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Site Design of a Four-Story 11,705 sq-ft Class A Office Building

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Western Michigan University
Lee Honors College – Senior Design Thesis
April 21, 2010

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Wednesday, April 21, 2010

Dear Lee Honors College Thesis Committee,

Following the presentation of our Engineering Senior Design Report, 'Site Design of a Four-Story, 111,705 ft^2 Class A Office Building', on Tuesday, April 20, 2010, we submit this report to you of our proposal, findings, and conclusions concerning this work.

We thank you for your time and hope you find our work interesting.

Sincerely,

Britney Richmond

Allison Porrett

Kimberly Warners

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Through the course of this project, the senior design team was aided by many mentors and engineering professionals without whose help, the team may not have had the success they did.

The team would specifically like to thank these individuals for their involvement.

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Executive Summary

This senior capstone design project was a two-semester long venture that began last fall with the formation of the team, the selection of the sponsored project, and the conclusion of a proposal. The purpose of the proposal was for the senior design team to display a thorough understanding of the project's scope of work and to declare the deliverables agreed upon by the team. The team began contact with the sponsor, Hurley & Stewart, prior to beginning the proposal writing in order to gain more details about the project at hand and to ask any questions. The team chose to add a few more areas to focus on, based on the personal interests of each member. The team drew up a production work plan as a guideline to follow in the achievement of their milestone deliverables. This production work plan was organized to allow for adjustments if the team found themselves behind schedule at any time in the later semester. This production work plan can be seen in Appendix 1. Once the proposal was accepted, the team began researching zoning, permits with the city of Portage, and the building site. With building setbacks known, two parking lot layouts, one connected to the neighboring lot and the other completely separate, were rendered and graded by hand using cut/fill methods. After some consideration, the team chose to go forth with the connected lot scenario. The sponsor then assisted the team in completing a grading plan using the parking lot layout utilizing computer software. Utilities and stormwater storage design were then performed. The team also chose to deliver a couple typical footing designs for the proposed building. The team also thought it was necessary to analyze the impact that the proposed building would have on the surrounding area through means of a traffic impact study.

Project Background

The proposed four-story, 111,705 ft^2, Class A office building in Portage, Michigan is to be the third office building built on the Trade Centre property, located on the north side of Interstate 94 shortly before the Westnedge Ave exit. A Class A office building is described by the Urban Land Institute as "... a building that has an excellent location and access, attracts high quality tenants, and is managed professionally. Building materials are high quality and rents are competitive with other new buildings."[1] The first two buildings were built starting in 2003 and the second was constructed in 2006. An access road (Trade Centre Way) from Westnedge was built to handle the amount of traffic that the buildings would attract, though Market Place Avenue, to the north of the property, is also used. Some features of the property include:

- Faces Interstate 94 on the north – good for marketability of businesses
- West Fork branch of Portage Creek and the City of Kalamazoo well field backs up into the south side of the property – MDEQ considerations
- High groundwater table – approximated as 2.5 to 4 ft below the surface

The property is zoned as Commercial Planned Development, for which there is not much area zoned but was granted to this land because of its proximity to the highway and intended use for business/retail. Future plans for the remainder of the property include a hotel and space for retail and restaurants. Because of the location of the site and the features listed above, there were many environmental and social factors that need to be addressed. The team considered these issues in analysis, design, and as it affected the scope of work.

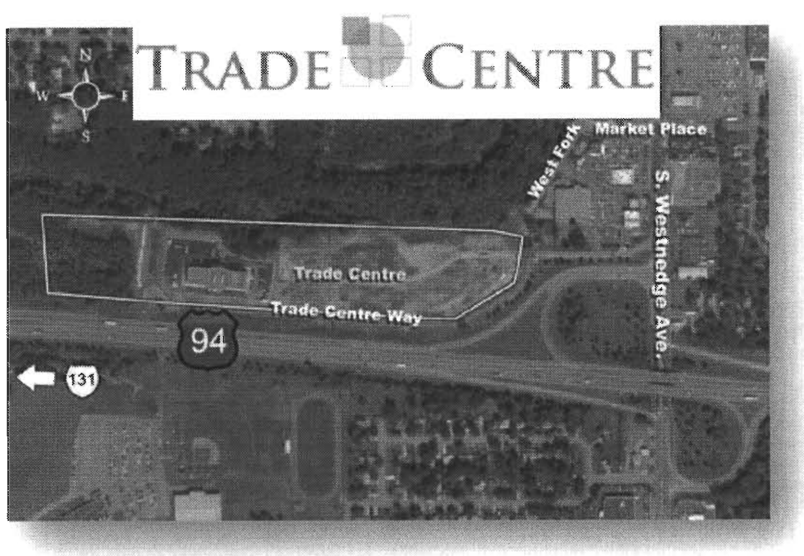


Figure 1: Site Location

Scope of Work

The project entailed site design and preparation for the implementation of a proposed four-story, Class A office building. The project required the analysis of all existing data for determining the infrastructure needed to serve this new building while taking the surroundings into consideration. The data to be analyzed as stated in the proposal scope of work were: geotechnical and groundwater analysis; wetland and floodplain mitigation; sheet pile wall design; municipal utility design for the new building; a traffic study to allow traffic to/from the busy intersection at Westnedge Avenue; site grading and earth balancing; environmentally sensitive stormwater design; footing structural design; and coordinating and permitting with MDOT, the City of Portage, and the Michigan Department of Environmental Quailty (MDEQ). After the team began the analysis of the available data, there were several aspects that no longer had to be considered, such as the wetland mitigation and the sheet pile wall design. The team designed the layout of the office building's parking lot to have a minimum impact on the wetlands and floodplains therefore it was not necessary to design sheet pile walls, which are used to protect against flooding and erosion. Once the analysis of the existing data was completed, the team developed plans for the parking lot layout, earthwork grading, stormwater retention layout, municipal utilities layout, and typical footings designed for the proposed building. The team also developed a traffic impact study and completed the necessary permits after the completion of the calculations.

Project Tasks

The four main deliverables of the senior design project are described in detail below.

Earthwork and Site Layout

Before starting to design, the team worked to learn more about the site and the regulations surrounding the construction of an office building. The site on which the team's proposed building is on has been given the special zoning designation of Commercial Planned Development because of its close proximity to the highway and intended use for business. (See Appendix 2) Since the site faces Interstate 94 at a major interchange in the area and runs just south of the West Fork Branch of the Portage Creek and City of Kalamazoo well field, this is not an area for residential building and is thus classified for commercial use because of its exposure. The placement of the site near the well field and creek also brings in the environmental considerations of floodplain mitigation. The team made a visit to the property to get a better idea about the layout of the site, the style and placement of the existing buildings, and the current methods of stormwater retention. From the site visit, it was discovered that there is a retention pond between the two existing buildings and a retaining wall on the back side of the building closest to the site. The team took both of these things into consideration as the project moved forward.

Additional research needed to be done after the visit to the site. The team looked into the City of Portage land development regulations for restrictions concerning the building setbacks, size of the parking lot, and placement of the building on the site. Though it took a while to sift through all the information to find the sections that pertained to Commercial Planned Development and the site, the team was able to glean the information needed. This process was helped in large part by the project mentor who, because of his experience with this project, the area, and the construction of other similar buildings, could help pinpoint the exact information.

After determining a regulated building setback of 75 ft, the team moved on to designing the parking lot surrounding the building. The team used prior Traffic Engineering textbooks and information from the Americans with Disabilities Act (ADA) to plan the number of parking spaces and handicap spaces needed for a Class A Office Building of this size. The general rule of thumb the team used was one parking space per every 150 ft^2 of gross floor area (GFA). The project mentor advised the team to only plan spaces for 75% of the building's square foot area because of the type of office building. A Class A office building features larger offices, hallways, and spaces for amenities versus a typical office building so there will be less people per square footage in a Class A. The team used regular size spaces (9' by 18' with 24' aisles) and a maximum walking distance of 300 ft in their design. The team used the equations below to establish the maximum amount of regular parking spaces:

$$111{,}705\ ft^2 \times 75\% = 83{,}779 ft^2$$

$$83{,}779 ft^2 \div \frac{150 ft^2}{1\ space} = 558.5\ \cong 559\ spaces$$

The team was advised to plan to pave 75% of the maximum spaces and bank (meaning design space for but do not pave) the other 25%.

$$559\ spaces \times 75\% = 419.25\ \cong 419\ spaces\ (to\ be\ paved)$$

$$559\ spaces \times 25\% = 139.75\ \cong 140\ spaces\ (to\ be\ banked)$$

According to ADA regulations, the total minimum number of accessible parking spots for a lot of this size was roughly eight or nine spaces within close proximity of the entrances by ramp access. One of eight accessible parking spaces must also be van-accessible which requires a wider access aisle of 96 inches to accommodate a wheelchair lift.[2] (See Appendix 3)

To aid in the site layout and design, the project mentor provided the team with an AutoCAD file of the topographical layout of the site's existing conditions. Review of the CAD file and the knowledge from the site visit really helped the team visualize the placement of the building and plan for the leveling and grading. The team designed two different parking lot layouts and subsequent building placements. One design included a parking lot which connected to the lot of the existing building next to the site because the city of Portage favors connecting parking lots to ease the traffic on roadways over short distances. The other design featured a completely separate parking lot which was located further from the existing building to avoid placement within the 100-year floodplain or wetland limits. After each layout was drawn up, the team began to set the elevations. From the known groundwater depth and the amount of depth needed for stormwater retention, the elevation of the building was set at 861 feet. The grading of the parking lot was set to be 2% for draining purposes at the advice of the project mentor. Six catch basins were planned at strategic points around the buildings to capture the water. The grading of the site catered to these localities so that when water would drain to the lowest point that would be the location of a catch basin. Therefore, the highest elevations on the site (861 ft) were the building footprint and parking lot edges and the lowest points (859 ft) would be at the catch basins. (Hand Sketches – See Appendix 4)

The designs were then hand graded using the cut/fill, borrow pit method, which required the site to be divided into 30 ft by 30 ft square sections. The elevation in regards to 861 ft was calculated at each corner and the sum of the corner elevations was entered into a spreadsheet. Conditional cell coloring with regards to elevation was used to visualize the site on the spreadsheet. Each cell was then multiplied by 25%, in regards to the four corners, and also by 900 ft^2, the square footage of each section. These fill volumes were then summed up to get the overall fill volume. The volume for the connected parking lot was 24,567 yd^3 and for the separate parking lot, the fill volume was 19,692 yd^3. (See Appendix 5)

The team chose to move forward with the connected parking lot design for several reasons. Along with the fact that the City of Portage favors connected parking lots, this design also utilizes the property better in that no space is wasted between buildings. This provides more space for future development on the property which would be in the best interest of the developer. The connected parking lot may require more fill but this design allows for easy connection of the utilities and sharing of parking lot usage.

Once the final design was chosen and the sketch was hand graded, the team rendered the site layout in AutoCAD Civil 3D on top of the existing topographical file of the build site. (See Appendix 6) With assistance from the project mentor, the team was able to render the design and then use the Poly-line function of the program to raise the design to the proper elevations designated during hand grading. AutoCAD Civil 3D allowed for quick calculation of the fill volume between the existing site topographical layout and the elevations of the building and parking lot set by the team. The fill volume calculated by the program was 24,982 yd^3. (See Appendix 7)

The fill volumes calculated by the two different methods were a lot closer than the team projected. The amount of error in the comparison of the hand grading versus the 'more exact' computer grading was roughly 1%.

$$24{,}982\ yd^3 \div 24{,}567 yd^3 = 1.017\ \%$$

Because of the precision of the volumes, the team felt that both methods can be deemed as acceptable means of obtaining the site fill volume. Having determined the fill volume, the team had to consider the floodplain impact of the fill before the earthwork and site layout could be complete.

The site limits and daylighting (4:1 grading down from the elevation at the parking lot edge to the existing elevation) did not extend into the wetland area but did impact some area beyond the limit of the 100-year floodplain. In accordance with the Michigan Department of Environmental Quality (MDEQ)/US Army Corps of Engineers Joint Permit Application, the volume of the floodplain that would be filled was calculated using AutoCAD Civil 3D. The floodplain impact volume was designated as seen in Figure 2.

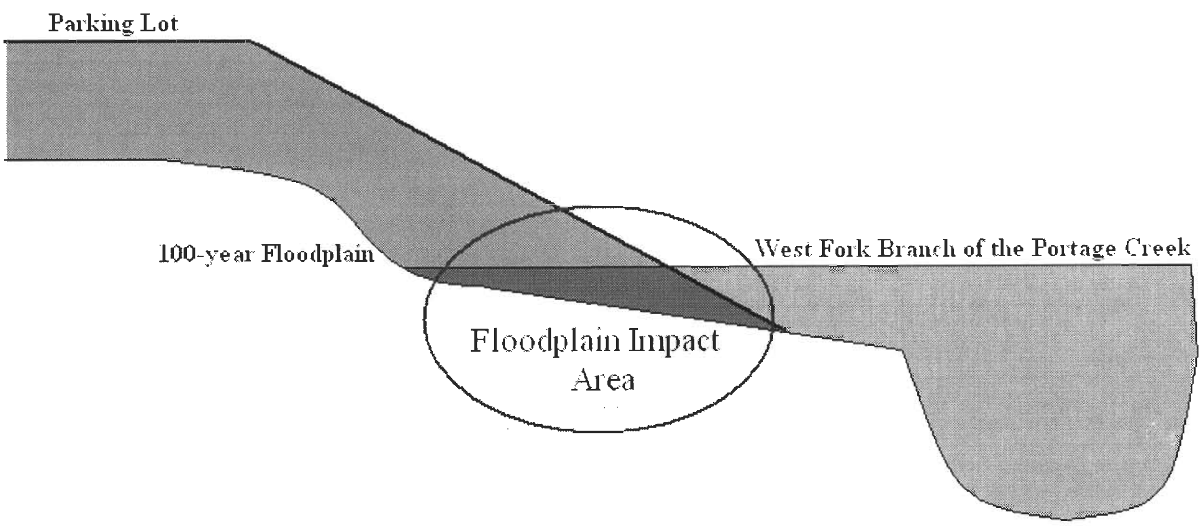


Figure 2: Sketch of Floodplain Impact Area

From the program, the affected land area was 3,795 ft^2 and the fill volume was calculated to be 29 yds^3. Volumes over 500 yds^3 are required by the MDEQ to have significant mitigation action taken so the fill volume on this site would be considered low impact and no further mitigation action would need to be taken. The MDEQ/USACE Joint Permit Application was filled out and would normally need to be submitted and approved before the construction phase could commence. (See Appendix 8)

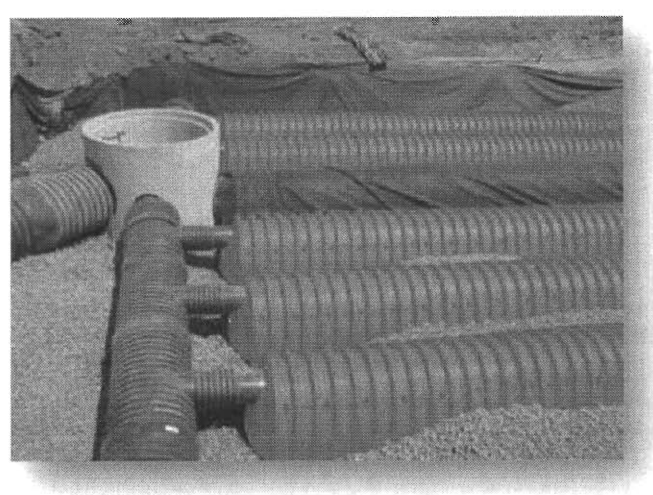
Utilities

With the current towers already present, the task of laying out the necessary municipal utilities for the proposed third building was a fairly simple task. All that needed to be done for this was to tie lines for the building into the existing utility lines. First, the existing utilities- water, gas, electric, telephone, sanitary, and storm sewers- were identified on the provided topographic map. These utilities ran near and along the service drive, Trade Centre Way. Referencing the layout of the existing buildings and their respective utilities, the team tied into the water line at the two parking lot entrances and looped it around the entire proposed building. The water line was inletted to the building on the west side and two fire hydrants were placed in the rear of the building, based on easy access for a fire truck. The gas, electric, and telephone lines were run up the west side as well. During the installation of the existing sanitary sewer system, a pipe and manhole were directed in the location of the future planned building, therefore the sanitary line was merely extended to service the building near the front entrance. (See Appendix 9) Lastly, the storm sewer was not continued to the building like it had been for the two existing towers. Instead, onsite infiltration was explored for this site using an underground storage system, which is discussed next.

