed there was a potential vertical rise analysis to be done to ensure the type of foundation proposed would be possible for the shrinkage or swell of the soil that can cause potential failure of the foundation. The site must also be designed in accordance with all of the site features we are given from the scope of work. The site must then be prepared for the cut and fill to properly grade the site for proper drainage and be in accordance with the 100-year flood plain. The design parameter must be met to ensure the design of the site is appropriate and in accordance with regulations from the city of Houston.

Data

From the boring log we were able to determine the soil characteristics in the area. The boring log indicates the location of the water table including the unit dry weight, moisture content, liquid limit, plasticity limit and index. The data was then

For the site design the proposed elevation to promote proper drainage was determined to be 3 feet above the existing elevation. The site did not have issues with current flood plains since it is far from possible flood zones when looking at the Harris county flood control map. The issue with the site is potential ponding near the center of the site increasing the risk of soil saturation decreasing the stability of the foundations that will be constructed

in the area. The site will be graded from the proposed elevation to improve the drainage in the area.

Section	Category	Area (Acres)
Zone 1	Residential Neighborhood	60
Zone 2	Community Center	20.72
Zone 3	Office Space	7
Zone 4	Future Development	30
Zone 5	Water and Wastewater Treatment plant	13.7
Zone 6	Detention Pond	11.4

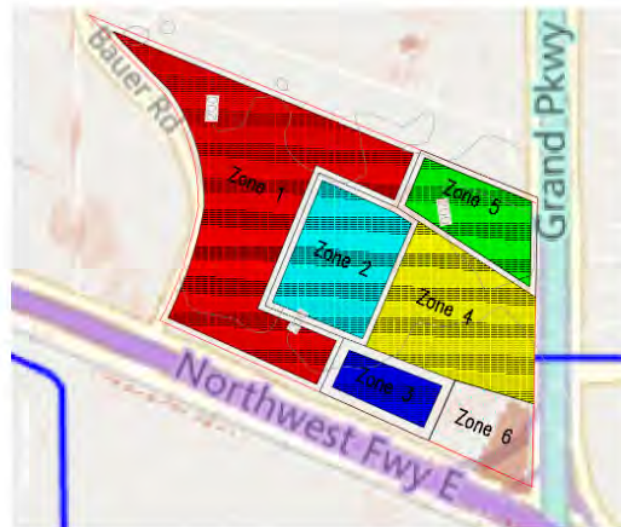


Figure 8. Site Sections

The site was subdivided into different sections to better address the design criteria for each of the intended designs of the site features. The different areas were also subdivided to include buffer areas to address the ponding problem and have the means to route the retained water in the site to the detention pond that will be designed in zone 6 from the map.

For the cut and fill of the section the site was determined to have six different zones and for each zone there was an intended proposed elevation to treat the potential problems of water backlog and the ponding issue. To ensure the cut and fill is done at the most inexpensive cost the determination of zones in which would be subjected to cut and fill were determined in the chart below. The zones to keep were used to route the possible ponded water to be routed to the detention pond naturally by runoff and the increased elevation of the other zones.



Table 1. Cut and Fill

Design Areas	Existing Elevation (ft.)	Cut, Fill, Keep	Proposed Elevation (ft.)
Zone 1	200	Fill	203
Zone 2	200	Fill	203
Zone 3	200	Fill	203
Zone 4	200	Keep	200
Zone 5	200	Fill	203
Zone 6	200	Keep	200

Discussion

The design for the foundations of the buildings was done with the use of Terzaghi's equation for shallow foundation design. For this iteration we used the design parameter for the use of square foundations to support the columns of the building to ensure proper support to the building.

With this we introduce Terzaghi's bearing capacity equation:

$$q_u = c'N_c + qN_q + \frac{1}{2}\gamma BN_\gamma \quad (1)$$

Where:

q_u = Ultimate Bearing Capacity

c' = Cohesion

N_c = Bearing Capacity factor

q = Surcharge

N_q = Bearing Capacity factor

γ = Weight of soil

B = Base of foundation

N_γ = Bearing Capacity factor 

To determine our bearing capacities, we must first define N_c , N_q , and N_γ which are expressed as:

$$N_c = \tan(\phi') (K_c + 1) \quad (2)$$

Where:

K_c = Earth pressure coefficient

ϕ' = Soil angle friction factor

$$N_q = K_q \tan(\phi') \quad (3)$$

Where:

K_q = Earth pressure coefficient

$$N_\gamma = \frac{1}{2} \tan(\phi') (K_\gamma \tan(\phi') - 1) \quad (4)$$

Where:

K_γ = Earth pressure coefficient

Thus, the completed Terzaghi's method for a square foundation can be expressed as:

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma \quad (5)$$

For the determination of the different variables needed for Terzaghi's method of bearing capacity, the values for the cohesion and the unit weight were also determined from experimental values relating. Relating the STP penetration number of blows and by interpolating the values were determined.

For the determination of the mat foundation needed for the office building the equation used for the design is shown below for the bearing soil capacity. The equation is the general bearing capacity equation which uses different factors taking into account the slope of the ground known as inclination, shape of the foundation, and a depth factor.

$$q_u = c'N_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + \frac{1}{2}\gamma BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i}$$

$F_{cs}, F_{qs}, F_{\gamma s}$ = Shape Factor

$F_{cd}, F_{qd}, F_{\gamma d}$ = Depth Factor

$F_{ci}, F_{qi}, F_{\gamma i}$ = Load Inclination Factor

Results

The results for the project consist of the potential vertical rise and the foundation design of the community center. The potential vertical rise was done to determine the possible effects the foundations in the site will face and the possible solutions that can be done to prevent major issues. An analysis for the potential vertical rise was done before and after to see the effectiveness of the proposed solution.

Potential Vertical Rise (PVR)

For the potential vertical rise of the soil before the adjustments are presented below.

Table 2. Potential Vertical Rise (Before Treatment) ▼

Depth (ft.)	PVR (in.)
0	0
2	1.13
4	0.60
6	0.27



8	0.16
10	0.10
12	0.06
14	0.03
16	0.00
18	0.00
20	0.00

From the given data we are able to see the problematic areas the soil poses from the swelling due to the moisture content in the soil further causing greater issues when the swelling subsides. The total vertical rise is shown below. From the total vertical rise we are able to determine the area where the most rise contributes. The limit for the potential vertical rise is limited to a maximum of 1 inch for foundations and since the current soil exceeds that there will need to be a correction or treatment of the present soil to make it suitable for future construction.

Table 3. Total Potential Vertical Rise (Before Treatment)

PVR
(in.)

1.29	
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From the previous analysis of the current soil in the existing site it was determined to have the problematic areas focused on the first 2 feet of the site. The first two feet contributed to 43 percent of the potential vertical rise. Reducing that will put us well under the 1 inch limit for the proper foundation to be designed and constructed. To ensure the treatment of the soil is correct the potential vertical rise was calculated after the soil adjustments and are shown below.

Table 4. Potential Vertical Rise (After Treatment)

Depth (ft.)	PVR (in.)
0	0
2	0.67
4	0.60
6	0.27
8	0.16
10	0.10

12	0.06
14	0.03
16	0.00
18	0.00
20	0.00

With the soil now treated we now see the total vertical rise for the adjusted soil meet the necessary requirements for the foundation design.

Table 5. Total Potential Vertical Rise (After Treatment)

PVR (in.)
0.73

Foundation Design

The design for the community center is shown to be a square foundation with the orientation of the square building supporting the columns. From the design of the steel reinforcement the necessary design requirements for the foundation were determined to properly support the building. From the structure the proper loads were able to be determined to start the design for the foundations needed to withstand the building.

For the foundation design of the community center the data needed was determined from the boring samples using the standard penetration number to get the soil properties. The soil properties were then used to determine the unit weight, angle of internal friction, and the cohesion for the soil. The design of the foundation would be designed for a shallow foundation which will be 5 ft below from the surface. The soil that is 5 feet below the surface offers suitable soil characteristics for the foundation to be placed on the stiff soil shown from the boring logs.

Table 6. Soil Characteristics for Foundation 

Angle of friction, ϕ	33°
Cohesion, C	1.88 kips/ft ²
Unit Weight of soil, γ	86 lb/ft ²
Depth to the bottom of Foundation, Df	5 ft
Base, B	3 ft
Factor of safety	3

The bearing capacity factors determined from the angle of internal friction are shown below.

Table 7. Bearing Capacity Factors

Bearing Capacity Factors	
Nc	48.09
Nq	32.33
N γ	31.94

Using the information above we were able to determine the necessary dimensions for the foundation with the applied bearing capacity shown being applied. The determination of the allowable bearing capacity and the ultimate bearing capacity can be

determined with the use of Terzaghi's bearing capacity equation and the factor of safety of 3.

Table 8. Bearing capacity

Bearing capacity	
q (ultimate)	43 kip/ft ²
q (allowable)	14 kip/ft ²

The bearing capacity was used to determine the allowable to reduce the possible maximum effects of the ultimate stress that may allow minimizing the long-term effects. The allowable is used to ensure there is a long-term design for the foundation that will support increase and possible changes for the intended use of the structure.

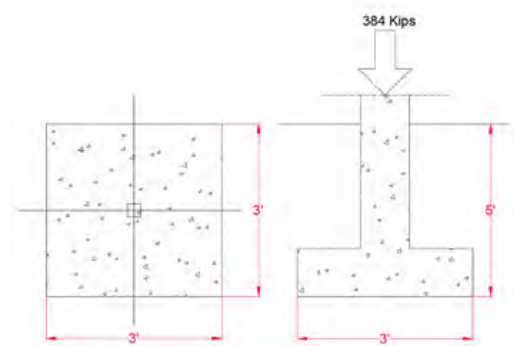


Figure 9. Foundation Design

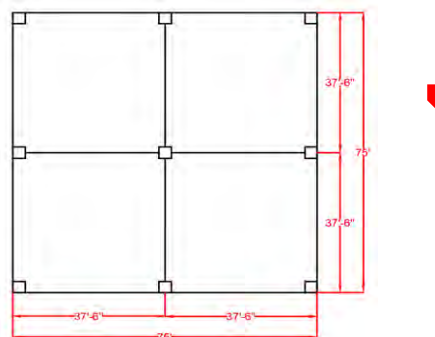


Figure 10. Foundation Layout

The diagram above shows the final orientation of the foundations that will be used in the design for the community center.

The values shown below are the values and results for the office building design.

Table 9. Soil Characteristics for Foundation

Angle of friction, ϕ	33°
Cohesion, C	1.88 kips/ft ²
Unit Weight of soil, γ	86 lb/ft ²
Depth to the bottom of Foundation, Df	2 ft
Base, B	80 ft
Factor of safety	3

The bearing capacity factors determined from the angle of internal friction are shown below.

Table 10. Bearing Capacity Factors

Bearing Capacity Factors	
Nc	38.64
Nq	26.09
N γ	35.19

Using the information above we were able to determine the necessary dimensions for the mat foundation for the office building with the applied bearing capacity shown being applied. The determination of the allowable bearing capacity and the ultimate

bearing capacity can be determined with the use of general bearing capacity equation and the factor of safety of 3.

Table 11. Bearing capacity

Bearing capacity	
q (ultimate)	200 kip/ft ² 
q (allowable)	66.3 kip/ft ²

Conclusion and Recommendation

For the design of the homes and the site feature there will be designed in the next phase of the project which will include the grading and new site elevations for the cut and fill complete calculator and evaluation of the site. The foundation for the office building will also be designed using the appropriate design constraints. The foundation and the site analysis has been completed in preparation for the complete site to ensure the foundation design of the new feature will be well for the type of soil found in the area.

The determination of the different foundations for the next buildings will potentially be a matt foundation to ensure the weight of the building won't have a major effect in the soil in the area. The structural analysis of the building will help determine the final design of the foundation.

Transportation

Introduction

This report presents the design for roadway structural components for the intersection design at Bauer Road in Harris County, TX. The transportation design aspects of the project include: a subdivision layout of street network, sidewalks, driveways, roadway expansion, pavement design, and signage for the project site. All roadway components must meet TXDOT and Harris County standards. Parking lots will be designed for all structures within the complex including the community center and office space. Parking will include bus and service truck parking to accommodate visitors to the facility.

The constraints are as follows: only two driveway entrances permitted into the complex. One entrance should be aligned so that traffic is regulated by a traffic signal. Maintain the maximum distances possible between drive lanes. Bus and service parking to be separated from cars to accommodate visitors coming to the facility. Provide accessibility per ADA throughout the fact. Sidewalks are required throughout the complex include the residential areas. A right-turn lane is required at the main entrance. All roadway designs must be following TXDOT specifications.

Design Task

The responsibilities of the transportation department include inspection design, roadway expansions, sidewalks, parking lots, driveways, pavement design, Signage and striping. The project streets are as shown below. A roadway layout must be created that shows the main road at entrance, road to late and also to water and wastewater treatment plant. The locational of signals, a one span bridge layout design , also plan and profile of typical local road.

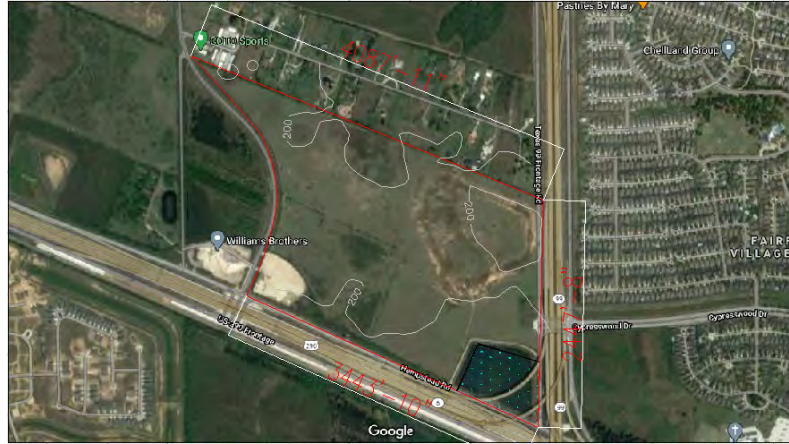


Figure 11. Site Plan

Community Road Expansion

The main entrance into the complex and subdivision is an expansion of Community Road to a 4-lane boulevard. Existing conditions of Community road are: 2 lanes (one each direction), 10' shoulders, No existing pavement markings. This will expand the roadway to a 4-lane (two each direction). The lane width of the roadway has a great influence on safety. Lane widths of 9' to 12' are generally used. A 12' lane is predominately used on most highway types. The plan is to use the maximum lane width of 12' for each traveling lane. With 60' of ROW available for the roadway this will be used for the main roadway. A sketch is shown below of the proposed cross section of Community Road.



Figure 12. Existing Road Conditions

Intersection Redesign

Sidewalk Design

The next step in the design process was determining the dimensions of the sidewalk in the complex area. Harris County has no standards regarding these dimensions, so standards from the city of Houston were used. Thus, the sidewalk width was set at 5 ft. The distance from the edge of pavement of the road to the edge of the sidewalk is 2 ft. The thickness of the sidewalk is 4.5 in. The sidewalk will be reinforced longitudinally with 4 #3 bars at 22 in. spacing with end bar spacing at 3 in. Transversely, there will be #3 bars spaced at 48 in.

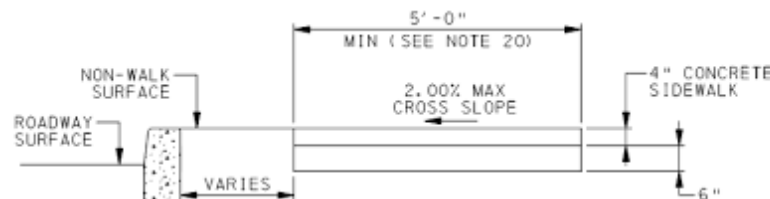


Figure 13. Sidewalk Layout

Parking Lot Design

When the design of the parking stalls began first is the selection of parking stall angles. A 90-degree parking angle was chosen for both parking lots. A 90-degree angle is appropriate for long term parking, efficient for developing the maximum amount of spaces while also accommodating vehicles of every type. To determine the appropriate number of stalls needed to properly design the parking lots I began with gathering the approximate square footage for each of the buildings located on site. Each component of the complex was taken into consideration when calculating the number of parking stalls needed for the complex grounds. The Americans with disabilities act (ADA) has regulations outlining minimum accessibility requirements for buildings and facilities. New construction projects must meet minimum standards with very few exceptions; alterations are also subject to strict requirements, although they may be more affected

by existing structural conditions. Thus far, the following parameters were extracted from a secondary cross reference to calculate the parking stalls accordingly:

- Wastewater Treatment Facility Parking
 - ❖ 187 Parking stalls
 - ❖ 6 ADA Parking stalls
- Water Treatment Facility
 - ❖ 220 Parking Stalls
 - ❖ 7 ADA Parking Stalls
- Office Building
 - ❖ 67 parking stalls
 - ❖ 4 ADA Parking stalls
- Community Center
 - ❖ 84 parking stalls
 - ❖ 4 ADA Parking Stalls
 - ❖ 4 Bus Parking Stalls (Separate from regular parking)

Layout of Subdivision

For the main entrance it is located at the US 290 Intersection and Bauer Road. To maximize the amount of space that is available Six Figure Engineering has decided to have a total of 60 residential lots. Within the subdivision there will be Cul de sac and local streets to help residents get to and from homes. One of the main roads within the subdivision will lead to the existing lake.

Pavement Deign

For the pavement design there were two options that were considered. Those two were rigid pavement or flexible pavement. Flexible pavement is low strength and high Maintenance cost. To be aware of efficacy Rigid pavement is the best option for the pavement design. Rigid pavement load transfer does not exist. It has high strength lifespan with a low Maintenance cost. Also damage and oils and leaks likely to damage them.

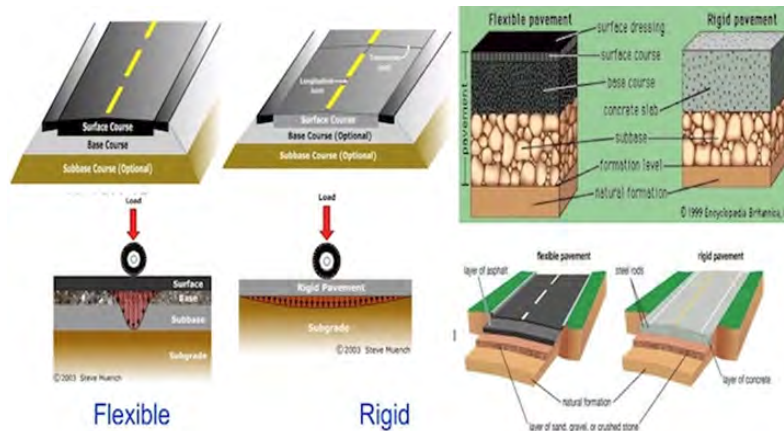


Figure 14. Pavement Design

Future Design

The next phase of design will include the completion of horizontal and vertical alignment. An examination of traffic warrants has been completed to determine if signalization of the intersections is necessary. Signage and striping for all roadways will be added, including the residential area. All warrants and standards will be verified for the state and county. A cost analysis for the transportation design aspects of the complex design will be completed and lastly, the parking lot design for the water and wastewater treatment plant will be designed. In addition the typical on span bridge design will be included as well

Environmental (Water Treatment and Distribution)

Introduction

The water treatment and distribution section were told to design a water treatment plant that would be able to reach the demand of a 10,000 population. We had to find a water source that would be able to source the surrounding buildings and subdivision. As well this treatment plant needed to reach all the requirements. The dimensions for the water treatment plant is 850'X 350'. It is approximately 350 feet away from the wastewater treatment plant and 200 feet away from the homes. The water source chosen will be lake Houston which is a water reservoir from the San Jacinto River. The river runs about 15 miles northeast from downtown Houston. There was a surface area of 11,852.8 acres. The goal for the water treatment plant is for the water to be disinfected, no odor or color. The water treatment plant will include screening, flocculation basin, sedimentation basin and rapid sand filter as well as disinfection and storage tank.

Water Demand Calculations:

Our population is 10,000 capita and our Annual Average Daily Flow being 150 GPCD, And our peak flow being 1.75 hourly factor. No seasonal correction factor needed.

$$Q_{\text{average}} = (\text{Population}) * (\text{AADF})$$

$$Q_{\text{average}} = 10,000 * 150 \text{ GPCD} = 1,500,000 \text{ GPD}$$

$$Q_{\text{Desing}} = (Q_{\text{average}}) * (\text{Peak F})$$

$$Q_{\text{Desing}} = 1,500,000 \text{ GPD} * 1.75 = 2,625,000 \text{ GPD}$$

Fire Demand

To find the fire demand the following formula was used:

American Insurance Association Formula:

$$Q(\text{gpm}) = 1020\sqrt{P(1-0.01\sqrt{P})}$$

$$Q(\text{gpm}) = 1020\sqrt{10(1-0.01\sqrt{10})} = 3,123.52 \text{ GPM}$$

$$\text{Once converted into GPD} = 4,497,868.8 \text{ GPD}$$

Total Water Distribution

$$Q_{\text{total}} = 2,625,000 \text{ gpd} + 4,497,868.8 = 7,122,868.8 \text{ gpd}$$

$$Q_{\text{total}} = (.15) * (7,122,868.8) = 1,068,430.32$$

$$Q_{\text{total}} = 7,122,868.8 - 1,068,430.32 = 6,054,438.48 \text{ gpd}$$

$$\text{Converted into MGD} = 6.05$$

Sedimentation

For the sedimentation calculations we ended up with two tanks.

$$Q_c = 2.625 \text{ MGD} / 2 = 1.312 \text{ MGD}$$

The volume came out to be 58,475.64 feet squared. While using an automatic sludge removal of 4 hours.

Depth : 11.13 ft

Area: 5,250 ft

Width: 36.24 ft

Length: 144.96 ft

Weir Length : 3.93 e10



Proposed Schematic

Will compose of the following:

- Screening - Coarse bar screen (Spaces = 3")
- Flocculation basin
- Sedimentation basin
- Rapid sand filter
- Disinfection
- Elevated storage tank
- Distribution

Conclusion

In conclusion some of the calculations for the water treatment section have been done for the population of 10,000. As well more detail and calculation need to be done for each of the water sections. By the end of the semester there will be a preliminary water treatment done.



Environmental (Wastewater Treatment and Collection)

Introduction

The purpose of the “Wastewater Treatment and Collection” section was to design a wastewater treatment plant that would serve a population of 10,000 persons and collect it only from PVHB’s Subdivision. The goal of this wastewater treatment plant was to remove contaminants that are typically in domestic wastewater to satisfy Lake Houston’s effluent limits, so that a NPDES permit could be retained. In this section of the report, the details of the site, treatment unit designs, and the collection system will be explained in full detail, keeping in mind that this is a preliminary design.

Without the full design of each of the treatment units and referring to other wastewater plants that serve around the same population. The dimensions for the lot were estimated to be a maximum of 800ft x 500ft, 10,000 people is a rather big population to serve. The location of this lot is in the northeast corner of the full site, keeping a 500ft distance away from the existing residential homes, and keeping a minimum of 400ft away from the lake that will be potentially used as a detention pond. The discharge source chosen is Little Cypress Creek, located 1.60miles away from a lot of the plant. Little Cypress Creek is the “22nd Watershed” or sub watershed of the major Cypress Creek watershed within Harris County, both watersheds eventually flowing into Lake Houston. As mentioned above, to obtain a NPDES permit for this wastewater treatment plant, the effluent limitations for Lake Houston were taken into consideration while designing this wastewater treatment plant.

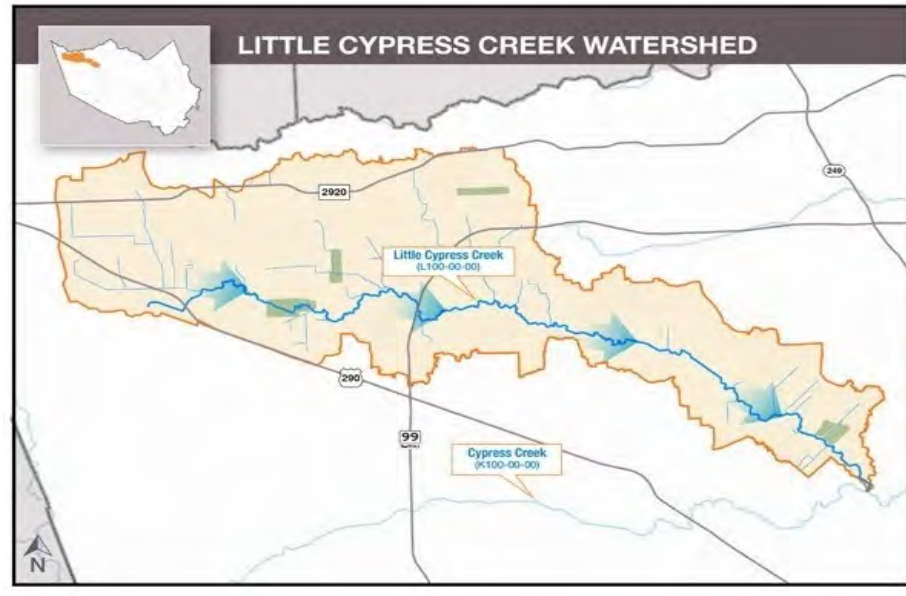


Figure 15. Little Cypress Creek Watershed

Wastewater Demand Calculations:

Table B.1. - Design Organic Loadings and Flows for a New Wastewater Treatment Facility

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Municipality	Residential	75-100	250-400	15-75
Subdivision	Residential	75-100	250-400	15-75
Trailer Park (Transient)	2½ Individuals per Trailer	50-60	250-350	15-75
Mobile Home Park	3 Individuals per Trailer	50-75	300	15-75
School	Cafeteria & Showers	20	300	15-75
	Cafeteria/No Showers	15	300	15-75
Recreational Parks	Overnight User	30	200	15-75
	Day User	5	100	15-75
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75
Hotel/Motel	Per Bed	50-75	300	15-75
Restaurant	Per Meal	7-10	1000*	15-75
Restaurant with bar or cocktail lounge	Per Meal	9-12	1000*	15-75
Hospital	Per Bed	200	300	15-75
Nursing Home	Per Bed	75-100	300	15-75
Alternative Collection Systems (Subchapter D of this chapter)	Per Capita	75	N/A	N/A

*Based on a restaurant with a grease trap

Figure 16. TAC Table B-1 Design Organic Loadings and Flows

Wastewater demand for the plant to treat was determined from the maximum capacity of the two buildings that can be served at the community center and the 3-story office facility; this is included in the 10,000 population that was given to design for.

From TAC Table B.1, the **Subdivision** annual average wastewater flow is given as 75 gpcd minimum and 100 gpcd maximum flow, for design purposes 100 gpcd will be used.

For the subdivision with a 10,000 population, the wastewater flow that will be discharged to the wastewater treatment plant is:

$$Q_{\text{avg}} = 10,000 \text{ capita (100 gpcd)} = 1,000,000 \text{ gpd}$$

TAC Title 30; “Peak flow. When site-specific data is unavailable, the peak flow must be determined by multiplying the design flow by a factor of at least 3.0”.

Therefore, the total average flow multiplied by the peak factor is **3,000,000 gpd = 4.64 cfs** (for pipe design).

Pipe Design



Figure 17. Mainline Location

In this section, the mainline coming from the subdivision entering the wastewater treatment plant, design and details will be explained.

The pipes were designed by the iteration method, with the following assumptions and design criteria:

- Full Flow
- Turbulent Flow $R > 4000$
- PVC pipe with an absolute roughness, $k = 0.0049\text{mm}$
- Temperature $70^\circ\text{F} \therefore \text{kinematic viscosity} = 1.059 \times 10^{-5}$
- Cause no head loss in excess of 0.328ft

- Assuming resistance coefficient, $f = 0.020$

With improved resistance coefficient; $f = 0.021$, $k/D = 0.00123$, $Re = 1.40 \times 10^5$

Assumed Length = 550 ft, Diameter = 4 ft with a Velocity of 0.37 ft/s

Schematic

The CWA requires that municipal wastewater treatment plant discharges meet a minimum of 'secondary treatment'. The schematic will consist of coarse and fine screens, primary clarifier, an aeration tank, secondary clarifier, and disinfection.



Design Parameters

Preliminary Treatment Units

45 degrees from vertical to facilitate cleaning. Velocity through the screens: 1.76 ft/s

Coarse Screens-

- Opening size: 1 inch
- 45 degrees from vertical to facilitate cleaning.

Fine Screens-

- Opening size: 0.2 inches

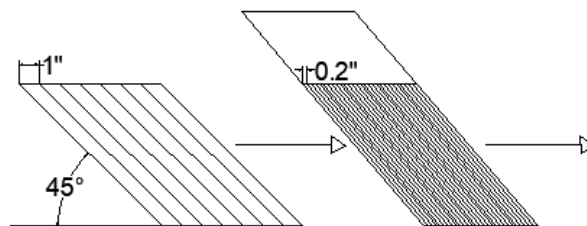


Figure 18. Preliminary Treatment Design

Primary Clarifier-

The clarifier process will consist of a total of 5 rectangular tanks, each having the design parameters listed below.

- Flow Rate: 600,000 gpd
- Surface Area: 510 ft²
- SLR: 1,177.63 gpd/ft²
- Detention Time: 1.8 hours
- Volume of Tank: 6,020 ft³
- 10ft SWD
- Velocity: 0.0047 ft/s
- Weir Length: 24 ft
- Rotating skimmer arm with bottom scrappers

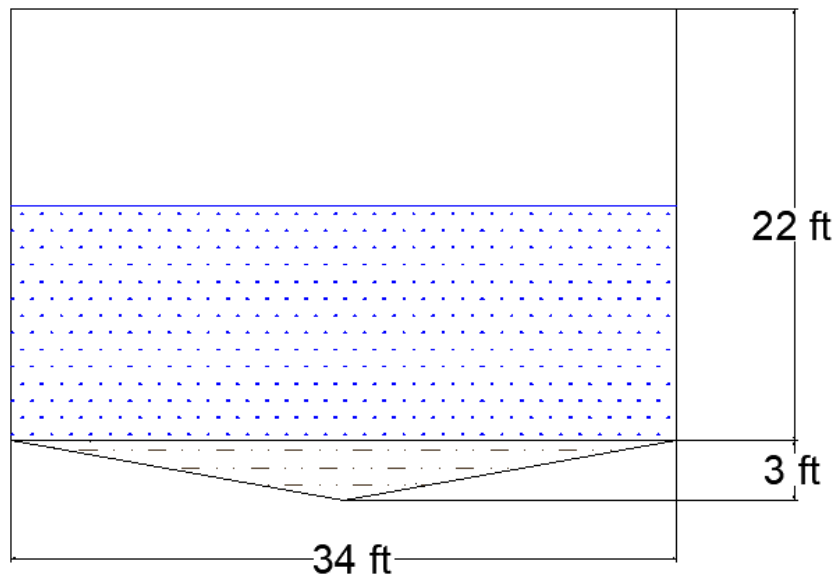


Figure 19. Primary Sedimentation Tank

Conclusion

This section for wastewater treatment and collection has the information for the required design parameters, the wastewater demand, location of the discharge source and the effluent limitations for that source, lot size and location. Those parameters were used to design the wastewater treatment plant and its units that will be used at this plant. Currently, the preliminary treatment tanks are sized and designed, this will later contain more detailed calculations and a full design of the other tanks within the wastewater treatment plant and the collection system for the PVHB subdivision.



Water Resources

The detention pond was designed to hold all the water that was collected on the subdivision without flowing to any of the other buildings. To design for the correct volume, the impervious surface had to be accounted for. Impervious surfaces are any surface that do not let any fluids pass through. The area of impervious surface was found by using AutoCAD to find the area of the entire subdivision Chapter 9 of the City of Houston Design Manual. When determining the Drainage for the subdivision we dealt with an area of 5,631.132sqft. This converted into acres comes out to 129.3 acres. The impervious cover was found based on the HCFCD manual for a larger residential development and lake. Now we take the two-total area of the site and 7,325,485.2sqft (168.17 acres). With this information we can determine our impervious cover:

$$\text{Impervious Cover} = \frac{129.3\text{acre}(20\%) + 11.4\text{acres}(100\%)}{168.17} = 22.16\%$$

Inflow Process

Once the impervious cover has been calculated we can then use the governing equation to determine the Inflow peak discharge of the subdivision. Using HCFCD MANUAL (Harris County Flood Control District) (chapter 3.3 pg. 3-4) We can find the equation as follows:

$$Q_p = bA^{m_m}$$

When,

Q_p Peak Inflow discharge

b, Variable that depends on the impervious cover

A, Total area of the of subdivision (acres)

m, 0.823 for areas between 20 and 640 acres

To determine the b variable The Harris county Flood district is called for to interpolate the be value and plug into the equation HCFCD manual this gave us b of 5.5.

Impervious Cover	50% Prob.		10% Prob.		1% Prob.		0.2% Prob.	
	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres
0%	0.6	1.2	1.2	2.1	2.0	3.4	2.8	4.8
10%	0.8	1.5	1.5	2.6	2.5	4.3	3.5	5.9
20%	1.0	1.8	1.8	3.1	3.1	5.3	4.3	7.3
30%	1.2	2.1	2.3	3.9	3.8	6.4	5.3	9.1
40%	1.4	2.4	2.7	4.6	4.3	7.3	6.0	10.7
85%	2.2	3.7	3.5	5.9	5.1	8.7	7.1	12.1

Figure 20.

This led to determining the inflow needed for the subdivision which gave a peak inflow discharge of 373.36 cfs. From with this number given we determine the time it will take to peak the equation in the HCFCD manual the equation is as follows:

$$T_p = \frac{V}{1.39Q_p}$$

Where,

T_p , Time to peak given inflow Discharge.

V , Total Volume Runoff:

Watershed: Name and HCFC Letter Designation	Total Rainfall (inches)	Direct Runoff (inches)		
		0% Impervious	40% Impervious	85% Impervious
Region I				
Addicks Tributaries (U) Barker Tributaries (T) Cypress Creek (K) Little Cypress Creek (L) Spring Creek (J) Willow Creek (M)	12.4	7.9	9.7	11.7

Figure 21. Direct runoff interpolation method.

Before creating the hydrograph, we need to determine the total volume runoff for the subdivision which would be to multiply the drainage area by the depth of direct runoff. The direct runoff depth was determined using the table for a 1% Probability event HCFC manual.

After interpolating from the table, we multiply the interpolated runoff depth by the total area of drainage.

$$V = Ah$$

Where,

h, Runoff depth

We get a volume of 4,177,295ft³ we can then plug in the volume of runoff to determine the time to peak given the peak discharge. The time to peak was 2.5hours. With knowing the peak discharge and time to peak we created our inflow hydrograph. The t_i and q_i were the limits for creating the hydrograph. For the rising limb the first time cannot exceed 1.25Tp and the second equation t_i is greater than 1.25Tp.

The Small Watershed Hydrograph Method consists of the following equations:

$$T_p = \frac{V}{1.39Q_p}$$

$$q_i = \left(\frac{Q_p}{2} \right) \left[1 - \cos \left(\frac{\pi t_i}{T_p} \right) \right] \quad t_i \leq 1.25 T_p$$

$$q_i = 4.34 Q_p e^{\left(-1.3 t_i / T_p \right)} \quad t_i > 1.25 T_p$$

in which:

Q_p = peak discharge in cubic feet per second from Site Runoff Curves

T_p = time to Q_p in seconds

V = total volume of runoff for the design storm in cubic feet

t_i and q_i = the respective time and discharges which determine the shape of the hydrograph

Figure 22. Peak Time given discharge equation from HCFCD manual

This gave us our complete inflow hydrograph which shows the time in with the water runoff will peak. Using the table generated from these values the hydrograph was created.

Inflow Hydrograph

This hydrograph shows the time in which it would take to reach the peak discharge for the subdivision. As seen the peak is roughly 2.5 hours.

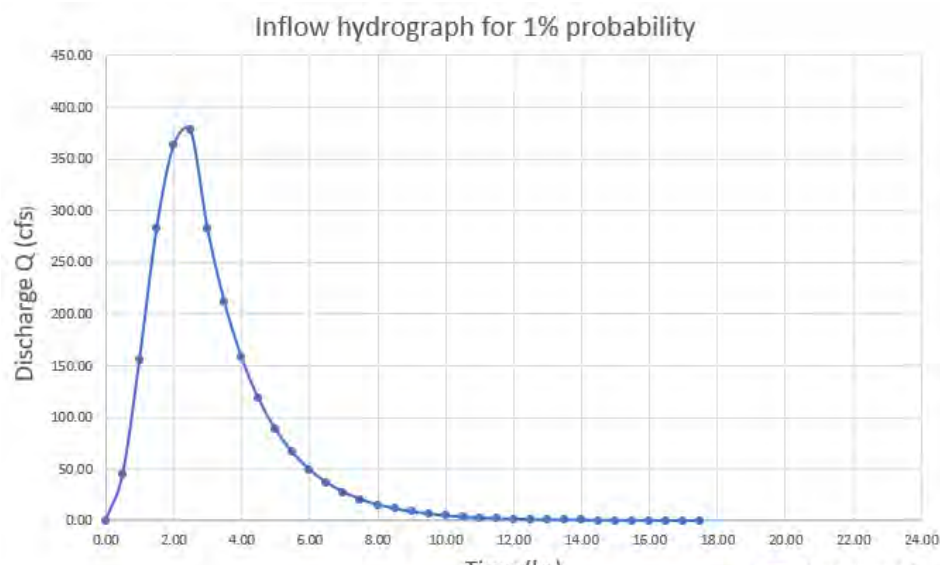


Figure 23. Inflow Unit Hydrograph

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Environmental Protection Agency

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[06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf](https://www.epa.gov/sites/production/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf)

- **FEMA Flood Map**

- <https://msc.fema.gov/portal/search?AddressQuery=hockley%2C%20texas#searchresultsanchor>

Appendix

Environmental (Wastewater)

Pipe Dia. for main line (from subdivision to WWTP)

Iteration method

Temp 70°F $\therefore$ kinematic viscosity = 1.059×10^{-5}

Assuming $L = 550$ ft

$$\frac{k}{D} = \frac{0.0015}{D} = \frac{0.0015 / 0.5048}{D} = \frac{0.0049}{D} \text{ (SI units)}$$

$$Re = \frac{4Q}{\pi D \mu} = \frac{4(4.64 \text{ cfs})}{\pi D (1.059 \times 10^{-5})}$$

$$D = f^{1/5} \left[\frac{(8)(550 \text{ ft})(4.64 \text{ cfs})^2}{\pi^2 (32.17 \frac{\text{ft}}{\text{s}^2}) (0.530 \text{ ft})} \right]^{1/5} = 7.85 f^{1/5}$$

Assuming $f = 0.020$

$$D = 7.85 (0.020)^{1/5} = 3.59$$

Plug in D

$$\frac{k}{D} = \frac{0.0049}{3.59} = 0.0014$$

$$Re = 1.55 \times 10^5$$

From Moody chart $\rightarrow f = 0.022$

$$\text{Using new } f \rightarrow D = 7.85 (0.022)^{1/5} = 3.66$$

$$\frac{k}{D} = 0.0013$$

$$Re = 1.52 \times 10^5$$

$$\therefore f = 0.022$$

$$\text{dia} = 3.60 \text{ ft} \approx 4 \text{ ft}$$

Primary Clarifier

- Assuming 5 Tanks

$$Q_{\text{per tank}} = \frac{3,000,000 \text{ gpd}}{5 \text{ tanks}} = 600,000 \text{ gpd/tank}$$

$$V = Q_{\text{per tank}} (\theta) = 600,000 \text{ gpd/tank} \left(\frac{1.8 \text{ hrs}}{24 \text{ hr}} \right) \left(\frac{1 \text{ ft}^3}{7.48 \text{ gal}} \right)$$

$$V_{\text{per tank}} = 6,016.04 \text{ ft}^3$$

- Assuming SLR = 1,000 gal/day-ft²

$$A_{\text{per tank}} = \frac{Q_{\text{per tank}}}{\text{SLR}} \Rightarrow \frac{600,000 \text{ gpd/tank}}{1,000 \text{ gpd-ft}^2}$$

$$A_{\text{per tank}} = 600 \text{ ft}^2/\text{tank}$$

$$\text{Depth per tank} = \frac{V}{A} = \frac{6,016.04 \text{ ft}^3}{600 \text{ ft}^2/\text{tank}} = 10.03 \text{ ft/tank}$$

$$\text{Depth} = 10.5 \text{ ft} + \text{SWD}$$

$$\text{Depth per tank} = 10.5 \text{ ft} + 10 \text{ ft} = 20.5 \text{ ft}$$

$$L = 4W$$

$$\text{Width per tank} = \sqrt{\frac{A}{4d}} = \sqrt{\frac{6,016.04 \text{ ft}^2}{4(20.5 \text{ ft})}} = 8.56 \text{ ft} \approx 9 \text{ ft}$$

$$\text{Length per tank} = 4(8.56 \text{ ft}) = 34.26 \approx 34.5 \text{ ft}$$

$$\text{Cross section } A = Wd \Rightarrow 9 \text{ ft} \times 20.5 \text{ ft} = 184.5 \text{ ft}^2$$

$$V = \frac{600,000 \text{ gpd}}{184.5 \text{ ft}^2} \left(\frac{1 \text{ ft}^3}{7.48 \text{ gal}} \right) = \frac{434 \text{ ft}}{d} \left(\frac{1 \text{ hr}}{24 \text{ hr}} \right) \left(\frac{1 \text{ min}}{60 \text{ min}} \right) \left(\frac{1 \text{ sec}}{60 \text{ s}} \right) = 0.00504 \text{ ft/s}$$

- Assume WLK = 25,000 gpd-ft

$$LW = \frac{600,000 \text{ gpd/tank}}{25,000 \text{ gpd-ft}} = 24 \text{ ft}$$

CSR ENGINEERING INC.

December 3, 2020

Dear Judges,

The attached report contains the detailed plans for a newly constructed subdivision and community center in northwest Harris County, Texas. This report includes the scope of work, the main components of each project and visual aids. A few main components include:

- 2D Office Building Conceptual Design
- 2D Housing Floor Plan
- Soil Analysis
- Subdivision Roadway Layout
- Water & Wastewater Treatment Plant
- Recreational Lake Design

CSR Engineering Inc. is available to answer any questions that you may have concerning this report or the project. You can contact our team lead Chantice Redeau at (phone number: 210-849-0082 or email: credeau@student.pvamu.edu)

Sincerely,

Jamal Baker
Marshall Green
Randelle Jones
Nykea Keitt
Chantice Redeau
Trevon Rogers

SAMPLE 2



College of Engineering

Senior Design Project



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INTRODUCTION

The proposed subdivision, located in northwest Harris County, has been designed based on the provided design data, environment, and the future needs for the public. CSR Engineering Inc. has decided to name the proposed subdivision, The Gateway. The area is northwest of Houston near the US 290 & SH 99 Grand Parkway Interchange. The 359 acre property is located south of US 290 and west of SH 99. The main entrance of the subdivision will be signalized and located at the Bauer Rd. & US 290 intersection. Within the subdivision, Water & Wastewater Treatment Plants will be designed to serve 10,000 people. Landscaping will also be considered to not only enhance the area, but to help with drainage. Placed in the center of the residential area, will be a recreational lake to serve as a detention pond and resident's leisure.

Additionally, the community center & office building are located within the 359 acres of land. The community center will be a 9600 square foot building that will provide residents with a place to host events. The office building will be 28,800 square feet and will be the headquarters of a major company.

CHAPTER 1: PROJECT SCOPE

1.1 Problem Statement

To design a subdivision which includes a community center and office building with a 30-year design period.

1.2 Project Goals & Objective

The project team is required to perform Civil Engineering Site Development, and Design services and address all aspects outlined in the reporting requirements and deliverable items of this project description. The purpose of this project is to provide an AutoCAD geometric design that includes a subdivision roadway layout and location of the recreational lake. Water & Wastewater Treatment plants are needed to serve 10,000 people for the subdivision and surrounding area.

In addition, a 2D conceptual layout design of the community center and office building are needed. Also in the area, parking facilities will be designed for each building. It is required to add a 5 foot sidewalk to the main road and near the community center and office buildings.

CHAPTER 2: PRELIMINARY DESIGN

2.1 Structural Engineering

2.1.1 Design of Homes

The homes in our subdivision measure 82 ft x 82 ft. and the entire area each home will be built on totals 13,000 square feet. The homes feature many luxury amenities including an in-home theatre, exercise room, and guest suite. STAAD Pro is a software that will be utilized to provide an illustrative model of the steel frame, by featuring maximum loadings based on beam self-weight and the calculated loads established. Each represents environmental sustainability due the versatility and reusability of the materials used. There are various live loads that are subjected to the overall structure, and to the floor of the steel frame. Live loads are forces that vary in location and magnitude of each load. They are a gravitational force that can be moved and placed based on the criteria and prior history of installation.

When it comes to the structural aspects of projects there are several softwares that aid in the design of steel structures. STAAD Pro is one of those softwares, STAAD or is a structural analysis and design software application originally developed by Research Engineers International. It can make use of various forms of analysis from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. When choosing the proper number steel beam and column multiple tests are run in the Staad Pro software until the displacement of the structure is a perfect match to the outline of the Steel frame .





Figure 2.1.1 Home Floor Plan (AutoCad)

2.2 Geotechnical Engineering

2.2.1 Site Assessment

The picture below is a topography map that shows the location of the site. The location of the site is south of 290, and west of 99. The size of the site is 2700 acres. The elevation of the site

goes into a downwards slope from 195 to 190 feet above sea level. Therefore the average elevation of the site is 192.5 feet above sea level.



Figure 2.2.1 Site Location

2.2.2 Soil Properties

The boring log data that was given for the location of the site is located below. This boring log displays the testing of the soil in order to classify the type of soil it is, the amount of stress it can take, as well as other properties of the soil that will make a difference when designing a structure on it.

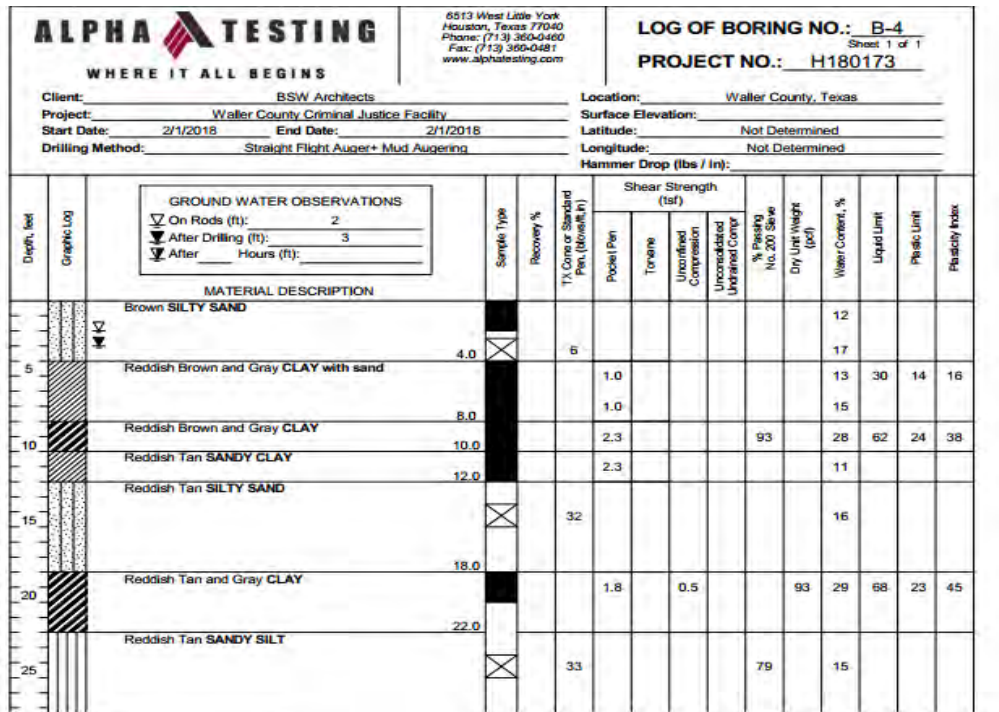


Figure 2.2.2 Boring Log Data of Site

The boring log tells the engineer the results from various tests of the soil within the site location. The log shows the depth of each kind of soil down to 22 feet. Based on the boring log data, the soil is classified as an A-6 Organic Sandy Clay. This was found by using the Liquid Limit (30), Plastic Limit (14), and Plasticity Index (16) shown on the boring log, and the use of the table and chart below to classify the soil of the site

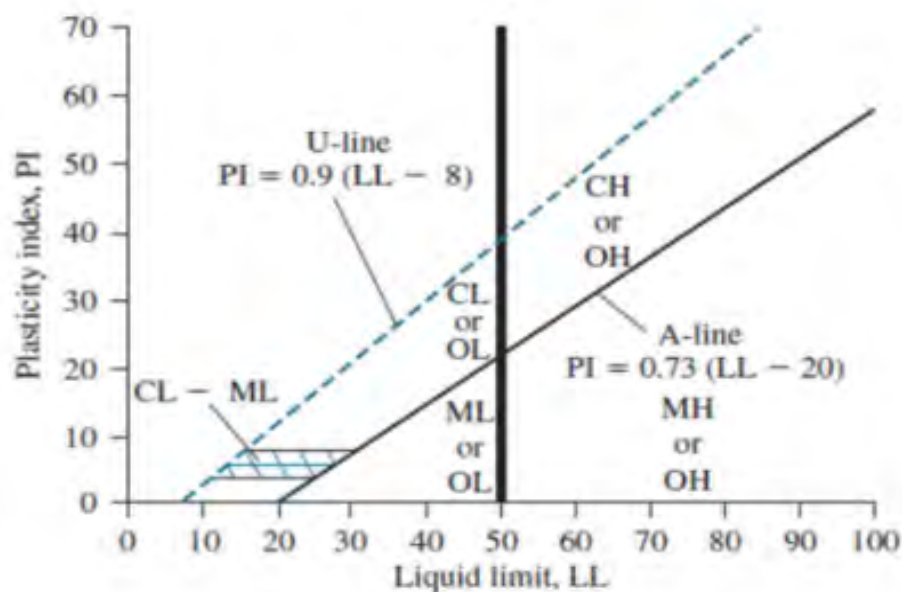


Figure 2.2.2A Plasticity Chart

Granular materials (35% or less of total sample passing No. 200 sieve)							
General classification	A-1		A-3	A-2			
Group classification	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (% passing)							
No. 10 sieve	50 max		51 min				
No. 40 sieve	30 max	50 max	10 max				
No. 200 sieve	15 max	25 max		35 max	35 max	35 max	35 max
For fraction passing No. 40 sieve							
Liquid limit (LL)				40 max	41 min	40 max	41 min
Plasticity index (PI)		6 max	Nonplastic	10 max	10 max	11 min	11 min
Usual type of material	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
Subgrade rating	Excellent to good						

Silt-clay materials (More than 35% of total sample passing No. 200 sieve)					
General classification	A-4		A-5	A-6	A-7
Group classification					A-7-5 ^a A-7-6 ^b
Sieve analysis (% passing)					
No. 10 sieve					
No. 40 sieve					
No. 200 sieve	36 min		36 min	36 min	36 min
For fraction passing No. 40 sieve					
Liquid limit (LL)	40 max		41 min	40 max	41 min
Plasticity index (PI)	10 max		10 max	11 min	11 min
Usual types of material			Mostly silty soil	Mostly clayey soil	
Subgrade rating	Fair to poor				

^aIf $PI \leq LL - 30$, the classification is A-7-5.

^bIf $PI > LL - 30$, the classification is A-7-6.

Figure 2.2.2B AASHTO Soil Classification System

2.2.3 Soil Bearing Capacity

The bearing capacity of the soil within the site, can be calculated by using Terzaghi's Equation:

$$Q_{ult} = cN_c + (\gamma_1) D_f N_q + 0.5 (\gamma_2) B N_\gamma$$

Figure 2.2.3 Terzaghi's Equation

Based on the number of blows (6) provided by the boring log data, the angle of friction (31 degrees) and unconfined compressive strength ($S_u = 0.75$ tons/ft) can be found using the guide for grain soil table. The angle of friction was then used to find the N_c , N_q , and N_γ values of Terzaghi's equation. The values of N_c , N_q , and N_γ can be found using Terzaghi's Table of Bearing capacity factors.

Nc value	40.41
Nq value	25.28
Ny value	22.65

Table 2.2.3a Terzaghi's Bearing Capacity Factors

The thickness of the slab (B) will be 4 feet thick, based on the slab to grade foundation that the structures will be designed for. The depth of the soil, Df will be assumed to be 6 foot. The cohesion value in Terzaghi's equation is found dividing the unconfined compressive strength by two, equating to 750 pounds per square feet. This cohesion value shows that the soil is stiff, and is possibly a good depth to build a slab foundation on. The saturated weight of the soil (gamma) is given by the boring log data (15 kilo-newtons per cubic meter = 3.37 pounds per cubic feet). Now solving for the bearing capacity, the total ultimate bearing capacity is calculated to be 12,971 pounds per cubic feet. Using a factor of safety of three, the allowable bearing capacity of the soil is calculated by dividing the ultimate bearing capacity by three. Thus equating an allowable bearing capacity of 4,324 pounds per cubic feet. (See appendix for hand calculations.)

2.2.4 Site Plan

The site plan of the subdivision is shown below, this site plan shows the sections within the subdivision where the individual sections (Area 1, Area 2, Area 3) are analyzed using the grid method for developing the earthwork (cut and fill) of the site.

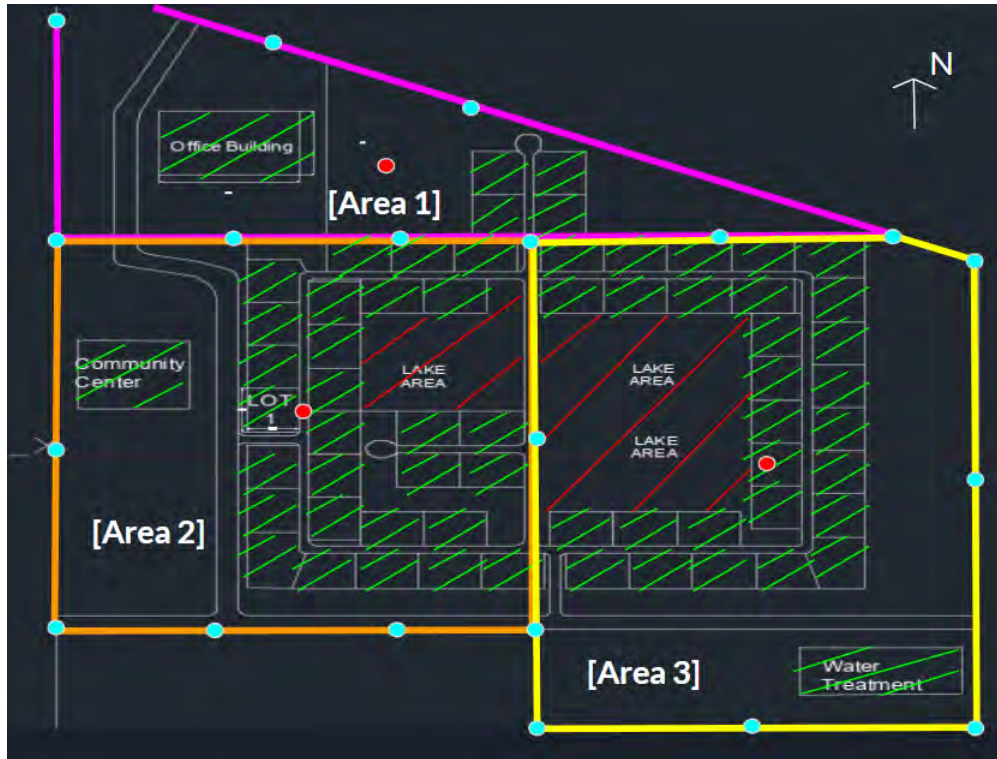


Figure 2.2.4 Site Division of Subdivision

2.2.5 Sub Division Areas

The center and existing ground elevations are set at 195 feet above sea level. However, because this area is mostly flat, the area where the office building as well as residential housing will be filled 3 feet (to 198 feet above sea level) for drainage purposes. The green lines on the picture below indicate places that will be filled on the site, and lines that a red indicated places where the soil will be excavated. The red dot indicates the center ground elevation of the area.



Figure 2.2.5a Area 1 of Subdivision

The second area of the subdivision has a center elevation set at 195 feet above sea level. The average Existing Ground Elevations are 192.5 feet above sea level.

Again, this area is mostly flat, the area where the community center of the subdivision as well as residential housing will be elevated by 3 feet (198 feet above sea level) for drainage purposes. However, toward the bottom of area 2, the elevation is 190, therefore the residential housing in this area will need to be filled an additional 4 feet to be consistent with the other housing within the subdivision.



Figure 2.2.5b Area 2 of Subdivision

The third area of the subdivision has a Center Elevation set at 195 feet above sea level. The average Existing Ground Elevations are 192.5 feet above sea level.

Again, this area is going down slope. The area where the water treatment facility is located as well as the lower half of residential housing will be filled 7 feet, while the rest of the residential housing within the subdivision will be elevated 3 feet (198 feet above sea level) for drainage purposes. However, toward the bottom of area 2, the elevation is 190, therefore the housing in this area will need to be filled an additional 4 feet.



Figure 2.2.5c Area 3 of Subdivision

The lake area is approximately 15,250,000 sq. feet.

The depth of the lake will be 12 feet. This means that the amount of Cut that is needed for the lake is 12 feet below the flat 195 elevation (183 feet).

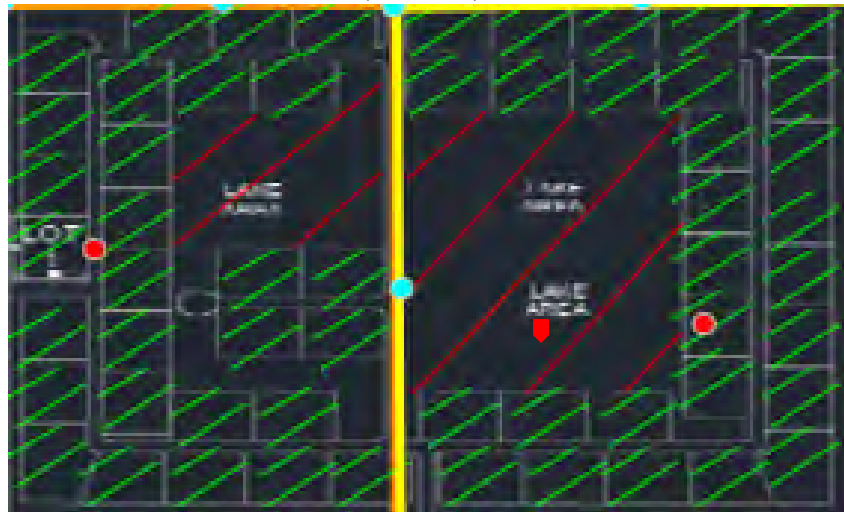


Figure 2.2.5d Lake Area of Subdivision

2.2.6 Cut and Fill Volumes

Cut and Fill Volumes determine the volume of soils needed to be either added or removed to make the elevation of a project sub area or of a proposed building level. The method used to calculate cut and fill is the grid method. The average existing elevations are subtracted from the

average proposed elevations. The result is multiplied by the area of either a building or a subarea to give the volume of cut-and-fill. A negative result indicates cut, and a positive result indicates fill. According to the TxDOT Specification Standards, the shrinkage/swelling factors are not needed to calculate the cut and fill volumes. Since the lake will cause a significant amount of excavation, the soil excavated will be used to fill the areas needing soil thus cutting cost down from the hauling process from an off site location.

Type of Building	Area of Building (sq. ft)	Average Existing Elevation (ft)	Proposed Elevation (ft)	Volume (cubic feet)	Cut or Fill
Office Building	9,600	195	198	19,200	Fill
Residential Home	6,800	192.5	198	81,600	Fill
Community Center	2,475	195	198		Fill
Lake	15,250,000	195	183	183,000,000	Cut

Table 2.2.6 Calculated Cut and Fill Volumes of Subdivision

2.2.7 Residential & Community Center Foundation Design

The foundation that will be provided for the community center, as well as the residential homes will be a slab-on-grade foundation. This foundation type is the most popular type of foundation for such type structures. The slab-on-grade foundation has many advantages and disadvantages. The advantages include: less expensive to construct, effective process, simplest foundation to construct, free from mold and mildew issues, and it allows a wide range of flooring options. The disadvantages included that it offers minimum protection to the home, potentially expensive repairs, and cracks can become an issue. Nonetheless the slab-on-grade foundation was chosen because of its cost effectiveness. An example of a slab-on-grade foundation is shown below.

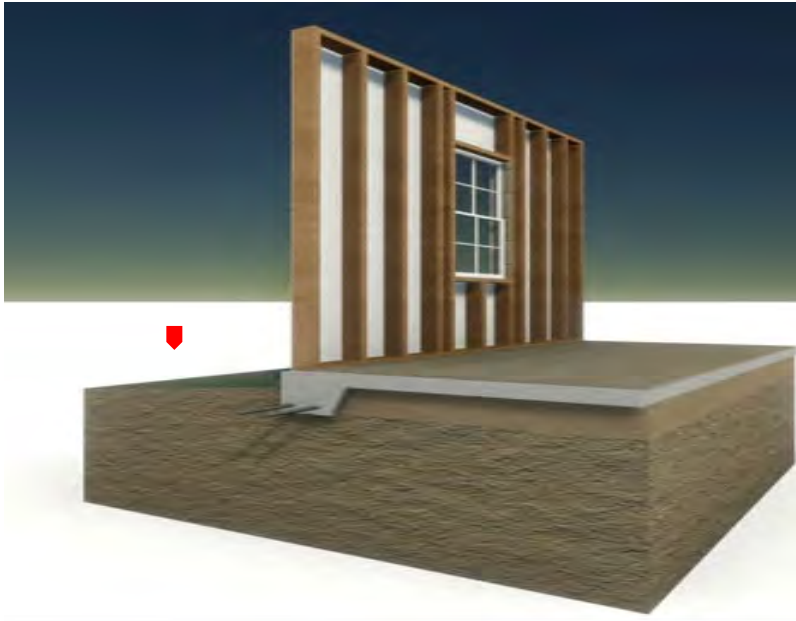


Figure 2.2.7a Slab on Grade Foundation Type



Figure 2.2.7b Slab on Grade Foundation Type

The foundation will have a depth of three feet. The foundation will also have a design period of 80-100 years. The foundation will have a thickness of 6 inch due to the normal standards of a

residential home with a slab foundation, as well as to ensure that the foundation can endure more strength. Similarly, the foundation will be concrete material, with no reinforcing bars/steel. The design drawing of the foundation is shown below.

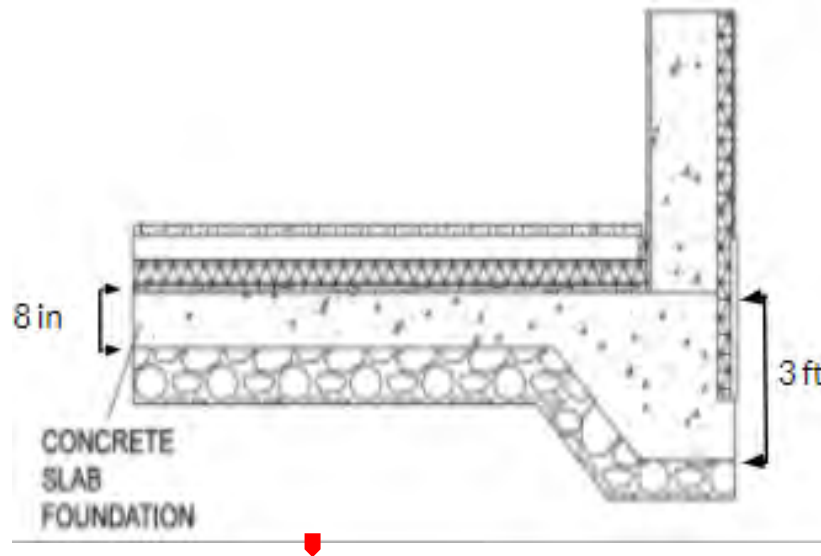


Figure 2.2.7c Slab to Grade Foundation Design Drawing

2.3 Transportation Engineering

2.3.1 Subdivision Roadway Layout

The subdivision roadway layout is designed to ensure every section has a calm traffic flow. As designed, the Office Building is located near the main entrance. The Community Center is located on the far west side of the property. Both buildings have access via the main road, Gateway Blvd. Gateway Blvd. travels north to south and terminates at the City of Houston ETJ proposed Mound Rd and is classified as a collector road. All residential properties are located east of Gateway Blvd. Located in the residential area are local roads and two cul-de-sacs. In addition, a secondary entrance to the subdivision will be at the proposed Mound Rd and SH 99 intersection. A typical one span bridge will travel across portions of the recreational lake located at the center of the residential section.

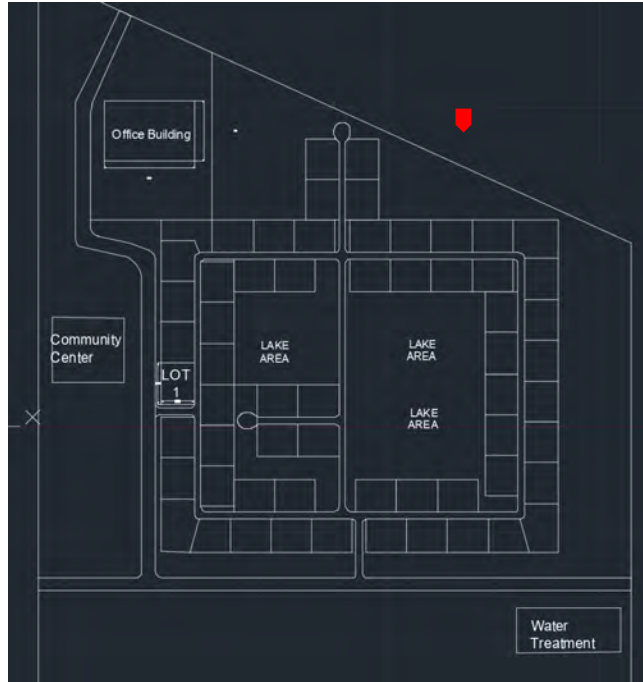


Figure 2.3.1 Subdivision Roadway Layout

Figure 2.3.1 displays the AutoCAD design of the roadway layout. All roadways were designed based on the Harris County Engineering Department Standards and Texas Department of Transportation Roadway Design Manual.