Stormwater Design

<u>Management System</u>

Upon suggestion by the sponsor and recognizing the plan for future development of the remaining property, the senior design team explored underground storm water storage and infiltration through a product by StormTech LLC called Landsaver^{TM} Stormwater Management System. This system collects storm water through means of catch basins, however instead of transporting it offsite in storm sewers; it filters and temporarily stores the water beneath the pavement. The water is stored in open-bottom, plastic chambers that are placed above a gravel layer that slowly recharges the water to the groundwater table. With an underground system, site space could be saved for future development where an above ground detention basin or pond would normally exist to store runoff from a high intensity storm. LandSaver^{TM} chamber systems have unique features to improve site



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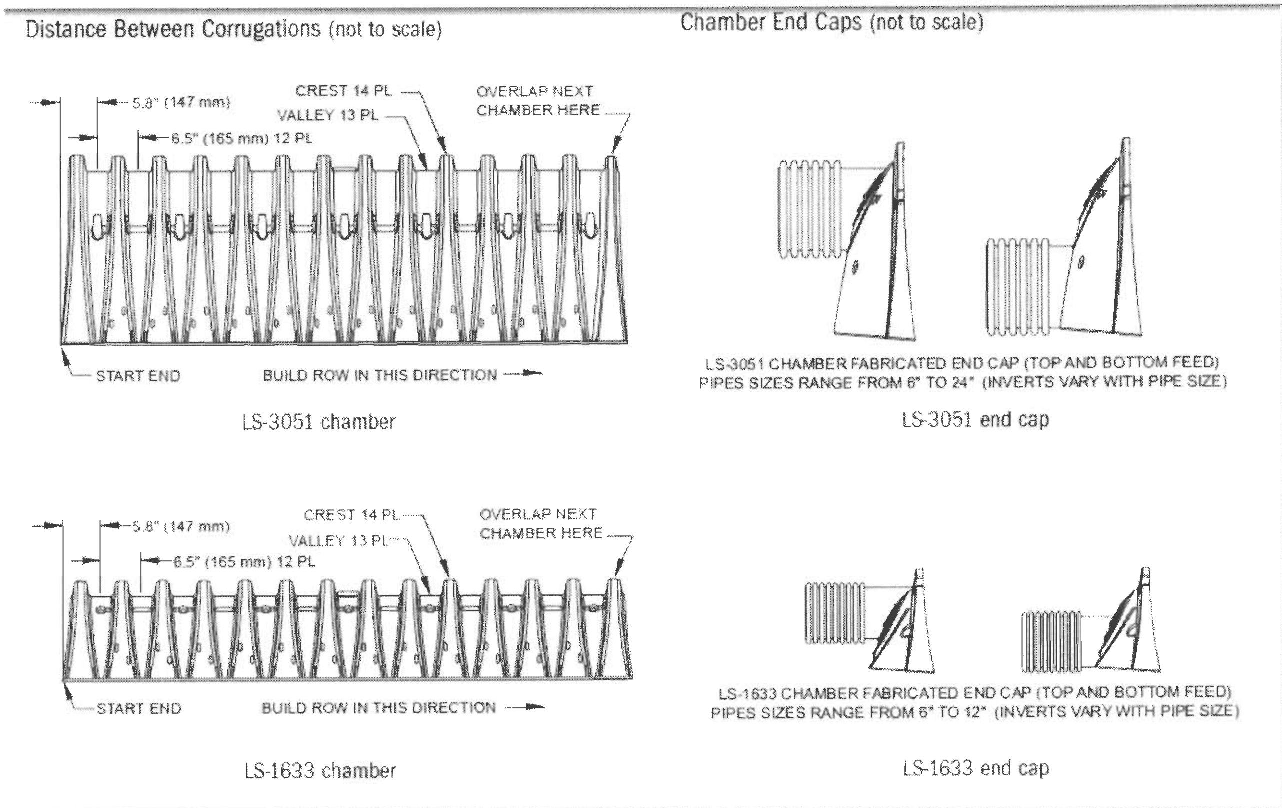
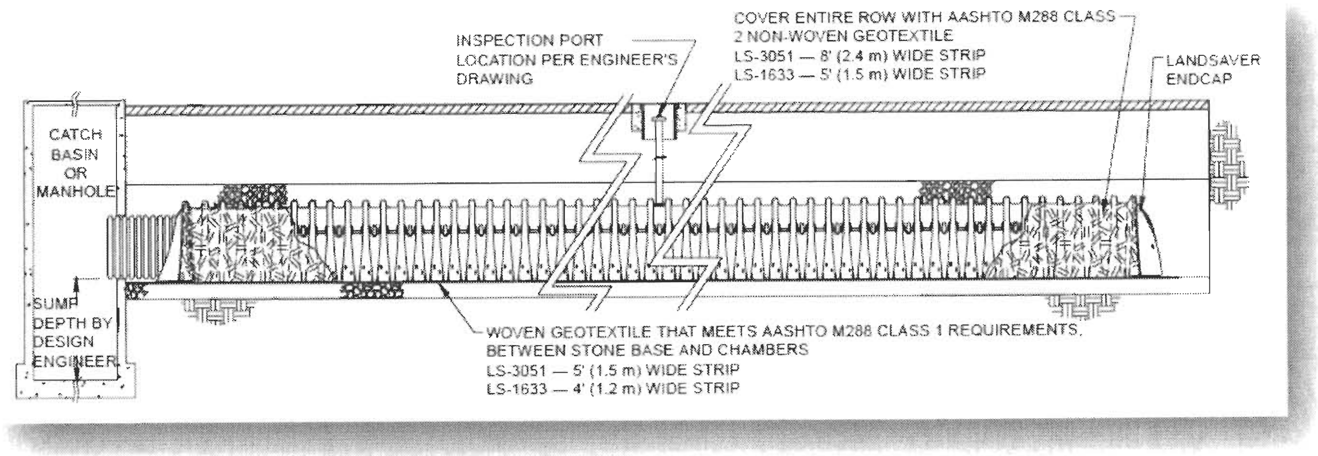


optimization and reduce product waste. There are two types of chambers available, LS-3051 and LS-1633. Each of these is detailed in Figure 4.

LandSaver™ incorporates a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance. The Isolator Row is a single row of standard chambers surrounded with filter fabrics and connected to a manhole for easy access. This application creates a filter/detention basin that allows water to outlet through the surrounding filter fabric while sediment is trapped within.[3] Figure 5 shows a typical profile view of an isolator row connected to a manhole. In Figure 3, the isolator row is the row covered by a black fabric.



'e 5: Isolator Row Profile View Detail

Calculations

The City of Portage Stormwater Design Criteria Manual was followed in the storm water calculations. This manual was available and downloadable from the City of Portage website. The manual provides a detailed organized methodology for the design of storm water systems in the City. It contains formulae, tables, graphs, and data for sizing piping systems, detention and infiltration basins, and other storm water drainage and treatment measures.

The storm water storage volume depends on the peak discharge of a storm event over the developed site. There are many methods to computing the peak discharge. The senior design team decided to use the Rational Method as explained in the Stormwater Design Criteria Manual and in many hydrology and hydraulic system textbooks. The rational method is described by the following equation and is generally acceptable for sites less than 120 acres.[4]

$$Q = CiA$$

Where:

Q = peak discharge rate (cfs)
C = runoff coefficient
i = rainfall intensity (in/hr)
A = contributing drainage area (acres)

From the grading plan created in the previous step, low areas in the parking lot were designated as the locations of the catch basins for storm water runoff. This runoff that needs to be collected will be due to the building, parking lot, and landscaping amenities; each of which has a different runoff coefficient, C. The runoff coefficient represents the portion of the storm water that will not infiltrate and in turn contribute to runoff. A coefficient of 1 was used for the area of the building, since it can be assumed that all of the water contributes to runoff. A coefficient of 0.9 was used for the parking lot and 0.3 used for landscaping areas. To apply the rational method, the lot was divided into four drainage areas for which the chambers will be responsible for storing. These four drainage areas were named watershed I-IV and are shown in Figure 6.

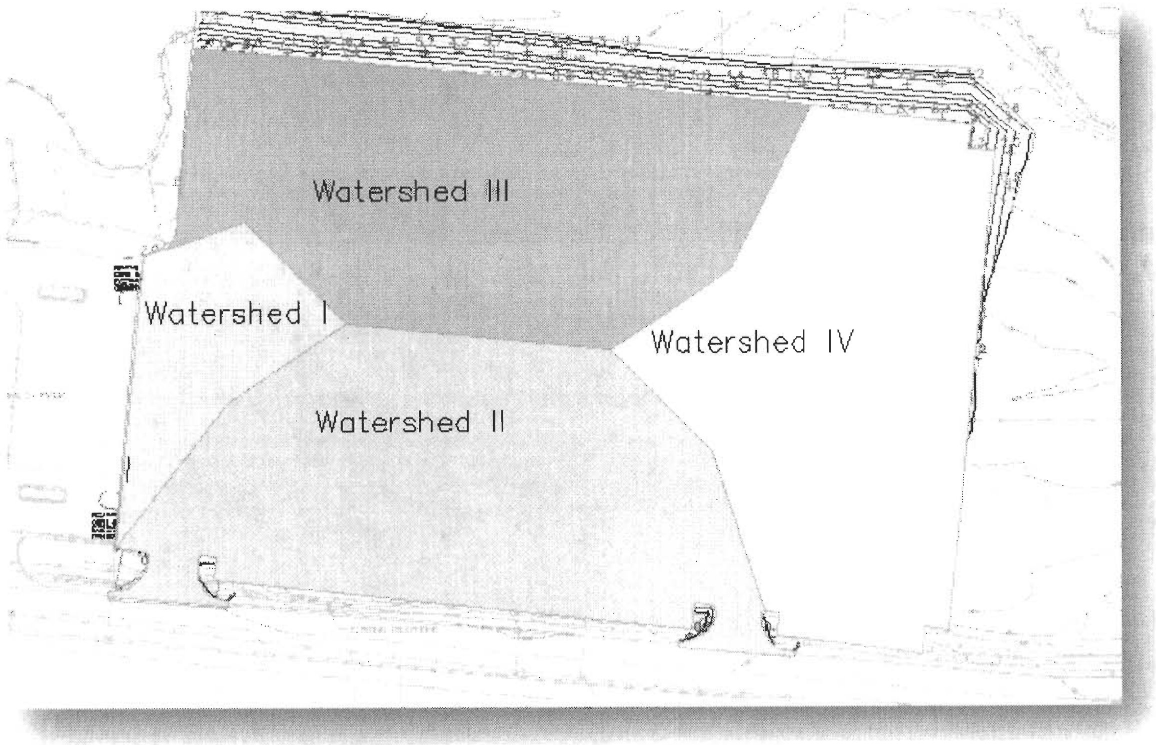


Figure 6: Watershed Division

Because each watershed had a portion of the building, parking lot, and landscaping, a weighted runoff coefficient was calculated and could be applied to the entire watershed area. The weighted coefficient, C_w, was determined by the following equation[5]:

$$C_w = \sum C_i \frac{A_i}{A_T}$$

All areas needed for this calculation were easily measured in the AutoCAD file. Table 1 tabulates the computation of C_w values for each watershed.

Table 1: Weighted Runoff Coefficient Computations

		Area Ratio	C	C_w
Watershed I				
	Landscape Subarea:	0.12	0.3	0.8462
	Roof Subarea:	0.182	1	
	Pavement Subarea:	0.698	0.9	
Watershed II				
	Landscape Subarea:	0.0586	0.3	0.88313
	Roof Subarea:	0.1667	1	
	Pavement Subarea:	0.7765	0.9	
Watershed III				
	Landscape Subarea:	0.064	0.3	0.87842
	Roof Subarea:	0.1682	1	
	Pavement Subarea:	0.7678	0.9	
Watershed IV				
	Landscape Subarea:	0.036	0.3	0.8829
	Roof Subarea:	0.045	1	
	Pavement Subarea:	0.919	0.9	

The manual also states that "infiltration basins shall be sized to store and infiltrate a minimum of 3,630 ft^3 per acre, or the runoff produced from a 2-year, 24-hour rainfall event assuming zero outflow."[4] Therefore, the Rational Method becomes the formula:

$$V_{fc} = CiA * 3{,}630$$

Where:

i = two year rainfall amount = 2.4 in
$C = C_w$ for the specific watershed
V_{fc} = flood control volume

An excel spreadsheet provided by the sponsor was used to calculate the flood control volumes and minimum drain time for each watershed. The minimum drain time was calculated as per the Stormwater Design Criteria Manual. (See Appendix 10 for these calculations) Table 2 summarizes the results from the excel spreadsheet.

Table 2: Summary of Rational Method for Each Watershed

	Watershed I	Watershed II	Watershed III	Watershed IV
A (acres)	0.4	1.68	1.64	1.57
C_w	0.85	0.88	0.88	0.88
i (in/hr)	2.4	2.4	2.4	2.4
V_{fc} (cft)	2,948.84	12,925.63	12,550.58	12,076.16

Design

One at a time, these volumes (ft^3) were entered into another excel spreadsheet to output a chamber configuration. (See Appendix 11) The team chose the larger chambers, LS-3051 type chambers (see Figure 4), due to the control volumes computed. The team also decided to connect all systems together to ensure adequate storage if overflow occurs in one of the chamber systems. The control volume was doubled for watershed IV to account for extra storage in the event of a major overflow in the combined system. Also, a pipe network was added to the northeast side to slow release into the Portage Creek. The full stormwater management plan can be seen in Appendix 12 and 13. Each group of chambers has one of the chamber rows designated as the isolator row as described in the previous section.

By utilizing underground storm water management, valuable and expensive lot area is saved for future development and groundwater recharge is maximized through onsite retention and infiltration. This achieves Standard 1 of the 9 Performance Standards given in the Stormwater Design Criteria Manual.[4]

Foundation Design

In the design of foundations, there are two design aspects to consider: geotechnical and structural. Geotechnical design takes into account bearing capacity and settlement, while structural design looks at the necessary reinforcement to ensure the concrete structure will withstand the applied loads. Typically the geotechnical design is performed first to obtain footing dimensions that satisfy the allowable bearing capacity and the allowable settlement. Due to a lack of information, the senior design team had to make many assumptions for this deliverable. These assumptions can be found throughout Appendices 15 - 17. With this lack of structural information on the proposed building, the team and their faculty advisor decided this task would best be accomplished through designing footings for a typical exterior and a typical interior column.

Column Loadings

First, the applied column loads needed to be estimated. This was achieved by using the tributary area method, estimating the self dead weights, and using ASCE 7-05 for live loads.[6] The columns and footings were assumed to be constructed from normal-weight concrete with a compressive strength of 4000 psi for the columns and a compressive strength of 3000 psi for the footings. The tributary areas shown in Figure 7 were created based on a column spacing of 25 feet on center and an assumed column size of 16" x 16".