2.3.2 Gateway Boulevard Road Design (Main Rd.)

Gateway Blvd. is a .72 mile collector road that travels in a northward and southward direction. The road begins at the US 290 and Bauer Rd. intersection and terminates at the City of Houston ETJ proposed Mound Rd. CSR Engineering plans to partner with the City of Houston to construct Gateway Blvd. within the proposed right of way for Bauer Rd., shown in the figure below.

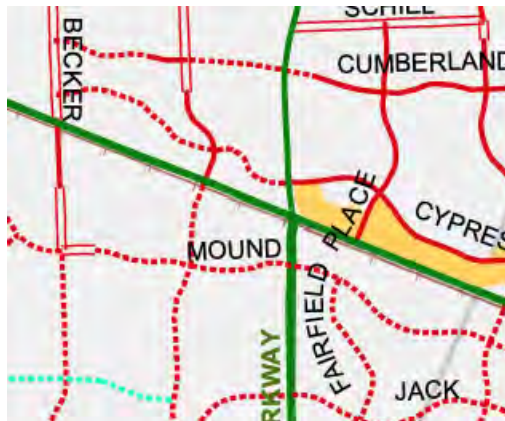


Figure 2.3.2 City of Houston Proposed Mound Rd.

Figure 2.3.2 shows the location of the proposed Mound Rd. The figure is a small display from the City of Houston's 2019 Major Thoroughfare and Freeway Plan. The dotted red line signifies a proposed major thoroughfare and the solid green line signifies a freeway or expressway.

The road will be widened from two lanes to four lanes to accommodate future traffic in the development. For the horizontal alignment, the centerline was first determined. Using the Google Maps, Point A was established at the intersection of US 290 & Bauer Road. as Station 0+00. The alignment terminates at Point B, Mound Road. The ending station of the alignment is 38+24.74. There are a total of 3 curves that make up .72 miles. The entrance to the residential neighborhood is at Station 28+00. In Figure 2.2.3, the horizontal alignment is drawn with the centerline and horizontal curve data. All curve data calculations can be found in the appendix.

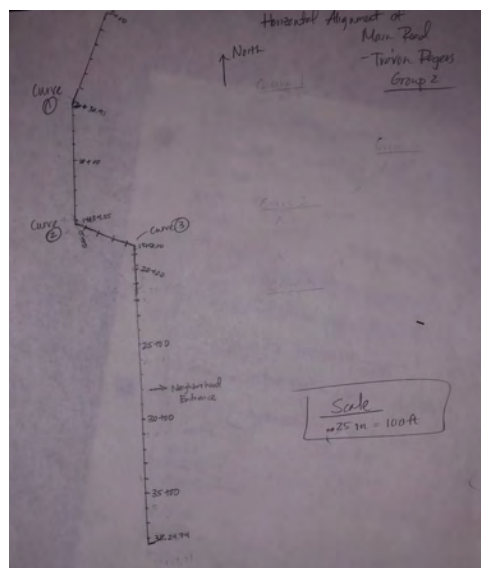


Figure 2.3.3 Horizontal Alignment of Gateway Blvd.

Table 2.3.1 consists of the data for each curve along the horizontal alignment. Curves are numbered in numerical order from north to south. The delta values are computed and tabulated in the table.



Table 2.3.1 Curve Data

Curve	Station	Delta (degrees)
1	6+30.91	24
2	14+34.55	15
3	18+50.00	18

The vertical alignment is currently still in development. The profile view will provide information to help determine the design speed and posted speed. Based on the contour map, the area is mostly flat at an elevation of 195 feet.

The widened four lane Gateway Blvd. will have a 84 feet right of way. Each lane will be 12 feet wide and a raised median width of 13 feet. 2 feet curb & gutters will be considered on both sides of the road, to help with drainage in addition to a 2 percent slope. All design standards were followed based on the Harris County Engineering Department. Table 2.3.2 shows the standard design values provided.

Table 2.3.2 Collector/Major Thoroughfare Roadway Design Standards

ROADWAY CLASSIFICATION	ROW (1)	4 LANES	4 LANES	4 LANES	6 LANES	
		80 FT.	90 FT.	100 FT.	100 FT.	
COLLECTOR OR MAJOR THOROUGHFARE	W	25 FT. (B-B)	25 FT. (B-B)	25 FT. (B-B)	34 FT. (B-B)	SEE COUNTY ENGINEER
	M	13 FT.	21 FT.	31 FT.	12 FT.	
	S	8.5 FT.	9.5 FT.	9.5 FT.	9.5 FT.	

Below is Figure 2.3.4 is an AutoCAD cross-typical section for Gateway Blvd. All drawings include 5 feet wide sidewalks on both sides. In the drawings, the dimensions are shown.

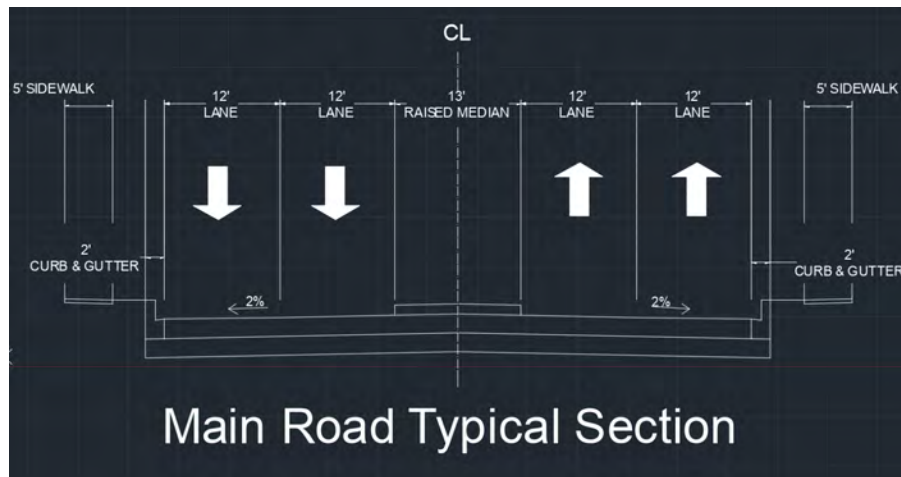


Figure 2.3.4 Main Road Typical Section

2.3.4 Local Residential Road Design

Local roads will be designed under Harris County Engineering Department design standards. Roads will have two 12 ft lanes and two cul-de-sacs with a 50 ft radius will be placed in the residential section of the subdivision. Table 2.3.3 provides the standard design dimensions. In addition, Figure 2.3.5 and 2.3.6 are cross-sectional sketches of a typical local road and bridge. Figure 2.3.7 displays the typical sketch of a cul-de-sac.

Table 2.3.3 Local Roadway Design Standards

ROADWAY CLASSIFICATION	SINGLE PAVING SECTION (W)	DOUBLE PAVING SECTION (W)	SINGLE PAVING SECTION WITH ROADSIDE DITCHES (W)	DOUBLE PAVING SECTION WITH ROADSIDE DITCHES (W)
LOCAL	28 FT. (B-B)	2/25 FT. (B-B)	22 FT. (E-E) WITH 6 FT. SHOULDERS	2/24 FT. (E-E) WITH 6 FT. SHOULDERS
COLLECTOR	41 FT. (B-B)	2/25 FT. (B-B)	41 FT. (E-E) WITH 6 FT. SHOULDERS	2/24 FT. (E-E) WITH 6 FT. SHOULDERS

B-B: BACK TO BACK
E-E: EDGE TO EDGE

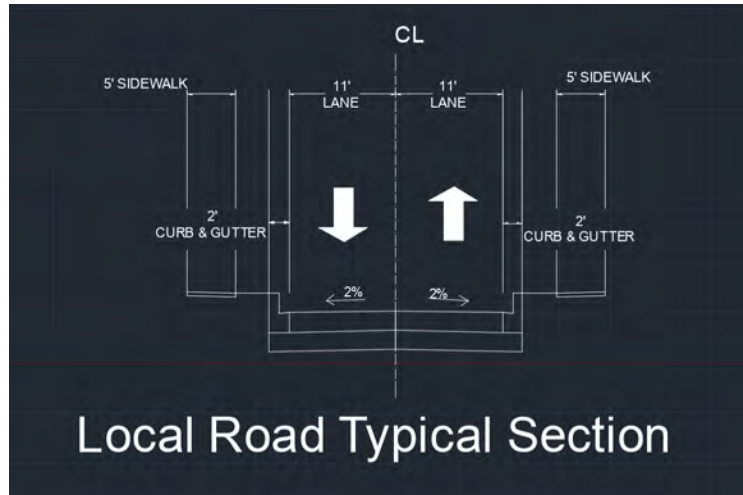


Figure 2.3.5 Local Road Typical Section

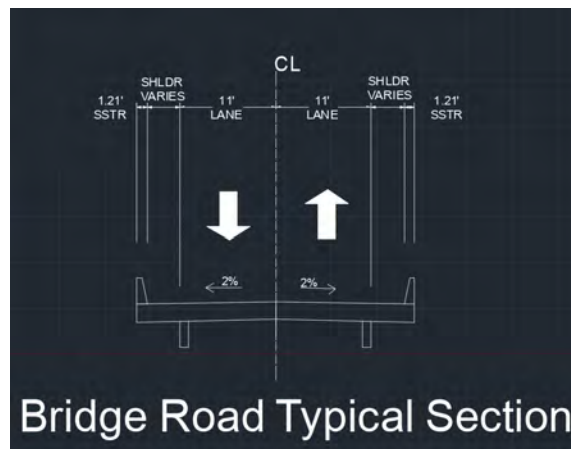


Figure 2.3.6 Bridge Road Typical Section

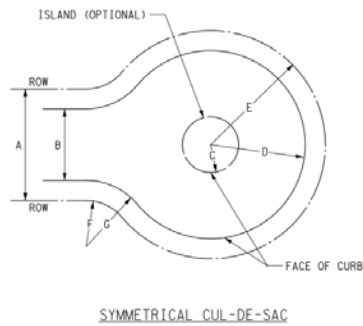


Figure 2.3.7 Symmetrical Cul-De-Sac Design

2.3.5 Pavement Design

Each road within the subdivision will consist of a rigid pavement design. All Texas Department of Transportation design standards will be followed to determine the needed base-course, subbase-course and how to treat the subgrade. A 10 inch concrete slab will top the pavement design.

2.3.6 Traffic Signal Location

Future design traffic data was calculated based on the current data obtained from the Harris County Engineering Department and the Texas Department of Transportation. The traffic signal will be located at the intersection of Gateway Blvd. and US 290. Future AADT was determined by assuming 40% of intersection traffic would travel onto Gateway Blvd. 2050 AADT was calculated to be 11936 vpd and 250 ADT was determined to be 20236 vpd. Figure 2.3.7 shows the current condition of the non-signalized intersection from Google Maps.



Figure 2.3.8 Gateway Blvd. & US 290 Intersection

The signalized intersection will be known as a Diamond Signalized Intersection. This is due to the intersection's conflict points and design. The intersection consists of the four lane Gateway Blvd. and two-three lane one way feeder roads. In order to ensure traffic flow is smooth, detection loops will be installed. Figure 2.3.8 is a design rendering from the Harris County Engineering Department of a diamond signalized intersection.

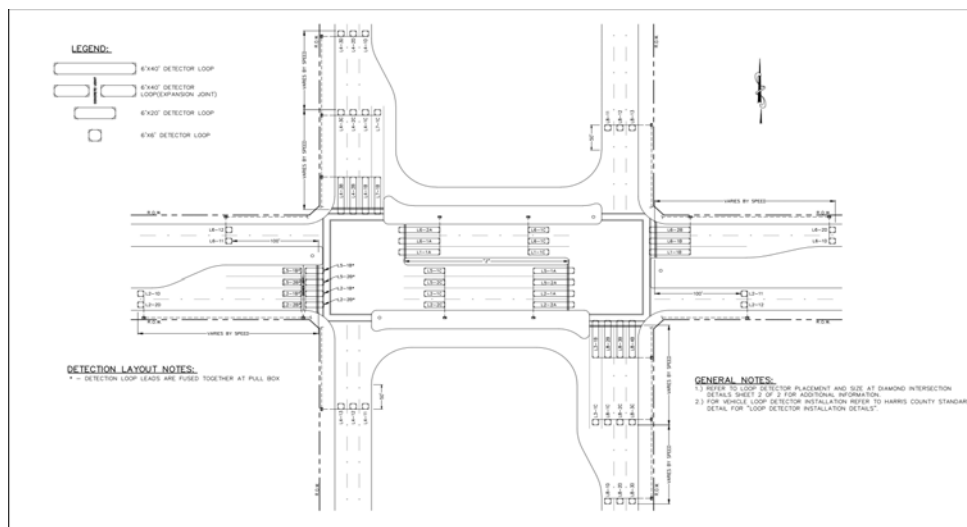


Figure 2.3.9 Diamond Intersection Design Rendering

2.3.7 Parking Facilities & Driveway Design

Parking facilities will be major components for the community center, office building and treatment plants. Off-street parking will help accommodate all parking needs within the subdivision. Parking data followed the American Disability Act Design Standards and City of Houston Municipal Parking Standards. In addition, building occupancies were determined using the International Fire Code by the Structural Engineer. Parking stalls will be 90 degrees and be 9 ft wide and 18 ft long. Table 2.3.4 includes the total number of parking stalls for each building within the subdivision.

Table 2.3.4 Parking Stall Count

Building	Parking Stall Count (stalls)	ADA (stalls)
Community Center	180	6
Office Building	196	6
Water & Wastewater Treatment Plant	34	1

Parking for the community center will be located at the front and rear of the building. Regular visitor parking will be in the front and 6 bus & van parking stalls will be at the rear. Office

building parking will be located near the front entrance of the building. Lastly, Water & Wastewater Treatment Plant parking will be in between both treatment plants. This will help accommodate the 500 ft separation requirement for the treatment plants.

Driveways for the parking facilities will adhere to the TxDOT Roadway Design Manual. Each building will have commercial driveways. The community center will have one entry lane and two exit lanes for the parking lot main entrance. There will be a 25 ft driveway radius and 40 ft throat width with 12 ft lanes. For the bus and van rear entrance, there will be a 30 ft driveway radius and 30 ft throat width with two 12 ft lanes. Figure 2.3.9 and 2.3.10 is a design rendering of both driveway designs.

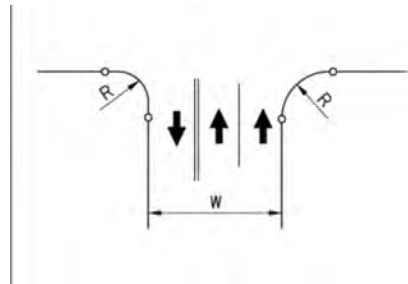


Figure 2.3.10 Commercial Three Lane Driveway Design

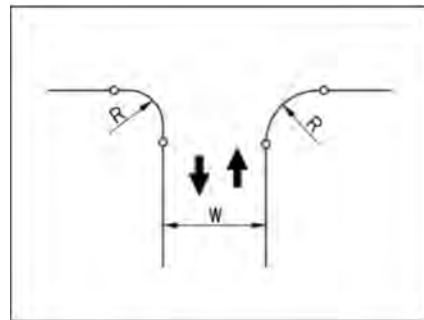


Figure 2.3.11 Commercial Two Lane Driveway Design

Residents will have two options for residential driveways. There can be a two-way or one-way driveway design. Two-way driveways will have a 24 ft throat width and 25 ft radius. One-way driveways will have a 14 ft throat width and 15 ft radius. Both will have a 2 ft curb offset to help with drainage. Figures 2.3.11 is an AutoCAD drawing of both residential driveways for the subdivision.

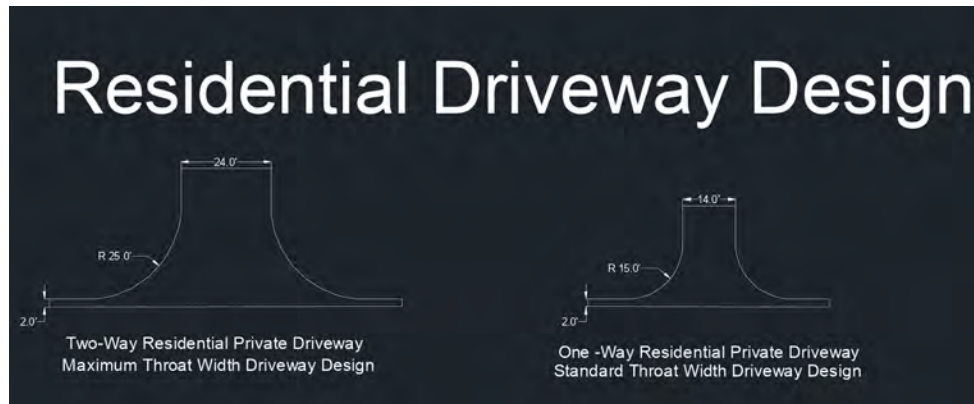


Figure 2.3.12 Residential Two-Way & One-Way Driveway Design

2.3.8 Sidewalks

Sidewalks will be around the subdivision to promote a pedestrian friendly area. All design standards were based on TxDOT Roadway Design Manual and the Harris County Engineering Department. Sidewalks will be 5 ft wide, 4.5 in thick, a 2% slope and 4 ft buffer zone from the curb. Figure 2.3.13 is a design rendering a typical sidewalk at crosswalk design.

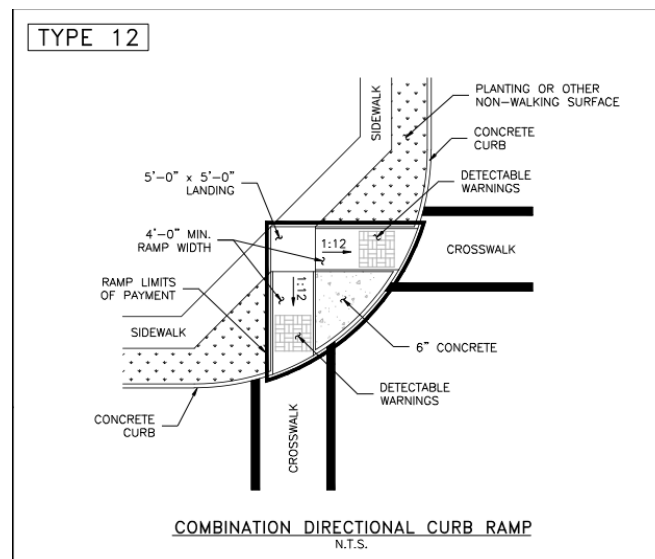


Figure 2.3.13 Sidewalk at Intersection Design

2.4 Environmental Engineering: Water Treatment

The proposed subdivision, located in northwest Harris County, has been designed based on the provided design data, environment, and the future needs for the public. CSR Engineering Inc. has decided to name the proposed subdivision, The Gateway. The area is northwest of Houston near the US 290 & SH 99 Grand Parkway Interchange. The 359 acre property is located south of US 290 and west of SH 99. Within the subdivision, Water & Wastewater Treatment Plants will be

designed to serve 10,000 people. Additionally, the community center & office building are located within the 359 acres of land. The community center will be a 9,600 square foot building that will provide residents with a place to host events. The office building will be 28,800 square feet and will be the headquarters of a major company.

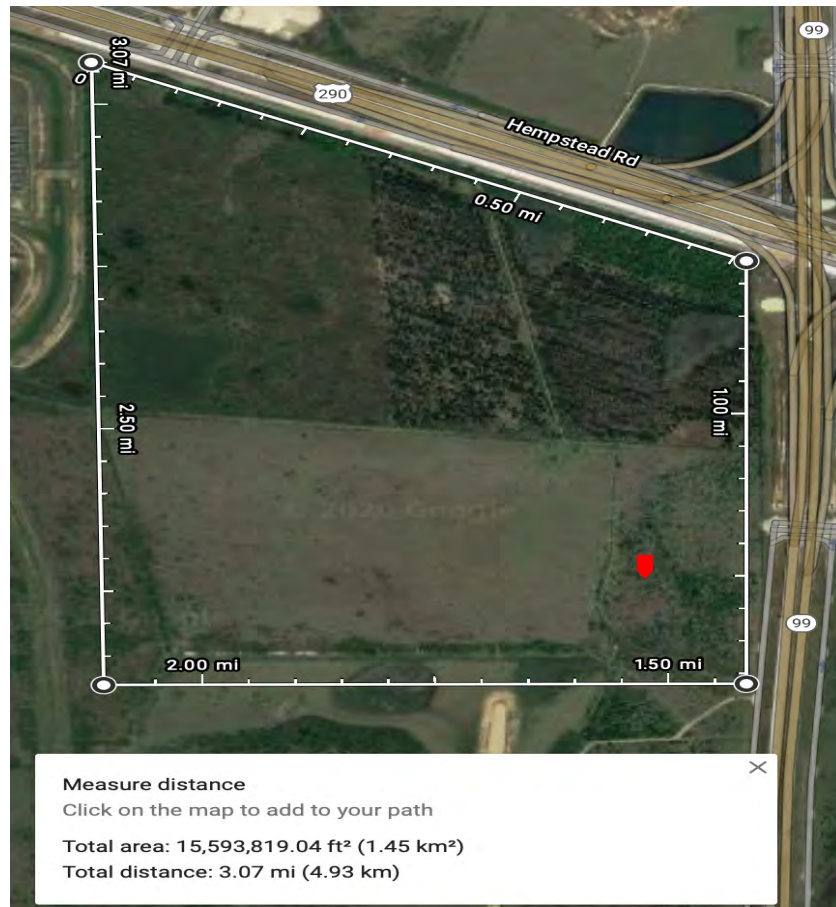


Figure 1. Site Map of PVHB Residential and Office Facility Development

2.4.1 Problem Statement

CRS Engineering Inc. has been asked to design a Water Treatment Plant for the PVHB Residential and Office facilities; it must be designed to supply the development to serve a population of 10,000 persons – including design and specifications for the plant. The report will discuss all aspects of water and wastewater treatment design. All guidelines will be followed based on the Texas Administrative Code (TAC).

2.4.2 Project Goals and Objective

The project team is required to perform Civil Engineering Site Development, and Design Services and address all aspects outlined in the reporting requirements and deliverable items of this project description. Some of the goals include design and specifications for the water treatment plant: Site Plan, Building footprint, Minimal parking, Water quantity calculations, supply lines, and pump station (water source from stream outside close and adjacent to boundary line), Details of treatment systems from beginning to end.

2.4.3 Site Assessments

CRS Engineering Inc. has been tasked with developing a new site for the public of the Greater Houston Area. The new PVHB Residential and Office Facility Project is along US 290 & SH 99 Grand Parkway Interchange. With every project, an Environmental Site Assessment (ESA) is needed to determine if an environmental impact was made. ESA's ensure that the surrounding area will not be disrupted negatively in any way. This includes checking for endangered & threatened species, noise pollution, odor pollution, risk management, and etc. The PVHB Residential and Office Facility Site is located in Harris County, and my team will be using the guidelines, regulations, and data of the Texas Administrative Code (TAC) & Texas Parks & Wildlife Department to ensure the proposed site is suitable for the given area.

2.4.4 Endangered Species

All proposed sites must consider rare, threatened, and endangered species before construction. If there is any species that meets this criteria in the area, either another location must be considered or proper measurements must be taken to reallocate the species. Attached below is a table of all the threatened and endangered species of Harris County, provided by The Texas Parks & Wildlife Department.

- [Site Assessment Species](#)

2.4.5 Noise Pollution

Noise pollution from water treatment plants is caused due to the machinery, which includes pump stations, fans, compressors, and etc. Effective noise control engineering can provide a wide range of solutions, but the two most effective are: Equipment/Site Location & Facility Ventilation. The Texas Administrative Code (Chapter 309, Subchapter B: Location Standards) states, “(c) A wastewater treatment plant unit may not be located closer than 500 feet from a public water well as provided by §290.41(c)(1)(B) of this title (relating to Water Sources) nor 250 feet from a private water well”. The distance given is just a minimum of what Texas Standards are; The TAC never gives a specific distance that would help eliminate noise control, but CRS Engineering will be using a distance of _____. This was determined using a similar distance of an actual Water Treatment Plant with some of the same requirements we were given. By locating the noisiest equipment as far from neighboring residential properties, the noise pollution is reduced significantly. Another tactic used to reduce noise pollution is Facility Ventilation. Although not necessary in water treatment plants in Texas, it is an effective solution to the noise produced. Facility Ventilation is the process of enclosing the Water Treatment Plant with fabricated materials that can reduce noise levels at neighboring areas.

2.4.6 Odor Pollution

Common odors lingering in and around treatment plants smell like rotten eggs, ammonia, or garlic, among other things. Sometimes the odor is described as earthy or organic. This can be a common problem around surrounding neighborhoods. Although we are designing a Water Treatment Plant, we will be using Wastewater Treatment Plant specifications given by the TAC to determine how to deal with odor pollution. Effective odor control engineering can provide a wide range of solutions, but the three most effective are: Site Location, Deodorizing Misting Systems, and Powder Activated Carbon. As stated above, when it comes to location of a site, we

have to ensure that the noise and odor are at a minimum. The distance of _____ will be used because this gives enough space to decimate the odor as well as noise. The next two tactics are not required by the TAC, but have been very effective in studies across the country. Deodorizing Misting Systems can be used to target airborne volatilized odor compounds by saturating outdoor facility air with sprayed deodorizing mists delivered through a network of pumps, filters, injectors, and hose-lines. Powdered Activated Carbon is a high performance absorbent engineered to remove harmful contaminants in the air, gas, and liquid phases. The potable water industry has long used this product to effectively remove taste and odor compounds, and provide clean water that is safe to drink.

2.4.7 Population Estimation

The second step for designing Water/Wastewater Plants is determining the future population. With the future population calculated, the correct water demand can be calculated when we multiply our population with the Average Annual Daily Flow (AADF). The PVHB Residential and Office Facility Site will have a future population of 10,000 people as given in the scope of work.

2.4.8 Water Demand

The average American family uses more than 300 gallons of water per day at home. Roughly 70 percent of this use occurs indoors. Nationally, outdoor water use accounts for 30 percent of household use yet can be much higher in drier parts of the country and in more water-intensive landscapes.

2.4.9 Water Demand

$$\begin{aligned} Q_{Average} &= (\text{Population}) \times (\text{AADF or Demand}) \\ &= (10,000 \text{ persons}) \times (180 \text{ gpcd}) \\ &= 1,800,000 \text{ gpd or } 1.8 \text{ MGD} \end{aligned}$$

$$\begin{aligned} Q_{Max \text{ Daily}} &= (Q_{Average}) \times (F) \\ &= (1,800,000 \text{ gpd}) \times (2.4) \\ &= 4,320,000 \text{ gpd or } 4.32 \text{ MGD} \end{aligned}$$

Note: No Seasonal Correction Factor Needed

$$\begin{aligned} Q_{Design} &= (Q_{Max \text{ Daily}}) \times (F_{\text{peak hourly}}) \\ &= (4,320,000 \text{ gpd}) \times (1.25) \\ &= 5,400,000 \text{ gpd or } 5.4 \text{ MGD} \end{aligned}$$

2.4.10 Fire Demand

American Insurance Association Formula

$$\begin{aligned} Q(\text{gpm}) &= 1020\sqrt{P}(1 - 0.01\sqrt{P}) \\ &= 1020\sqrt{10}(1 - 0.01\sqrt{10}) = 3,123.52 \text{ gpm} \\ &= (3,123.52 \text{ gpm}) \times (1440 \text{ min/d}) = 4,497,868.8 \text{ gpd or } 4.50 \text{ MGD} \end{aligned}$$

Note: Not Used for Treatment Design

2.4.11 Total Water for Distribution

$$\begin{aligned}Q_{Total} &= 5,400,000 \text{ gpd} + 4,497,868.8 \text{ gpd} = 9,897,868.8 \text{ gpd} \\&= (.15)(9,897,868.8 \text{ gpd}) = 1,484,680.32 \text{ gpd} \\Q_{Total} &= 8,413,188.48 \text{ gpd or } 8.4 \text{ MGD}\end{aligned}$$

2.4.12 Acquisition of Water

https://www.publicworks.houstontx.gov/sites/default/files/assets/003-regional_water_supply_map.pdf

2.4.13 General Water Treatment Methods

i. Screening Treatment

Screening is mostly the first step in purifying surface water (water from lakes and rivers), which often has large debris, such as sticks, leaves, fish, trash, and other large particles. This may interfere with subsequent purification steps. These objects can clog the water-treatment system and must be removed before the water enters the treatment plant. Screening is a separation of particles on the basis of physical characteristics like size in water.

Screening is commonly categorized into either coarse screening or fine screening. Screens may be physically or mechanically cleaned, with only the older and smaller treatment facilities using physically cleaned screens as their primary or only screening device. Coarse screens are naturally used as primary preventive devices, and usually have openings of 10mm or larger. Fine screens are used to remove material that may cause operation & maintenance problems in the treatment process. Typical opening sizes for fine screens are 3 to 10mm. With science improving everyday advances with openings of less than 3mm are now being used to reduce material that may enter the water treatment process.

ii. Coagulation and Flocculation Treatment

The second water treatment method is coagulation. By adding ferric sulfate and polyelectrolyte, this starts the purification process of the water coming from the Mississippi River. The chemicals are added at precise dosage and mixed with the river water to ensure complete coagulation. Ferric sulfate is the primary coagulant and polyelectrolyte is a coagulant aide. Coagulant chemicals cause the very fine particles that make up the suspended solids present in the river water to clump together, or coagulate.

The third water treatment is flocculation. This is another mixing treatment just like coagulation, but without the chemicals. The mixing will make the particles appear larger than the particles that came out of the coagulation treatment.

iii. Sedimentation

In the water treatment process, sedimentation is the process of removal of suspended particles that are heavier than water by gravitational settling. Most raw water will contain mineral and organic particles. During the sedimentation stage, water slowly courses through large tanks, commonly called primary sedimentation tanks". These tanks hold large volumes of water and are designed to allow water to have a smooth, even flow at a velocity and turbulence of the water to be decreased to the point that the water will no longer transport the flocculated solids and they will settle to the bottom of the basin. The main purpose of the sedimentation stage is to remove turbidity, suspended and dissolved solids by allowing them the time to settle out of the water into a sludge that can be separately processed. Primary settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to possible further sludge treatment stages. At the end of the settling basin, hydrated lime, $\text{Ca}(\text{OH})_2$, is added to the water to increase its pH. This is necessary because the alum that is added during the coagulation/flocculation process is acidic. After pH adjustment, chlorine is added for disinfection and to prevent aquatic growth on the filters during the next treatment process.

iv. Filtration and Disinfection

This part of the filtration process is normally used to remove the passing of particulate and other impurities, including floc, from the water being treated. These impurities consist of suspended particles, fine, silts, and clays. The material used in filters for public water supply is normally a bed of sand, coal, or other granular substance. Filtration processes can generally be classified as being either slow or rapid. The majority of municipal plants treat the settled water liquid using filtration and disinfection.

The water will course from the sedimentation tanks into the filter bed. Filters contain material of graduated size in layers that remove solids from the water. The first layer of a filter will usually be anthracite coal and the second layer is sand. Underneath the sand is a layer of stone or plastic composite. At the bottom of the filter is an under-drain system that supports the filter. Water is pumped onto the filters. As the water is being pumped into the filters, suspended matter is left on the filters. Floc, that is larger than the openings on the filter, are captured. Some suspended matter sticks to the surface of the filter or the previously deposited material. After the water is passed through the filter, the disinfectant is applied. During the disinfection, disease-causing organisms are destroyed or disabled. Chlorine is the most common disinfectant used in the United States because it is practical, effective, and economical. Chlorine dissipates rapidly. It is important to add the right amount of chlorine at the water treatment plant to make sure disinfection continues while the water is flowing through the distribution system. After a certain period of time, the filter will get clogged by excess floc and need to be cleaned and backwashed. Backwashing is the reversal of the direction of the water flow through the filter. A rapid upward flow lifts the particles and keeps them in suspension until they can be washed out.

v. Storage

Although the water is now consumable, it must be stored and transferred properly. Stabilization is a protective measure that reduces corrosion in water lines. Polyphosphate, a chemical that prevents corrosion, is added to the finished water as a preventive measure. Corrosive waters can cause problems related to public health, aesthetics, and economics. The water flows to the fluoridation, which is a safe and economical process that is endorsed by public health groups worldwide to reduce tooth decay. Fluoride is added to the line leaving the storage tank, so the fluoride dosage can be very precisely controlled. In designing, it's commonly forgotten to leave a sufficient amount of sodium hypochlorite, essentially a strong bleach. That is added to the finished water. This is done, so that a minimum amount of chlorine remains in the water until it reaches the customer's tap. Finally, pumping is necessary. Pumping systems include electric as well as diesel pumps to ensure continuous water service, even during power outages.



2.5 Water Resources Engineering

The main goal is to design the rainwater drainage system and utility pipelines designed for water distribution and wastewater collection. The preliminary design consist of:

- Determining the location of the lake
- Finding the rainfall intensity of where the site is located
- Determining the quantity of water
- Determining the direction of the water flow
- Designing stormwater runoff, to avoid flooding risks and property damage
- Providing a profile and cross-section of the drainage
- Providing a profile and cross-section of the rainwater detention center
- Preparing plans and drawings showing utility lines, water lines, and storm sewer lines

2.5.1 Location of the Lake

The location of the lake will be in the middle of the subdivision, so that the residents can enjoy it. The lake will occupy 350 acres of the site. The quantity of the water in the lake will be 7,623,000 ft³.

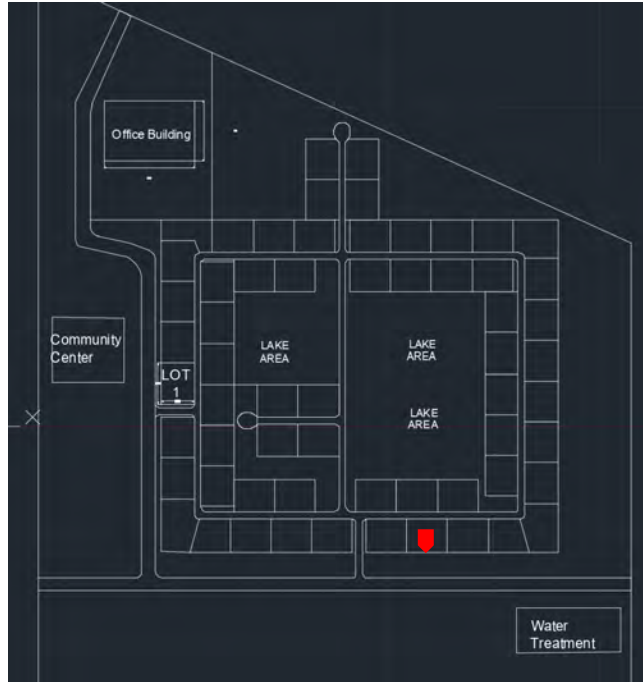


Figure. 2.5.1 Location of the Lake

2.5.2 Rainfall Intensity

The rainfall intensity can be found from Harris County Flood Control Sector. In this case, the rainfall intensity is very low. Since the rainfall intensity is very low, the detention pond will not be as huge. The location of the subdivision is not in a flood zone.

2.5.3 Quantity of Water

The quantity of water can be determined by multiplying the direct runoff by the drainage area. The direct runoff is 15.1 inches and the drainage area is 48.67 acres.

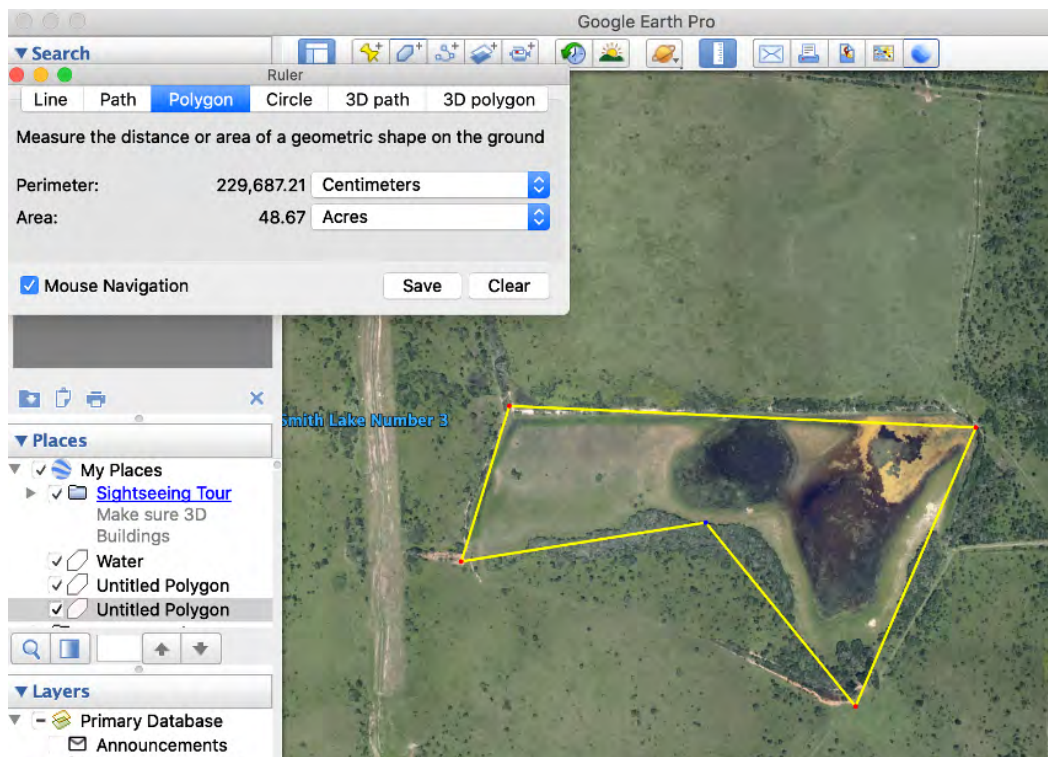
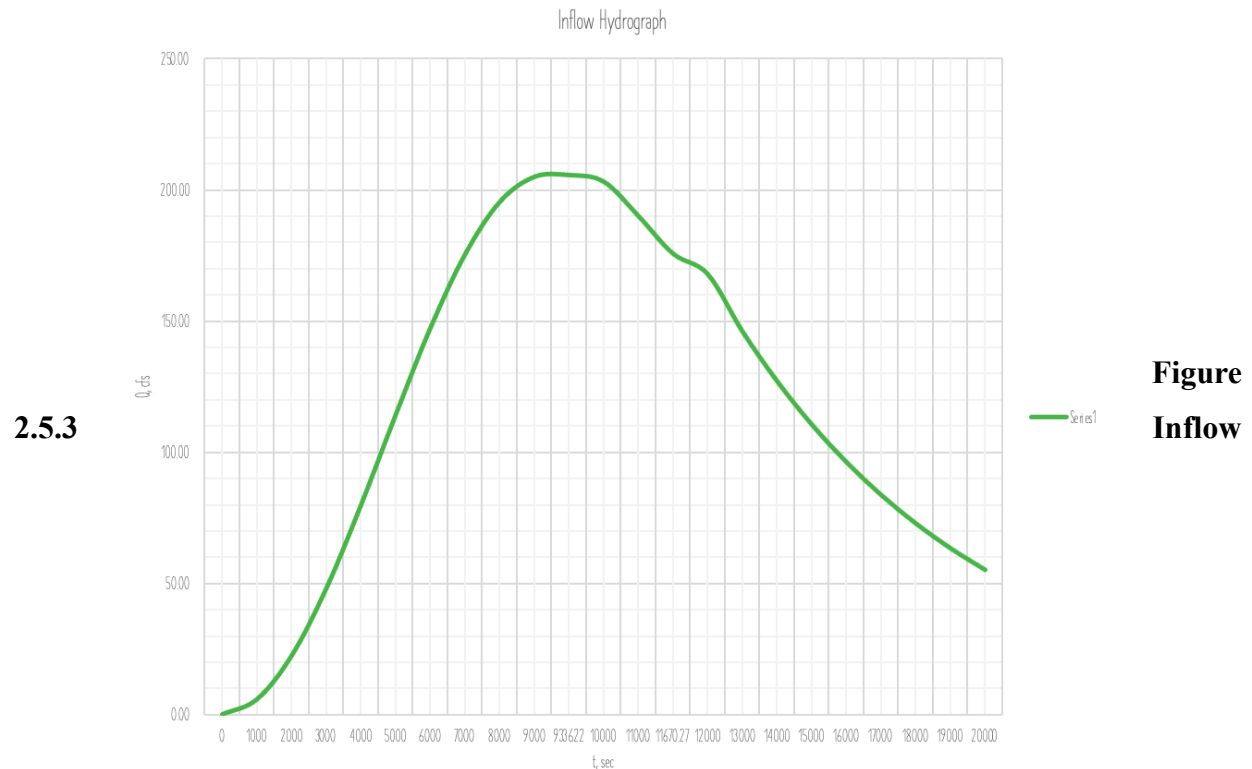


Figure 2.5.2 Drainage Area

2.5.4 Stormwater Detention Basin

The peak discharge is found from an equation given in the Harris County Flood Control Manual. The peak discharge came out to be 205.57 cfs.

The dimensions of the basin is determined by creating a hydrograph to determine the outflow of the basin. The next step will be to route this inflow hydrograph to get the outflow of the basin. The peak discharge is also determined from the inflow hydrograph and a set of equations given in the Harris County Flood Control Manual. The equations used to formulate the hydrograph are:



Hydrograph of the Area

2.5.5 Projections

The next things that need to be done in the Water Resources Area are to route the inflow hydrograph, determine the dimensions of the detention basin, and figure out the drainage part of the project. Utility plans will be the next thing going forward.

2.6 Wastewater Management

2.6.1 Wastewater Treatment

The objective of a wastewater treatment is to produce an effluent that can be discharged without causing serious environmental impacts. The processes for wastewater and water treatment plants are similar except, the biological methods are different. The treatment required for a wastewater treatment plant will depend on the effluent discharge requirements. There are three different types of treatment identifications. They are identified as primary, secondary, and advanced. The primary treatment involves sedimentation of solid waste within the water, which occurs after filtering out large contaminants and solids. The secondary treatment utilizes oxidation to further purify wastewater. This is done by three different ways which are biofiltration, aeration, and oxidation ponds. The advanced treatment is normally used for removing phosphates and nitrates from the water supply. The most commonly used materials that assist in this process are substances like activated carbon and sand.

Standards from the Texas Administrative Code (TAC) and the Texas Commission on Environmental Quality (TCEQ) will be utilized when designing the wastewater treatment plant. Some assumptions must be made in order to design, such as the quality of wastewater, the flow through the plant, and the total waste being produced. The treatments that will be designed are: screening, grit chambers, primary clarifiers, trickling filters, secondary clarifiers, and disinfection methods. Below is a table provided by TCEQ of standards to follow for wastewater characteristics, along with a diagram showing the treatment processes.

Table 2.6.1 - Major Constituent of Typical Domestic Wastewater

Constituent	concentration in mg/l
Total Solids	1200
Dissolved Solid	850

Suspended Solid	350
Nitrogen	85
Phosphorus	20
Chloride	100
Alkalinity as Caco3	200
Grease	150
BOD5	400

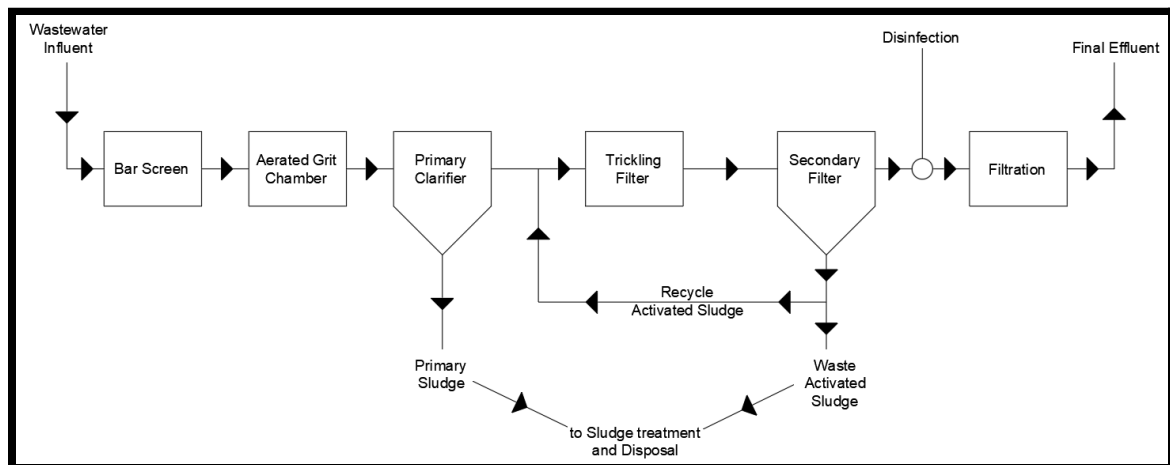


Figure 2.6.1. Diagram of Wastewater Treatment Facility Layout

Table 2.6.2 - The Wastewater Flow from TAC Title 30

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Municipality	Residential	75-100	250-400	15-75
Subdivision	Residential	75-100	250-400	15-75
Trailer Park (Transient)	2½ Individuals per Trailer	50-60	250-350	15-75
Mobile Home Park	3 Individuals per Trailer	50-75	300	15-75
School	Cafeteria & Showers	20	300	15-75
	Cafeteria/No Showers	15	300	15-75
Recreational Parks	Overnight User	30	200	15-75
	Day User	5	100	15-75
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75
Hotel/Motel	Per Bed	50-75	300	15-75
Restaurant	Per Meal	7-10	1000*	15-75
Restaurant with bar or cocktail lounge	Per Meal	9-12	1000*	15-75
Hospital	Per Bed	200	300	15-75
Nursing Home	Per Bed	75-100	300	15-75
Alternative Collection Systems (Subchapter D of this chapter)	Per Capita	75	N/A	N/A
*Based on a restaurant with a grease trap				

Hempstead , Tx Wastewater Estimations:

The wastewater usage for 2050 was obtained by the assumption that 80% of the water that will be provided to the forecast population will come back as wastewater. It was obtained by getting 80% of 35.4 MGD which is 28.32 MGD. The wastewater per gal/capita*day came out to be 102.4 gal/capita*day which is out the range provided by TAC title 30 chapter 2.17 (75-100 gal/capita*day).

2.6.2 Aerated Grit Chamber

An aerated grit chamber removes grit from wastewater streams. As shown in Figure 1, grit is removed by causing the wastewater to flow in a spiral pattern. Air is introduced in the grit chamber along one side, causing a perpendicular spiral velocity pattern to flow through the tank. Heavier particles are accelerated and diverged from the streamlines, dropping to the bottom of the tank, while lighter organic particles are suspended and eventually carried out of the tank.

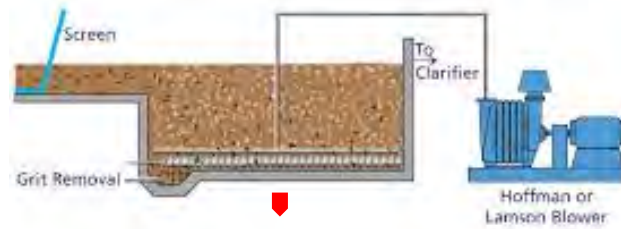


Figure 2.6.2. Aerated Grit Chamber

Using a detention time of 3 minutes, a peak flow of 238.4 MGD, and a depth of 10 feet. The dimensions of the grit chamber were found by using the following equation:

$$V = Q * \theta$$

Where,

V = Volume

Q = Flow

θ = Detention Time

2.6.3 Trickling Filter

Trickling filters are utilized to eliminate organic matter from the wastewater after it has gone through the essential clarifier. The trickling channel is a high-impact treatment framework that uses microorganisms joined to a medium to eliminate organic matter from wastewater. It

empowers natural material in the wastewater to be consumed by a huge number of microorganisms joined to the medium as an organic film or sludge layer approximately 0.1 to 0.2 mm thick. Water streams in a meager film throughout the medium to permit time for treatment. As the layer thickens, on account of the microorganisms bit by bit connecting themselves to the medium, oxygen can't enter the medium face, and anaerobic life forms create. As the natural film continues developing, the microorganisms close to the surface begin to kick the bucket and accordingly lose their capacity to stick to the medium and a part of the sludge layer tumbles off the channel. This cycle is known as sloughing. The sloughed solids are then moved to the secondary clarifier for expulsion from the waste water. The trickling Filter is intended to give a last emanating of 20 mg/l, with the essential settling tank eliminating 45% of BOD and 65% of Total Suspended solids. There will stream channels for this wastewater treatment plant. The expulsion proficiency is roughly 90.9% with each channel seeing about 17.8 MGD. The influent solids stacking rate was resolved to be 32,659.44 lb. /day. Each channel will have measurements of 6 ft depth and a diameter of 62 ft and will have the option to hold a volume of 21,410 ft³.

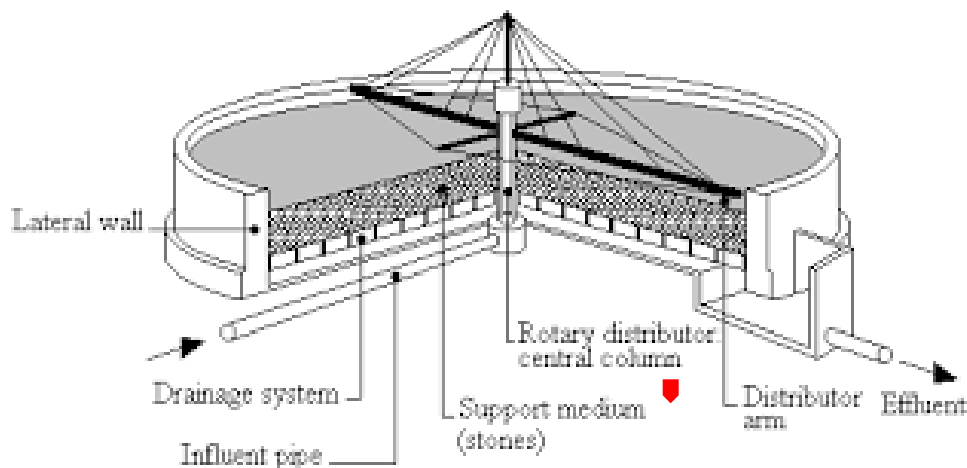


Figure 2.6.3 - Cross-Section of a Trickling Filter

2.6.4 Secondary Clarifier

The secondary clarifier is a basic part of the wastewater treatment plant. Its key capacities are to isolate the organic floc from the treated fluid waste stream and the thickening and capacity of the slope from the natural treatment measure. The secondary clarifier works in a similar way as the essential clarifier portrayed already. A portion of the solids gathered in the secondary clarifier are sent back to the trickling filter to experience a similar cycle once more. Aerobic natural treatment is acted within the sight of oxygen by aerobic microorganisms that utilize the natural issue in the wastewater, along these lines creating more microorganisms and inorganic finished results.

Table 2.6.3 - Secondary Clarifier Tank Dimensions

Design	Dimension
Number of tanks	2
Diameter	86.67ft
Depth	4.18 ft
Weir Length	272.28 ft
Weir Loading	$17382.84 \frac{ft^2}{day}$
Free board	2ft

Circular Secondary Clarifier (2)

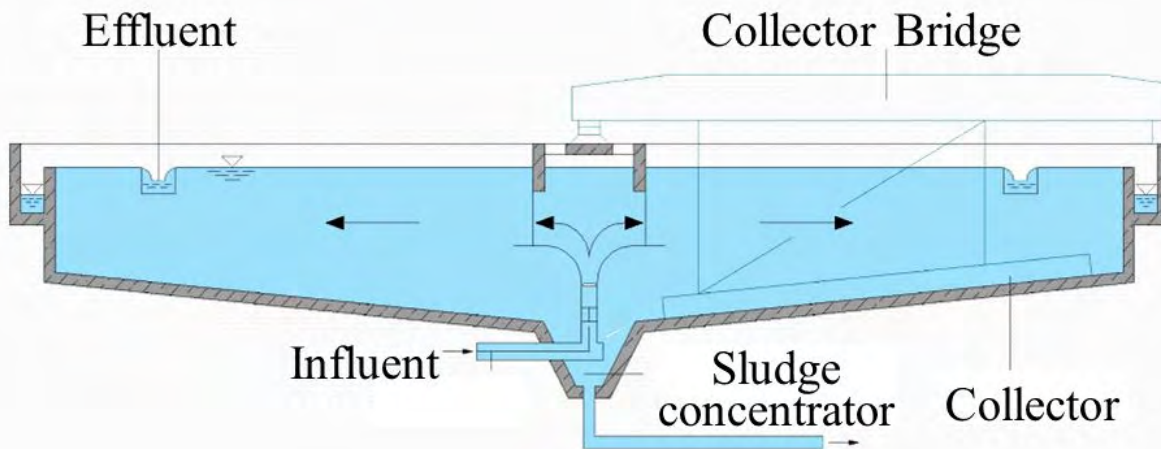


Figure 2.6.4 - Secondary Clarifier Design

CHAPTER 3: CONCLUSION

3.1 Conclusion

In conclusion, The Gateway subdivision preliminary design includes all major components to accommodate the future growth of northwest Harris County and Cypress area. The Greater Houston Metropolitan Area is continuously growing and the Grand Parkway at US 290 intersection will allow the subdivision to thrive. All structural, geotechnical, transportation,

environmental and water resources designs were developed to guarantee and sustainable subdivision for the future.

CHAPTER 4: REFERENCES

4.1 References

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APPENDIX

Transportation Design Calculations

Trevon Rogers

Main Road Horizontal Alignment

Curve 1

$$D_a = 60^\circ \quad \theta = 1.15 \quad \Delta = 24^\circ$$

degrees radians

$$R = \frac{180 \cdot 30}{\pi D^\circ} = \frac{180 \cdot 30}{\pi (60^\circ)} = 1492.18 \text{ ft}$$

$$L = \frac{R \Delta \pi}{180} = \frac{(1492.18 \text{ ft})(24^\circ)\pi}{180} = 624.97 \text{ ft}$$

$$T = R \tan \frac{\Delta}{2} = (1492.18 \text{ ft}) \tan \left(\frac{24^\circ}{2} \right) = 317.17 \text{ ft}$$

$$E = R \left[\frac{1}{\cos \left(\frac{\Delta}{2} \right)} - 1 \right] = (1492.18 \text{ ft}) \left[\frac{1}{\cos \left(\frac{24^\circ}{2} \right)} - 1 \right] = 33.34 \text{ ft}$$

$$LC = 2R \sin \frac{\Delta}{2} = 2(1492.18 \text{ ft}) \sin \left(\frac{24^\circ}{2} \right) = 620.48 \text{ ft}$$

$$M = R(1 - \cos \frac{\Delta}{2}) = (1492.18 \text{ ft}) \left(1 - \cos \frac{24^\circ}{2} \right) = 32.61 \text{ ft}$$

PC Station

PT Station

$$\begin{array}{r} 630.91 \text{ PI} \\ - 317.17 \text{ T} \\ \hline 313.02 \text{ PC station} \end{array}$$

$$\begin{array}{r} 313.02 \text{ PC} \\ + 624.97 \text{ L} \\ \hline 937.99 \text{ PT station} \end{array}$$

$$\begin{array}{l} \text{PC} = 3+13.02 \\ \text{PT} = 9+37.99 \end{array}$$

Curve 2

$$D_a = 75^\circ \quad \theta = \dots \Rightarrow \Delta = 15^\circ$$

degree radian

$$R = \frac{180 \cdot 30}{\pi (75^\circ)} = 1313.12 \text{ ft} \quad L = \frac{(1313.12 \text{ ft})(15^\circ)\pi}{180} = 343.77 \text{ ft}$$

$$T = (1313.12 \text{ ft}) \tan \left(\frac{15^\circ}{2} \right) = 172.88 \text{ ft} \quad E = (1313.12 \text{ ft}) \left[\frac{1}{\cos \left(\frac{15^\circ}{2} \right)} - 1 \right] = 11.33 \text{ ft}$$

$$LC = 2(1313.12 \text{ ft}) \sin \left(\frac{15^\circ}{2} \right) = 342.79 \text{ ft} \quad M = (1313.12 \text{ ft}) \left[1 - \cos \left(\frac{15^\circ}{2} \right) \right] = 11.23 \text{ ft}$$



Tre'Von Rogers

Curve 2 cont'd

PC Station

$$\begin{array}{r} 1424.55 \text{ PI} \\ - 172.88 \text{ -T} \\ \hline 1251.67 \text{ PC station} \end{array}$$

L

PT Station

$$\begin{array}{r} 1251.67 \text{ PC} \\ + 343.77 \text{ L} \\ \hline 1595.44 \text{ PT station} \end{array}$$

$$PC = 12 + 51.67$$

$$PT = 15 + 95.44$$

Curve 3

$$D_a = 72^\circ$$

$$\Delta = 18^\circ$$

$$R = \frac{180 \cdot 36}{\pi(72)} = 1367.84 \text{ ft} \quad L = \frac{(1367.84 \text{ ft})(18^\circ)\pi}{180} = 429.72 \text{ ft}$$

$$T = (1367.84 \text{ ft}) \tan\left(\frac{18^\circ}{2}\right) = 216.61 \text{ ft} \quad E = (1367.84 \text{ ft}) \left[\frac{1}{\cos \frac{18^\circ}{2}} - 1 \right] = 17.05 \text{ ft}$$

$$LC = 2(1367.84 \text{ ft}) \sin\left(\frac{18^\circ}{2}\right) = 427.95 \text{ ft} \quad M = (1367.84 \text{ ft}) \left(1 - \cos \frac{18^\circ}{2}\right) = 16.84 \text{ ft}$$

PC Station

$$\begin{array}{r} 1850.00 \text{ PI} \\ - 216.61 \text{ -T} \\ \hline 1633.36 \text{ PC} \end{array}$$

PT Station

$$\begin{array}{r} 1633.36 \text{ PC} \\ + 429.72 \text{ L} \\ \hline 2063.08 \text{ PT} \end{array}$$

$$PC_{\text{station}} = 16 + 33.36$$

$$PT_{\text{station}} = 20 + 63.08$$

of Parking Stalls (90 Degree Parking)

Regular Stall

$$9 \text{ ft} \times 18 \text{ ft} \\ 162 \text{ ft}^2$$

Total Property Size

$$200 \text{ ft} \times 200 \text{ ft} \\ 40,000 \text{ ft}^2$$

Bus Stall

$$15 \text{ ft} \times 40 \text{ ft} \\ 600 \text{ ft}^2$$

Building Size

$$9,000 \text{ ft}^2$$

International Fire Code

$$50 \text{ ft}^2/\text{person}$$



$$\frac{9,000 \text{ ft}^2}{50 \text{ ft}^2/\text{person}}$$

$$180 \text{ people}$$

↑
Max Occupancy

$$\begin{array}{rcl} 40,000 \text{ ft}^2 & \text{total area} & \\ - 9,000 \text{ ft}^2 & \text{building area} & \\ \hline 30,400 \text{ ft}^2 & \text{remaining area} & \\ - 21,060 \text{ ft}^2 & \text{total reg. area} & \\ \hline 9,340 \text{ ft}^2 & & \\ - 1,800 \text{ ft}^2 & \text{total bus area} & \\ \hline 7,540 \text{ ft}^2 & \text{remaining} & \end{array}$$

3 Bus Spots

$$3(600 \text{ ft}^2) = 1,800 \text{ ft}^2$$

130 Reg. Spots

$$130(162 \text{ ft}^2) = 21,060 \text{ ft}^2$$

3 Aisles

$$22 \text{ ft} \times 40 \text{ ft}$$

$$3(880 \text{ ft}^2) = 2,640 \text{ ft}^2$$

Lane Width (Entrance/Exit)

- 12 ft Lanes

Entrance (Main)

- 25 ft Driveway Radius
- 40 ft Throat Width

Trucks/Bus Entrance/Exit

- 30 ft Driveway Radius
- 30 ft Throat Width

TXDOT
Roadway Design
Manual

WASTEWATER DEMAND

(All calculations are rounded to the nearest whole number)

$$Q_{2050} = \text{Average Wastewater Daily Flow per capita} * P_{2050}$$

$$= 100 \text{ gal/capita*day} * 1,192,744 \text{ persons}$$

$$119.2 \text{ MGD} * 0.003785 \frac{m^3}{d} = 451,453 \frac{m^3}{d}$$

The Average peak factor is 2. It is necessary to calculate the average peak flow

$$Q_{\text{peak}} = 119.2 \text{ MGD} * 2 = 238.4 \text{ MGD} * 0.003785 \text{ m}^3/\text{d} = 902,344 \text{ m}^3/\text{d}$$

Distribution System - Total Max Daily Demand = Fire Demand + Max Daily Demand

- Future Population - 10,0000 people
- AADF - 180 gal/dayperson (From Table 1.9)
- Peak Correction Factor, $F_p = 1.75$ (From ____)

Fire Demand = $1020\sqrt{P}(1 - 0.01\sqrt{P})$ (American Insurance Association Formula)

- P - Population (in thousands)
- **Fire Demand = $1020\sqrt{10}(1 - 0.01\sqrt{10}) = 3124 \text{ gal/min}$**
- **Fire Demand = 3124 gal/min**

Max Daily Demand = (Qmax daily)(Population)(Fp)(Fs)

- **Qmax daily = (AADF)(Population)**
 - AADF - Average Annual Daily Flow
- **Fp - Peak Correction Factor**
- **Fs - Seasonal Correction Factor (NO SEASONAL FACTOR NEEDED)**
- **Max Daily Demand = (180 gal/dayperson)(10,000 people)(1 day/ 1440 min)(1.75) = 2188 gal/min**

Distribution System - Total Max Daily Demand = 3124 gal/min + 2188 gal/min = 5312gal/min

Mostly leakage within the distribution system - 15%

$$(.15)(5311.02 \text{ gal/min}) = 797 \text{ gal/min}$$

$$(5311.02 - 796.65) \text{ gal/min} = \underline{4515 \text{ gal/min}}$$

WASTEWATER PIPELINES

- Material of Pipes: Polyvinyl Chloride
- Number of Pipes :
- Placement and Layout of the Pipes
- Water Demand for the Community:
 - 2.79×10^9 gal/ year
 - 7.64×10^6 gal/day
- Pipe Dimensions : 24in at a downward slope of 1.3% with capacity 50% filled

SECONDARY CLARIFIER TANK DIMENSIONS

$$\text{Total Area Required} = \frac{Q}{SLR}$$

Where:

Q (peak) = 36 MGD

Q (avg.) = 18MGD

SLR= surface loading rate (1500 gal/ft²-day)

Total area required was found 23,600ft²

Next, the number of tanks was calculated:

$$A = \frac{\pi d^2}{4}$$

Assuming 2 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 23,600 \text{ ft}^2 / 2 = 11,800 \text{ ft}^2$$

$$d = \sqrt{\frac{4 \cdot A}{\pi}}$$

$$d = 123 \text{ ft} > 100 \text{ ft (DOES NOT WORK!)}$$

Assuming 3 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 23,600 \text{ ft}^2 / 3 = 7,866.67 \text{ ft}^2$$

$$d = \sqrt{\frac{4 \cdot A}{\pi}}$$

$$d = 100.08 \text{ ft} > 100 \text{ ft (DOES NOT WORK!)}$$

Assuming 4 tanks, and using a max diameter of 100 ft.

$$Area_{new} = 23,600 \text{ ft}^2 / 4 = 5900 \text{ ft}^2$$

$$d = \sqrt{\frac{4 \cdot A}{\pi}}$$

$$d = 86.67 \text{ ft} < 100 \text{ ft (WORKS!!)}$$

Therefore, 4 tanks with a diameter of 86.67ft will be used. And the depth is calculated to be:

$$V = Q \cdot \phi$$

$$V = 4733000 \text{ ft}^3/\text{day} \cdot 2 \text{ hrs} \cdot \frac{1 \text{ day}}{24 \text{ hrs}} = 394,416.67 \text{ ft}^3$$

$$V = A \cdot \text{Depth}$$

$$\text{Depth} = \frac{V}{A} = \frac{394,416.67 \text{ ft}^3}{23,600 \text{ ft}^2} = 16.71 \text{ ft} / 4 = 4.18 \text{ ft}$$

The weir length is calculated,

$$\text{Weir length for a circular basin} = \pi \cdot d = \pi \cdot 86.67 \text{ ft} = 272.28 \text{ ft}$$

And the Weir loading,

$$WLR = \frac{Q}{L_w} = \frac{4733000 \text{ ft}^3/\text{day}}{272.28 \text{ ft}} = 17,382.84 \frac{\text{ft}^2}{\text{day}}$$

TRICKLING FILTER CALCULATIONS

$$\text{BOD} = 400 \text{ mg/L} \quad \text{BOD eff} = 20 \text{ mg/L} \quad \text{Depth} = 6 \text{ ft}$$

$$\text{TSS} = 90 \text{ mg/L} \quad R = 2 \quad Q = 35.4 \text{ MGD}$$

(45 % BOD removal)

$$1 - 0.45 = 0.55$$

$$C_m = 0.55 \cdot (400 \text{ mg/L}) = 220 \text{ mg/L}$$

$$S_{eff} = 20 \text{ mg/L}$$

$$E = (220-20)/220=0.909*100=90.9\%$$

$$(2 \text{ filters}) Q/2 = 35.4 \text{ MGD} / 2 = 17.8 \text{ MGD}$$

$$W = 220 \text{ mg/l} * 17.8 \text{ MGD} * 8.34 = 32,659.44 \text{ lb/day}$$

$$F = 1 + R / (1 + 0.1R)^2 = 2.083$$

$$90.9 = \frac{100}{1 + 0.0561 \left(\frac{28,577.01}{V^{2.083}} \right)^{1/2}}$$

$$V = 56,717 \text{ ft}^3 \quad A = 9453 \text{ ft}^2 \quad \text{Diameter} = 109.7 \text{ ft}$$

ASSIGNMENTS FOR OUTCOME “1”

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

**CVEG 4201 Senior Design and Professionalism II
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

SPRING 2022

Instructor: Dr. Md Jobair Bin Alam

Title of Assignment

Senior Design Midterm Report

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Brief Description of the suitability of this assignment for the outcome

The Midterm Report contained project scope and statement of the various components that make-up the assigned project. The report contains the cover page, table of contents and the team make-up and tasks. The students also submitted a set of calculations in the appendix.

80

**Prairie View A&M University
Roy G. Perry College of Engineering**



**Civil & Environmental Department
CVEG 4200: Senior Design Project**

SAPS Engineering

Autumn Carter

Shadaria Lynch

Scott McGary

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**Prairie View A&M University
Prairie View, Texas 77446**

SAPS Engineering Inc.

March 10, 2022

Dear Professor Alam,

The attached report contains the detailed plans for a newly constructed business and distribution center, IT Hub, and office development in Colorado County, Texas. This report includes the scope of work, six disciplines of civil engineering to design the development adequately.