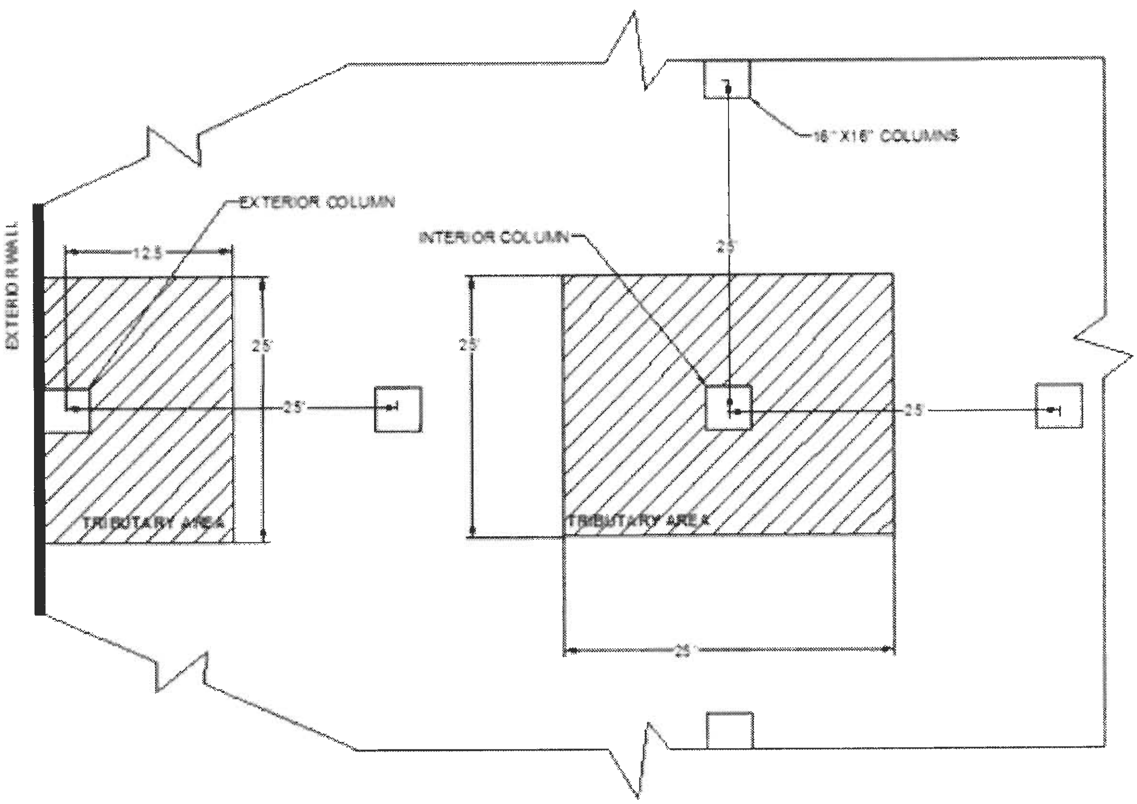


Figure 7: Tributary Areas

Dead loads (DL) and live loads (LL) were assumed to be equally distributed over the tributary area for each case. Therefore, the dead and live loads in terms of force per area are multiplied by the respective tributary area to get the distributed load as a force load, preferably in kips. A live load reduction was applied to the live loads according to ASCE 7-05 Minimum Design Loads for Buildings and Other Structures[6] as follows:

$$L_{reduced} = L\left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}}\right)$$

Where:

L = unreduced design live load per square foot,
K_{LL} = live load element factor,
A_T = tributary area in square foot

The dead loads were calculated by summing up the self weights of the column, roof, and slab floors. For detailed calculations and steps, see Appendix 15. Table 3 summarizes the total dead and total live loads determined for each of the footing cases. These loads will determine the applied column loading for which the footings will be designed for.

Table 3: Dead and Live Loads for Each Footing Case

	Exterior Case	Interior Case
Total Dead Load (Kips)	85	152
Total Live Load (Kips)	47	77

Geotechnical Design

The first step to geotechnical design was to obtain soil data for the construction site. A geotechnical report for the first building of the Trade Centre property was obtained and assumed to be adequate for this project. The soil report gave valuable soil data such as the soil type and unit weights (γ), groundwater table elevation, Soil Penetration Test (SPT) N values, and the allowable bearing capacity (q_a). For a detailed summary of valuable data obtained from the geotechnical report used in the foundation design of this project, see Appendix 14.

Geotechnical design has two important requirements a footing must satisfy: bearing capacity and settlement. Geotechnical design is based on the method of allowable stress design (ASD), therefore the total column loading is found by simply adding the dead and live loads as Pu = DL + LL.

For Exterior Case: 85 Kips + 47 Kips = 132 Kips = Pu

For Interior Case: 152 Kips + 77 Kips = 229 Kips = Pu

The sponsor informed the team that the footings for the proposed building are to be spread footings because of the size and layout of the building and groundwater depth. Therefore this design load, Pu, was used in the following bearing pressure equation to determine an adequate footing size.

$$q_a = \frac{P_u + W_f}{A} - u_D$$

Where:

q_a = allowable bearing capacity
W_f = self weight of soil and footing

A = cross sectional area of footing
u_D = pore water pressure

Once the footing size, length and width, were determined based on the allowable bearing capacity of 2000 psi, the settlement was calculated using Schmertmann's Method.[7] Schmertmann's equation is shown below.

$$\delta = C_1 C_2 C_3 (q - \sigma_{zD}') \sum \frac{I_e H}{E_s}$$

$$C_1 = 1 - 0.5\left(\frac{\sigma_{zD}'}{q - \sigma_{zD}'}\right)$$

$$C_2 = 1 + 0.2 \log\left(\frac{t}{0.1}\right)$$

$$C_3 = 1.03 - 0.03\frac{L}{B} \geq 0.73$$

Where:

δ = settlement of footing
C_1= depth factor
C_2 = secondary creep factor
C_3 = shape factor = 1 for square foundations
q = bearing capacity
σ_{zD}' = effective vertical stress at a depth D below the ground surface
I_e = influence factor at midpoint of soil layer
H = thickness of soil layer
Es = equivalent modulus of elasticity in soil layer
t = time since application of load in years
B = foundation width
L = foundation length

Because the factor, C_2, in the above equation is time dependent, the team decided to express the settlement as a graph over time for each footing case. These curves are shown in Figure 8.

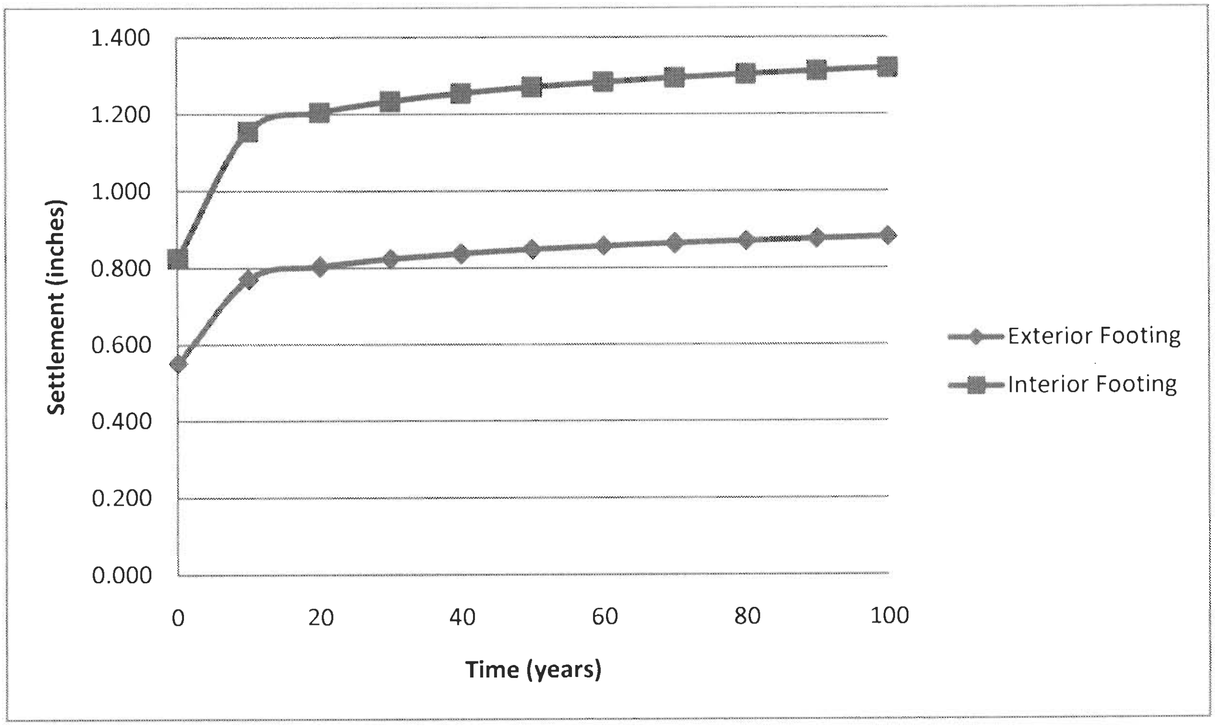


Figure 8: Plot of Settlement Curves

The geotechnical report gave an allowable settlement of around one inch. From the graph above, it can be seen that the settlement of the exterior footing stays within the allowable settlement for 100 years' time. The settlement of the interior footings plateaus around 1.3 inches in 100 years but this is deemed acceptable because of the high assumptions made for column loads.

See Appendix 16 for detailed geotechnical calculations.

Structural Design

The next aspect to foundation design is structural. This step involves specifying a reinforcement bar configuration based on Load Resistant Factor Design (LRFD) methodology, as laid out in ACI Code 318-08. First, the team estimated a footing thickness based on the rule of thumb of one to two times the width of the column. The team chose to estimate the footing thickness as 1.5 times the assumed column width of 16 inches which results in 24 inches. To be conservative, this estimation was raised to 28 inches and used for both the interior and exterior case. Next, the thickness was checked for two-way shear, also referred to as punching shear, by validating that the factored shear from the applied loads was less than the nominal shear strength by the following equation[8].

$$V_u \leq \emptyset V_n$$

Where:

V_u = shear from factored applied loads
$\emptyset$ = strength reduction factor = 0.75 for shear
V_n = nominal shear strength = $V_s + V_c$

The factored shear (V_u) is determined by dividing the factored column load, P_u, by the respective footing area and then multiplying it by the tributary area for that footing. The tributary area is the area between the critical perimeter and the exterior perimeter of the footing. An example is shown in the figure below and detailed in Appendix 17.

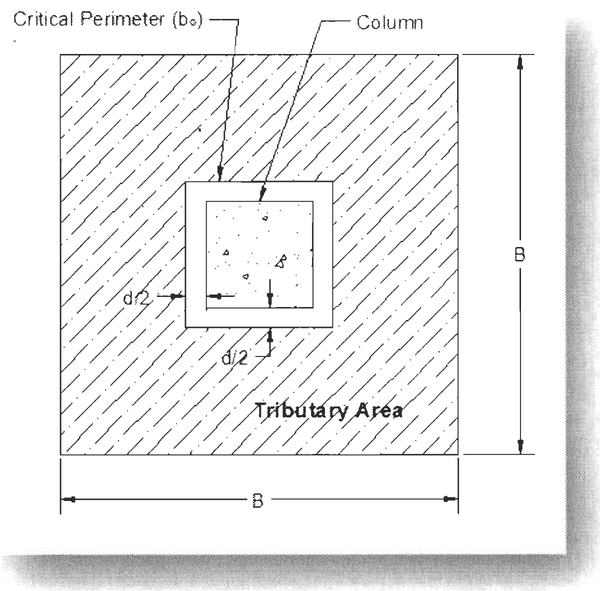


Figure 9: Tributary Area for Two-way Shear

The nominal shear strength is given by the summation of the shear taken by the stirrups (V_s) and the shear taken by the concrete (V_c). For the case of footings, stirrups are seldom used, thus making the nominal shear strength (V_n) equal to the shear taken by the concrete (V_c) alone. The value V_c, is found as the smallest of the following ACI equations[8].

[ACI Eq. 11-33] $$V_c = \left(2 + \frac{4}{\beta_c}\right)\lambda\sqrt{f'_c}b_o d$$

[ACI Eq. 11-34] $$V_c = \left(2 + \frac{\alpha_s d}{b_o}\right)\lambda\sqrt{f'_c}b_o d$$

[ACI Eq. 11-35] $$V_c = 4\lambda\sqrt{f'_c}b_o d$$

Where:

β_c = the ratio of the long side to the short side of the column
f'_c = compressive strength of concrete (assumed 3000 psi for footings)
α_s = 40 for columns centered on square footings
b_o = critical perimeter
λ = 1 for normal weight concrete
d = effective depth

The effective depth, d, was found by subtracting a concrete cover of three inches and the diameter of a standard No. 4 bar from the footing thickness, h. This gave an effective depth of 24 inches. The effective depth is the average depth from the top of the footing to the centroid of the reinforcement bars. The critical perimeter is the perimeter created by offsetting a distance equal to half of the effective depth from all sides of the column. This is shown in Figure 9. With all the above parameters known, the shear taken by the concrete, V_c, can be determined and multiplied by the strength reduction factor, ϕ, to obtain the nominal shear strength to ensure this value is equal to or greater than the applied shear, V_u. Both cases were found to satisfy this requirement for two-way shear under the estimated parameters.

One-way shear needed to be checked as well before reinforcement bars could be chosen. The value of V_u is determined as described in two-way shear; just a different tributary area is used. This area is measured from the column edge toward the footing edge a distance of d. This area is shown below.

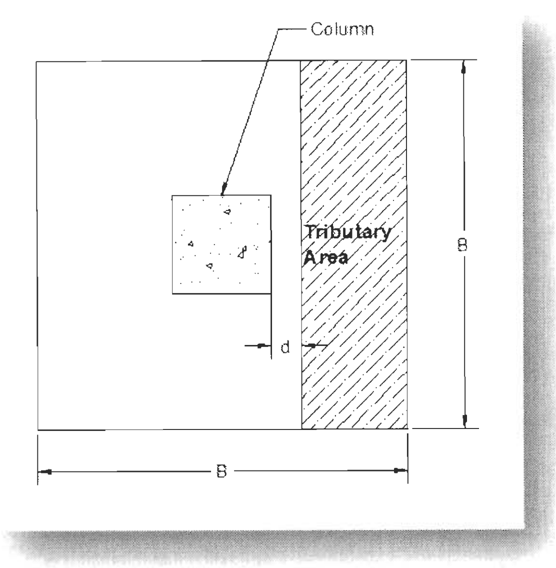


Figure 10: Tributary Area for One-way Shear

However, V_c is determined using a different equation[8], seen below.

$$V_c = 2\lambda\sqrt{f'_c}bd$$

The same requirement of $V_u \leq \phi V_c$ must be satisfied under one-way shear as well. Again, for both interior and exterior case one-way shear was satisfied under the estimated parameters.

With both one-way and two-way shear satisfied, the team designed for flexural reinforcement, assuming Grade-60 steel. The required bar area was found by[8]:

$$A_s = \frac{M_u}{\emptyset f_y jd}$$

Assuming j= 0.95 and the footings are tension controlled sections, in which $\emptyset = 0.9$, the factored applied moment, M_u, was calculated by the following equation[8]; where the tributary areas for both cases are shown cross hatched in the above figures.

$$M_u = \frac{1}{2}\omega l^2$$

ACI code states that this A_s value must be equal to or greater than the minimum required area found by ρ*b*h. The team found that the minimum required area governed their choice in bar configuration. Reinforcement bars were chosen using Table A-1 and bar development lengths were checked using Table A-6, both from the *Reinforced Concrete* reference book[9]. The last structural design check performed looked at the column-footing joint. To ensure a joint failure would not occur under loading, dowel bars were implemented.

Full detailed design steps for both exterior and interior footings can be found in Appendix 17.

With all necessary design steps completed, the team rendered footing drawings for the typical exterior and typical interior footings for the proposed building. These drawings show the dimensions and bar configurations for the design of the footings. See Appendix 18 for detailed plans for the typical exterior and interior column footings.

Traffic Impact Study

Introduction

A traffic impact study was performed to analyze the impact of the additional traffic volume from the team's proposed office building volumes on the surrounding arterial and freeway. Trade Centre Way is the current connection road available for the existing office buildings located next to the team's proposed building. This road connects to the main arterial, Westnedge Avenue, near a major freeway, Interstate Highway 94 (I-94). The team examined existing traffic patterns provided by previous traffic studies, developed an estimate of the anticipated increase in traffic volumes based on the growth over time, determined the impact of the additional traffic from the proposed building on the traffic flow, identified problem areas in the network, and suggested recommendations.

To perform the analysis for this traffic impact study, the team obtained data from previous studies developed for the City of Portage focusing on the Trade Centre property. A Western Michigan University transportation engineering faculty member provided the team with a traffic impact study for the City of Portage from 2004. A traffic engineer for the City of Portage provided an additional study from 2009. These reports were reviewed and compared to get a thorough idea of the existing traffic volumes and trip distributions of the current traffic from the Trade Centre property.

The reports were used to estimate the current conditions of several intersections along Westnedge Avenue including the I-94 interchange ramps. After the data was reviewed and compiled, the traffic volumes had to be approximated for the current year of 2010 using a 1% growth rate. With this data, a number of traffic models were created using the traffic analysis program Synchro™ (version 6). This analysis tool predicts traffic operations by modeling traffic volume data and the physical characteristics of the roadways which and combining them with traffic management strategies such signals. The initial analysis on Synchro™ produced a model known as the "baseline" conditions, against which all future model scenarios would be compared. Using the baseline model, it is possible to identify the estimated existing traffic conditions based on the level of service (LOS) at each intersection. These baseline traffic service levels can then be compared to the levels after the proposed additional traffic is added to the model, providing a more accurate idea of the impact the additional traffic volumes have on the network.