SAPS Engineering Inc. is available to answer any questions you may have concerning this report or the project. You can contact our team lead Scott McGary at (phone number: 901-647-5996 or email: smcgary@pvamu.edu)

Sincerely,

Autumn Carter

Shadaria Lynch

Scott McGary

Perla Zaldivar

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Acknowledgment

The project was prepared by Scott McGary, Autumn Carter, Shadaria Lynch, and Perla Zaldivar collectively. The completion of the project would not have been possible without the hard work and productivity of each team member. Also, a special thanks to Dr. Alam and the Civil & Environmental Engineering Department for providing resources and guidance throughout the semester. Prior knowledge from each design course allowed us to have an advantage in creating a well-planned project.

Gantt Timeline

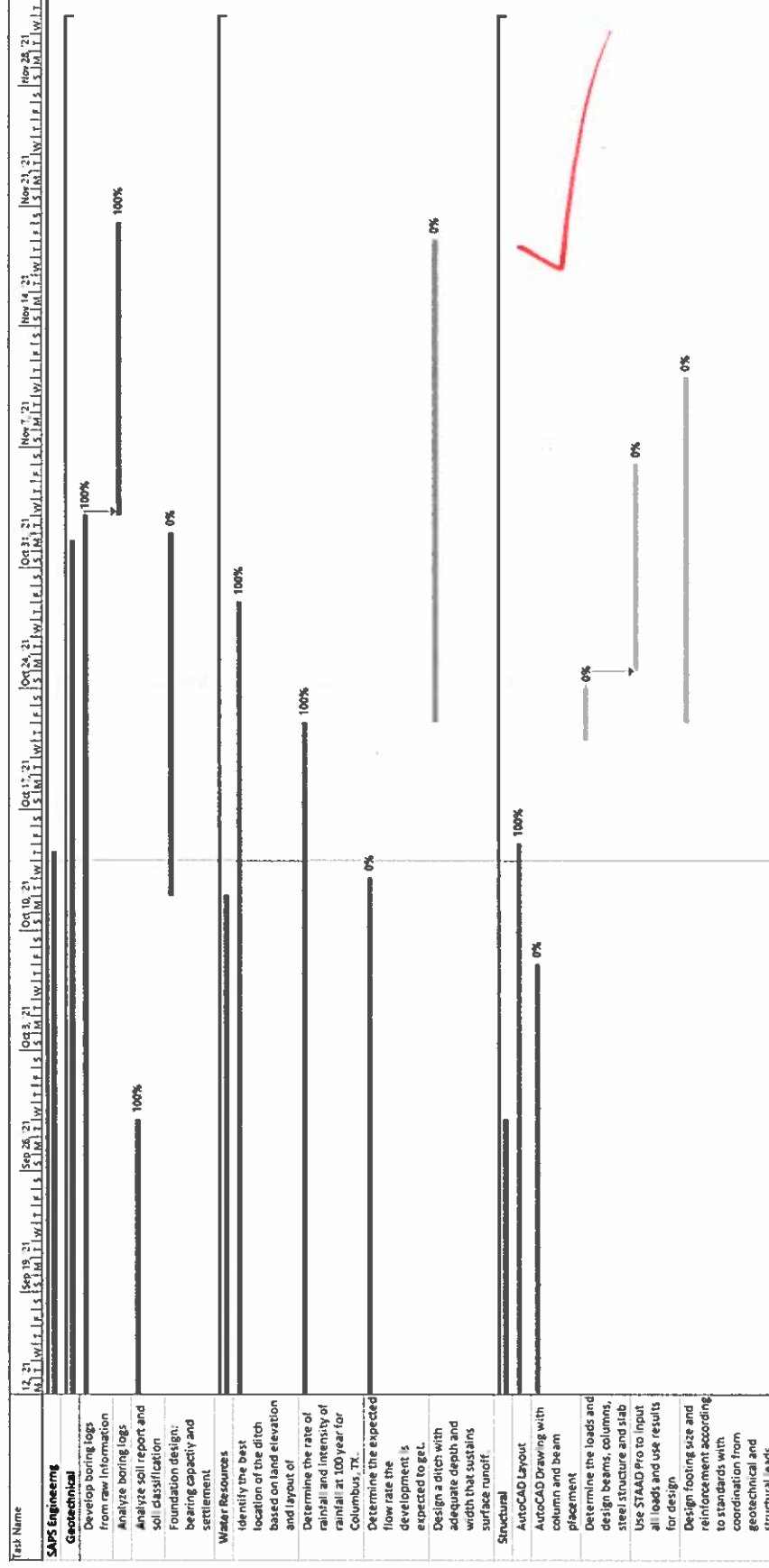


Figure 1. Gantt chart



Figure 1.2 Gantt Chart

Introduction

The proposed development is located south of Columbus, TX in Colorado County. The proposed development will be located on 400 acres of land near I-10. The property was designed for 20,000 it will consist of 4 buildings, parking lots that accommodate employees, visitors, and trucks. Within the development, a detention basin and drainage ditch were added to prevent stormwater damage. A wastewater treatment process facility based on the population projection for 15 years. SAPS Engineering designed the roads and parking to effectively and efficiently allow the flow of traffic from I-10 to the Amazon distribution center and other buildings on the property.



Chapter 1: Project Scope

1.1 Problem Statement

Design a two five-story commercial office building, a steel structure warehouse, a three-story convention center, and parking lots for Amazon located in Colorado County, Texas

1.2 Project Goals

The design team was required to perform civil engineering site development and design services and address all aspects outlined in the reporting requirements and deliverable items of this project description. This project aims to provide an AutoCAD geometric design that includes an Amazon distribution headquarters with a roadway layout and a detention pond. Water & Wastewater Treatment plants are needed to serve 20,000 people for the center and surrounding area. In addition, a 2D conceptual layout design of the and office building is needed. Also, in the area, parking facilities will be designed for each building.

Chapter 2: Task Definition and Project Design

2.1 Engineering Design

To first complete this aspect of the project the task had to be defined first. This task needed to analyze the topography map to develop boring logs from raw information and analyze those boring logs to develop the soil classification. Once this is done the foundation design can begin. To complete this project the foundation design needs to be completed where I will go for both shallow foundation and deep foot foundation and choose which is the most safe at the best cost.

The picture below is a topography map that shows the location of the site. The location of the site is south of I-10, in Colorado County TX. The size of the site is 400 acres. The elevation of the site goes into a downwards slope from 300 to 289 feet above sea level. Therefore the average elevation of the site is 294.5 feet above sea level. The black circles shown on the topographic map represent the locations where the borings were taken.



Figure 2.1 Proposed Site

AutoCAD was used in this project to create a preliminary layout of the 400 Acres. In the plan view provided by Google Maps; 2 miles scales to $\frac{1}{2}$ inch. In order to follow the constraints of the project the layout includes two five-story commercial office buildings, a steel structure warehouse, three-story convention center, facility parking lots, new road network development, sidewalks, driveways, and extension of major highways and connecting local road with highway and a storm water ditch connecting a lake. The layout below shows the preliminary layout of the

proposed site plan. The layout includes a main entrance for 2-axle cars containing a right-turn lane, traffic signal, and ability to make left turn movements into each entrance. Also in the layout service truck parking for the warehouse is provided. A wastewater treatment plant with a retention pond provides both stormwater attenuation and water quality treatment by providing additional storage capacity to retain runoff and release at a controlled rate. The design of the pond features includes an emergency spillway for safe overflow when storage capacity is exceeded.

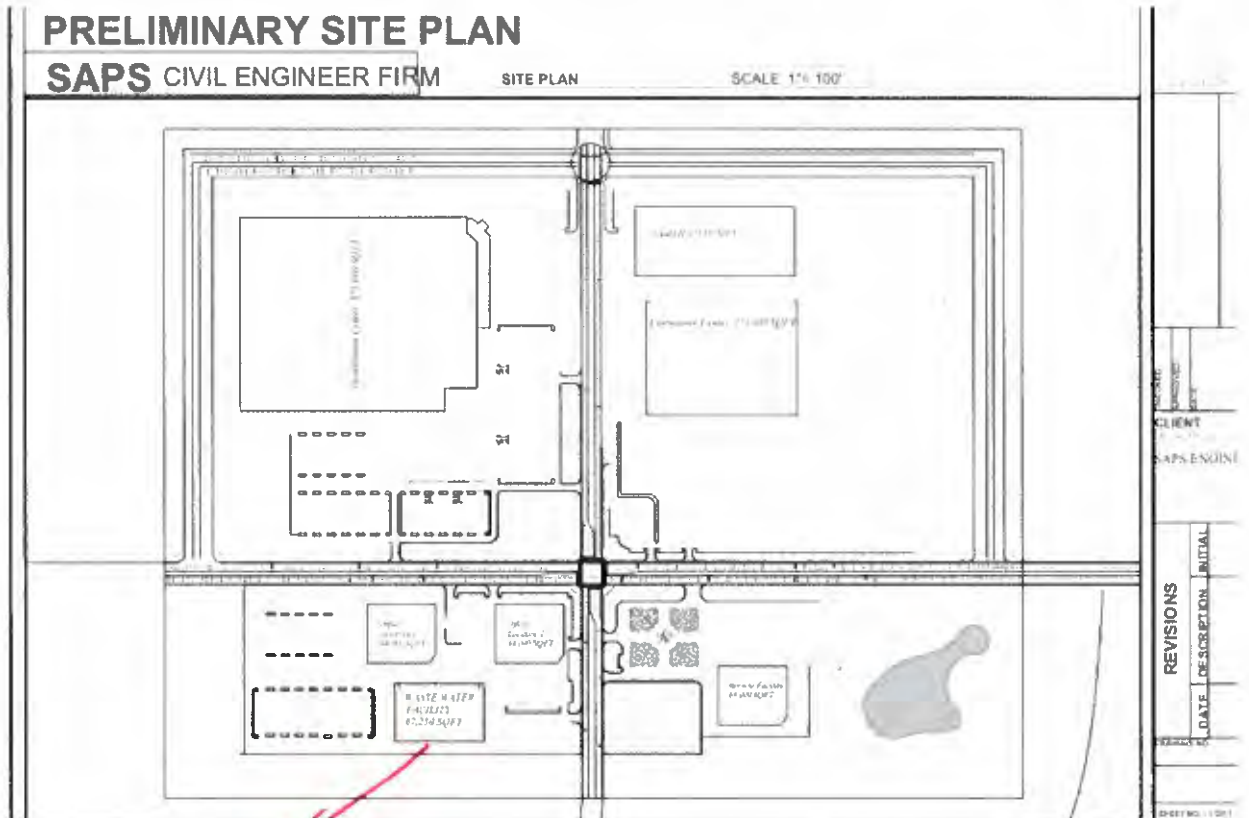


Figure 2.2 Preliminary Layout

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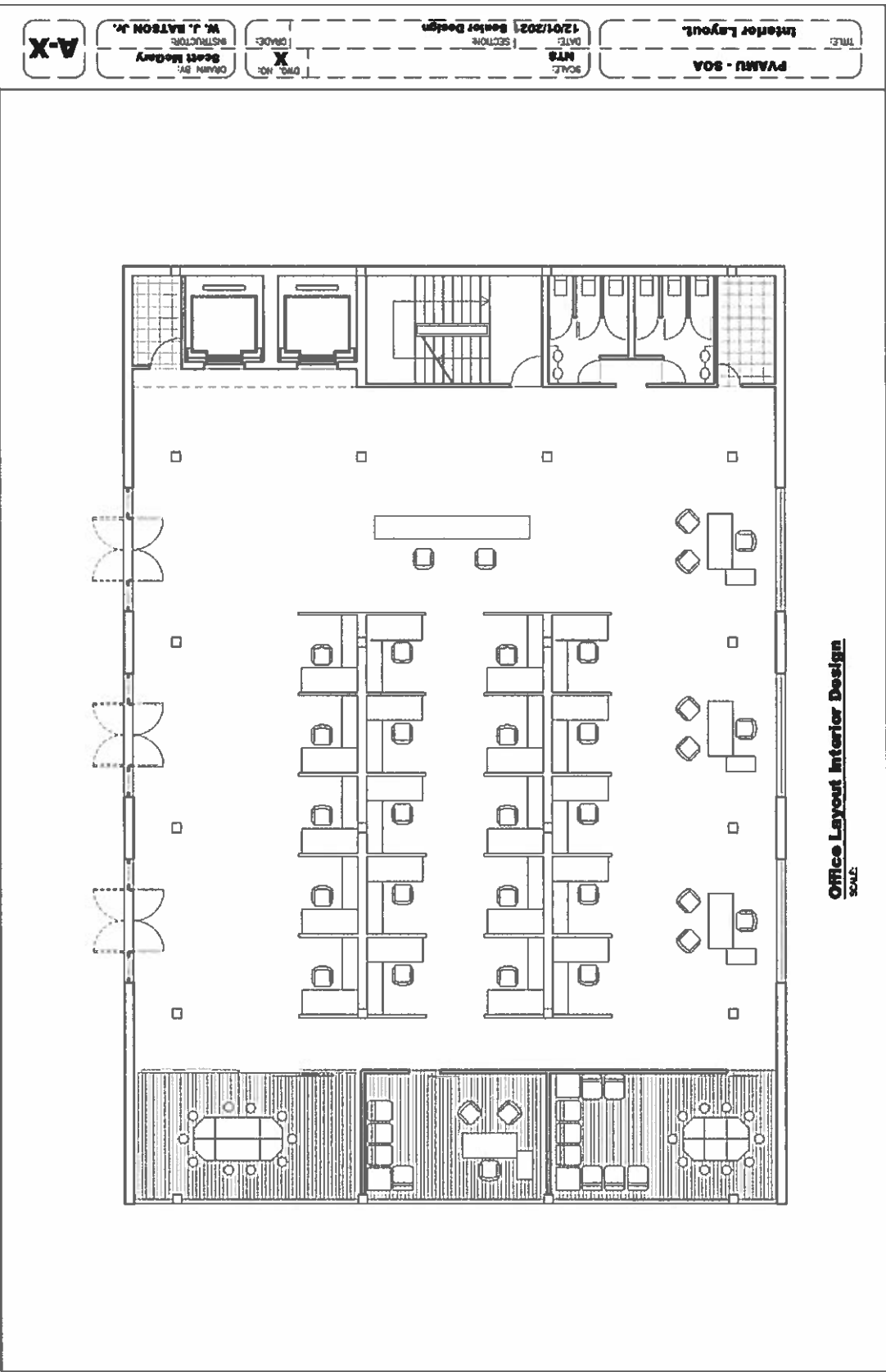


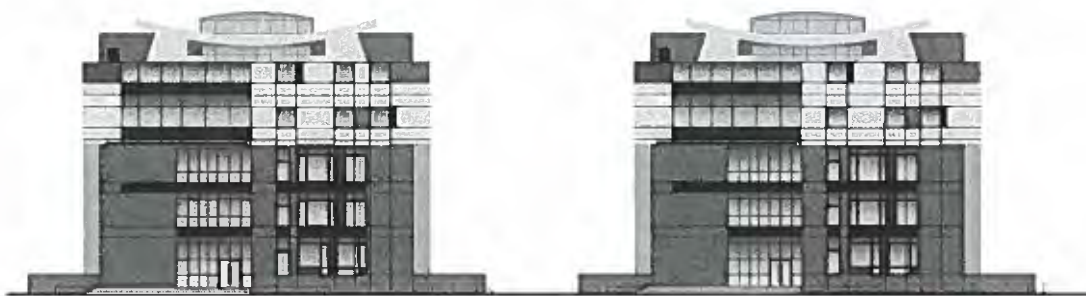
Figure 2.3 Office Layout

Architecture Components

The two identical five story office buildings were designed to be the highlights of Amazon's campus.

- Office Building A: 225,000 sf (150 ft x 300 ft) .5 acres occupied
- Office Building B: 225,000 sf (150 ft x 300 ft) .5 acres occupied

800 Employees per office building



AMAZON 5 STORY OFFICE BUILDINGS

SCALE: 1/8" = 1' - 0"

SAPS Eng^{Design}

PVAMU
100 UNIVERSITY DRIVE
PAIDEE NEW, TEXAS 77408

DESIGNED BY: SHERY BOLDY
FILED: AMAZON OFFICE SPACE
DATE: FEB 09, 2007
INSTRUMENT NO.: 06-ALAM

Sheet No.
A-1

2.1.2 Soil Properties

The boring log data for the location of the site is located below. This boring log displays the testing of the soil to classify the type of soil it is, the amount of stress it can take, as well as other properties of the soil that will make a difference when designing a structure on it.

The boring log tells the engineer the results from various tests of the soil within the site location. The log shows the depth of each kind of soil down to 70 feet. Based on the boring log data, the soil is classified as mostly Sandy Elastic Silt from boring 1 and Sandy Fat Clay from boring 2. Excel was utilized in developing a table to analyze this data. This was found by using the Liquid

Limit (50), Plastic Limit (30), and Plasticity Index (29) according to the first table and Liquid Limit (60), Plastic Limit (27), and Plasticity Index (32) for the second table. This is shown on the boring log, and the use of the table and chart below to classify the soil of the site.

The bearing capacity of the soil was calculated by using the bearing capacity equation along with the safety factor.

$$q_u = 1.3cN_c' + qN_q' + 0.4\gamma BN\gamma' \text{ (square foundation)}$$

Where

c = cohesion

B = width of footing

Footing will be placed at 5', with a SPT of 14 blows/ft at 15'. The angle of friction and the dry unit weight can be calculated to be 0 degrees and 126 lb/ft³ respectively.

In designing the footing foundation for the canopy we used the square foundation equation shown below to determine the ultimate bearing capacity and the base design of our footing.

Before determining the bearing capacity we had to determine the N_c' , N_q' , $N\gamma'$ by using the Terzaghi Bearing Capacity Factors table. Due to the angle of friction being 0 for clay. The value we obtained was $N_c'=5.7$, $N_q'=1$, $N\gamma'=0$.

The exact calculations of this are provided in the appendix. Using a FS factor of safety, of 3, the allowable bearing capacity, q_{allow} , was found.

$$q_{allow} = \frac{q_u}{FS}$$

Table 2.1 Soil Classification 1

Depth(ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification
2.5	48	20	28	54%	46%	13%	CL	Sandy Lean Clay
5	51	32	19	69%	31%	14%	MH	Sandy Elastic Silt
10 ~	~	~	~	~	~	8%		Sand
12.5	46	19	27	74%	26%	18%	CL	Sandy Lean Clay
17 ~	~	~	~	~	~	10%		Sand
20	32	16	16	59%	41%	13%	CL	Sandy Lean Clay
25	60	31	29	81%	19%	21%	MH	Sandy Elastic Silt
30	72	31	41	82%	18%	20%	CH	Sandy Fat Clay
40	68	39	29	62%	38%	4%	MH	Sandy Elastic Silt
50	80	39	41	69%	31%	18%	MH	Sandy Elastic Silt
60	68	34	34	84%	16%	20%	MH	Sandy Elastic Silt

Table 2.2 Soil Classification 2

Depth(ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification
2.5	43	16	27	71%	29%	19%	CL	Sandy Lean Clay
7.5	47	19	28	81%	19%	12%	CL	Sandy Lean Clay
8.5 ~	~	~	~	20%	80%	6%	~	Sand
15	51	24	27	69%	31%	13%	CH	Sandy Fat Clay
20 ~	~	~	~	16%	84%	8%	~	Sand
25	62	30	32	80%	20%	15%	CH	Sandy Fat Clay
30	62	27	35	79%	21%	13%	CH	Sandy Fat Clay
40	69	28	41	83%	17%	17%	CH	Sandy Fat Clay
50	71	33	38	72%	28%	18%	CH	Sandy Fat Clay
60	69	34	35	79%	21%	19%	CH	Sandy Fat Clay

The Plasticity chart which is a graph between plasticity index (PI) and liquid limit (LL) in percentage which is used for the classification of fine-grained soils in accordance with the USCS. From the graph the geotechnical engineer can determine that low plasticity has a (LL) = < 35%, Intermediate plasticity (LL) = 35-50%, High plasticity (LL) = 50-70%, Very High plasticity (LL) 70-90%, and Extremely High plasticity (LL) = > 90%

To develop the boring logs AutoCAD needed to be used. The raw data given was tabulated, and the data produced was essential in creating the boring logs used to show the various fine-grained soils. This boring log also shows the elevations from which the raw information was taken.

Table 2.3 Boring 1 Analysis For Square Pile Section

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	0	0	0	0	0	0	0	0	0
2.5	7	900	0.43	0.72	32400.00	3240.00	35640.00	648	1620
7.5	10	1200	0.57	0.6	43200.00	14040.00	57240.00	720	5400
9	15	0	0.00	0	0.00	14040.00	14040.00	0	0
15	15	2000	0.96	0.49	72000.00	43440.00	115440.00	980	14700
20	20	0	0.00	0	0.00	43440.00	43440.00	0	0
30	25	3400	1.63	0.38	122400.00	120960.00	243360.00	1292	38760
40	39	5300	2.54	0.34	190800.00	265120.00	455920.00	1802	72080
50	53	7100	3.40	0.34	255600.00	506520.00	762120.00	2414	120700
60	60	8000	3.83	0.34	288000.00	832920.00	1120920.00	2720	163200
68	89	9400	4.50	0.34	338400.00	1267576.00	1605976.00	3196	217328
								Sum	633788

Table 2.4 Boring 2 Analysis for Square Pile Section

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	0	0	0.00	0.00	0.00	0.00	0.00	0	0
2.5	8	1000	0.48	0.67	36000.00	6700.00	42700.00	670	1675
5	10	1200	0.57	0.61	43200.00	21340.00	64540.00	732	3660
10	16	2100	1.01	0.48	75600.00	61660.00	137260.00	1008	10080
12.5	17	2250	1.08	0.47	81000.00	114535.00	195535.00	1057.5	13218.75
15	20	2500	1.20	0.41	90000.00	176035.00	266035.00	1025	15375
20	24	3300	1.58	0.39	118800.00	278995.00	397795.00	1287	25740
30	24	3300	1.58	0.39	118800.00	433435.00	552235.00	1287	38610
40	54	7200	3.45	0.34	259200.00	825115.00	1084315.00	2448	97920
50	44	5600	2.68	0.34	201600.00	1205915.00	1407515.00	1904	95200
60	72	9400	4.50	0.34	338400.00	1972955.00	2311355.00	3196	191760
68	98	9400	4.50	0.34	338400.00	2842267.00	3180667.00	3196	217328
								Sum	69748.75

capacity curve?

provided later $\rightarrow$ okay ✓

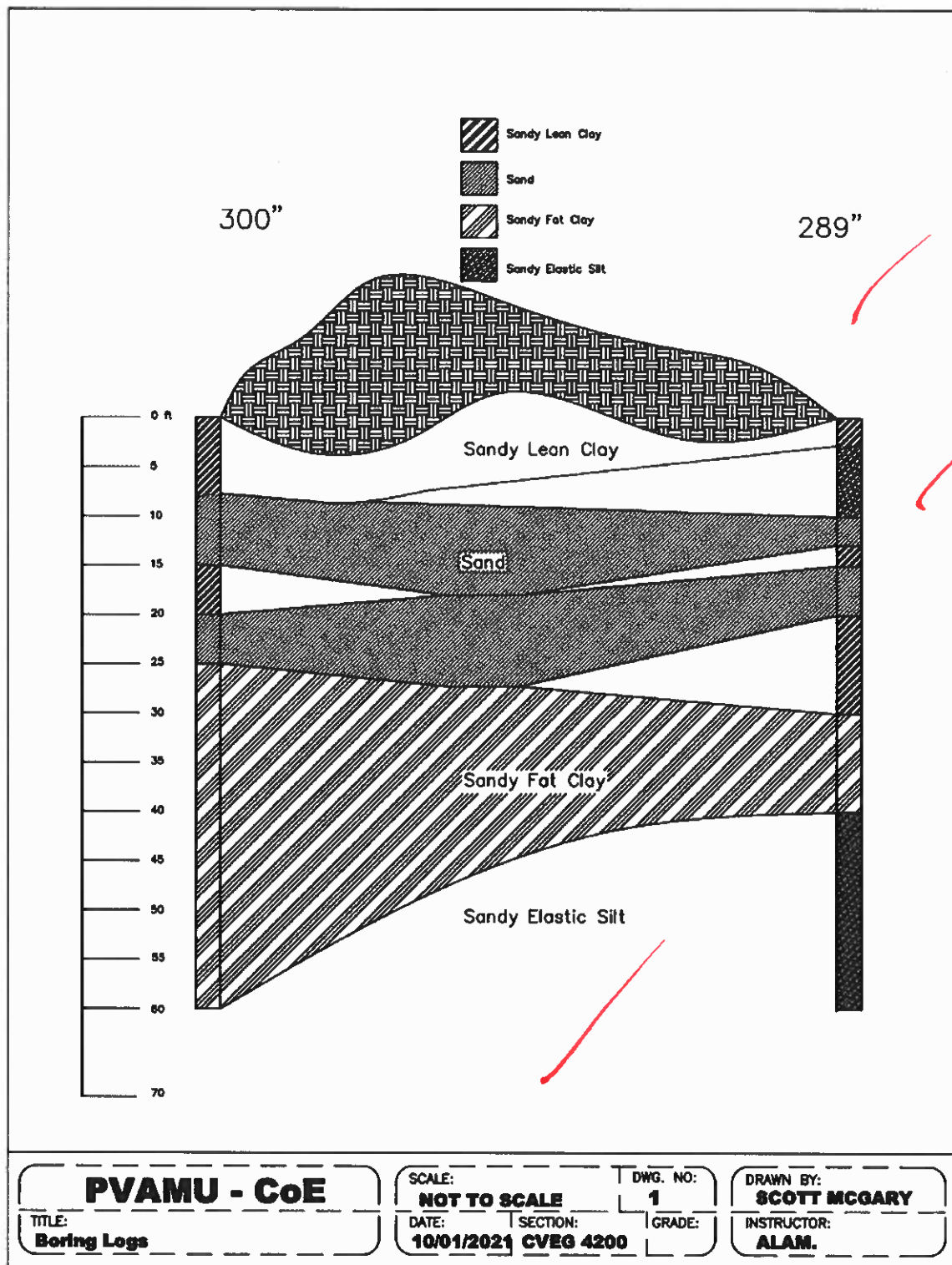


Figure 2.4 Boring Logs

2.2 Water Resources Engineering

2.2.1 Water Resources Objective

The objective of water resources is to design a ditch and a detention basin for the development of 400-acre land. The location of the proposed stormwater ditch was located at the lowest elevation of the proposed site using the local topographic map. The rainfall intensity for 100-year flooding was determined for Colorado County. The quantity of water and stormwater runoff was determined in order to build a ditch that can sustain the flow and detention basin.

2.2.2 Rainfall Intensity

The rainfall intensity was determined by using NOAA's National Weather Service. Using the chart the intensity interval for the 100 year flood period was found to be 4.17 in/hr. Reference Figure A.4 in Appendix that displays the precipitation frequency for Columbus, TX.

2.2.3 Stormwater Runoff

The water runoff depends upon the precipitation that infiltrates the ground. Once the infiltration capacity of the soil exceeds, the water begins to runoff. Development typically increases runoff and decreases absorption of water. Therefore, it is essential to determine the expected stormwater runoff to prevent damage to the property. To manage the stormwater, the pre-development runoff was determined. The runoff can be calculated with the rational equation,

$$Q = ciA$$

Q = peak runoff rate (cfs)

c = runoff coefficient

i = storm intensity (in/hr)

A = area (acres)

The area taken into account for pre-development was 400 acres since the land has no existing buildings. The runoff coefficient was determined to be 0.3 for farmland, the runoff for the pre-development was determined to be 500.4 cfs.

2.2.4 Drainage Ditch

An open channel is an integral part of a stormwater ditch design. In order to design an open trapezoidal channel, the manning equation was utilized.

$$Q = \frac{1.49}{n} AR^{2/3} S_o^{1/2}$$

Q = discharge, ft^3/s

n = roughness coefficient

A = flow area, ft^2

R = hydraulic radius

S_o = channel slope

The hydraulic radius can be expressed as,

$$R = \frac{A}{P}$$

P = perimeter, ft

The area and perimeter can be defined as,

$$A = by_o + zy_o^2$$

$$P = b + 2y_o\sqrt{1 + z^2}$$

z = side slope of the bank

y_o = channel depth, ft

b = bottom width, ft

The manning equation can be written as,

$$Q = \frac{1.49}{n} \frac{A^{5/3}}{P^{2/3}} S_o^{1/2}$$

The continuity equation can be written to find the design velocity,

$$Q = VA$$

$$V_{design} = \frac{Q}{A}$$

V_{design} = velocity, ft/s

The channel freeboard equation can be written as,

$$F = 0.55\sqrt{Cy}$$

2.2.5 Drainage Ditch Design

The ditch is a grass lined channel as it is a cost effective and low maintenance option. The grass can infiltrate the stormwater as it continues to flow through the ditch. The Manning's equation

and continuity equation were used to find the ditch dimensions. Manning's roughness coefficient for a grass lined channel is 0.033 with a max permissible channel velocity of 4 ft/s. The slope of the channel is based on the elevation on the property, which was determined to be 0.0011. The slope of the drainage ditch will be 1:2. By manipulating the manning equation the hydraulic radius was found to be 4.36ft. The ditch has a cross sectional area of 125.1 square feet and a wetter perimeter of 28.69 ft. The permissible tractive force was found to be 0.37 lb/ft^2 . The channel depth was found to be 5.39 ft deep, 4.59ft wide and freeboard at 1.65ft. Figure 2.5 displays the section view of the grass channel.

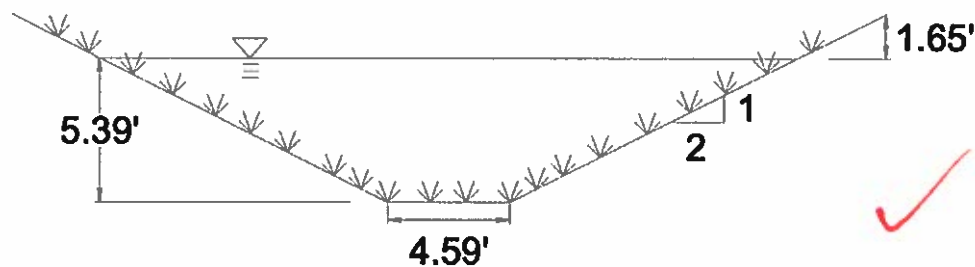


Figure 2.5 Section View of Trapezoid Ditch

The dimensions of the trapezoidal channel will support the discharge for the 100-year flood. Figure 2.6 displays the profile view of the trapezoid ditch.

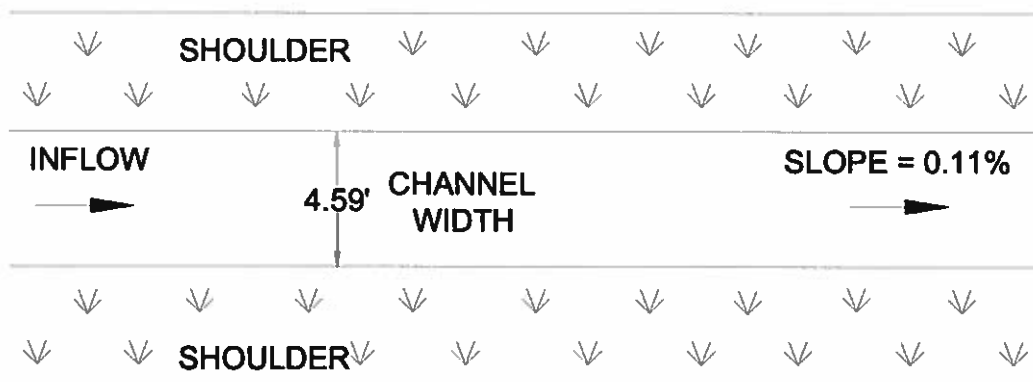


Figure 2.6 Profile View of Trapezoid Ditch

2.2.6 Stormwater Basin

The development requires a stormwater basin that allows the storage of runoff water in order to prevent flooding. With the data found on USGS the inflow of the ditch can be determined.

design → ??

2.3 Structural Engineering

Structural requires a 2D drawing of the office buildings, warehouse, and convention center. To determine structural load calculations, wind, dead, and live load will be taken for each structure. The load calculations will then be put into STAAD Pro, to provide maximum values of BM, shear, and axial load. Moreover, the structural design will include slab design, beam, and column design, the steel structure design of the warehouse, and reinforcement bars, and reinforced concrete design for foundations, including footing size, reinforcement.

2.3.1 Structural Plan Layout

The steel warehouse has dimensions of 1000ft by 2000ft by 36ft equaling 2,000,000 sq. ft. The two office buildings have the same dimensions of 150ft by 300ft by 65ft equaling 225,000 square feet for each building.

2.4 Transportation Engineering

2.4.1 Roadway Layout

The design of the roadway connecting to a highway will be completed in the next couple of weeks. Students are working with a new software (Civil 3D) to create a plan and profile view for a typical road in the development. The transportation engineer will also be meeting with the respective professor for questions regarding the designs and standards. Figure 2.4.1 displays the site and roadway layout of the development.

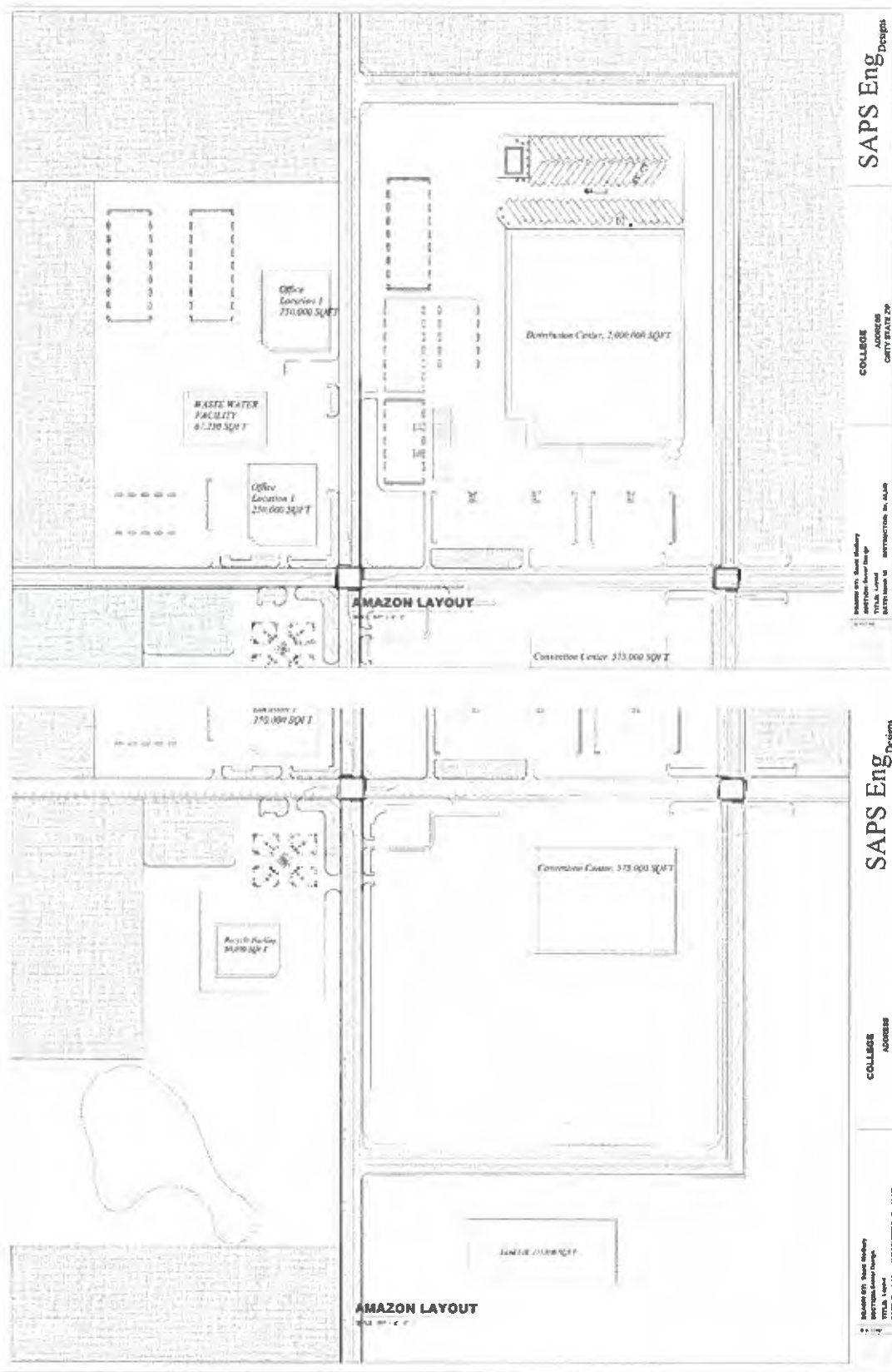


Figure 2.4.1 Site and Roadway Layout

2.4.2 Parking

Parking facilities will be major components for the convention center, office buildings and warehouse. Off-street parking and loading areas will help accommodate all parking needs within the development. Parking data followed the American Disability Act Design Standards and City of Houston Municipal Parking Standards. Parking stalls will be 90 degrees and be 10 ft wide and 18 ft long and parking access aisles will be at least 25 feet wide. Truck parking stalls will be at a 45 degree angle and there will be 15 van accessible parking provided to follow ADA standards and codes. Table 2.4.2 includes the total number of parking stalls for each building within the development.

Table 2.4.2 Number of Parking Spaces Required

Building	Parking Spaces	Accessible Parking
Amazon Fulfillment Center	5000	60
Office Building A	625	13
Office Building B	625	13
Convention Center	1250	23

2.4.3 Typical Local Road

Local roads will be designed following the TxDOT Roadway Design Manual. Figure 2.4.3 shows a cross-sectional sketch of a typical local road in the development.

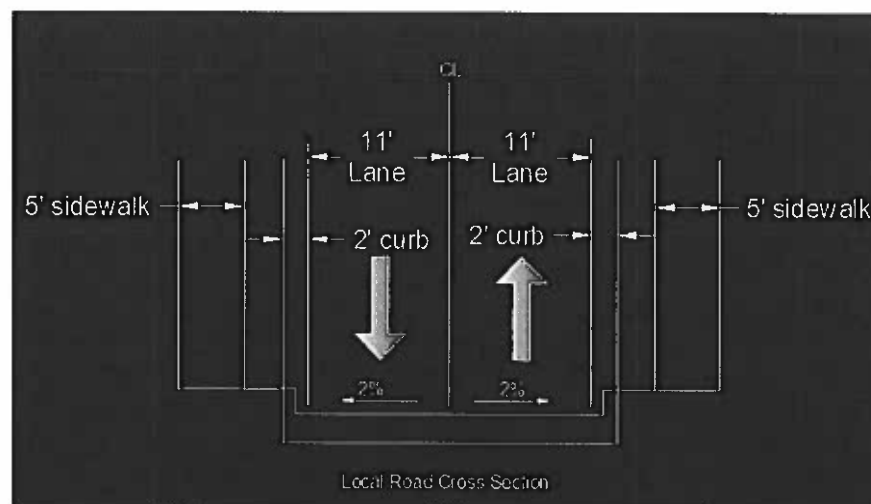


Figure 2.4.3 Cross Section of Typical Local Road

The roadway cross section shows two travel lanes, each traveling in opposing directions. Each travel lane is 11 feet wide with one two feet curb on the side of each travel lane, five feet sidewalks on the side of each curb, and a 2% slope.

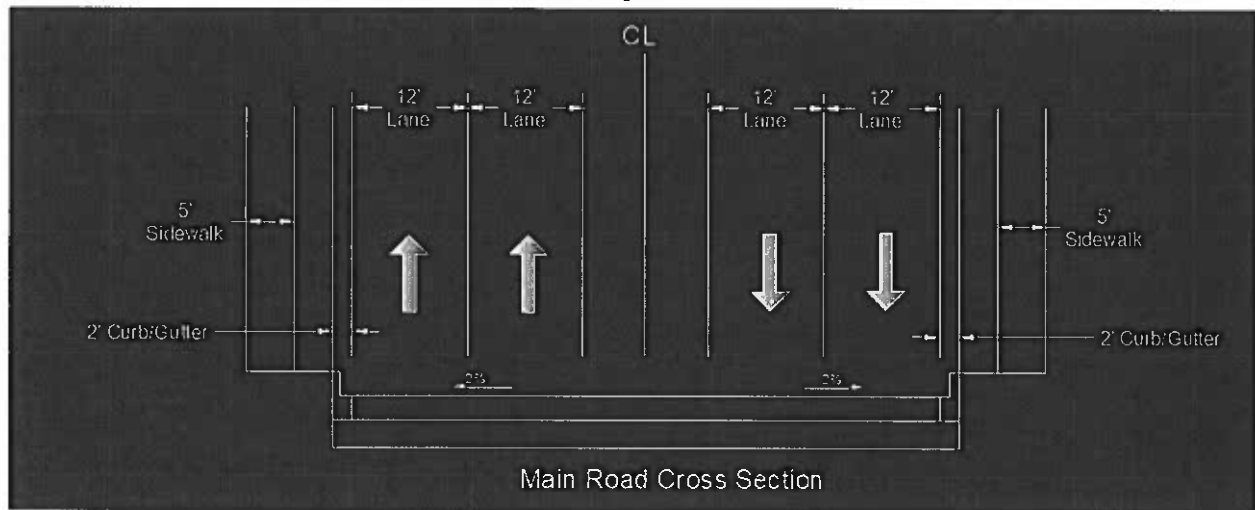


Figure 2.4.4 Cross Section of Typical Main Road

2.4.5 Pavement Design

A rigid pavement design will be used on all roads in the neighborhood. Portland Cement and lime will be used to design the pavement, following Texas Pavement Design Manual. To determine the required base-course, subbase-course, and how to treat the subgrade, all Texas Department of Transportation design regulations will be followed.

2.4.6 Landscaping

Landscaping will be followed by TxDOT Landscaping Manual and Houston Tree and Shrub Ordinance. The ordinance requires one tree for every 30 feet of road frontage and every 10 spaces, trees must be planted at least 20 feet apart, each parking space must be within 120 feet of a parking lot or street tree. Therefore, there will be 750 trees throughout the parking lots (500 for amazon fulfillment center, 63 for each office building, and 125 for the convention center).

2.5 Environmental Engineering

The beneficial purpose of environmental designing in the vicinity of Amazon's Distribution Center and IT Hub is to provide an efficient amount of water used for primary purposes that are useful to human life. The importance of water is to control and eliminate diseases, quality of life, carry out waste, and commercial and industrial activities. The municipal water use for this project will be categorized into domestic, and commercial/industrial usage; initializing the quality and quantity of water that will be useful on this site.

As the environmental engineer on this project, we will estimate the inflow water demand for the facility population of twenty thousand and estimate the wastewater quantity for the job site. With the inflow of water throughout the quarters of the premises we'll have to follow EPA (Environmental Protection Agency) regulations regarding the Maximum Contaminant Level (MCL) that is legally enforced for human consumption and usage; National Primary Drinking Water Regulation. The placement of our wastewater treatment plant (WWTP) is located in the lower southeast region of our 400-acre lot, as of now, we are still working on the methodology for cleaning the wastewater before the disposal of effluent into a source of surface water. The disposal source for the facilities will be Griffin Lake following the Texas Administrative Code (TAC).

2.5.1 Design for a New Wastewater Treatment Facility

The design criteria for a new wastewater treatment plant are found in the Texas Administrative Code Title 30 Chapter 217, Subchapter B, "The design of a new wastewater treatment facility must be based on the flows and loadings in paragraphs (1) - (3) of this subsection, unless subsection (b) of this section applies." The wastewater facility will be designed to treat Office Buildings or Factories which are expected to have a daily wastewater flow of 20 gallons per person. According to Table B.1 Design Organic Loadings and Flows for a New Wastewater Treatment Facility. The wastewater plant must operate at maximum.

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75

2.5.2 Solve for Q

Q is obscured to find the flow rate of water in the units of million gallons per day (MGD). The formula used to obtain this information is population multiplied by the daily wastewater flow. Amazon has a population of twenty thousand and a daily wastewater flow of 20 MGD. After calculating and converting values from english to SI units the Q is found to be 1514 cubic meters per day. Calculation will be shown in the appendix.

2.5.3 Wastewater Treatment Plant

you need to provide some schematic diagram

Screening

Screening is the first step of operation at all water treatment plants. Screen is the operative device used to retain solids found in the water such as logs, rags, trash, and branches. The main purpose of screening is to remove solid materials that could cause damage to other process equipment, cause reduction in efficiency of the operation system, and taint waterways. There is a classification of three types of screens which are coarse, fine, and microscreens. A screening system will be included in the wastewater treatment plant.



Grit Chamber

For peak flow according to the TAC. When site-specific data is unavailable, the peak flow must be determined by multiplying the design flow by a factor of at least 4.0. If site-specific data or projections are available, the peak flow must be based on the site-specific data (TAC)

The grit chamber design criteria are expressed in the Texas administrative code, and the specifications are to provide two chambers that will operate at peak flow. An aerated grit chamber must have a hydraulic detention time of at least 3.0 minutes.

Calculations for the grit chamber will be shown in the appendix section of the report. The finalized dimensions are as follows; Length= 2 meters, Depth= 3 meters, and width= 0.648 meters.

Primary Clarifier

- (i) Detention time at peak flow must be at least 54 minutes (0.9 hour).
- (ii) Detention time at design flow must be at least 108 minutes (1.8 hours).(TAC)

Calculations for the primary clarifier will be expressed in the appendix section of this report.

Due to having two identical primary clarifiers there is a diameter of 10 meters for each and a depth of 3 meters. The overflow rate that has been determined for each tank will be 40 cubic meters per day per meter squared and with a weir loading rate of 96.37 cubic meters per day per meter.

Chapter 3: References

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Appendix 1 Images

Geotechnical Data Collected

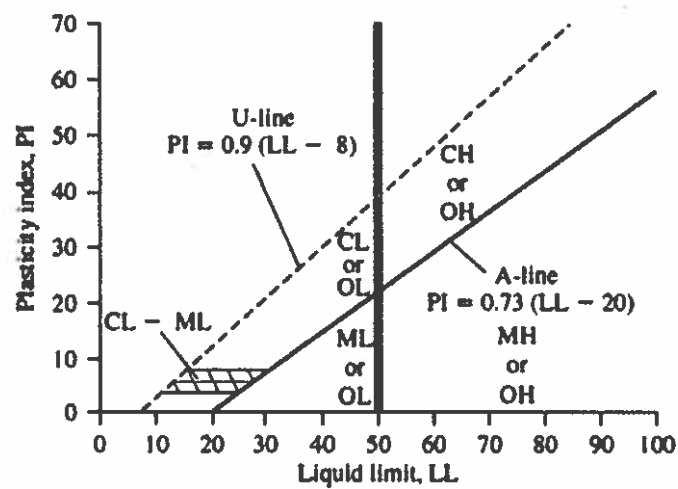


Figure A.1 Plasticity Chart

Table 3.1 Terzaghi's Bearing Capacity Factors—Eqs. (3.4), (3.5), and (3.6) a From Kumbhojkar (1993)

ϕ'	N_c	N_q	N_γ^a	ϕ'	N_c	N_q	N_γ^a
0	5.70	1.00	0.00	26	27.09	14.21	9.84
1	6.00	1.10	0.01	27	29.24	15.90	11.60
2	6.30	1.22	0.04	28	31.61	17.81	13.70
3	6.62	1.35	0.06	29	34.24	19.98	16.18
4	6.97	1.49	0.10	30	37.16	22.46	19.13
5	7.34	1.64	0.14	31	40.41	25.28	22.65
6	7.73	1.81	0.20	32	44.04	28.52	26.87
7	8.15	2.00	0.27	33	48.09	32.23	31.94
8	8.60	2.21	0.35	34	52.64	36.50	38.04
9	9.09	2.44	0.44	35	57.75	41.44	45.41
10	9.61	2.69	0.56	36	63.53	47.16	54.36
11	10.16	2.98	0.69	37	70.01	53.80	65.27
12	10.76	3.29	0.85	38	77.50	61.55	78.61
13	11.41	3.63	1.04	39	85.97	70.61	95.03
14	12.11	4.02	1.26	40	95.66	81.27	115.31
15	12.86	4.45	1.52	41	106.81	93.85	140.51
16	13.68	4.92	1.82	42	119.67	108.75	171.99
17	14.60	5.45	2.18	43	134.58	126.50	211.56
18	15.12	6.04	2.59	44	151.95	147.74	261.60
19	16.56	6.70	3.07	45	172.28	173.28	325.34
20	17.69	7.44	3.64	46	196.22	204.19	407.11
21	18.92	8.26	4.31	47	224.55	241.80	512.84
22	20.27	9.19	5.09	48	258.28	287.85	650.67
23	21.75	10.23	6.00	49	298.71	344.63	831.99
24	23.36	11.40	7.08	50	347.50	415.14	1072.80
25	25.13	12.72	8.34				

^aFrom Kumbhojkar (1993)

Figure A.2: Terzaghi Bearing Capacity Factors

Table 24. Approximate values of undrained shear strength for cohesive soils based on SPT blow count N-values (from Terzaghi and Peck, 1967)

Soil Consistency	SPT N (See Note)	S_u (psf)
Very Soft	< 2	< 250
Soft	2 - 4	250 - 500
Medium	4 - 8	500 - 1000
Stiff	8 - 15	1000 - 2000
Very Stiff	15 - 30	2000 - 4000
Hard	> 30	> 4000

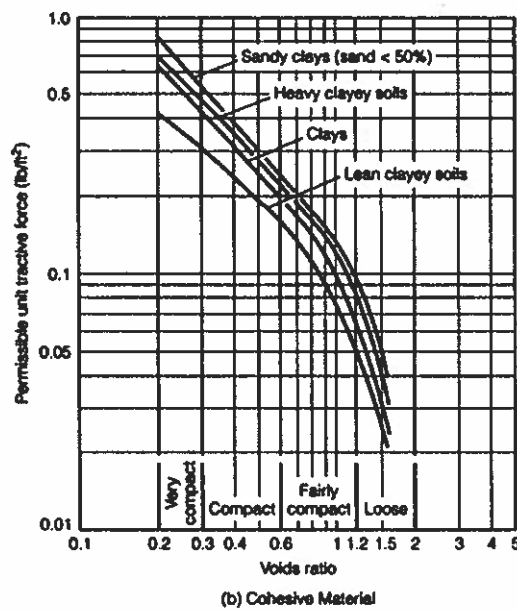
Figure A.3: Approximate Value of C_u , SPT and soil consistency

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.72 (0.33-1.57)	0.81 (0.09-0.06)	0.90 (0.16-10.0)	0.22 (0.06-12.3)	18.8 (7.92-15.0)	12.1 (6.59-17.1)	13.4 (9.23-16.4)	14.8 (9.64-21.8)	16.3 (10.45-25.2)	17.6 (11.2-27.9)
10-min	4.63 (3.44-6.01)	6.26 (4.02-8.89)	8.43 (4.90-8.46)	7.40 (5.55-9.86)	8.72 (0.35-12.0)	9.79 (8.90-13.7)	10.7 (7.39-15.5)	11.7 (7.64-17.4)	12.8 (8.37-19.8)	13.9 (8.71-21.8)
15-min	3.84 (2.91-5.08)	4.42 (3.30-5.80)	5.38 (4.10-7.08)	6.17 (4.83-8.22)	7.24 (5.26-9.92)	8.04 (5.89-11.3)	8.84 (6.10-12.6)	9.66 (6.50-14.4)	10.8 (6.99-16.6)	11.6 (7.34-18.3)
30-min	2.74 (2.07-3.61)	3.13 (2.40-4.11)	3.79 (2.90-4.99)	4.33 (3.25-5.77)	5.06 (3.67-6.92)	5.89 (3.95-7.86)	6.14 (4.23-8.90)	6.73 (4.63-10.0)	7.54 (4.90-11.6)	8.19 (5.16-12.9)
60-min	1.78 (1.35-2.36)	2.06 (1.58-2.70)	2.51 (1.92-3.31)	2.88 (2.17-3.85)	3.40 (2.46-4.64)	3.77 (2.88-5.31)	4.17 (2.87-6.04)	4.60 (3.10-6.86)	5.23 (3.40-8.07)	5.74 (3.63-8.67)
2-hr	1.07 (0.816-1.41)	1.28 (0.973-1.64)	1.60 (1.22-2.06)	1.87 (1.41-2.48)	2.28 (1.65-3.08)	2.57 (1.82-3.60)	2.90 (2.01-4.16)	3.28 (2.22-4.85)	3.84 (2.50-5.80)	4.31 (2.74-6.76)
3-hr	0.778 (0.594-1.02)	0.947 (0.720-1.21)	1.20 (0.921-1.56)	1.43 (1.06-1.89)	1.77 (1.29-2.40)	2.03 (1.45-2.84)	2.33 (1.62-3.34)	2.68 (1.81-3.94)	3.19 (2.08-4.86)	3.61 (2.30-5.65)
6-hr	0.447 (0.342-0.579)	0.561 (0.424-0.700)	0.728 (0.559-0.934)	0.884 (0.671-1.16)	1.12 (0.824-1.51)	1.31 (0.943-1.83)	1.54 (1.07-2.19)	1.79 (1.22-2.62)	2.17 (1.42-3.20)	2.49 (1.60-3.86)
12-hr	0.250 (0.193-0.323)	0.323 (0.243-0.395)	0.435 (0.327-0.538)	0.524 (0.398-0.680)	0.675 (0.502-0.910)	0.808 (0.584-1.12)	0.962 (0.673-1.36)	1.13 (0.771-1.64)	1.39 (0.912-2.00)	1.60 (1.03-2.47)
24-hr	0.141 (0.108-0.181)	0.186 (0.139-0.224)	0.248 (0.191-0.312)	0.309 (0.237-0.396)	0.405 (0.303-0.544)	0.491 (0.358-0.679)	0.591 (0.438-0.819)	0.698 (0.476-1.00)	0.854 (0.563-1.27)	0.981 (0.632-1.50)
2-day	0.080 (0.062-0.101)	0.107 (0.080-0.127)	0.144 (0.112-0.180)	0.182 (0.140-0.233)	0.241 (0.183-0.324)	0.297 (0.219-0.409)	0.358 (0.253-0.499)	0.419 (0.287-0.597)	0.500 (0.330-0.738)	0.562 (0.363-0.854)
3-day	0.058 (0.045-0.073)	0.078 (0.056-0.092)	0.105 (0.082-0.130)	0.132 (0.102-0.168)	0.174 (0.133-0.234)	0.214 (0.158-0.294)	0.257 (0.182-0.357)	0.299 (0.205-0.424)	0.354 (0.235-0.521)	0.398 (0.256-0.599)
4-day	0.047 (0.036-0.059)	0.062 (0.047-0.073)	0.083 (0.065-0.103)	0.104 (0.080-0.132)	0.136 (0.104-0.181)	0.166 (0.122-0.226)	0.198 (0.140-0.274)	0.230 (0.159-0.325)	0.272 (0.181-0.399)	0.305 (0.197-0.458)
7-day	0.031 (0.024-0.039)	0.040 (0.031-0.048)	0.053 (0.041-0.065)	0.065 (0.050-0.082)	0.083 (0.063-0.109)	0.099 (0.073-0.134)	0.117 (0.083-0.161)	0.135 (0.093-0.191)	0.161 (0.107-0.234)	0.181 (0.117-0.271)
10-day	0.024 (0.018-0.030)	0.030 (0.024-0.037)	0.040 (0.031-0.049)	0.048 (0.038-0.061)	0.061 (0.046-0.080)	0.072 (0.053-0.097)	0.084 (0.060-0.116)	0.097 (0.067-0.136)	0.115 (0.077-0.168)	0.130 (0.086-0.184)
20-day	0.016 (0.012-0.019)	0.019 (0.015-0.023)	0.025 (0.019-0.030)	0.028 (0.023-0.037)	0.036 (0.027-0.048)	0.041 (0.030-0.055)	0.047 (0.034-0.064)	0.053 (0.037-0.074)	0.062 (0.042-0.080)	0.069 (0.045-0.103)
30-day	0.012 (0.010-0.015)	0.015 (0.012-0.018)	0.019 (0.015-0.023)	0.022 (0.017-0.028)	0.027 (0.020-0.035)	0.031 (0.022-0.040)	0.034 (0.025-0.046)	0.038 (0.027-0.053)	0.044 (0.030-0.063)	0.048 (0.032-0.072)
45-day	0.010 (0.008-0.013)	0.012 (0.010-0.015)	0.015 (0.012-0.019)	0.018 (0.014-0.022)	0.021 (0.016-0.027)	0.023 (0.017-0.031)	0.026 (0.019-0.035)	0.029 (0.020-0.040)	0.032 (0.022-0.046)	0.035 (0.023-0.051)
60-day	0.009 (0.007-0.011)	0.011 (0.009-0.013)	0.013 (0.010-0.016)	0.015 (0.012-0.019)	0.018 (0.013-0.023)	0.020 (0.015-0.026)	0.022 (0.016-0.029)	0.024 (0.017-0.033)	0.026 (0.018-0.037)	0.028 (0.018-0.041)

Figure A.4 Precipitation Point Frequency

Table 4.4-2 Roughness Coefficients (Manning's n) and Allowable Velocities for Natural Channels		
Channel Description	Manning's n	Maximum Permissible Channel Velocity (ft/s)
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass and weeds; little or no brush	0.030	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.035	3 to 6
4. Some weeds, heavy brush on banks	0.050	3 to 6
5. Some weeds, dense willows on banks	0.060	3 to 6
For trees within channels with branches submerged at high stage, increase above values by	0.010	
Irregular section with pools, slight channel meander, increase above values by	0.010	
Floodplain – Pasture		
1. Short grass	0.030	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.030	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.040	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.050	3 to 6
2. Wooded	0.120	3 to 6
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or	Range from 0.028 to 0.060	3 to 6

Figure A.5 Roughness Coefficient



Permissible Unit Tractive Force in Channels in Cohesive Material (Figure 3.49b, Chin 2006)

Figure A.6 Permissible Tractive Force

Transportation

Houston Municipal Parking Standards require 2.5 parking spaces per 1000 sq ft. Following ADA requirements, it was determined that there will be 60 accessible parking spaces and 8 van accessible.

- Amazon Fulfillment Center: 900,000 sf (900ft x 1000ft) 21 acres occupied
 - Number of parking spaces: $900 \times 2.5 = 2250$
- Office Building A: 100,000 sf (100 ft x 250 ft) .5 acres occupied
 - Number of parking spaces: $100 \times 2.5 = 250$
- Office Building B: 100,000sf (100ft x250 ft) .5 acres occupied
 - Number of parking spaces: $100 \times 2.5 = 250$
- Convention Center: 250,000 sf (250 ft 350 ft) 2 acres occupied
 - Number of parking spaces: $250 \times 2.5 = 625$

Appendix 2 Calculations

Water Resources

Stormwater Runoff

$$Q = CiA$$

$$Q = (0.3)(4.17 \text{ in/hr})(400 \text{ acres})$$

$$Q = 500.4 \text{ cfs}$$

Trapezoidal Channel

known:

$$Q = 500.4 \text{ cfs (ft}^3/\text{s)} \quad Z = 2$$

$$S_0 = 0.0011 \text{ ft/ft}$$

solution:

- Find Mannings roughness

soil: sandy lean clay

$$n = 0.030 \text{ (grass)}$$

max permissible velocity
= 4 ft/s

- Hydraulics Radius (R)

$$R = \left(\frac{V_n}{1.49 S_0^{0.5}} \right)^{1.5}$$

$$R = \left(\frac{(4 \text{ ft/s})(0.030)}{1.49 (0.0011 \text{ ft/ft})^{0.5}} \right)^{1.5}$$

$$R = 4.30 \text{ ft}$$

- cross-sectional area (A)

$$A = \frac{Q}{V}$$

$$A = \frac{500.4 \text{ ft}^3/\text{sec}}{4 \text{ ft/sec}}$$

$$A = 125.1 \text{ ft}^2$$

- Wetted perimeter (P)

$$P = \frac{A}{R}$$

$$P = \frac{125.1 \text{ ft}^2}{4.30 \text{ ft}}$$

$$P = 28.89 \text{ ft}$$

- Determine b and y

permissible tractive force

$$T_b = 0.37 \text{ lb/ft}^2$$

$$T_b = \gamma y S_0$$

$$0.37 \text{ lb/ft}^2 = (62.4 \text{ lb/ft}^3) y (0.0011)$$

$$0.37 \text{ lb/ft}^2 = (0.06864 \text{ lb/ft}^3) y$$

$$y = 5.39 \text{ ft}$$

$$P = b + 2y\sqrt{1+Z^2}$$

$$28.89 \text{ ft} = b + 2(5.39 \text{ ft})\sqrt{1+2^2}$$

$$28.89 \text{ ft} = b + 24.10 \text{ ft}$$

$$b = 4.59 \text{ ft}$$

- Channel Freeboard

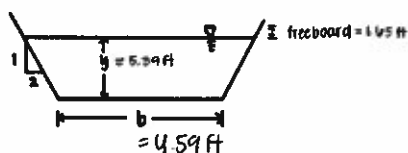
$$F = 0.55 \sqrt{Cy}$$

$$C = 1.48$$

$$y = 5.39 \text{ ft}$$

$$F = 0.55 \sqrt{1.48 (5.39 \text{ ft})}$$

$$F = 1.65 \text{ ft}$$



Geotechnical

Foundation 1

- Depth of Foundation = 5 ft, SPT = 10, $c = 1400$ psf, $N_c = 5.7$, $N_q = 1$, $N_y = 0$
- Factor of safety = 3
- $\gamma = 126$ lb/ft³
- $q_u = 1.3cN_c + qN_q$
- $q = \gamma D_f = (126 \text{ lb/ft}^3)(5 \text{ ft}) = 630 \text{ lb/ft}^2$
- $q_u = 1.3(1400 \text{ psf})(5.7) + 630 \text{ lb/ft}^2 = 11004 \text{ psf}$
- $q_{all} = 11004 \text{ psf} / 3 = 3668 \text{ psf}$

Foundation 2

- Depth of Foundation = 4 ft, SPT = 8, $c = 1000$ psf, $N_c = 5.7$, $N_q = 1$, $N_y = 0$
- Factor of safety = 3
- $\gamma = 126$ lb/ft³
- $q_u = 1.3cN_c + qN_q$
- $q = \gamma D_f = (126 \text{ lb/ft}^3)(4 \text{ ft}) = 504 \text{ lb/ft}^2$
- $q_u = 1.3(1000 \text{ psf})(5.7) + 504 \text{ lb/ft}^2 = 7914 \text{ psf}$
- $q_{all} = 7914 \text{ psf} / 3 = 2638 \text{ psf}$

Transportation

Houston Municipal Parking Standards require 2.5 parking spaces per 1000 sq ft. Following ADA requirements, it was determined that there will be 109 accessible parking spaces and 15 van accessible total.

- Amazon Fulfillment Center: 2,000,000 sf (900ft x 1000ft) 21 acres occupied
 - Number of parking spaces: $2000 \times 2.5 = 5000$ (60 accessible, 8 van accessible)
- Office Building A: 250,000 sf (100 ft x 250 ft) .5 acres occupied
 - Number of parking spaces: $250 \times 2.5 = 625$ (13 accessible, 2 van accessible)
- Office Building B: 250,000sf (100ft x250 ft) .5 acres occupied
 - Number of parking spaces: $250 \times 2.5 = 625$ (13 accessible, 2 van accessible)
- Convention Center: 500,000 sf (250 ft 350 ft) 2 acres occupied
 - Number of parking spaces: $250 \times 2.5 = 1250$ (23 accessible, 3 van accessible)

Environmental

Solving for Q

Population = 20000

Q demand = 20 gal/capita day (TAC)

$Q = (Q \text{ demand})(\text{Population})$

$$= \left(\frac{20 \text{ gal}}{\text{cap-d}} \right) (20,000) = 400,000 \text{ gal/day}$$

$$\left(\frac{400,000 \text{ gal}}{\text{d}} \right) \left(\frac{3.785 \text{ L}}{1 \text{ gal}} \right) \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right) = 1614 \text{ m}^3/\text{d}$$

$$Q = \text{m}^3/\text{d}$$

Grit Chamber

-hydraulic detention time of at least 3.0 minutes

-design flow of a factor of at least 4.0

Determine Q_{peak}

$$Q_{\text{peak}} = (Q)(PF)$$

$$= (1614 \text{ m}^3/\text{d})(4) = 6456 \text{ m}^3/\text{d}$$

$$\frac{L}{W} = 3; h = 3$$

$t = 3$ (detention time)

$$\text{Volume} = 6456 \frac{\text{m}^3}{\text{d}} \cdot 3 \frac{\text{hr}}{24 \text{ hr}} \cdot \frac{1 \text{ hr}}{24 \text{ hr}} = 12.61 \text{ m}^3$$

Volume per chamber

$$\frac{12.61 \text{ m}^3}{2} = 6.305 \text{ m}^3$$

$$(L)(W)(h) \Rightarrow \sqrt{\frac{\text{Volume per chamber}}{(L)(h)}}$$

$$W = \sqrt{\frac{6.305}{(3)(3)}} = 0.648 \text{ m}$$

$$L = (0.648 \text{ m})(3 \text{ m}) = 2 \text{ m}$$

$$h = 3 \text{ m}$$

Report must be
professional — No
hand written content
all computer typed

Primary Clarifier

- Retention time at peak must be at least 20 minutes (0.3 hr)
- Retention time at average flow must be at least 100 minutes (1.6 hr)

$$Q_{peak} = (Q)(PF) = (1014 \text{ m}^3/\text{d})(1.4) = 1419.6 \text{ m}^3/\text{d}$$

$$3 \text{ days} = 72 \text{ hr}$$

$$\text{Hydraulic retention time} = 2 \text{ min}$$

$$V_{total} = (1419.6 \text{ m}^3/\text{d})(1.6 \text{ hr})(\frac{1 \text{ d}}{24 \text{ hr}}) = 96.3 \text{ m}^3$$

$$V_{total} = \frac{V_{total}}{2} = \frac{96.3 \text{ m}^3}{2} = 48.15 \text{ m}^3$$

$$\text{Area per tank} = \frac{V}{h} = \frac{48.15 \text{ m}^3}{3} = 16.05 \text{ m}^2$$

$$\text{Diameter} = \sqrt{\frac{A \cdot 4}{\pi}} = \sqrt{\frac{16.05 \text{ m}^2 \cdot 4}{\pi}} = 4.5 \text{ m}$$

$$\text{Lay out diameter} = (D)(1.0) = 51.42 \text{ m}$$

$$\text{Use 2 tanks}$$

$$\text{WLR} = \frac{Q_{peak}}{2} = \frac{1419.6 \text{ m}^3/\text{d}}{2} = 709.8 \text{ m}^3/\text{d}$$

$$\text{OFR} = \frac{Q}{A} = \frac{1014 \text{ m}^3/\text{d}}{16.05 \text{ m}^2} = 63.2 \text{ m}^3/\text{d} \cdot \text{m}^2$$

$$\text{Diameter} = 10 \text{ m}; h = 3 \text{ m}$$

Dimensions of two identical clarifiers has
have a diameter of 10 meters.