Area Roadways

Westnedge Avenue is a major arterial linking Portage and Kalamazoo to I-94. The cross streets included in this study area were Andy Avenue/Market Place and Trade Centre Way, which is a road used to directly access the Trade Centre Property. The exit and entrance ramps are also included in the intersections analyzed in the study area. The existing I-94 interchange has a partial cloverleaf configuration. The Michigan Department of Transportation (MDOT) has begun the reconstruction of this interchange to a configuration known as a single point urban interchange (SPUI).

Trade Centre Way is the route to the Trade Center property that intersects Westnedge Avenue just north of I-94. This intersection is currently located within 20 feet and parallel to the I-94 westbound on ramp resulting in limited access to Trade Centre Way from Westnedge. Currently, traffic entering or exiting Trade Centre Way can only turn right from southbound Westnedge Avenue, and can only exit to the south by making a right turn onto Westnedge Avenue. This proposes a problem for traffic entering or exiting onto northbound Westnedge Avenue. The traffic exiting the Trade Centre property must travel north on West Fork Crossing to the signalized intersection, Market Place and Westnedge Avenue to travel northbound. As for the northbound entering traffic, they must also travel north to the signalized intersection, Andy Avenue/Market Place and Westnedge Avenue to make a left turn onto Market Place and follow West Fork Crossing south to Trade Centre Way.

The signalized intersection at Westnedge and Andy Avenue/Market Place is an additional area of interest in this study. This intersection is a concern because of the current trip distribution of the additional traffic from the team's building.

Data collection

The data that was used for this study was obtained from the previous traffic impact study created for the City of Portage in 2004. The volume counts from that study were taken between the hours of 7:00 – 9:00 AM and 4:00 – 6:00 PM to define the AM and PM peak hours of 7:45 – 8:45 AM and 4:45 – 6:45 PM, respectively. Intersection physical measurements were estimated using the aerial photography provided online in Google Maps.

Study Procedure

For this study, the team used the concepts and methods from the Highway Capacity Manual to classify the roadway operations based on traffic flow and delay. The methods were implemented in the analysis when modeling the traffic in Synchro™ to assess the impacts of traffic and intersections. The traffic flow and delay characteristics are measured based on the Level of Service (LOS), which is a standardized evaluation of the congestions and vehicle delay experienced by the motorists. The LOS is assessed using a letter scale with A as the highest LOS and F as the lowest. The optimum LOS is the letter C, due to the fact that LOS C intersections flow efficiently without being overdesigned and costing more. The following two tables list the constraints that define the levels and are provided from the Highway Capacity Manual.[10]

Table 4: Level of Service Criteria for Unsignalized Intersections[10]

	Delay/Veh (sec)	
A	≤ 10	Little or no delay, very low main street volumes
B	> 10 and < 15	Short traffic delays, many acceptable gaps
C	> 15 and < 25	Average traffic delays, frequent gaps still occur
D	> 25 and <35	Long traffic delays, limited number of acceptable gaps
E	> 35 and ≤ 50	Very long traffic delays, very small number of acceptable gaps
F	> 50	Extreme traffic delays, virtually no acceptable gaps in traffic

Table 5: Level of Service Criteria for Signalized Intersections[10]

	Delay/Veh (sec)	
A	≤ 10	Most vehicles do not stop at all
B	> 10 and < 20	More vehicles stop tan for LOS A
C	> 20 and < 35	The number of vehicles stopping is significant, although many pass through without stopping
D	> 35 and <55	Many vehicle stops, Individual cycle failures are noticeable
E	> 55 and ≤ 80	Considered being the limit of acceptable delay. Individual cycle failures are frequent
F	> 80	Extreme traffic delays, virtually no acceptable gaps in traffic

For this study, the LOS for each intersection was estimated from the baseline scenario of 2010 before the construction of the team's building, then the 2010 after the construction of the office building, and finally, after proposed changes were added to the after build scenarios. Using these separated models in Synchro™, the impact of the proposed office building can be easily identified.

To estimate the number of trips added to the network volumes, the team used the ITE Trip Generation Model, 7^{th} Edition, for a General Office Building. These trips were calculated for the AM and PM peak hours based on the usable square foot area of the building which the team estimated to about 75% of the total square foot area of the building. Since the building is 111,705 ft^2, the usable area is equivalent to 83,779 ft^2. The equations below are taking from the ITE Trip Generation Manual and were used to calculate these trips. The AM peak hour is generally when most traffic is entering the office building so the traffic was distributed 88% entering and 12% exiting. The opposite distribution percentages were used for the PM peak hour trips.[11]

AM Peak $Ln(t) = 0.8*Ln(t)+1.55$

PM Peak $t = 1.12 (x)+78.81$

Table 6: General Office Building Trips Per GFA[11]

ITE Trip Generation Manual 7th Edition								
			a.m. Peak Hour			p.m. Peak Hour		
Use	Code	GFA	Total	In	Out	Total	In	Out
General Office	710	83789	163	143	20	173	152	21

After the models were developed, problems were identified in the after build scenario at many areas that had LOSs below optimum C. These problems required proposed recommendations for the effected intersections to mitigate the adverse traffic impacts from the additional trips. A final model is then developed with the proposed changes to determine if these changes are adequate and effective.

Data Analysis

Figures found in Appendix 19 of this report were developed to illustrate the AM and PM peak hour traffic volumes of the intersections that were analyzed in this study. The volumes on the diagrams are labeled with letters "A", "B", and "C", "A" values are for the baseline traffic volumes, "B" values are for the traffic volumes after the construction the team's proposed office building, and "C" values are the traffic volumes after the proposed changes were implemented.

Figures in the Appendix 19 of the report illustrate the LOS calculations for the AM and PM peak hour traffic volumes. Again, these values were labeled in the same way as the traffic volumes with letters "A" through "C".

Baseline Scenario

Table 7: Summary of 2010 Baseline Peak Hour Intersection Volumes (veh/hr)

Intersection	AM Peak	PM Peak
Andy/ Market Place	2489	4049
Trade Centre Way	2459	4056
WB I-94 On Ramp	2675	4440
WB I-94 to SB Westnedge	2680	4239
WB I-94 to NB Westnedge	2680	4239
EB I-94 to SB Westnedge	2477	3979
EB I-94 to NB Westnedge	2590	4048
EB I-94 On Ramp	2555	4402
Totals	20605	33452

Table 8: AM Peak Hour 2010 Baseline LOS

		NB			**SB**			**EB**			**WB**			**ICU**
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	A	A	C	A	A	C	B	C	C	B	B	C	A
Trade Center Way	stop	-	A	-	A	A	-	B	-	-	-	-	-	A
WB I-94 On Ramp	n/a	-	A	B	A	A	-	-	-	-	-	-	-	A
WB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	A
WB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	C	-	-	B
EB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	C
EB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	C
EB I-94 On Ramp	n/a	A	A	-	-	A	C	-	-	-	-	-	-	A
Trade Center & W. Fork	stop	A	A	-	-	A	-	-	-	-	A	-	A	A

Table 9: AM Peak Hour Signal Delay

	SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	5.1	23.7	-	8.4	22.8	12.7	21	25	-	12.4	25

Table 10: PM Peak Hour 2010 Baseline LOS

		NB			SB			EB			WB			ICU
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	B	B	C	C	D	C	A	C	C	B	B	E	C
Trade Center Way	stop	-	A	-	A	A	-	B	-	-	-	-	-	D
WB I-94 On Ramp	n/a	-	A	F	A	A	-	-	-	-	-	-	-	D
WB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	D
WB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	D
EB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	D
EB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	D
EB I-94 On Ramp	n/a	A	A	-	-	A	F	-	-	-	-	-	-	B
Trade Center & W. Fork	stop	A	A	-	-	A	-	-	-	-	B	-	B	A

Table 11: PM Peak Hour Signal Delay

	SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	12.2	24	-	51	22.9	9.6	20.7	29.2	-	13.4	70.5

After Build Scenario

The trips estimated using the ITE Trip Generation Manual were then distributed using approximate flow distribution percentages obtained from the previous Traffic Impact Study from 2009. The diagram of this traffic flow from the building can be found in Appendix 19.

Table 12: Summary of 2010 After Build Peak Hour Intersection Volumes (veh/hr)

Intersection	AM Peak	PM Peak
Andy/ Market Place	2632	4135
Trade Centre Way	2597	4142
WB I-94 On Ramp	2753	4507
WB I-94 to SB Westnedge	2754	4280
WB I-94 to NB Westnedge	2749	4239
EB I-94 to SB Westnedge	2326	4019
EB I-94 to NB Westnedge	2643	4088
EB I-94 On Ramp	2575	4442
Totals	21029	33852

Table 13: AM Peak Hour 2010 After Build LOS

		NB			SB			EB			WB			ICU
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	A	A	C	A	A	C	B	C	C	B	B	C	A
Trade Center Way	stop	-	A	-	A	A	-	A	-	-	-	-	-	A
WB I-94 On Ramp	n/a	-	A	B	A	A	-	-	-	-	-	-	-	A
WB I-94 off to SB	yield	-	A	-	-	A	-	B	-	-	-	-	-	B
WB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	D	-	-	B
EB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	C
EB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	C
EB I-94 On Ramp	n/a	A	A	-	-	A	C	-	-	-	-	-	-	A
Trade Center & W. Fork	stop	A	A	-	-	A	-	-	-	-	A	-	A	A

Table 14: AM Peak Hour After Build Signal Delay

	SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	5.1	23.7	-	8.4	22.8	12.7	21.3	25	-	12.4	25

Table 15: PM Peak Hour 2010 After Build LOS

		NB			SB			EB			WB			ICU
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	B	B	D	C	C	D	B	C	D	C	C	F	C
Trade Center Way	stop	-	A	-	A	A	-	B	-	-	-	-	-	D
WB I-94 On Ramp	n/a	-	A	F	A	A	-	-	-	-	-	-	-	D
WB I-94 off to SB	yield	-	A	-	-	A	-	C	-	-	-	-	-	D
WB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	D
EB I-94 off to SB	yield	-	A	-	-	A	-	B	-	-	-	-	-	D
EB I-94 off to NB	yield	-	A	-	-	A	-	-	-	-	F	-	-	D
EB I-94 On Ramp	n/a	A	A	-	-	A	F	-	-	-	-	-	-	B
Trade Center & W. Fork	stop	A	A	-	-	A	-	-	-	-	B	-	B	A

Table 16: PM Peak Hour After Build Signal Delay

	SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	9.1	38.1	-	20.7	35.2	13.8	32.5	52.8	-	20.7	83.4

After Proposed Changes Scenario

The previous tables identify several problem areas at the Andy/Market Place intersection and at a number of I-94 ramps. For this project, the team decided to develop changes to the intersections that were directly affected by the increased trips without including the traffic volumes from the I-94 SPUI configuration. This was because of time constraints and because the SPUI configuration is assumed to alleviate the major LOS problems on the ramps. The changes did however take into consideration the configuration of the ramps at the completion of the SPUI system when proposing recommendations to the intersections.

The problems areas related directly to the impact of additional traffic volumes from the proposed building at the Andy/Market Place intersection were identified as the northbound left turn lane and the eastbound left turn lane. The LOSs at these locations were both a LOS D which is below the optimum level. Rather than changing the Andy/Market Place intersection, the team decided to focus on the root of the problem at Trade Centre Way. As stated before, Trade Centre Way has limited access for vehicles entering and exiting at Westnedge Avenue. Much of the traffic has to use the Andy/Market Place signalized intersection to make left turns to travel into or out of the Trade Centre Property. Therefore, the team decided to add an actuated-coordinated signal at the Trade Centre Way intersection allowing additional traffic to make left turns from northbound and eastbound. This decreases the volumes turning left at Andy/Market Place which improves the LOSs at this location. The signal will also allow for a more direct access to the Trade Centre Property from I-94 which is a priority for many of the businesses in those office buildings. The actuated signal was chosen because the high traffic volumes on Westnedge should have priority over the Trade Centre Property volumes, and having a signal that only changes when vehicles are detected from Trade Centre Way is an adequate solution for these concerns.

Below are tables with traffic volumes and LOSs for the proposed changes. There is also an illustration of the suggested proposed design for the Trade Centre Way intersection light that was modeled in Synchro™ (See Figure 11).

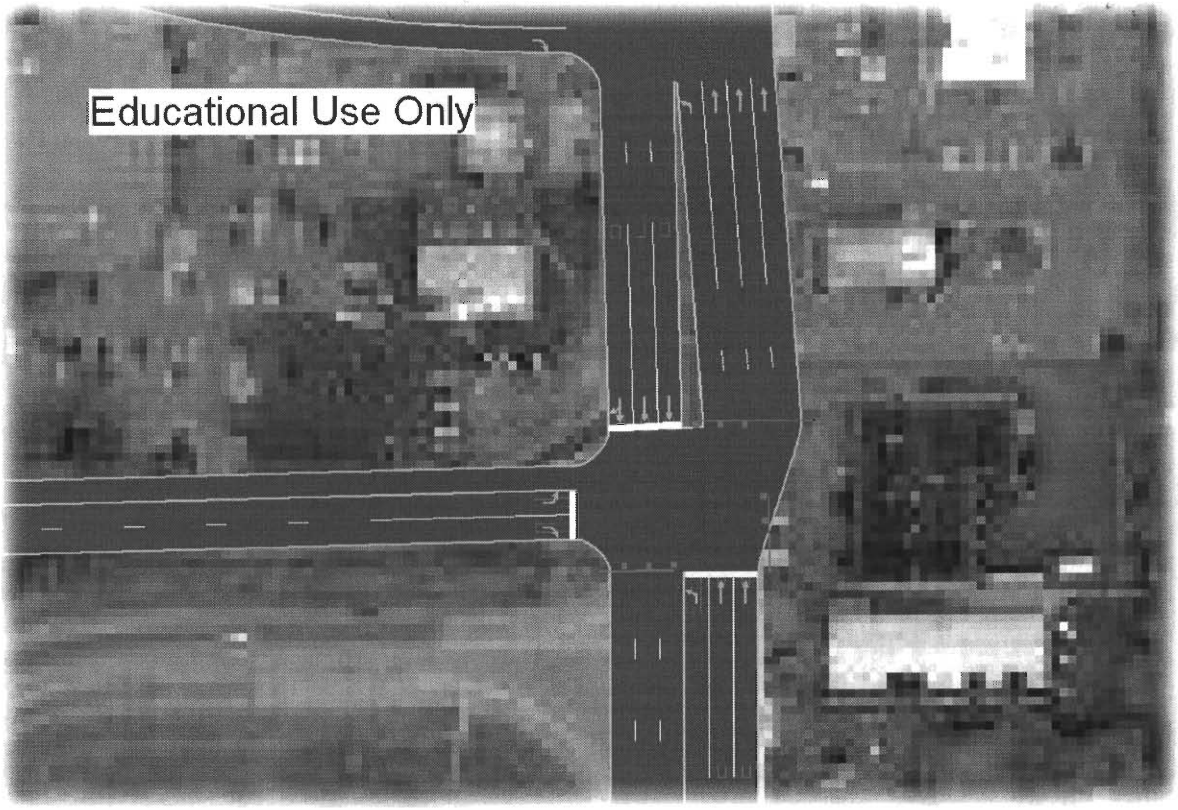


Figure 11: Proposed Changes to Trade Centre Way after SPUI

Table 17: Summary of 2010 After Proposed Changes Peak Hour Intersection Volumes (veh/hr)

Intersection	AM Peak	PM Peak
Andy/ Market Place	2573	4127
Trade Centre Way	2599	4139
Totals	5172	8266

Table 18: AM Peak Hour 2010 After Proposed Changes LOS

		NB			**SB**			**EB**			**WB**			**ICU**
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	A	A	C	A	A	C	B	C	C	B	B	C	A
Trade Center Way	signal	-	A	A	A	A	-	A	-	B	-	-	-	A

Table 19: AM Peak Hour After Proposed Changes Signal Delay

	AM SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	5.1	23.5	-	6.2	22.8	13.4	21	25.2	-	12.4	25
Trade Center Way	-	2.3	2.8	-	1.2	-	8.3		14	-	-	-

Table 20: PM Peak Hour 2010 After Proposed Changes LOS

		NB			**SB**			**EB**			**WB**			**ICU**
		RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT	
Andy/Market Place	signal	B	B	C	D	D	C	A	C	C	B	B	E	C
Trade Center Way	signal	-	C	A	B	B	-	B	-	B	-	-	-	B

Table 21: PM Peak Hour After Proposed Changes Signal Delay

	PM SIGNAL DELAY (seconds)											
	NB			SB			EB			WB		
Andy/Market Place	RT	TH	LT	RT	TH	LT	RT	TH	LT	RT	TH	LT
	-	12.2	24	-	50	22.9	9.5	20.5	40.8	-	13.8	87.5
Trade Center Way	-	22.1	7	-	12.9	-	16.1		10.5	-	-	-

Summary

The Team examined existing traffic patterns from previous traffic impact studies created for the City of Portage and used that information to create models to analyze the impact of additional traffic volumes from the new office building in the Trade Centre Property. Problem areas were identified before and after the completion of the new office building based on the LOS of each intersection. This was performed to properly identify areas that were a problem specifically because of new traffic and not because of prior ineffective traffic flow. The impact of the addition of the new office building was estimated using the ITE Trip Generation Manual and distributed evenly throughout the network based on the distribution of the existing two buildings' traffic obtained from a previous traffic impact study.

The recommendations were made considering the current reconstruction of the Westnedge/I-94 interchange to a SPUI configuration. This new configuration removed the geometrical conflict between the entrance to Trade Centre Way and westbound I-94 on ramp. The proposal was to add an actuated-coordinated signal to the Trade Centre Way intersection to allow for left turning traffic northbound and eastbound. In doing so, this alleviates the traffic volume impact at the northbound and eastbound left turn lanes at the Andy/Market Place signalized intersection. The team did consider how close the two signalized intersections would be and realized the possibility of rerouting Trade Centre Way closer to the SPUI signal to be included in the light timing. Given the limited knowledge the team had about the reconfiguration of the interchange, the analysis of the Trade Centre Way signal was performed without including I-94. Traffic signals are generally spaced at a minimum of a ¼ mile (1320ft) and the Andy/Market Place signal is only about 800ft from the proposed additional signal, which in some cases can cause disruptions in the traffic and result in excessive delays and queues. Yet after analyzing the intersections, the team discovered that coordinating both actuated signals allowed for less disruption in the traffic flow so the proposal kept the proposed additional signal.

Project Summary and Conclusions

With the completion of this project, the team gained experience in designing a site layout including calculating earthwork quantities, designing stormwater retention, designing footings for a large scale office building, and traffic impact analysis. Having a broad project scope including these different areas allowed the team to work together but individually focus on different areas of interest. This worked well because a site design involves many different civil engineering disciplines.

The team is proud of their work and deliverables including:

- Site Layout and Grading Plan
- Municipal Utilities Plan
- Stormwater Storage Plan
- Typical Footing Plans
- Traffic Impact Study

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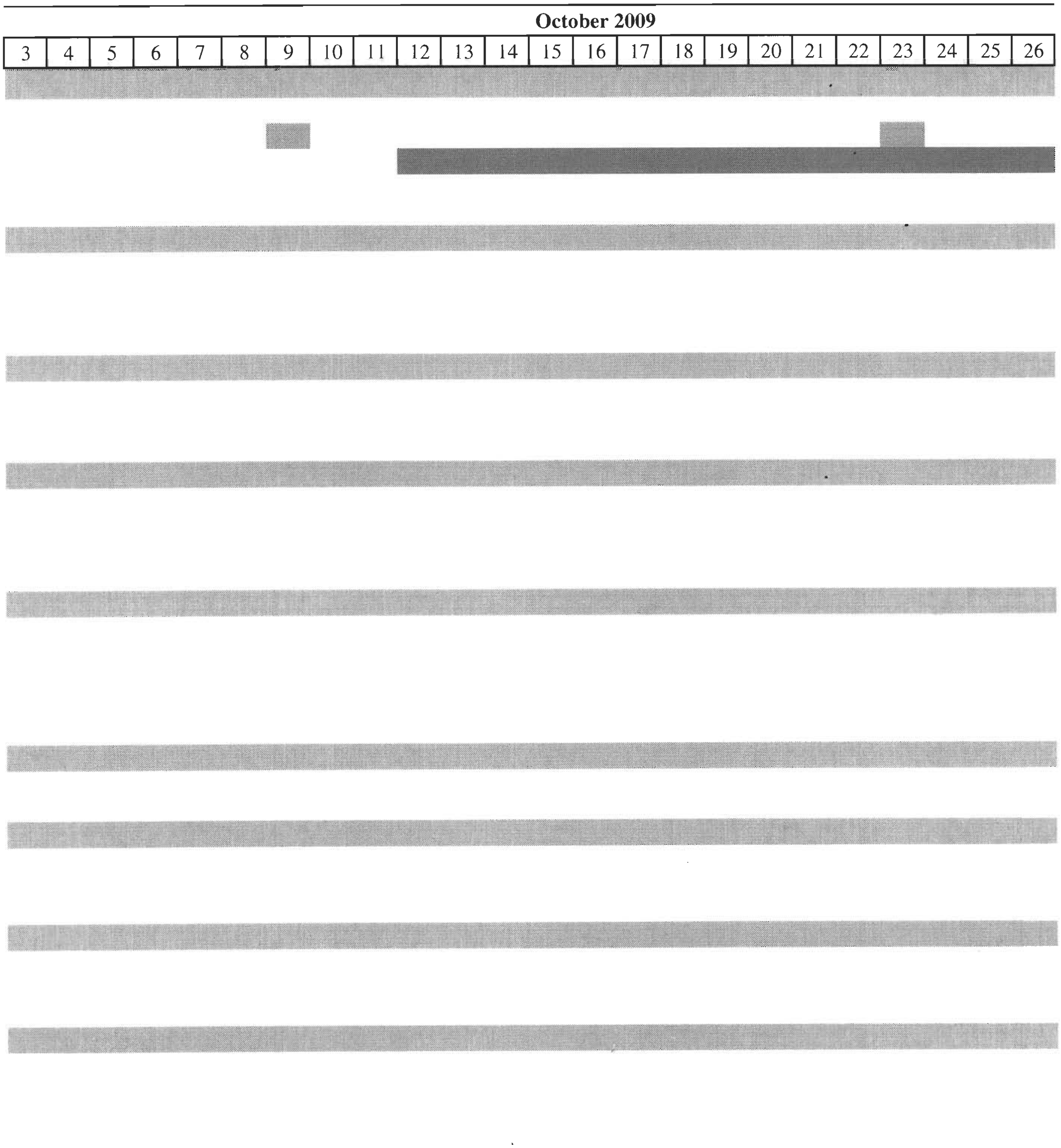
Appendix 1

Senior Capstone Design Factory Project
Four-Story Class A Office Building
Production Work Plan

Activity	Duration Dates		Primary Personal	September 2009 27	28	29	30	1	2
Milestone 1: Proposal	BEGIN	END							
Project Assigned	9/28/2009		BR AP KW						
Meet with Sponsor	10/9/2009	10/30/2009	BR AP KW						
Write Proposal	10/12/2009	11/2/2009	BR AP KW						
Proposal Due		11/2/2009	BR AP KW						
Review/Rewrite	11/9/2009	11/15/2009	BR AP KW						
Milestone 2: Research									
Zoning, Permits	11/16/2009	11/20/2009	AP						
Obtain Traffic Data (MDOT)	11/20/2009	1/11/2010	BR						
Stormwater Mitigation	11/25/2009	11/30/2009	AP						
Foundation Information	11/30/2009	2/2/2010	KW						
Milestone 3: Permits									
Complete Volume Calculations		3/15/2010	KW						
Fill out Permit Paperwork	12/3/2009	3/15/2010	BR						
Submit Permit		3/15/2010	KW BR						
Milestone 4: Site Layout									
Site Visit/Exisiting Conditions		1/20/2010	BR AP KW						
Zoning, Building Setbacks	1/11/2010	1/22/2010	BR AP KW						
Hand Sketches	1/17/2010	1/26/2010	BR AP KW						
Review Site Layout with TH	1/26/2010	1/29/2010	BR AP KW						
Milestone 5: Earthwork Grading									
Grading on Computer	2/1/2010	2/10/2010	BR AP KW						
Review Soil Reports	2/5/2010	2/10/2010	BR						
Cut/Fill; Leveling	2/8/2010	2/17/2010	BR AP KW						
Construction Costs	2/18/2010	3/12/2010	AP						
Retaining Wall Consideration	2/17/2010	3/12/2010	BR AP KW						
Milestone 6: Stormwater									
Calculations	2/15/2010	3/5/2010	BR AP KW						
Design Layout	2/24/2010	3/16/2010	AP						
Milestone 7: Structual/Foundation Design									
Loads for Foundation	2/15/2010	3/19/2010	KW						
Analysis	2/19/2010	3/26/2010	BR AP KW						
Draw up Plans	2/26/2010	3/31/2010	BR AP KW						
Milestone 8: Traffic Study									
Review Traffic Data from MDOT	3/1/2010	3/19/2010	BR						
HCM/Multilane Analysis/Syncro	3/5/2010	3/31/2010	BR AP KW						
Recommendations	3/19/2010	4/2/2010	BR AP KW						
Milestone 9: Final Report and Presentation									
Report	3/16/2010	4/21/2010	BR AP KW						
Presentation	3/26/2010	4/20/2010	BR AP KW						
Senior Design Presentation		4/20/2010	BR AP KW						
Report Due		4/21/2010	BR AP KW						


October 2009
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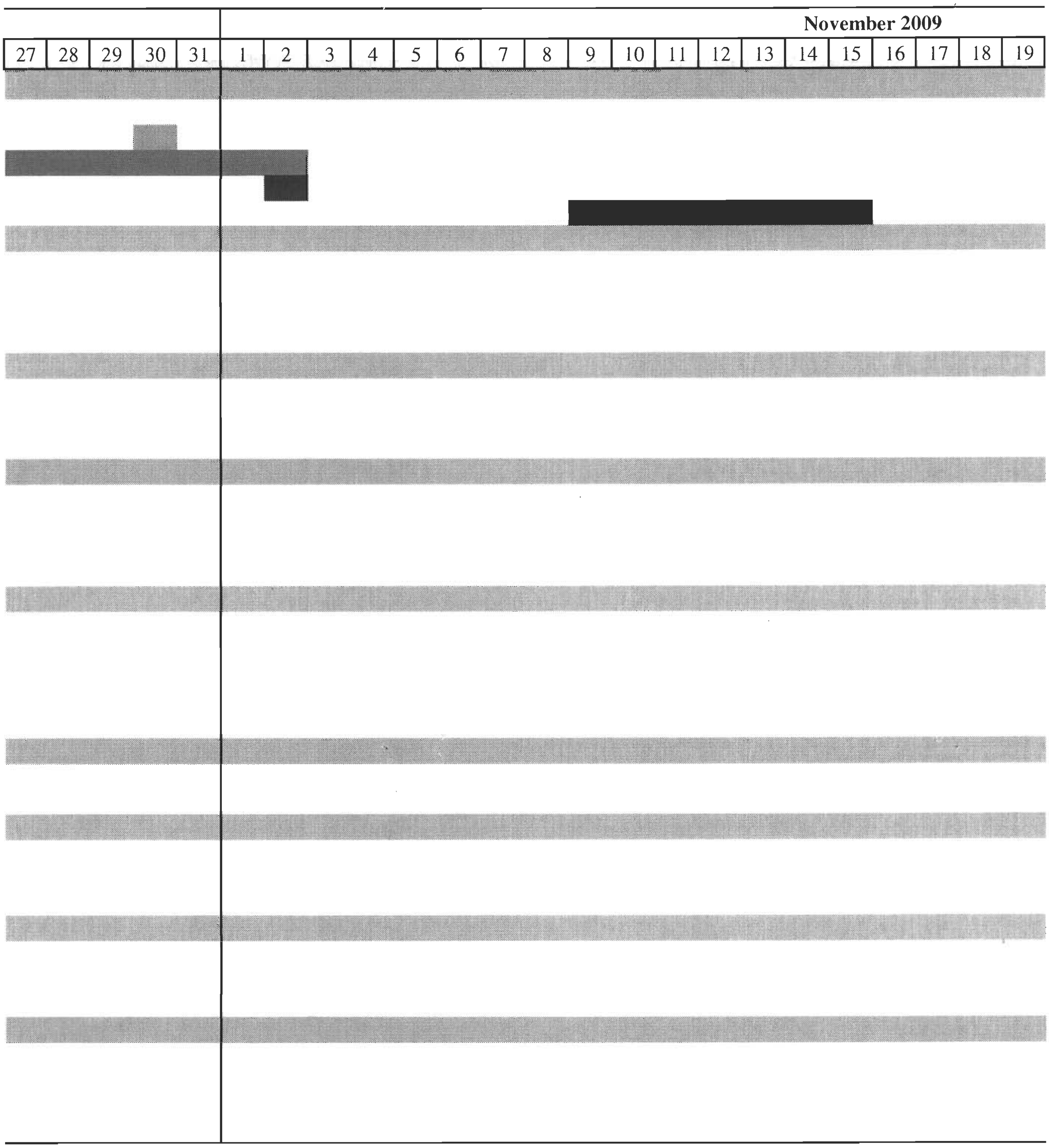
November 2009
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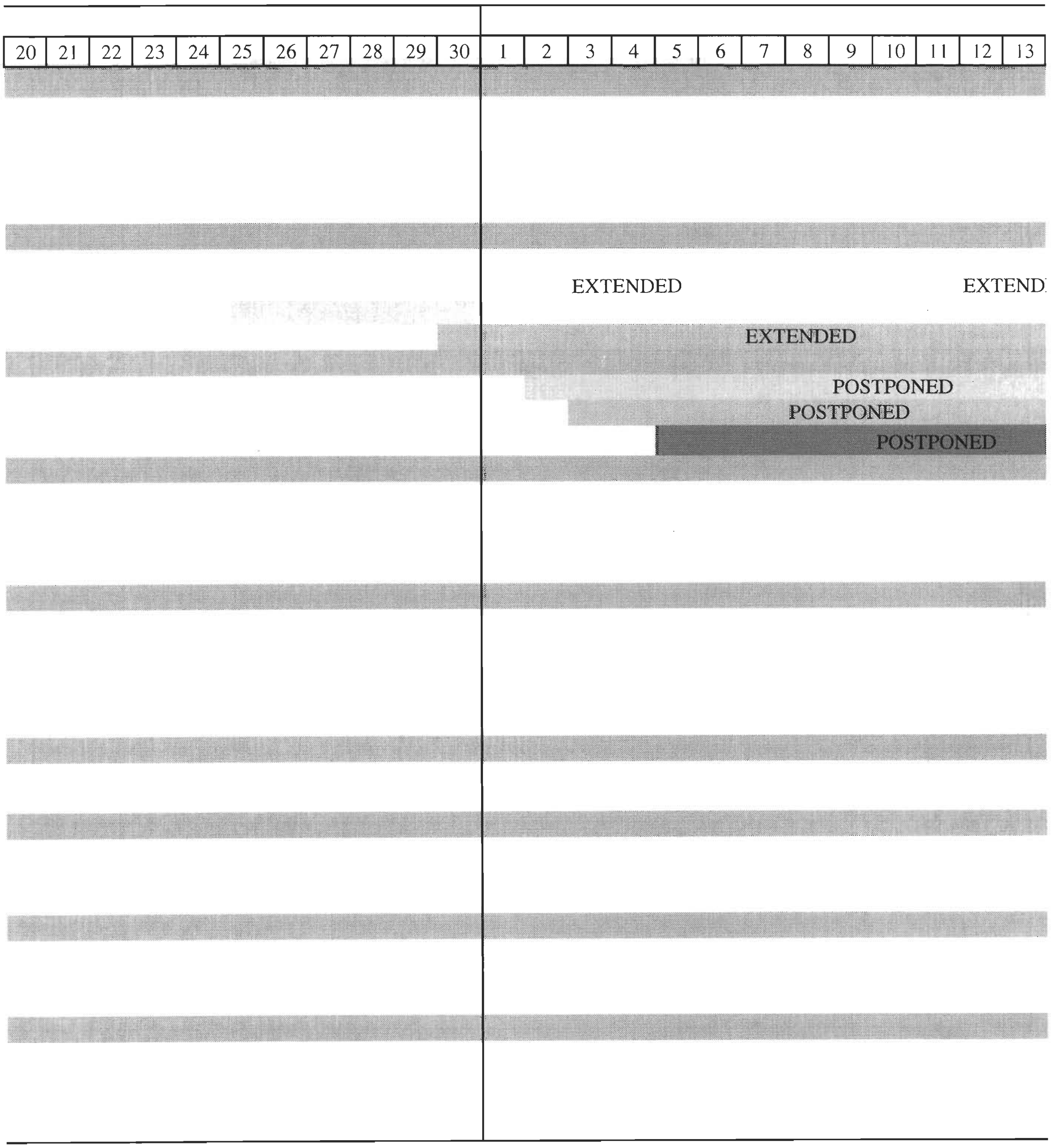
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EXTENDED
EXTEND
EXTENDED
POSTPONED
POSTPONED
POSTPONED