80

Prairie View A&M University
Roy G Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4201-P01 – Senior Design
Spring 2022

Project Report 1- Development of Business and
Distribution Center, and IT Hub for Amazon

Submitted to:

Dr. Jobair Bin Alam

Submitted by: JJMPS Consulting

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Date Due: March 3rd, 2022

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Abstract

During this senior design capstone, JJMPS will be developing and designing an office development for amazon, on a 400-acre site location in Harris county, TX. This project will be touching on all of the civil engineering sub disciplines which include: Transportation, Environmental, Structural, Water Resources, and Geotechnical Engineering. Specifically, our structural portion will consist of developing and designing two five-story commercial office buildings, a steel structure warehouse, and a three story convention center. Our transportation engineer will be designing the parking lots, and any roadway design. The environmental engineer will be designing a wastewater treatment plant, and solid waste disposal facility. The treatment plan will include a grit chamber, primary clarifier, trickling filter, secondary clarifier and finally, disinfection. The water resource engineer will design the stormwater ditch that will be connecting to a major lake and/or river nearby. The geotechnical engineer will be doing the soil analysis of the site using two boring logs. We will also be performing the geotechnical analysis of the site and designing the ditches for the storm water runoff.

Introduction

PVAMU Civil Engineering Students are to develop and design the business and distribution center, IT Hub, and office development on a 400-acre site located in Waller, Washington and Colorado Counties located south of major Highways (US 290 and I-10) for Amazon. The specific scope of the project will include Civil Engineering Development and Design services for the entire site which will include two five-story commercial office buildings, a

steel structure warehouse, a three-story convention center, and parking lots. The students will also perform new road network development, engineering design of pavement and pavement subgrade, intersections, sidewalks, driveways, and extension of major highways/service road and connecting local road with highway, a storm water ditch connecting a major lake, a municipal solid waste and a temporary recyclables disposal facility, and wastewater treatment process and facility. The facilities will be designed for 20,000 people or based on population projection for 15 years. A map showing site locations is included at the end of this document.

Project Scope

The project team is required to perform Civil Engineering Site Development and Design services and address all aspects outlined in the project description:

Employee Count – 20,000 employees

- o 9000 employees in the warehouse
- o 6000 of employees in the office buildings
- o 2000 of employees in the IT Hub
- o 3000 of employees in the convention center

Location – Waller County



Figure 1.1: Waller County Project Location

Transportation

Roadway Layout

For the roadway layout, the AASHTO manual and the TXDOT manual were both utilized to determine the dimensions for the traffic lanes and the shoulders. The lanes were designed to be 12 feet in width with 4 feet shoulders and 4 feet medians between roadways with two lanes going in one direction. In order to ensure commuters would be able to freely travel in and out of the project boundaries, there are a total of 4 entrances, one in which is designated for semi-truck only. This was done to ensure smooth traveling for employees and guests as well as truck drivers. Creating this semi-truck only entrance allows truck drivers to deliver loads and exit the project boundaries without much traffic and delay and prevents potential collisions with commuter vehicles as a result. The overall roadway layout for the project can be seen in figure 2.1 below with 3 entrances.

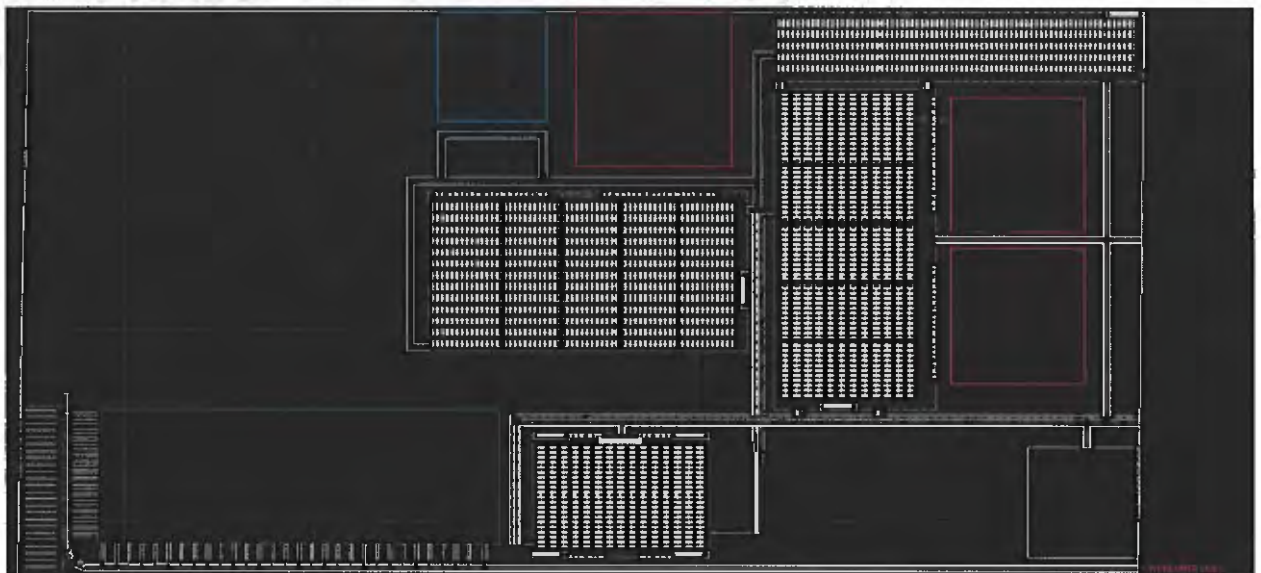


Figure 2.1 Roadway Layout

Interchange Design

There are four different interchanges on the project. The detailed designs are shown below. These were selected to allow commuters to move throughout the project boundaries with little to no traffic.

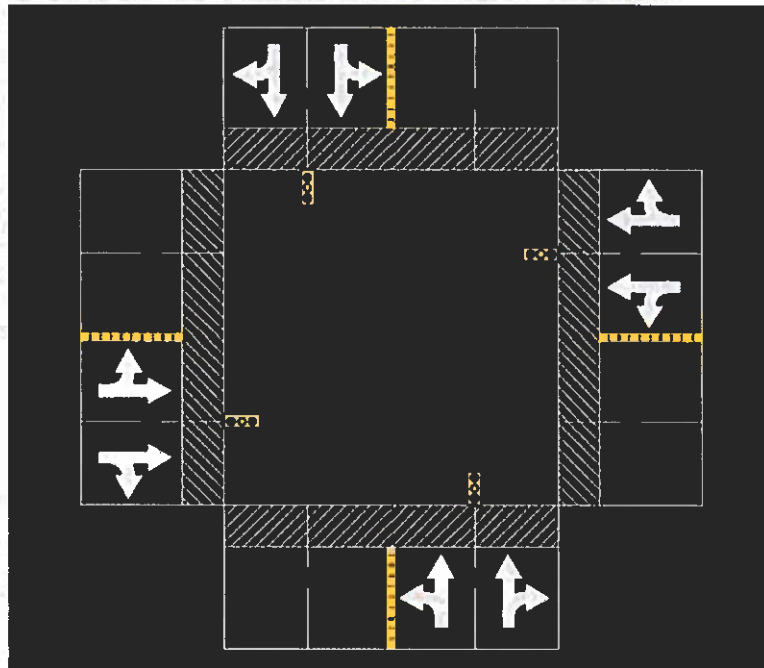


Figure 2.2 Four-way intersection with traffic lights

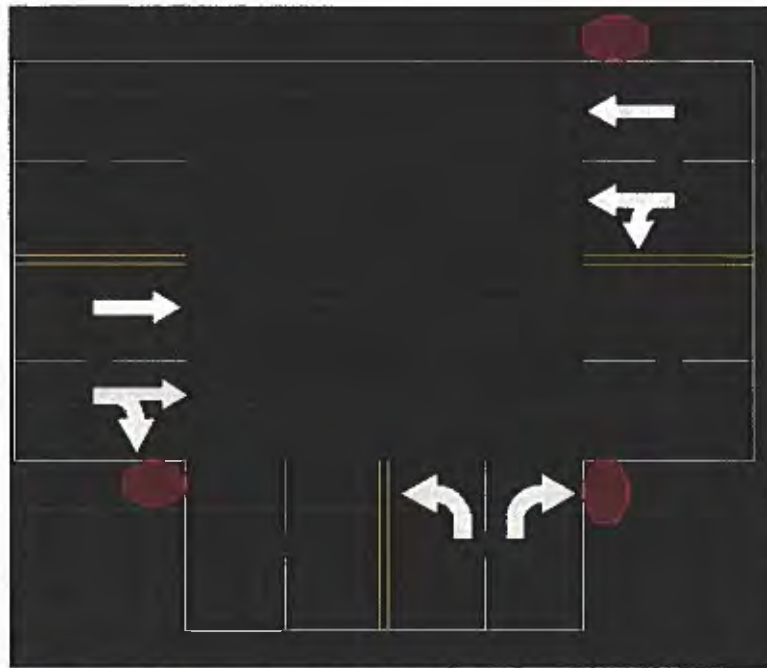


Figure 2.3 Three-way intersection with stop signs

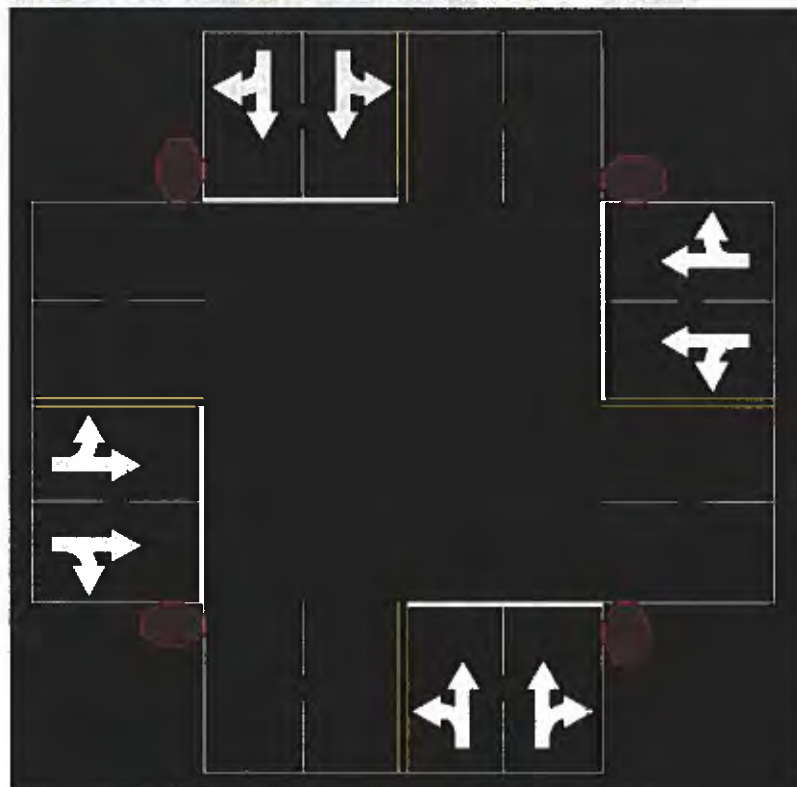


Figure 2.4 Four-way intersection with stop signs

white background
will look good!

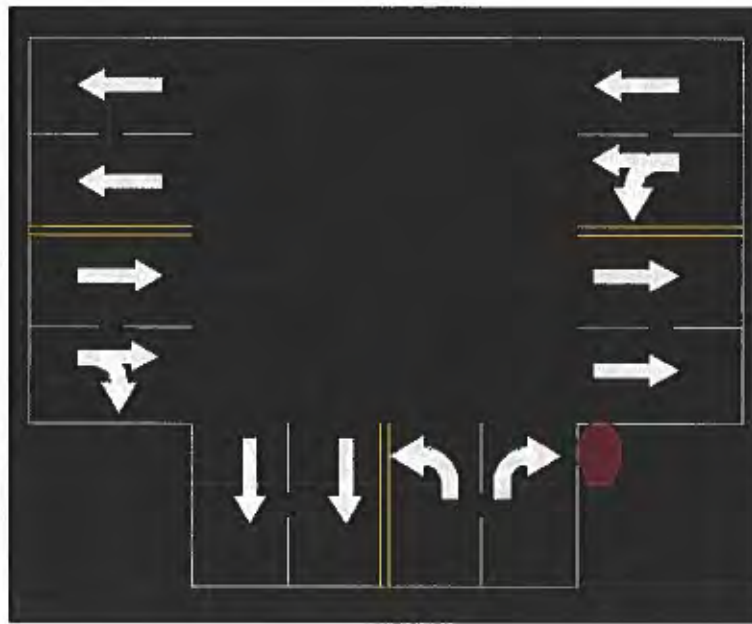


Figure 2.5 Continuous traffic with stop sign

Parking Lot Design

The parking lot was designed to allow access to 20,000 employees during various shifts. Shown below in figure 2.6 is the aerial view of the parking lots. Combined there are 14,700 stalls which are set to occupy 70% of the employees that work on the project. The other 30% are expected to work virtually due to covid and permanent working from home. Number of parking spots per building based on employees expected to work in each building are: warehouse (40% of employees): 8000, office development (35% of employees): 7000, convention center (15% of employees): 3000 and IT Hub (10% of employees): 2000.

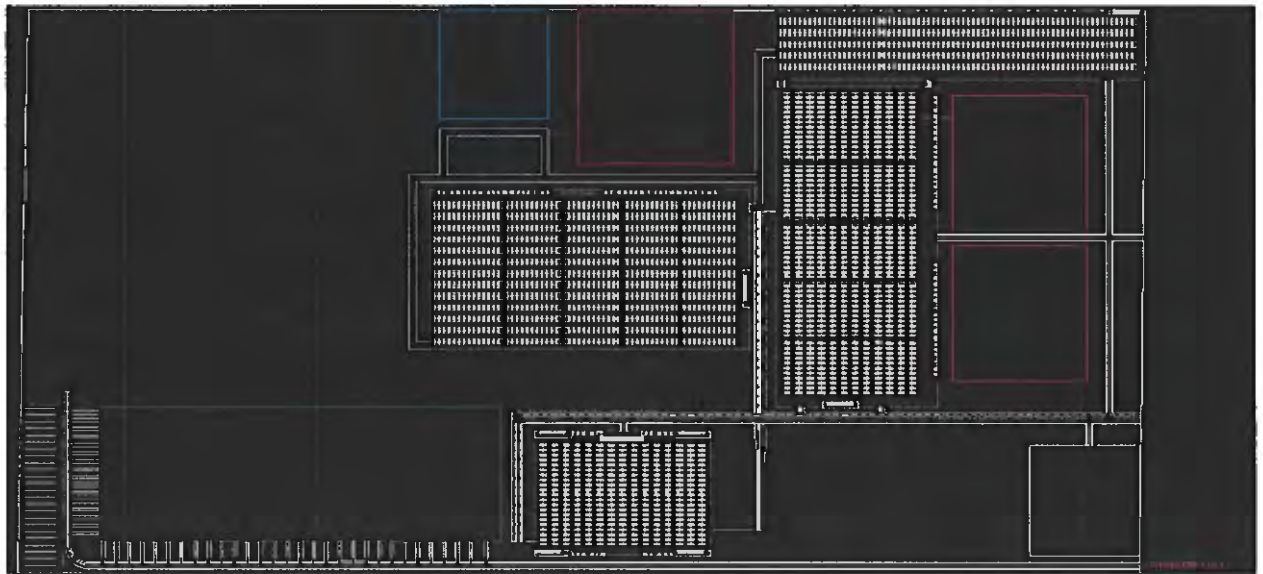


Figure 2.6 Aerial view of parking lots

Signal Location and Traffic Study

This portion of the project is on its way to being completed by utilizing the TXDOT manual and ensuring the traffic study takes into account all commuters entering and exiting the boundaries of the project.

Plan and Profile

As of now the plan and profile is being drastically altered with the assistance of a transportation expert. This will be included in the upcoming report.

Pavement Cross Section Design

The pavement cross section has been designed with a 2% slope going either way from the centerline in order to assist with collecting runoff water in the gutters. Twelve foot lanes and 4 foot shoulders were selected to comply with TXDOT manual requirements. A 4 foot median was also designed to prevent traffic conflicts and also for aesthetic purposes. This is displayed below in the figures below.

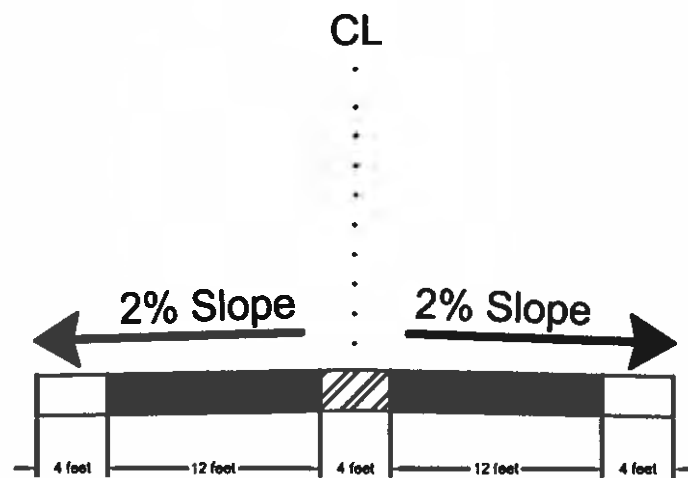


Figure 2.7 Two Lane Cross section

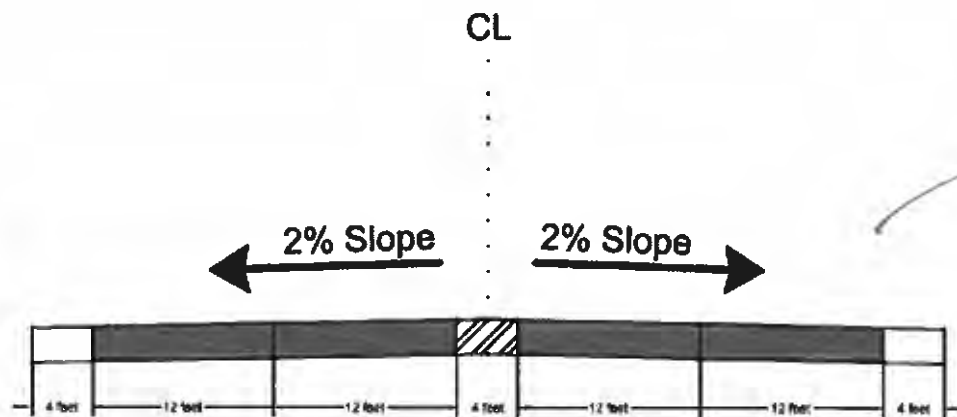


Figure 2.8 Four Lane Cross section

Environmental

Simply stated, wastewater is used water. Whether it is used for bathing/showering, agriculture, human waste, businesses, industrial, and even stormwater runoff. It is nutrient rich and highly contaminated that must be purified to a safe level before being released back into the environment. Nature can handle small amounts of wastewater, but in large quantities, the biological and chemical imbalances can greatly harm the ecosystem of the local rivers, lakes, and oceans. The United States Geological Survey states that WWTPs “reduce pollutants in wastewater to a level nature can handle” (1). Wastewater treatment plants (WWTPs) are necessary to help treat or clean the water before being released back into the environment. Typically, WWTPs collect wastewater from a multitude of different municipalities. However, in the case of this senior design capstone, this WWTP will only be used to collect the waste associated with the amazon hub. The WWTP that is being designed will include the following:

- Bar screening
- Grit chamber
- Primary clarifier
- Trickling filter
- Secondary clarifier
- Disinfection

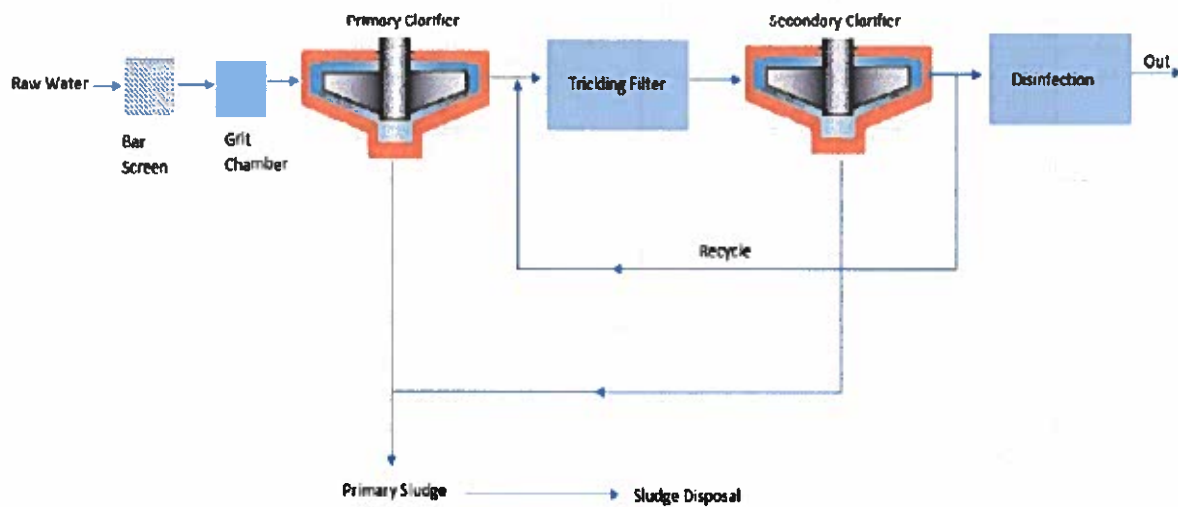


Figure 2.9 Wastewater Treatment Plant Layout

This amazon hub will be classified as an office building and/or factory. According to the TAC chapter 217 table (table below) the value of 20 gallons/per person will be used in order to determine the wastewater flow rate. The TAC states, "If available, actual organic loading data must be used as the basis for the design of the wastewater treatment facility. If actual organic loading data is not available, the design organic load must be determined by using the following table" [2].

Source	Remarks	Daily Wastewater Flow (gallons/person)	Wastewater Strength (mg/l BOD ₅)	Wastewater Strength (mg/l NH ₃ -N)
Municipality	Residential	75-100	250-400	15-75
Subdivision	Residential	75-100	250-400	15-75
Trailer Park (Transient)	2½ Individuals per Trailer	50-60	250-350	15-75
Mobile Home Park	3 Individuals per Trailer	50-75	300	15-75
School	Cafeteria & Showers	20	300	15-75
	Cafeteria/No Showers	15	300	15-75
Recreational Parks	Overnight User	30	200	15-75
	Day User	5	100	15-75
Office Building or Factory	A facility must be designed for the largest shift	20	300	15-75
Hotel/Motel	Per Bed	50-75	300	15-75
Restaurant	Per Meal	7-10	1000*	15-75
Restaurant with bar or cocktail lounge	Per Meal	9-12	1000*	15-75
Hospital	Per Bed	200	300	15-75
Nursing Home	Per Bed	75-100	300	15-75
Alternative Collection Systems (Subchapter D of this chapter)	Per Capita	75	N/A	N/A

*Based on a restaurant with a grease trap

Table 1.0. Design Organic Loadings and Flows for a New Wastewater Treatment Facility

To determine the design organic load we will be taking the high value for office building/factory, 20 gal/day, and multiplying it by our population, 20,000.

$$\text{Annual Average Daily Flow (AADF)} = \text{Population} \times \text{Average Daily Flow per Capita}$$

$$AADF = 20000 \text{ ppl} \times 20 \frac{\text{gal}}{\text{Capita-day}} = 40000 \frac{\text{gal}}{\text{day}} = 40 \text{ MGD}$$

$$Q = 40 \text{ MGD} \times 0.003785 \frac{\text{m}^3}{\text{gal}} = 1514 \frac{\text{m}^3}{\text{day}}$$

The flow rate of $1514 \frac{\text{m}^3}{\text{day}}$ will be used in the calculations of all of the design parameters.

Environmental → need some schematic diagram

A. Grit Chamber

$$Q_{peak} = 1514 \frac{m^3}{d} \times PF$$

The peak factor can be found using the following equation.

$$PF = 5(P)^{-0.16}$$

$$PF = 5(40)^{-0.16} = 2.77$$

Where P is the population in thousands.

$$Q_{peak} = 1514 \frac{m^3}{d} \times 2.77 = 4193.78 \frac{m^3}{d}$$

$$\text{Volume of grit chamber} = 4193.78 \frac{m^3}{d} \times 3 \text{ min} \times \frac{1 d}{1440 \text{ min}} = 8.74 m^3$$

$$\text{Volume per chamber} = \frac{8.74 m^3}{2} = 4.37 m^3$$

Our length to width ratio is $\frac{L}{W} = 2$, assuming a depth of 3m.

$$4.37 m^3 = 2W^2 \times D$$

$$W = \sqrt{\frac{4.37}{2 \times 3}} = 0.853 m$$

$$L = 2(0.853 m) = 1.71 m$$

$$D = 3 m$$

B. Primary Clarifier

The primary clarifier will be used to slow down the flow of the wastewater. The design specifications for the facility's peak flow will be calculated below. The Texas administrative code specifies a detention time of 0.9 hours or 54 minutes for a main clarifier operating at peak flow. The detention time for ordinary flow is set to 1.8 hours. The main clarifier is expected to reduce biological oxygen use by 35% on day five. The overflow rate of a main clarifier is in the range of 30 to 50 cubic meters per day per square meter, although it is significantly greater during peak flow. Below are the design criteria for two big tanks that will be built after the grit chambers. [3]

$$V_{reqd} = Q \times \theta = 1514 \frac{m^3}{d} \times 1.8 \text{ hr} \times \frac{1d}{24\text{hr}} = 113.55m^3 \rightarrow 114m^3$$

$$A = \frac{V}{\text{depth}} = \frac{114m^3}{3m} = 38m^2$$

$$OFR = \frac{Q}{A} = \frac{1514 \frac{m^3}{d}}{38m^2} = 39.8 \frac{m^3}{d-m^2} \rightarrow 40 \frac{m^3}{d-m^2}$$

$$V_{\text{tank}} = \frac{V_{\text{total}}}{\# \text{ tanks}} = \frac{114m^3}{2} = 57m^3$$

$$A_{\text{per tank}} = \frac{57m^3}{3m} = 19m^2$$

$$\text{Diam.} = \sqrt{\frac{A_{\text{per tank}} \times 4}{\pi}} = \sqrt{\frac{19 \times 4}{\pi}} = 4.91m \rightarrow 5m$$

$$WL = \pi \times \text{Diam.} = \pi \times 5m = 15.7m \rightarrow 16m$$

$$WLR = \frac{Q_{\text{per tank}}}{WL} = \frac{757 \frac{m^3}{d}}{16m} = 47.3125 \frac{m^3}{d-m} \rightarrow 48 \frac{m^3}{d-m}$$

Geotechnical

The CME 75 Drilling Rig was used for the drilling. The location of both drilling holes are shown below in Figure 1. The subgrade soils were investigated with a continuous flight auger that was used to advance the hole's dryness. Soil samples were collected using thin-walled tubes in accordance with ASTM D 1587 during the drilling operation, and split spoon sampler testing (STP) was performed in accordance with ASTM D 1586. Because bedrock was encountered, continuous push tube samples were taken for the ground surface to a depth of 70 feet, and the borings were spaced 80 feet apart. The changes in soil strata noticed during drilling operations were meticulously calculated and recorded on the boring logs. The procedures outlined in ASTM D 2487, based on the Unified Soil Classification System, were used to classify all soil samples (shown in Figure 2). Furthermore, using the methods provided in the Plasticity Chart, the soils

are documented in the boring logs (Shown in figure 3). The Boring logs' soil Classification were placed in Table 1 and Table 2 shown below.

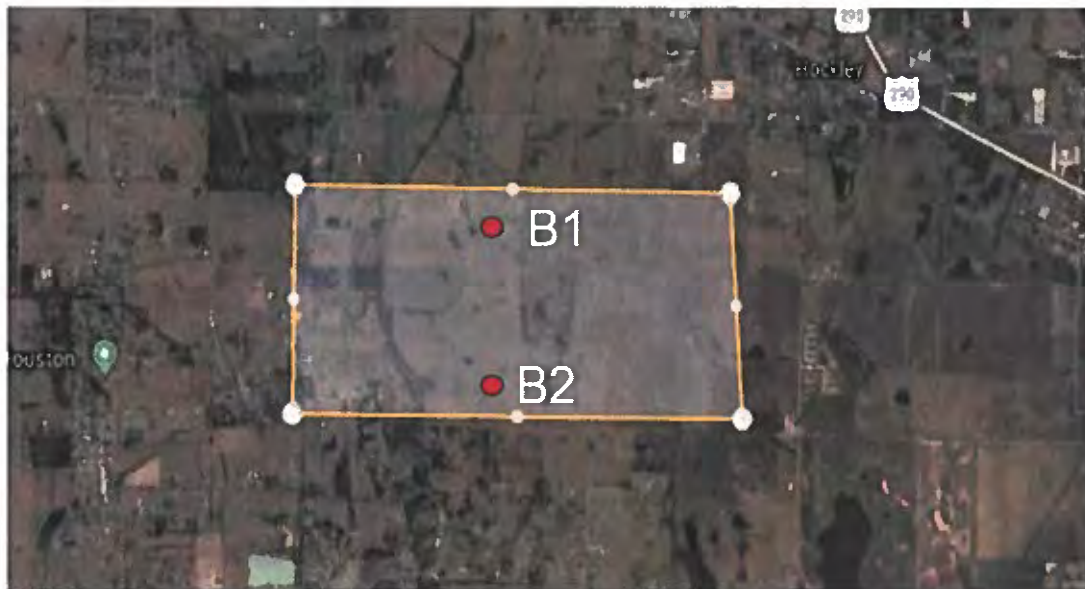
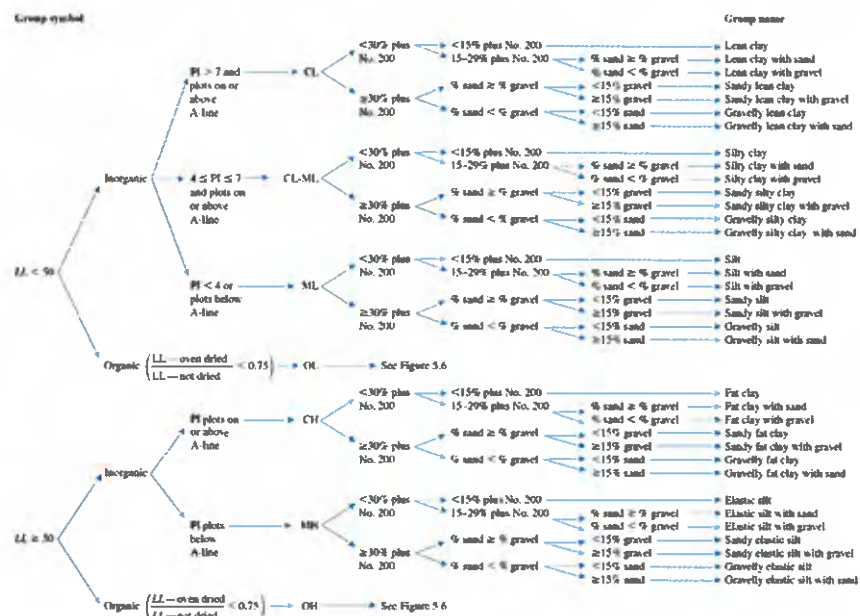
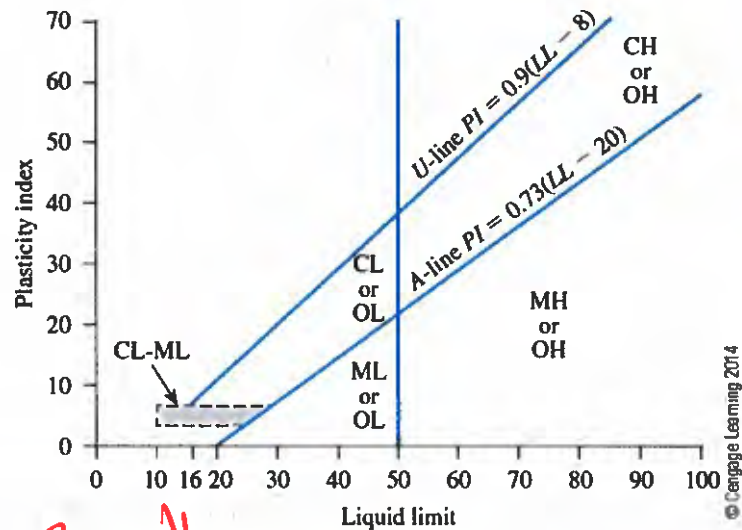


Figure 4.1: Boring Location



little

Figure 4.2: Unified Soil Classification System



Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification
2.5	43	16	27	71%	29%	19%	CL	Sandy lean Clay
7.5	47	19	28	81%	19%	12%	CL	Sandy lean Clay
8.7	-	-	0	20%	80%	6%	-	Sand
15	51	24	27	69%	31%	13%	CH	Sandy Fat Clay
20	-	-	0	16%	84%	8%	-	Sand
25	62	30	32	80%	20%	15%	CH	Sandy Fat Clay
30	62	27	35	79%	21%	13%	CH	Sandy Fat Clay
40	69	28	41	83%	17%	17%	CH	Sandy Fat Clay
50	71	33	38	72%	28%	18%	CH	Sandy Fat Clay
60	69	34	35	79%	21%	19%	CH	Sandy Fat Clay

Table 4.1: Soil Classification for Test hole #1

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification
2.5	48	20	28	54%	46%	13%	CL	Sandy lean Clay
5	51	32	19	69%	31%	14%	MH	Sandy Elastic Silt
10	-	-	-	-	-	8%	-	Sand
12.5	46	19	27	74%	26%	18%	CL	Sandy lean Clay
17	-	-	-	-	-	10%	-	Sand
20	32	16	16	54%	46%	13%	CL	Sandy lean Clay
25	60	31	29	81%	19%	21%	MH	Sandy Elastic Silt
30	72	31	41	82%	18%	20%	CH	Sandy Fat Clay
40	68	39	29	62%	38%	4%	MH	Sandy Elastic Silt
50	80	39	41	69%	31%	18%	MH	Sandy Elastic Silt
60	68	34	34	84%	16%	20%	MH	Sandy Elastic Silt

Table 4.2: Soil Classification for Test hole #2

The next step is to gather the unit weight of each soil layer and after recently receiving the Unconsolidated Undrained test we can now calculate the settlement conditions, allowable

bearing capacity, and develop a foundation recommendation. The foundation will not only be safe for loading but will also be very cost efficient.