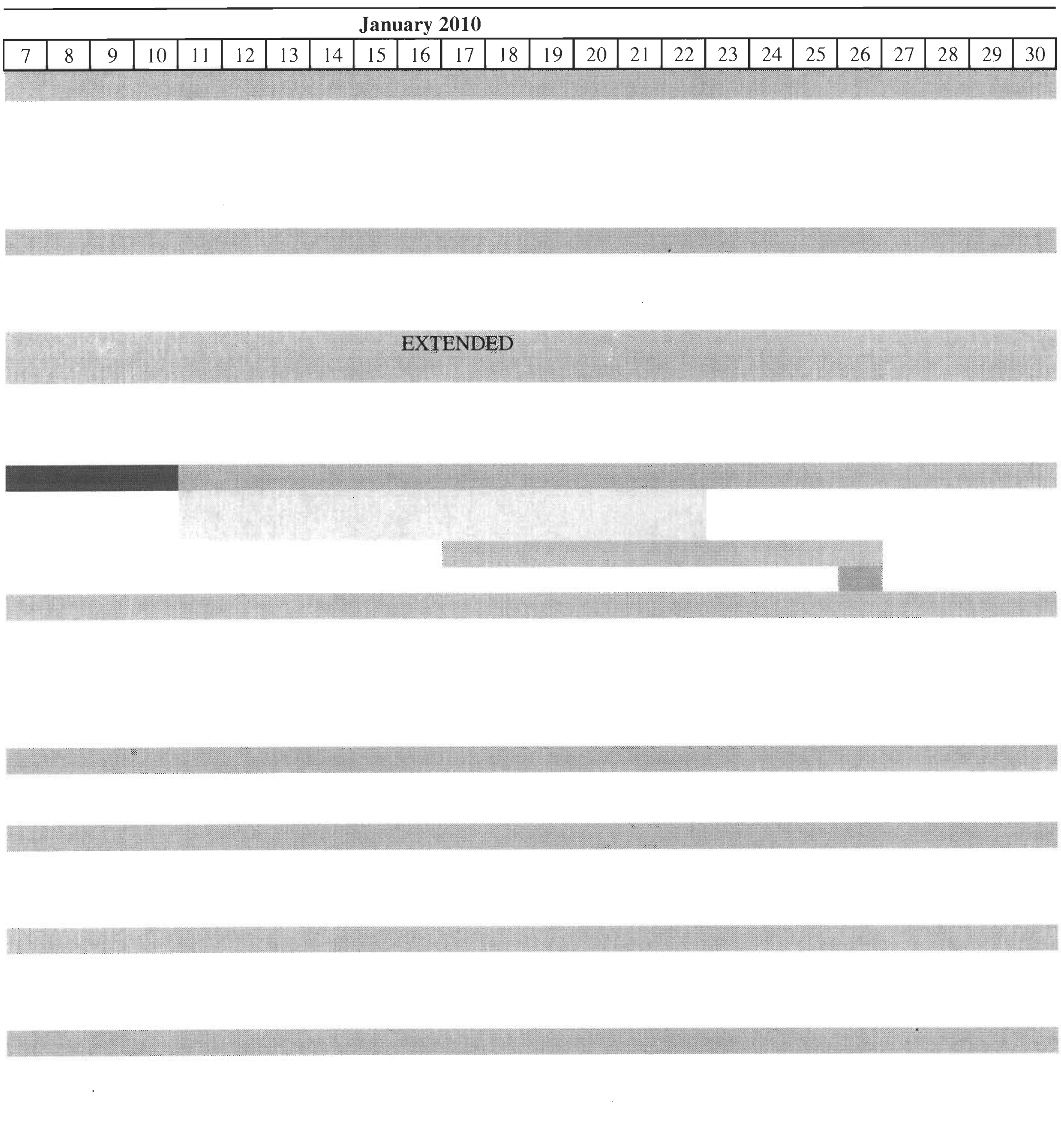
December 2009

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6

ED EXTENDED EXTENDED

EXTENDED EXTENDED

EXAM WEEK CHRISTMAS BREAK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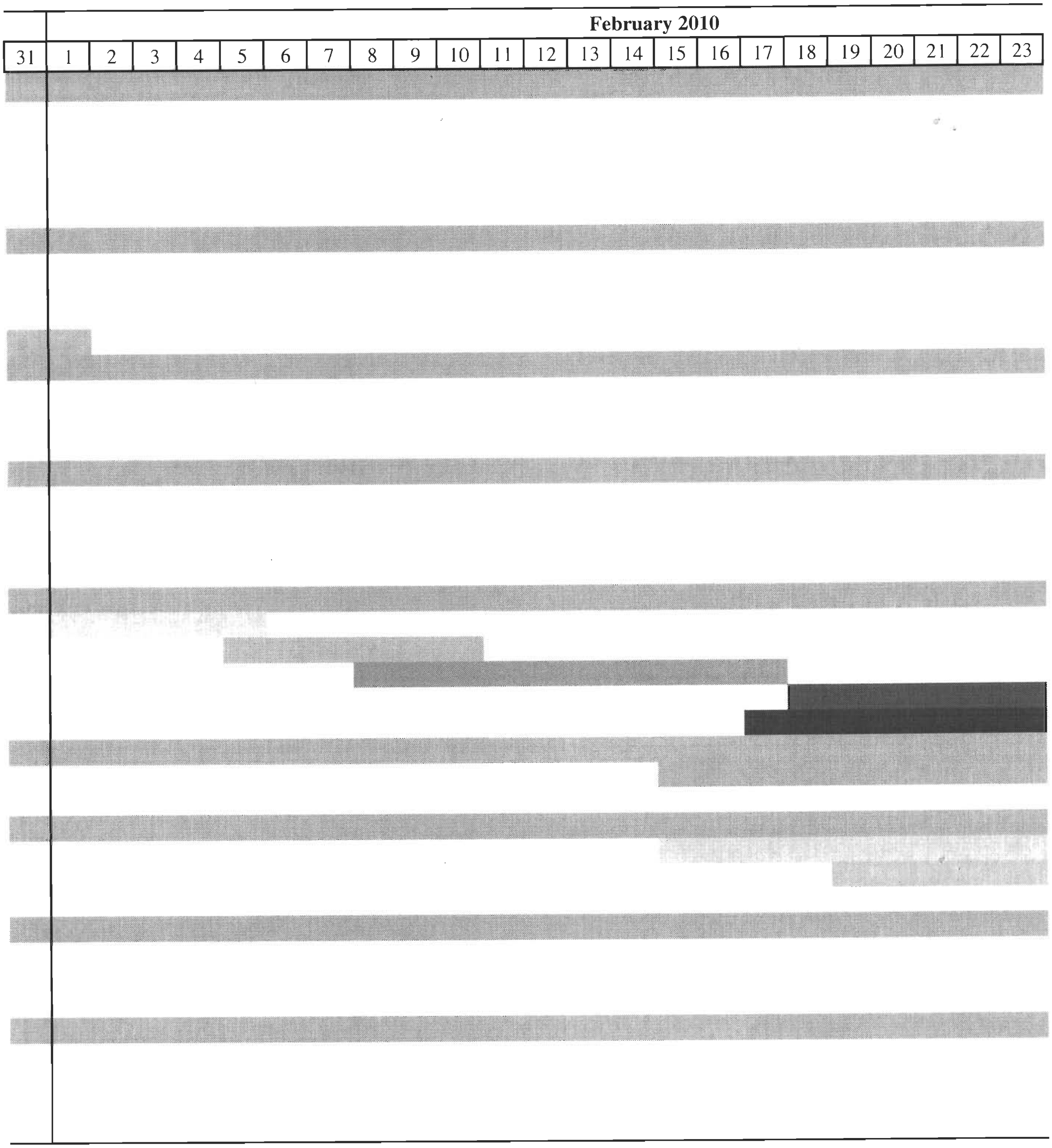
EXTENDED


February 2010
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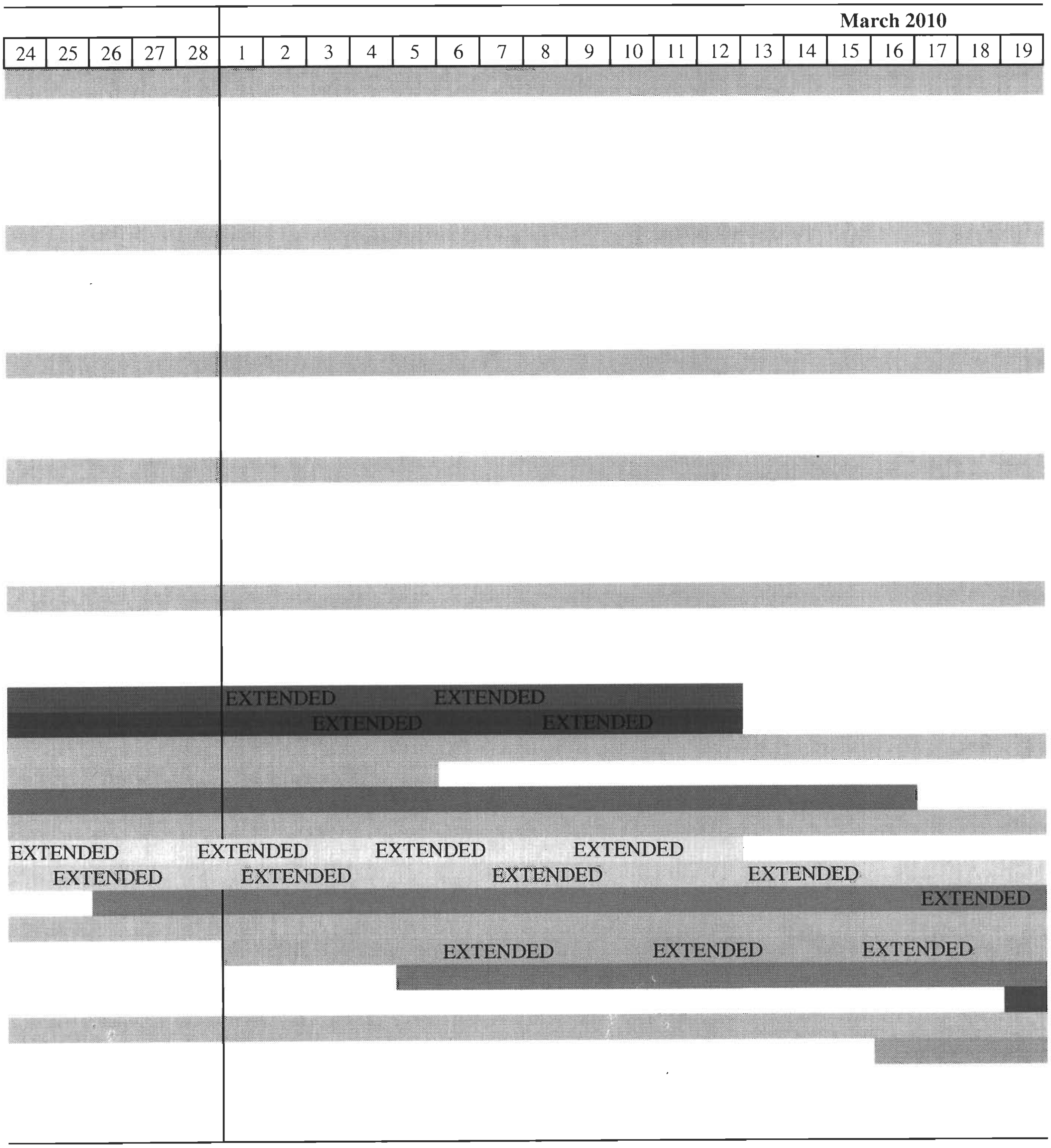

March 2010
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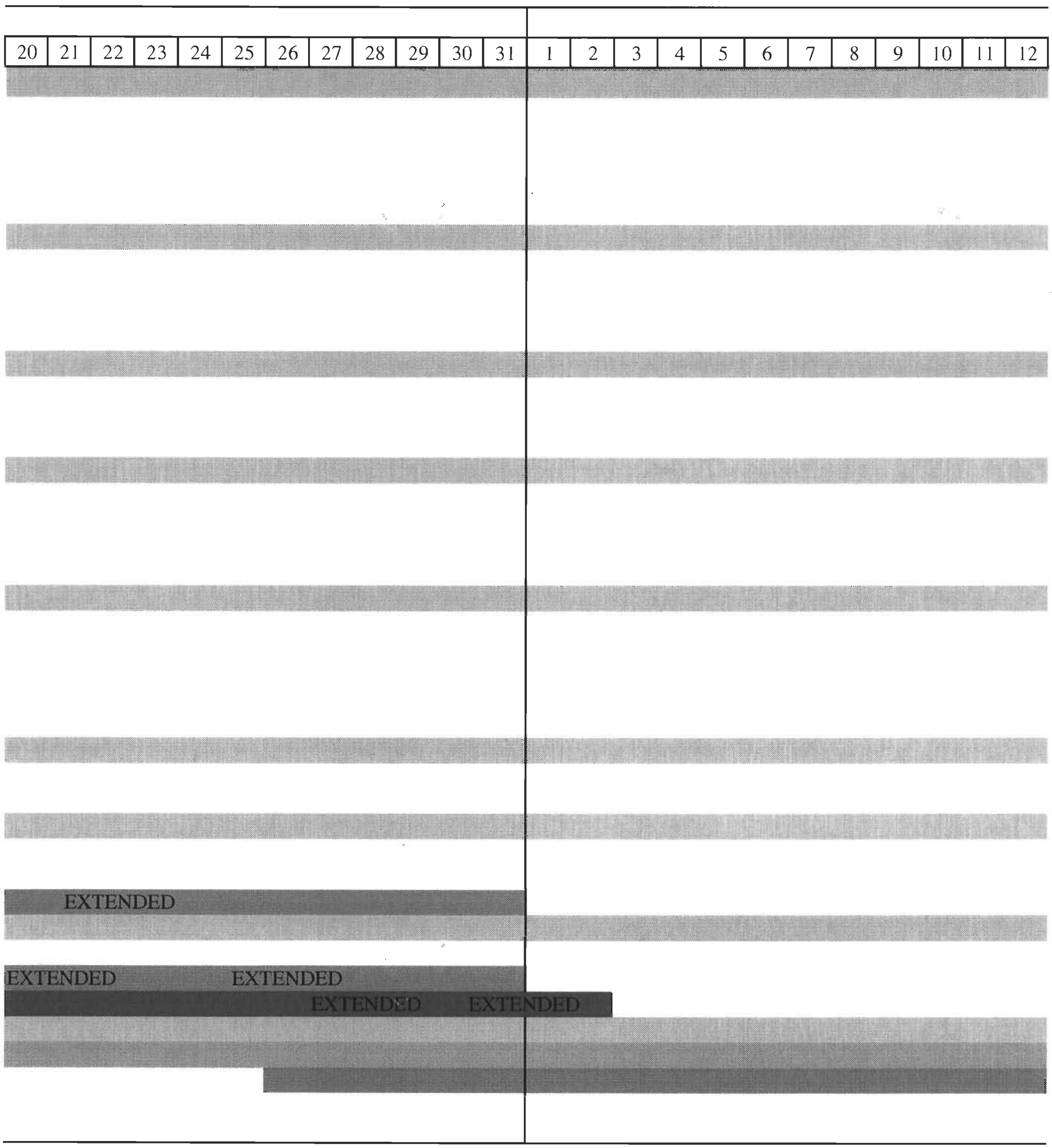
EXTENDED EXTENDED
EXTENDED EXTENDED
EXTENDED EXTENDED EXTENDED EXTENDED
EXTENDED EXTENDED EXTENDED EXTENDED
EXTENDED
EXTENDED EXTENDED EXTENDED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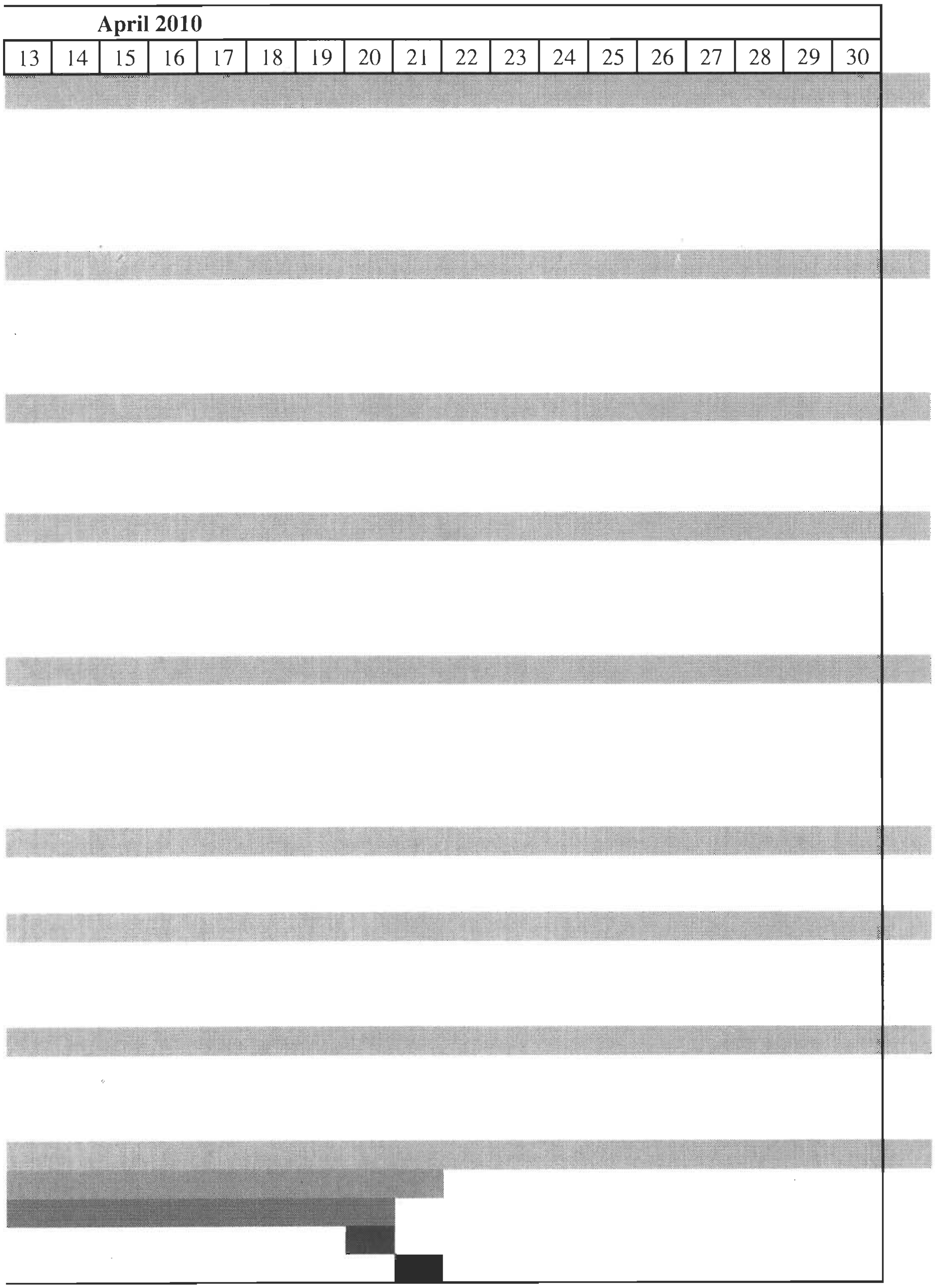
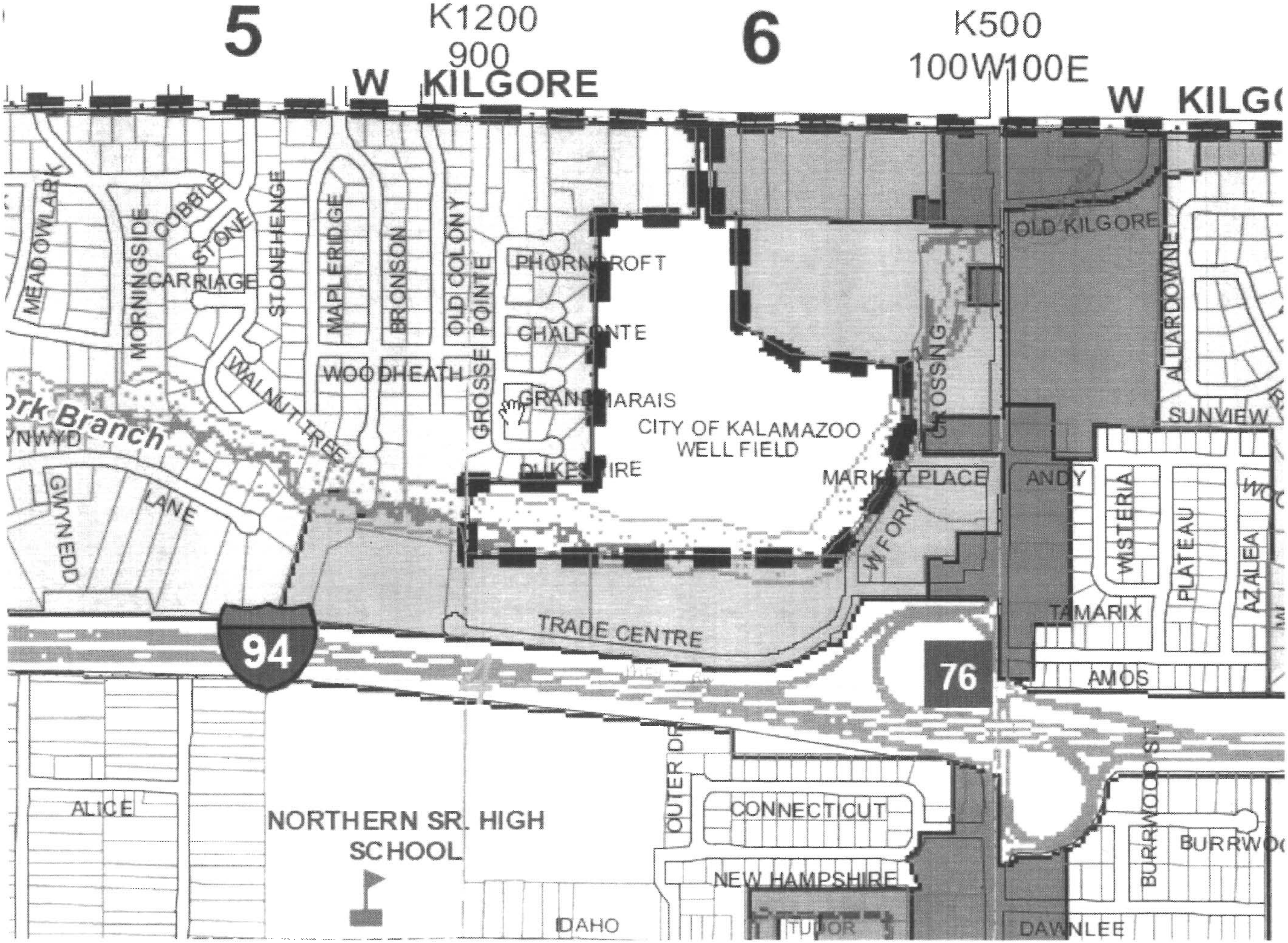
EXTENDED
EXTENDED
EXTENDED
EXTENDED
EXTENDED


April 2010
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Appendix 2


5
K1200
900
W KILGORE
6
K500
100W
100E
W KILG
MEADOWLARK
MORNINGSIDE
COBBLE
STONE
CARRIAGE
STONEHENGE
MAPLERIDGE
BRONSON
OLD COLONY
GROSSE POINTE
WOODHEATH
WALNUT TREE
PHORNCROFT
CHALFONTE
GRAND MARAIS
DUKESHIRE
CITY OF KALAMAZOO
WELL FIELD
CROSSING
MARKET PLACE
W FORK
OLD KILGORE
ALLARDOWNE
SUNVIEW
ANDY
WISTERIA
PLATEAU
AZALEA
TAMARIX
AMOS
GWYNEDD
LANE
TRADE CENTRE
94
76
ALICE
NORTHERN SR. HIGH
SCHOOL
OUTER DR
CONNECTICUT
NEW HAMPSHIRE
IDAHO
TUDOR
BURRWOOD ST
DAWNLEE

t
ourse
tery
tation
/
ark
School
pal
C.
ear Floodplain
ad

- B-1 Local Business
- B-2 Community Business
- B-3 General Business
- CPD Commercial Planned Development
- I-1 Light Industry
- I-2 Heavy Industry
- OS-1 Office Service
- OTR Office Technology and Research
- P-1 Vehicular Parking
- PD Planned Development

- R-1A One
- R-1B One
- R-1C One
- R-1D One
- R-1E Esta
- R-1T Atta
- RM-1 Mu
- RM-2 Mu
- MHC Mol

Appendix 3

U.S. Department of Justice
Civil Rights Division
Disability Rights Section

ADA Design Guide **1**

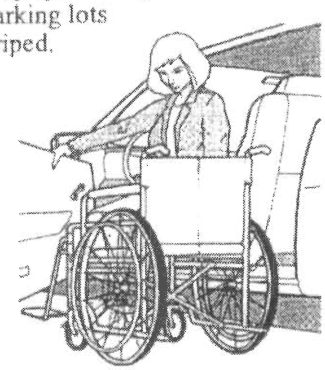
Restriping Parking Lots

Accessible Parking Spaces

When a business, State or local government agency, or other covered entity restripes a parking lot, it must provide accessible parking spaces as required by the ADA Standards for Accessible Design. Failure to do so would violate the ADA.

In addition, businesses or privately owned facilities that provide goods or services to the public have a continuing ADA obligation to remove barriers to access in existing parking lots when it is readily achievable to do so. Because restriping is relatively inexpensive, it is readily achievable in most cases.

This ADA Design Guide provides key information about how to create accessible car and van spaces and how many spaces to provide when parking lots are restriped.



Accessible Parking Spaces for Cars

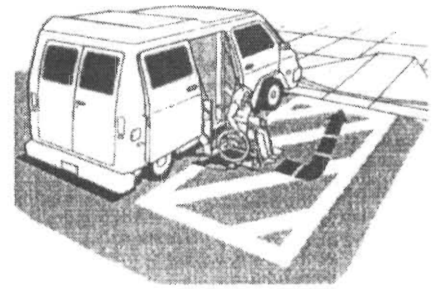
Accessible parking spaces for cars have at least a 60-inch-wide access aisle located adjacent to the designated parking space. The access aisle is just wide enough to permit a person using a wheelchair to enter or exit the car. These parking spaces are identified with a sign and located on level ground.

Van-Accessible Parking Spaces

Van-accessible parking spaces are the same as accessible parking spaces for cars except for three features needed for vans:

- a wider access aisle (96") to accommodate a wheelchair lift;
- vertical clearance to accommodate van height at the van parking space, the adjacent access aisle, and on the vehicular route to and from the van-accessible space, and
- an additional sign that identifies the parking spaces as "van accessible."

One of eight accessible parking spaces, but always at least one, must be van-accessible.



Minimum Number of Accessible Parking Spaces

ADA Standards for Accessible Design 4.1.2 (5)

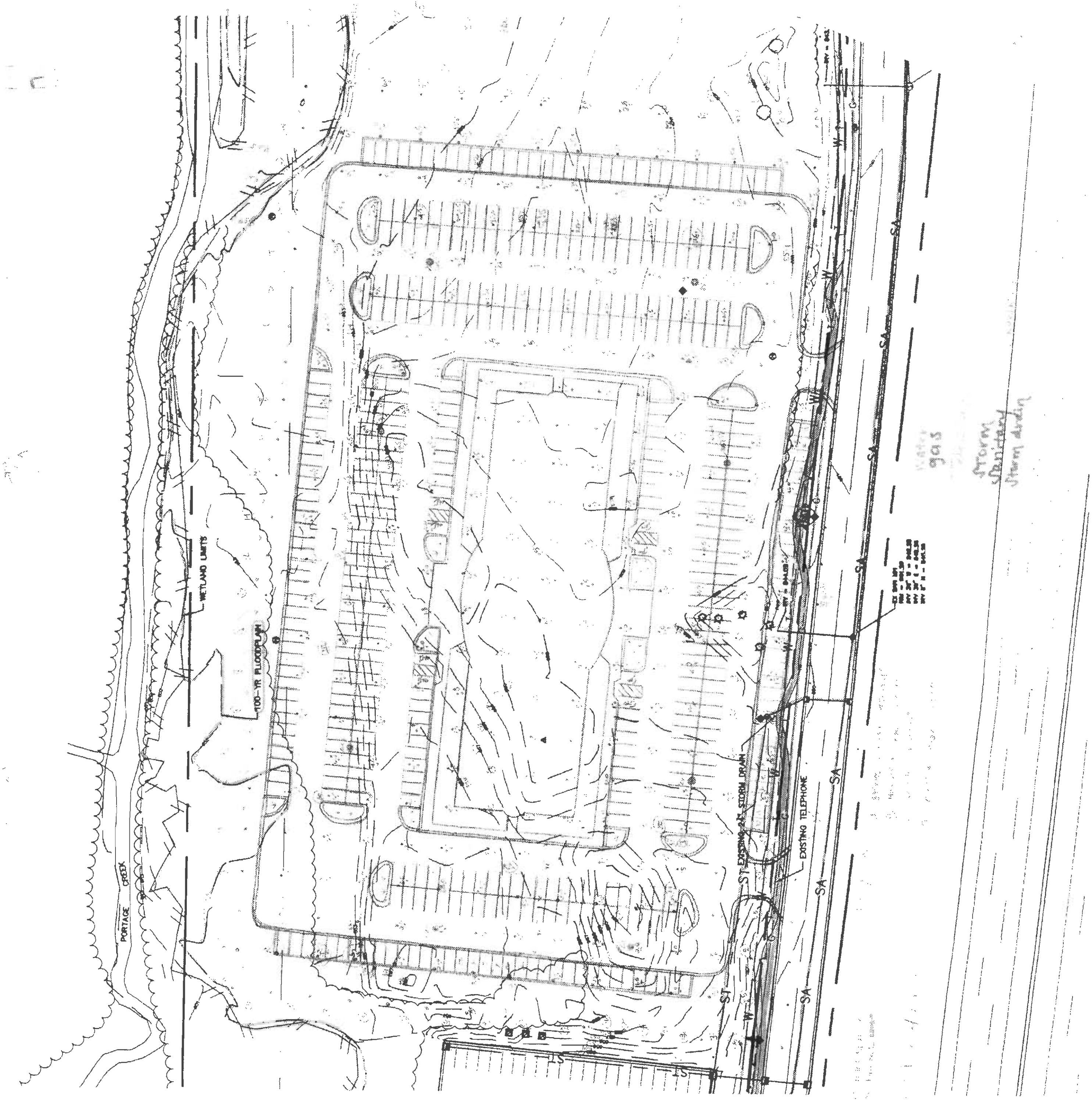
Total Number of Parking spaces Provided (per lot)	Total Minimum Number of Accessible Parking Spaces (60" & 96" aisles)	Van Accessible Parking Spaces with min. 96" wide access aisle	Accessible Parking Spaces with min. 60" wide access aisle
	Column A		
1 to 25	1	1	0
26 to 50	2	1	1
51 to 75	3	1	2
76 to 100	4	1	3
101 to 150	5	1	4
151 to 200	6	1	5
201 to 300	7	1	6
301 to 400	8	1	7
401 to 500	9	2	7
501 to 1000	2% of total parking provided in each lot	1/8 of Column A*	7/8 of Column A**
1001 and over	20 plus 1 for each 100 over 1000	1/8 of Column A*	7/8 of Column A**