This paragraph of the report is the progress made in the spring 2022 semester for the geotechnical engineering portion of the Amazon Business building and Distribution center. The starting point for this project was the SPT test. The Standard Penetration Test (SPT) is a method of determining the geotechnical parameters of subsurface soil. This test is inexpensive and can accurately estimate the density and shear strength of soil. To conduct this test, a standard, thick-walled sample tube is driven into the earth at the bottom of a borehole. Strikes from a slide hammer mechanism with a set weight and fall distance accomplish this. Soil Classification has been determined for both borings and has been discovered to contain mostly clay soil with some patches of sand in the shallow part of the drilling. The major stresses in the Mohr circle were developed this semester and are supposed to be the vertical stress v and the horizontal stress h , however these stresses could have any orientation in actuality. We used the Mohr circle (Figure 4.3) to also find ϕ which was found to be 0.

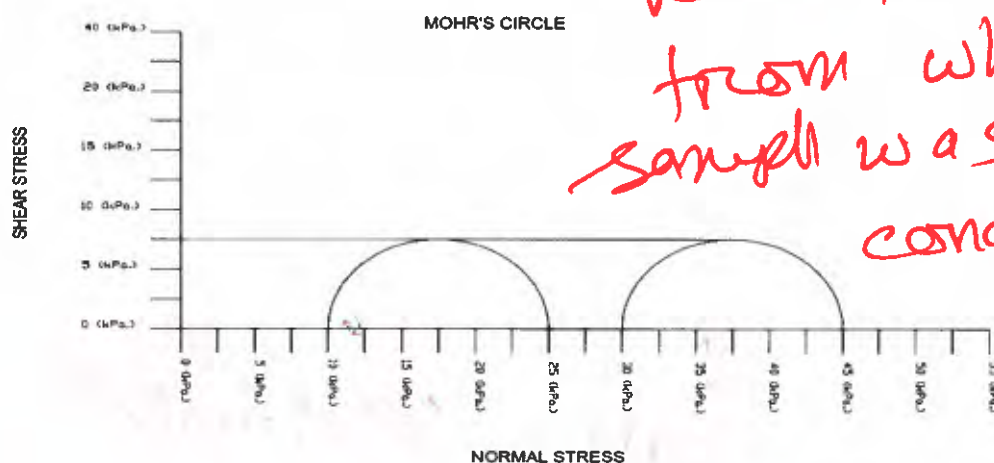


Figure 4.4: Mohr's Circle

A shallow foundation was also developed this semester using a square foundation. The depth of the footing is at 15 ft for both foundations to ensure an accurate comparison could be made. Following Terzaghi's Bearing Capacity Theory a bearing capacity for both foundations. Boring hole 1 (Figure 4.4) with a shallow foundation developed gave a 47.5 kips load and Boring hole 2 (Figure 4.5) has a 57.79 kips allowable load. Although the soil has decent strength the loads will not support the majority of our buildings. To make sure our facility has a safe/cost efficient environment a mat foundation and pile foundation were also developed.

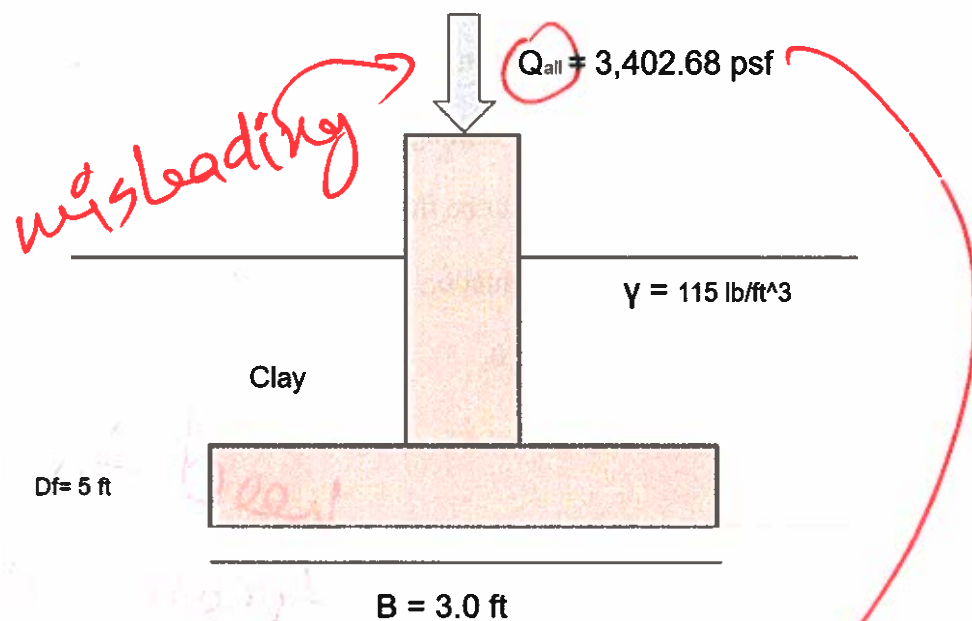


Figure 4.5: Shallow Foundation for Boring 1

$$Q_{all} = 3402.68 \text{ psf}$$

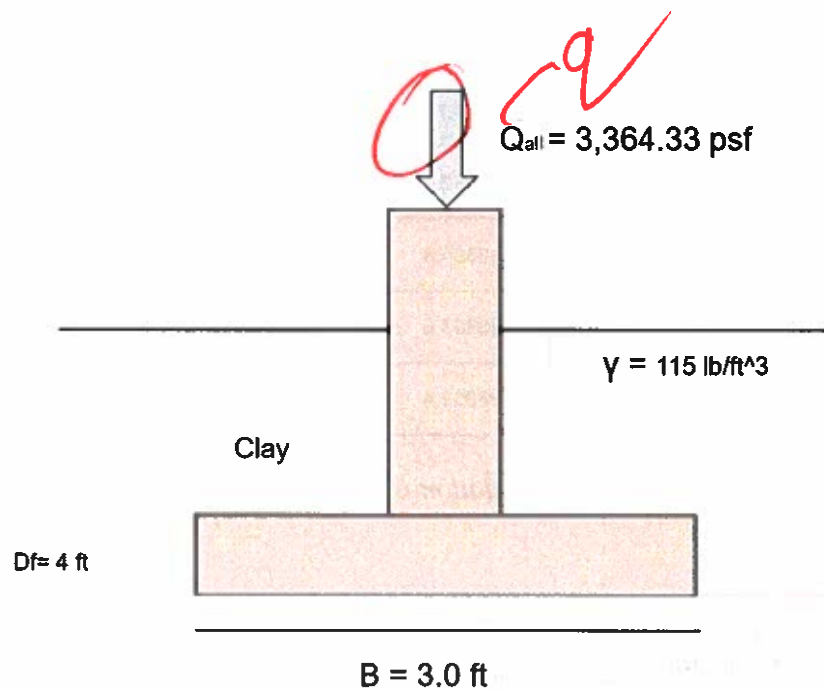


Figure 4.6: Shallow Foundation for Boring 2

A mat foundation was found to be 4,099.637 psf for boring 1 and 4,510.418 psf for boring 2.

The cost of a raft foundation ranges from \$5 to \$10 per square foot. The average cost of constructing a 1,350-square-foot raft foundation is \$10,125. Reinforcing the concrete with rebar adds \$1 to \$2 per square foot to the expense. A pile foundation was also develop and the calculations were shown below with the capacity curves.

Depth	Q_p (lb)	Q_s (lb)	Q_u (lb)
2.5	9963	6543.45	16506.45
7.5	13284	13912.2	27196.2
8.5	42444	13912.2	56356.2
15	22140	26055.9	48195.9
25	70740	26055.9	96795.9

table 1876

30	49815	30948.75	80763.75
40	63099	76163.4	139262.4
50	70848	85516.8	156364.8
60	80811	97542.6	178353.6
68	100737	97275.36	198012.4

Figure 4.7: Pile Foundation Calculations for Boring 1

Depth	Qp (lb)	Qs (lb)	Qu (lb)
5	11070	13951.5	25021.5
10	13284	15562.8	28846.8
12.5	13284	15562.8	28846.8
17	24354	18286.29	42640.29
20	24354	18286.29	42640.29
25	36531	25289.55	61820.55
30	36531	25289.55	61820.55
40	66420	80172	146592
50	58671	70818.6	129489.6
60	78597	94870.2	173467.2
68	110700	106896	217596

Figure 4.8: Pile Foundation Calculations for Boring 2

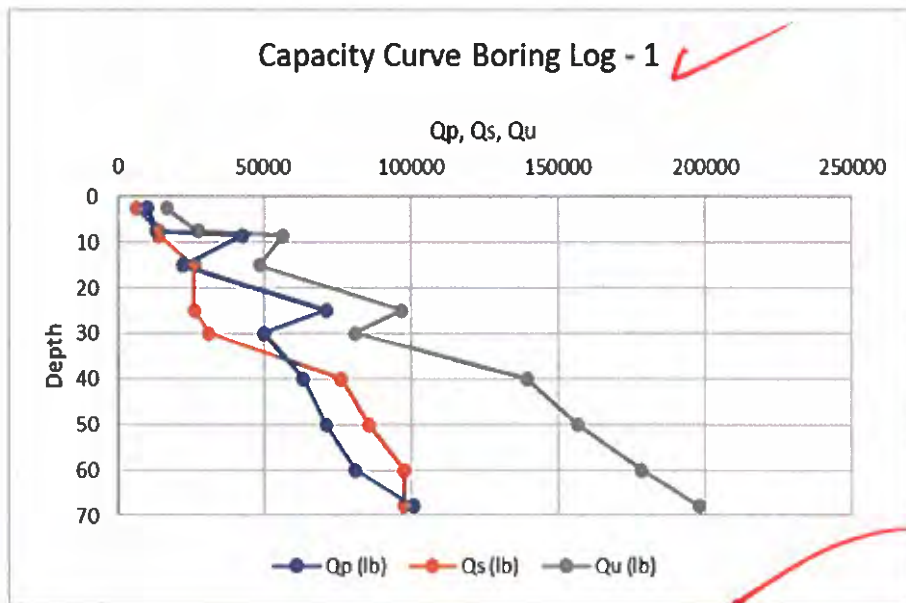


Figure 4.8: Capacity Curves for Boring 1

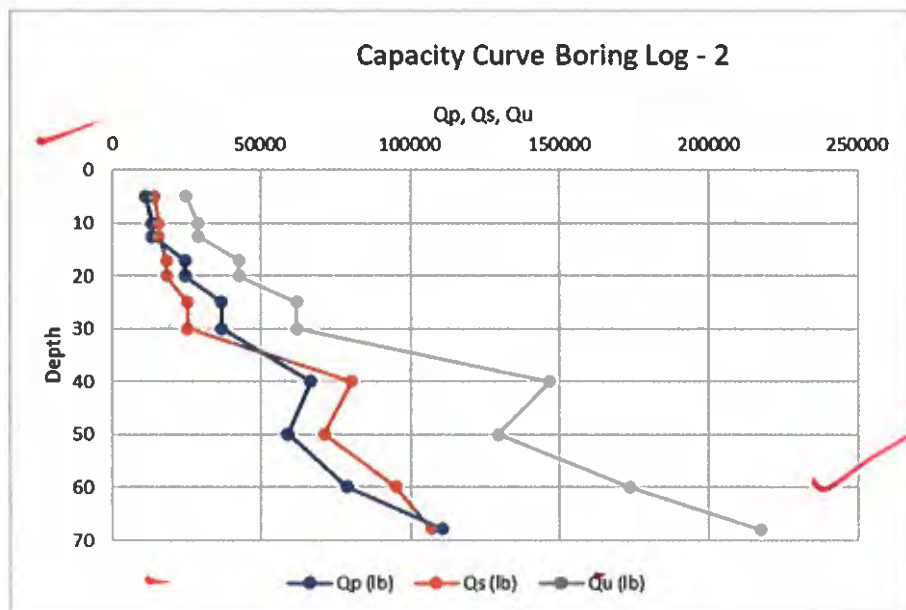


Figure 4.8: Capacity Curves for Boring 2

6/2

Water Resources

As part of the Water Resources part of the project, it is important to determine the placement of inlets, pipe sizes, and size of the detention pond. These factors in the design were discussed and placed with the help of the transportation and geotechnical authorities so that all aspects balance out. Engineers studied the site using google maps to understand the elevation of the construction site. Obtaining that information, the inlets could be designed by the use of gravity to create flow from the highest elevation. Below is a demonstration of how we use elevation to create flow to the detention basin:



Figure 5.1: Direction of flow to the Detention

The quantity of water was calculated by using the rational method. This equation represents the relationship between rainfall intensity and catchment area as independent variables and the investigation of the 100 year peak flood discharge as a dependent variable. This will help with determining Q , the storm water runoff to

avoid risk of flooding and property damage.



Figure 5.2: Inlets and Piping System

The Detention pond is where all water obtained through the outlets and pipes will go . A square foot is equivalent to 1 acre when divided by 43,560 ft², which is a formula used to calculate the volume needed for a given area. In order to determine the required volume of water, find the site's area in acres. Due to the truncated square pyramid shape of the detention pond, the following equation is used to calculate its dimensions.

$$V = \frac{1}{3} (a^2 + ab + b^2) h$$

professional look

By utilizing this equation the length for a, b and h can be found. Figure below displays the shape of each detention and represents each dimension based on the variable.

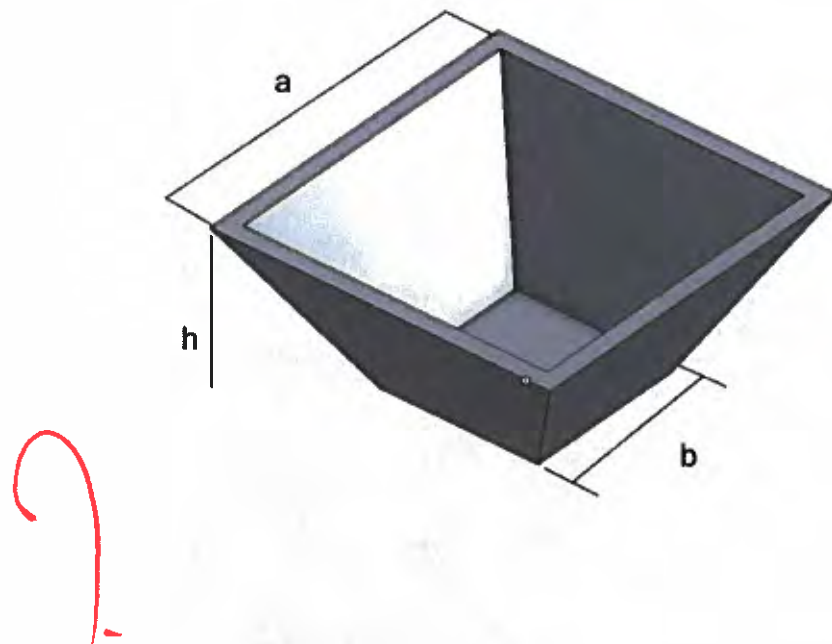


Figure 5.3: Overview of Detention

Structural

Requirements and Designs

- a. 2D Drawing- For the purpose of understanding, the IT Hub will be fully disclosed with figures and an explanation as a guide to how the other buildings were designed and accurately accounted for. The below information is the beginning steps of the project by creating the dimensions.
 1. IT Hub
 - a. AREA:
 - i. 344,000 square feet
 - ii. 586.5' x 586.5'
 - b. 4 – story building
 - c. This building is to be able to employ 10% of the projected 20,000 employees that are to be hired by Amazon.

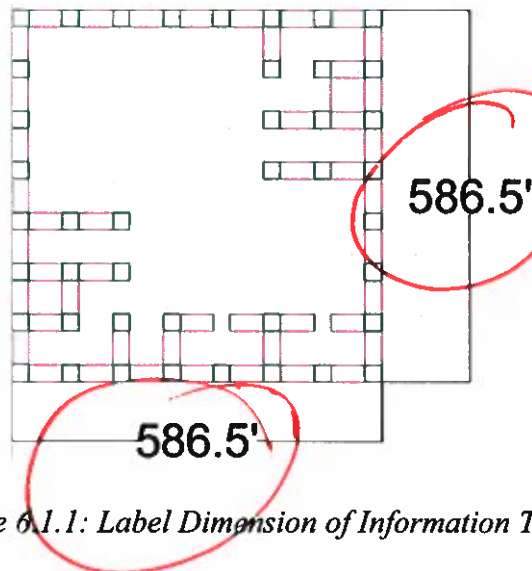


Figure 6.1.1: Label Dimension of Information Tech Hub

2. Office Buildings
 - a. AREA:
 - i. 516,000 square feet (Combined)
 - ii. 11.85 acres roughly per building
 - b. 5 – story building each
 - c. These buildings are to be able to employ 30% of the projected 20,000 employees that are to be hired by Amazon.

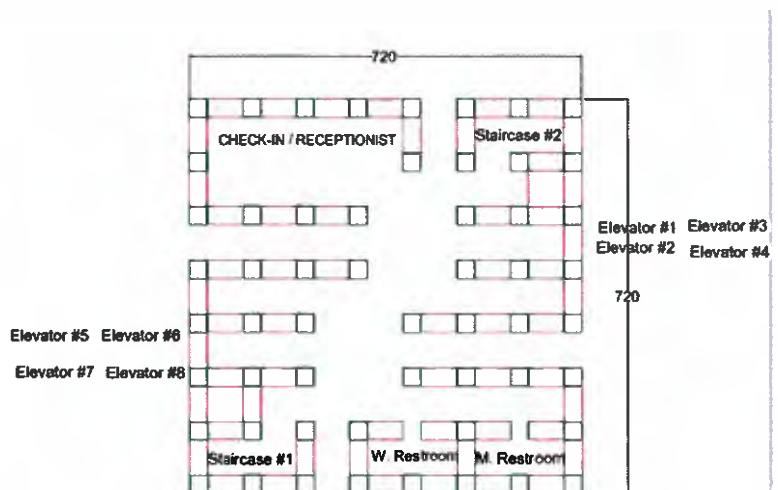


Figure 6.1.2: Label Dimension of Office Building

3. Convention Center

a. AREA:

- i. 516000 square feet
- ii. 11.85 acres (largest structure)

b. 3 – story building

- c. This building is to be able to employ at least 15% of the projected 20,000 employees that are to be hired by Amazon.

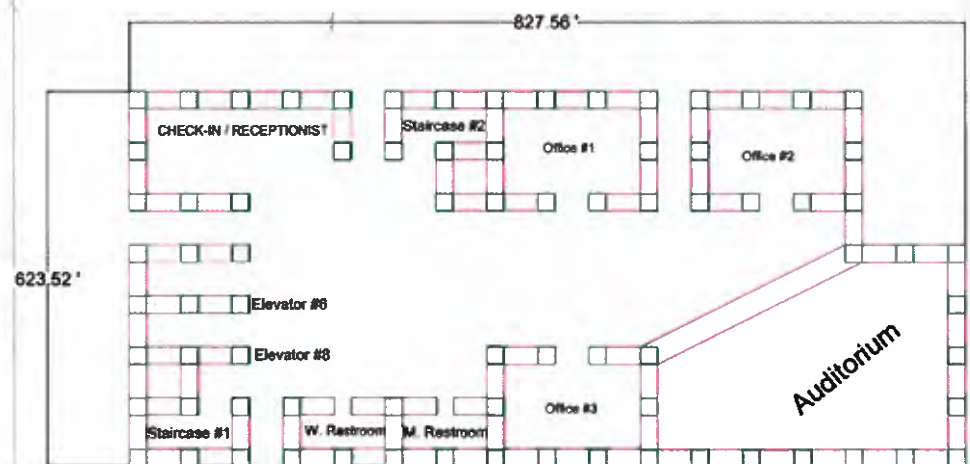


Figure 6.1.3: Label Dimension of Convention Center

4. Warehouse

a. AREA:

- i. 1,548,000 square feet

- ii. 2155'x 718.33'
- b. 1 – story building
- c. This building is to be able to employ at least 45% of the projected 20,000 employees that are to be hired by Amazon.
- d. The below screenshot of the warehouse is presented. As the current build for the warehouse.

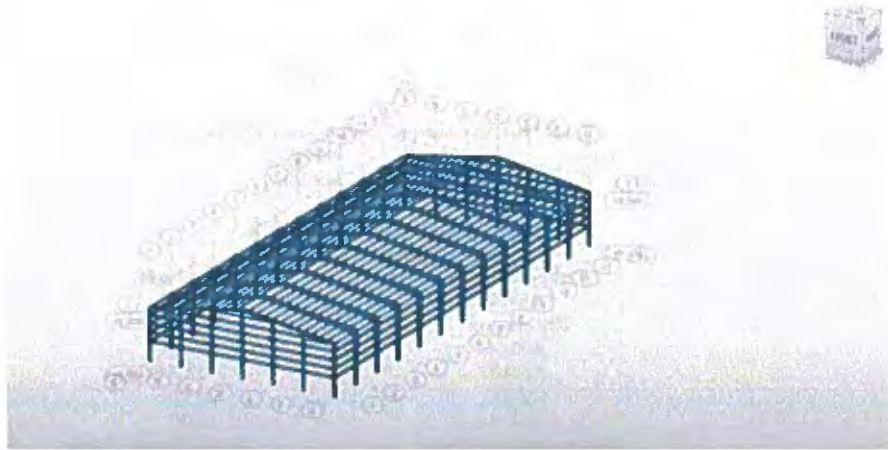


Figure 6.1.4: 3-D version of 2-D Amazon Warehouse Structure

2. Structural load calculation/ Slab Design

- i. As an update, the determination of load for each structure is being calculated and appraised with regards to references from multiple manuals and from similar buildings of the same structure in the nearby area.
- ii. Column Load Calculation:
 - 1. IT Hub

Load Calculations on Column						
	Length		Width		Height	
	Feet	Meters	Feet	Meters	Feet	Meters
Stub Columns	1.31	0.4	2.625	0.5	10	3.048
Columns	1.31	0.4	2.625	0.5	40	12.19
Concrete Volume Calculations(Cubed Meters)						
Stub Columns	0.6096					
Columns	2.438					
Concrete Veight Calculations(Kilograms)						
Stub Columns	1463.04					
Columns	5851.2					
Steel Weight Calculations 1X (Kilogram)						
Stub Columns	47.8536					
Columns	191.383					
Total Column Weight Calculations(Kilograms)						
Stub Columns	1510.8936					
Columns	6042.583					
Total Number of Column = 17						
Conversion Calculations						
Cubed Meters			Cubic Feet			
0.6096			68.889			
Kilograms			Pounds			
1463.04			983.75			
5851.2			3932.362			
47.8536			32.25			
191.383			129.02			
Kilograms per Meter			Pounds per Foot			
1510.8936			3248.875			
6042.583			4060.71			

Table 6.2.1: Column Calculations per column in the Convention Center

2. Office Buildings

Load Calculations on Column

	Length		Width		Height	
	Feet	Meters	Feet	Meters	Feet	Meters
Stub Columns	1.9686	0.6	0.9843	0.3	10	3.048
Columns	1.9686	0.6	0.9843	0.3	50	15.24

Concrete Volume Calculations(Cubed Meters)

Stub Columns	0.54864
Columns	2.7432

Concrete Weight Calculations(Kilograms)

Stub Columns	1316.736
Columns	6583.68

Steel Weight Calculations 1x (Kilogram)

Stub Columns	43.06824
Columns	215.3412

Total Column Weight Calculations(Kilograms)

Stub Columns	1359.80424
Columns	6799.0212

Total Number of Column = 17

Conversion Calculations

Cubed Meters	Cubic Feet
0.54864	68.889
Kilograms	Pounds
1316.736	884.808
6583.68	4424.24
43.06824	28.94
215.3412	145.155
Kilograms per Meter	Pounds per Foot
1359.80424	913.8778
6799.0212	4569.389

Table 6.2.2: Column Calculations per column in the Office Building

3. Convention Center

- The calculations presented for the table below shows the load presented per column in the building. Changes may be made once errors appear in Staad. Pro Input but for now the calculations hold true.

Load Calculations on Column							
	Length		Width		Height		
	Feet	Meters	Feet	Meters	Feet	Meters	
Stub Columns	2.625	0.8	2.625	0.8	10	3.048	
Columns	2.625	0.8	2.625	0.8	30	9.144	
Concrete Volume Calculations(Cubed Meters)							
Stub Columns				1.95072			
Columns				5.85216			
Concrete Weight Calculations(Kilograms)							
Stub Columns				4681.728			
Columns				14045.184			
Steel Weight Calculations 1% (Kilogram)							
Stub Columns				153.13152			
Columns				459.39456			
Total Column Weight Calculations(Kilograms)							
Stub Columns				4834.85952			
Columns				14504.57856			
Total Number of Column = 17							
Conversion Calculations							
Cubed Meters				Cubic Feet			
1.95072				68.889			
Kilograms				Pounds			
4681.728				10321.443			
14045.184				30964.33			
153.13152				337.597			
459.39456				1012.78159			
Kilograms per Meter				Pounds per Foot			
4834.85952				3248.875			
14504.57856				9746.626			

Table 6.2.3: Column Calculations per column in the Convention Center

4. Warehouse

Table 6.2.4: Column Calculations per column in the Convention Center

iii. Beam Load Calculation

1. IT Hub

Load Calculations on Beam						
	Length		Width		Height	
	Feet	Meters	Feet	Meters	Feet	Meters
Stub Beams	1.31	0.4	2.6247	0.8	1.9685	0.6
Beams	1.31	0.4	2.6247	0.8	1.9685	0.6
Concrete Volume Calculations(Cubed Meters)						
Stub Columr				0.192		
Columns				0.192		
Concrete Veight Calculations(Kilograms)						
Stub Columr				460.8		
Columns				460.8		
Steel Veight Calculations 1x (Kilogram)						
Stub Columr				30.144		
Columns				30.144		
Total Column Veight Calculations(Kilograms)						
Stub Columr				490.944		
Columns				490.944		
Total Number of Beams = 16						
Conversion Calculations						
Cubed Meters			Cubic Feet			
0.192			68.889			
Kilograms			Pounds			
460.8			309.78			
460.8			309.78			
30.144			20.831			
30.144			20.831			
Kilograms per Meter (Self-Veight)			Pounds per Foot (Self-Veight)			
490.944			329.937			
490.944			329.937			

Table 6.3.1: Beam Calculations per beam

2. Office Buildings

Load Calculations on Beam

	Length		Width		Height	
	Feet	Meters	Feet	Meters	Feet	Meters
Stub Beams	48.933	0.6	2.6247	0.6	1.9685	0.6
Beams	48.933	0.6	2.6247	0.6	1.9685	0.6
Concrete Volume Calculations(Cubed Meters)						
Stub Columr				0.216		
Columns				0.216		
Concrete Veight Calculations(Kilograms)						
Stub Columr				518.4		
Columns				518.4		
Steel Veight Calculations 1x (Kilogram)						
Stub Columr				33.912		
Columns				33.912		
Total Column Veight Calculations(Kilograms)						
Stub Columr				552.312		
Columns				552.312		
Total Number of Beams = 16						
Conversion Calculations						
Cubed Meters			Cubic Feet			
0.216			68.889			
Kilograms			Pounds			
518.4			348.75			
518.4			349.75			
33.912			22.78			
33.912			23.78			
Kilograms per Meter (Self-Weight)			Pounds per Foot (Self-Weight)			
552.312			371.6			
552.312			371.6			

Table 6.3.2: Beam Calculations per beam

3. Convention Center

Load Calculations on Beam

	Length		Width		Height	
	Feet	Meters	Feet	Meters	Feet	Meters
Stub Beams	48.933	14.9148	2.62467	0.8	1.9685	0.6
Beams	48.933	14.9148	2.62467	0.8	1.9685	0.6
Concrete Volume Calculations(Cubed Meters)						
Stub Columns:					7.159093632	
Columns					7.159093632	
Concrete Weight Calculations(Kilograms)						
Stub Columns:					17181.82472	
Columns					17181.82472	
Steel Weight Calculations 1% (Kilogram)						
Stub Columns:					1123.9777	
Columns					1123.9777	
Total Column Weight Calculations(Kilograms)						
Stub Columns:					18305.80242	
Columns					18305.80242	
Total Number of Beams = 16						
Conversion Calculations						
	Cubed Meters			Cubic Feet		
	7.159093632			68.889		
	Kilograms			Pounds		
	17181.82472			10321.443		
	17181.82472			30964.33		
	1123.9777			337.597		
	1123.9777			1012.78159		
	Kilograms per Meter (Self-Weight)			Pounds per Foot (Self-Weight)		
	18305.80242			3248.875		
	18305.80242			9746.626		

Table 6.3.3: Beam Calculations per beam

4. Warehouse

Table 6.3.4: Beam Calculations per beam

iv. Wall Load Calculation

a. IT Hub

Load Calculations on Wall								
	Length		Width		Height		Density	
	Feet	Meters	Feet	Meters	Feet	Meters	PCF	Kg/M ³
Stub Concrete	1.31	0.4	2.625	0.8	10	3.048	55	881
Concrete Wall	1.31	0.4	2.625	0.8	40	12.19	80	1281
Load per meter (Kg/m)								
Wall	359.212896							
kN/m	3.6							

Table 6.4.1: Wall Calculations per wall

b. Office Buildings

Load Calculations on Wall								
	Length		Width		Height		Density	
	Feet	Meters	Feet	Meters	Feet	Meters	PCF	Kg/M ³
Stub Concrete	48.933	0.6	2.625	0.6	10	3.048	55	881
Concrete Wall	48.933	0.6	2.625	0.6	30	9.144	80	1281
Load per meter (Kg/m)								
Wall	538.819344							
kN/m	5.38							

Table 6.4.2: Wall Calculations per wall

c. Convention Center

- i. For extra support on the wall we will be using concrete blocks. With this being used we can experience greater load values and for cost efficiency will be using AAC (Autoclaved Aerated Concrete) blocks specifically which have a lesser density than what is used to calculate load on the wall.

Load Calculations on Wall								
	Length		Width		Height		Density	
	Feet	Meters	Feet	Meters	Feet	Meters	PCF	Kg/M ³
Stub Concrete	48.933	14.9148	2.625	0.8	10	3.048	55	881
Concrete Walls	48.933	14.9148	2.625	0.8	30	9.144	80	1281
Load per meter (Kg/m)								
Wall	13393.95186							
kN/m	133.9							

Table 6.4.2: Wall Calculations per wall

d. Warehouse

Table 6.4.2: Wall Calculations per wall

v. Footing Load Calculation

1. IT Hub

Table 6.5.1: Footing load calculation per footing

2. Office Buildings

Table 6.5.2: Footing load calculation per footing

3. Convention Center

Table 6.5.3: Footing load calculation per footing

4. Warehouse

Table 6.5.4: Footing load calculation per footing

vi. Slab Design Calculation

1. IT Hub

Slab Design Calculations				
Length(Ly)		Width (Lx)		Density
Feet	Meters	Feet	Meters	Kilograms
6.56	7.0375	0.3283	7	2400
Determination of Slab			0.99467	TRUE
Two- way Slab - Determination				

Table 6.6.1: Footing load calculation per footing

2. Office Buildings

Slab Design Calculations				
Length(Ly)		Width (Lx)		Density
Feet	Meters	Feet	Meters	Kilograms
6.56	4	0.3283	0.75	2400
Determination of Slab			0.1875	TRUE
Two- way Slab - Determination				

Table 6.6.2: Footing load calculation per footing

3. Convention Center

- a. After carefully determining, the known variable values. We are able to determine what type of slab we will need to use in order to be in compliance with national standards such as Technical Manuals.

Slab Design Calculations

Length(Ly)		Width (Lx)		Density
Feet	Meters	Feet	Meters	Kilograms
6.56	8	0.3283	2	2400
Determination of Slab		0.25		TRUE

Two- way Slab - Determination

Table 6.6.3: Slab Design per ground floor

4. Warehouse

Table 6.6.4: Footing load calculation per footing

3. Completion of Steel Structure

4. STAAD Pro

Reinforcement Materials

Where is
STAAD Pro
output and
software Frame of your
structure

Reference Page

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