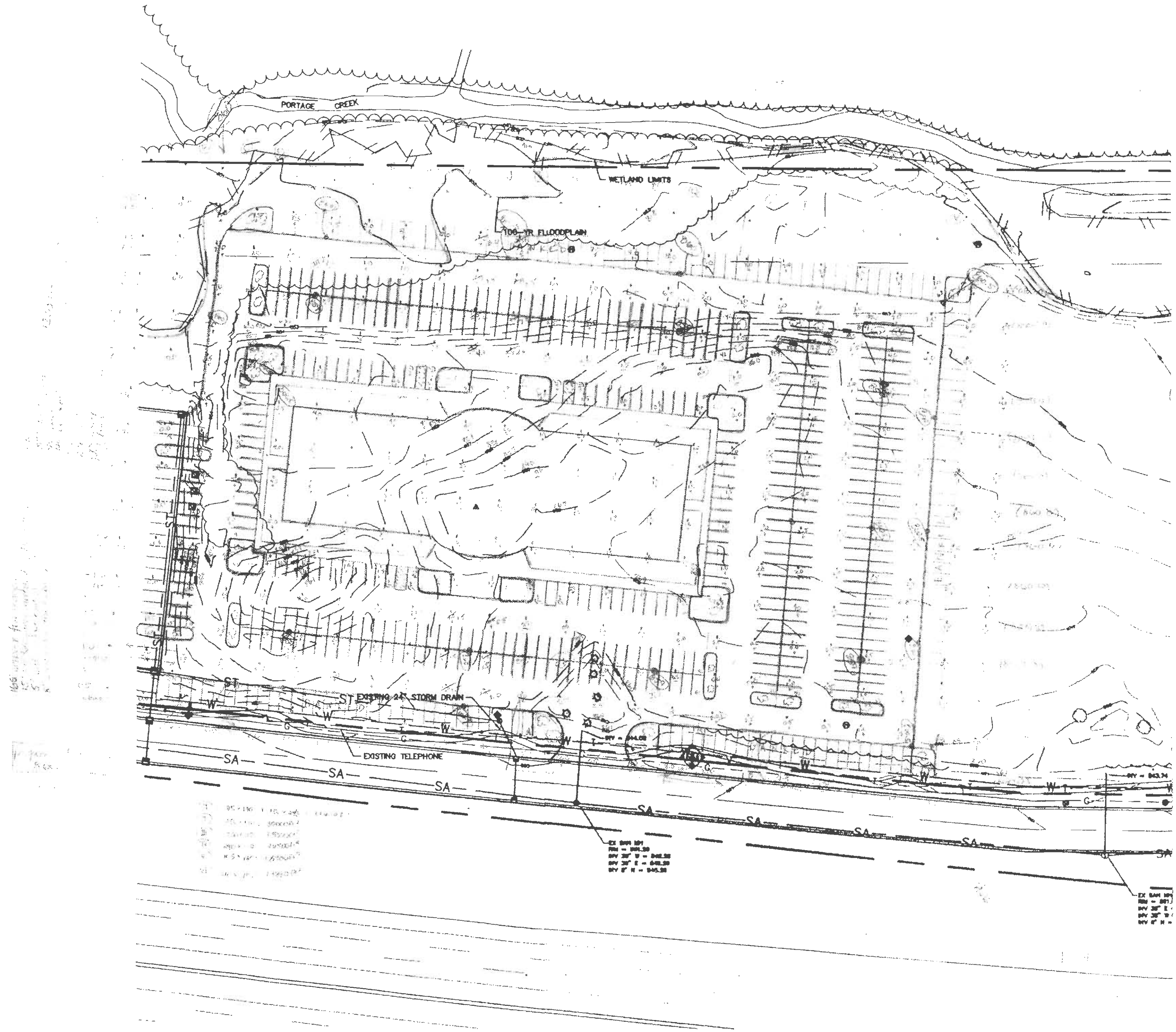
* one out of every 8 accessible spaces ** 7 out of every 8 accessible parking spaces

Existing
Proposed

180 Existing Non Accessible Parking Spaces
4 Existing Accessible Parking Spaces
[illegible]

Appendix 4


PORTAGE CREEK
WETLAND LIMITS
100-YR FLOODPLAIN
EXISTING 24" STORM DRAIN
EXISTING TELEPHONE
water
gas
storm
sanitary
storm drain


PORTAGE CREEK
WETLAND LIMITS
100-YR FLOODPLAIN
EXISTING 24" STORM DRAIN
EXISTING TELEPHONE

Appendix 5

GRADING TOTALS FOR CONNECTED PARKING LOT

Sum of Corner Cuts

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1																							
2		14	28.5	29	29	29.5	30.5	31	30	29	29	29	29	29	29.5	29.5	28	28.5	29	29	29	27	24.5
3		14	27	27	27	27	27	27	27	27	26.5	25.5	24	22	21	20	19	19	20	20.5	22	21.5	21
4		14	26.5	25.5	25.5	25	24.5	23	21	20	19	17.5	15	10.5	7	4.5	3.5	5.5	9	12.5	14.5	15.5	17
5		13.5	22.5	19	19.5	19	19	18.5	17	15	13.5	11	6	1.5	-0.5	-1.5	-1	2	7	10.5	13	14	14.5
6		12.5	19	13.5	14.5	15.5	16.5	17.5	17.5	15.5	12	7	2.5	1	1.5	2	3	5.5	8.5	10.5	12	13	13.5
7		10	17.5	15	15.5	16.5	17.5	17	14.5	11	6.5	3	2	2.5	4	5	5.5	7	9	10	10.5	11	11.5
8		8	17	17.5	17.5	17.5	16	12	7.5	4.5	2.5	2	2.5	4	5.5	6	6.5	8	9.5	10	10	10	10.5
9		7	17	19.5	19	17.5	14.5	10	4	2	2	2.5	4	5.5	6	5.5	6.5	8.5	9.5	10	10	10	10
10		5.5	15	18.5	15.5	11	9.5	9	6	4	3	2.5	4	5	5	4	4.5	6	6.5	7	7	7	6.5
11		5.5	12.5	12	5	0.5	4	7.5	6.5	4	1.5	0.5	1.5	2	2	1.5	1.5	2	2.5	3	3	3	3
12		5	10	8.5	3.5	1.5	5.5	7.5	5.5	2	-1	-1.5	-2.5	-2.5	-1	-0.5	0	0	1	2.5	3	3	3
13		3	8	11	11.5	10.5	9	7	5	2.5	0	-3.5	-7.5	-5.5	-2	-1	0.5	1	1.5	3	4	4	4
14		-1	-0.5	2	3.5	4.5	3.5	1.5	1	0	-1	-3	-6	-5	-4	-4.5	-3	-2	-1.5	-1	-1	-1	-1

GRADING TOTALS FOR UNCONNECTED PARKING LOT

Sum of Corner Cuts

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1																							
2		29	29.5	28	26	25	26	27	27	27	27	27	25.5	24	24	23	23	24	24	23.5	23	24	25.5
3		26.5	26	25.5	23.5	21	19.5	19.5	20	19	17	15	11	8	9	10.5	13	16	17	18.5	19.5	21	23
4		16.5	16.5	17	17.5	17	15	14	13.5	10.5	6	3	0.5	0	2.5	6.5	10.5	12.5	12.5	14	15.5	18.5	21.5
5		7.5	9	12	15	17	16.5	14.5	11	6	2	1	1.5	3.5	6	8.5	10.5	11	11	10.5	13	17	19.5
6		9	10	14	17	16	14.5	10.5	6	3	2	2.5	4	6	7.5	9	10	10	9.5	8.5	11.5	14.5	16
7		10.5	11.5	14.5	15	11	7	4.5	2.5	2	2.5	4	5.5	7	8.5	9.5	10	9.5	7.5	7.5	10.5	13	13.5
8		12	12.5	13.5	12	6.5	2.5	2	2	2.5	4	5.5	6	7	9	10	9.5	8.5	7	7	9.5	12	12
9		10.5	6.5	5.5	9	8.5	5	3.5	3	3.5	5	6	6	6.5	8	9	8.5	7.5	6	6	8	10	10
10		6.5	-4	-1.5	6	8	5.5	4	4	4	4.5	5	5	5	5.5	6	5.5	5	3	3	5.5	8	8
11		7	1	4.5	7	6	3	1.5	2	1.5	1	1	1.5	2	2	2	2	2	1.5	2	4	6	6
12		9	10.5	10.5	8	4.5	1.5	-0.5	-1	-3	-5	-3.5	-1.5	-0.5	0	0	0	0.5	1	1.5	3	4.5	3.5
13		4.5	4.5	4	2	0.5	-0.5	-2.5	-4	-5.5	-7	-5	-3	-2.5	-1.5	-1	-1	-0.5	0	0	0	2	1
14																							

GRADING TOTALS FOR CONNECTED PARKING LOT

Volumes (cu ft)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1																							
2		3150	6413	6525	6525	6638	6863	6975	6750	6525	6525	6525	6525	6525	6638	6638	6300	6413	6525	6525	6525	6075	5513
3		3150	6075	6075	6075	6075	6075	6075	6075	6075	5963	5738	5400	4950	4725	4500	4275	4275	4500	4613	4950	4838	4725
4		3150	5963	5738	5738	5625	5513	5175	4725	4500	4275	3938	3375	2363	1575	1013	788	1238	2025	2813	3263	3488	3825
5		3038	5063	4275	4388	4275	4275	4163	3825	3375	3038	2475	1350	337.5	-113	-338	-225	450	1575	2363	2925	3150	3263
6		2813	4275	3038	3263	3488	3713	3938	3938	3488	2700	1575	562.5	225	338	450	675	1238	1913	2363	2700	2925	3038
7		2250	3938	3375	3488	3713	3938	3825	3263	2475	1463	675	450	562.5	900	1125	1238	1575	2025	2250	2363	2475	2588
8		1800	3825	3938	3938	3938	3600	2700	1688	1013	562.5	450	562.5	900	1238	1350	1463	1800	2138	2250	2250	2250	2363
9		1575	3825	4388	4275	3938	3263	2250	900	450	450	562.5	900	1238	1350	1238	1463	1913	2138	2250	2250	2250	2250
10		1238	3375	4163	3488	2475	2138	2025	1350	900	675	562.5	900	1125	1125	900	1013	1350	1463	1575	1575	1575	1463
11		1238	2813	2700	1125	113	900	1688	1463	900	337.5	112.5	337.5	450	450	337.5	338	450	563	675	675	675	675
12		1125	2250	1913	788	338	1238	1688	1238	450	-225	-338	-563	-563	-225	-113	0	0	225	563	675	675	675
13		675	1800	2475	2588	2363	2025	1575	1125	562.5	0	-788	-1688	-1238	-450	-225	113	225	338	675	900	900	900
14		-225	-113	450	788	1013	788	338	225	0	-225	-675	-1350	-1125	-900	-1013	-675	-450	-338	-225	-225	-225	-225

(Fill) **total volume** **663300** cu ft

24567 cu yd

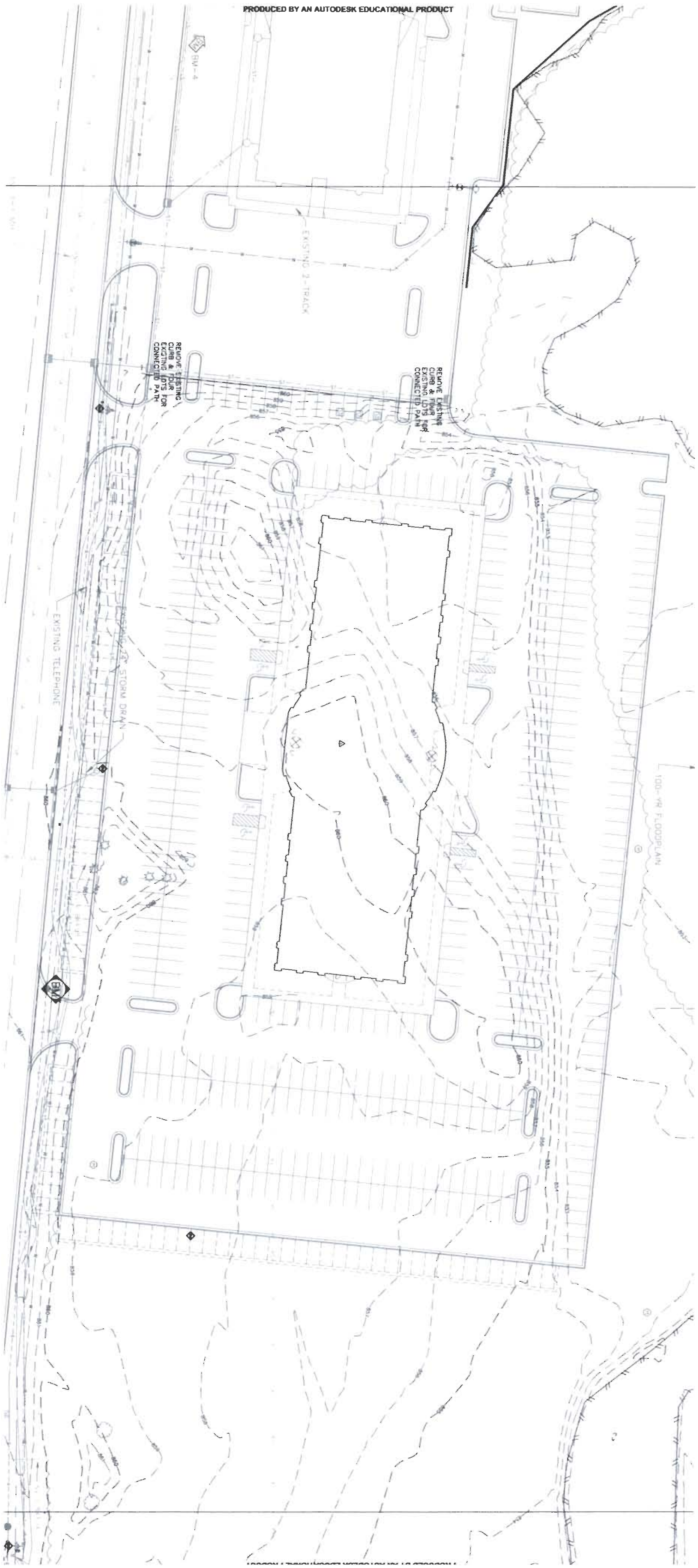
GRADING TOTALS FOR UNCONNECTED PARKING LOT

Volumes (cu ft)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1																							
2		6525	6638	6300	5850	5625	5850	6075	6075	6075	6075	6075	5738	5400	5400	5175	5175	5400	5400	5288	5175	5400	5738
3		5963	5850	5738	5288	4725	4388	4388	4500	4275	3825	3375	2475	1800	2025	2363	2925	3600	3825	4163	4388	4725	5175
4		3713	3713	3825	3938	3825	3375	3150	3038	2363	1350	675	112.5	0	563	1463	2363	2813	2813	3150	3488	4163	4838
5		1688	2025	2700	3375	3825	3713	3263	2475	1350	450	225	337.5	787.5	1350	1913	2363	2475	2475	2363	2925	3825	4388
6		2025	2250	3150	3825	3600	3263	2363	1350	675	450	562.5	900	1350	1688	2025	2250	2250	2138	1913	2588	3263	3600
7		2363	2588	3263	3375	2475	1575	1013	563	450	562.5	900	1238	1575	1913	2138	2250	2138	1688	1688	2363	2925	3038
8		2700	2813	3038	2700	1463	563	450	450	562.5	900	1238	1350	1575	2025	2250	2138	1913	1575	1575	2138	2700	2700
9		2363	1463	1238	2025	1913	1125	788	675	787.5	1125	1350	1350	1463	1800	2025	1913	1688	1350	1350	1800	2250	2250
10		1463	-900	-338	1350	1800	1238	900	900	900	1013	1125	1125	1125	1238	1350	1238	1125	675	675	1238	1800	1800
11		1575	225	1013	1575	1350	675	338	450	337.5	225	225	337.5	450	450	450	450	450	338	450	900	1350	1350
12		2025	2363	2363	1800	1013	338	-113	-225	-675	-1125	-788	-338	-113	0	0	0	113	225	338	675	1013	788
13		1013	1013	900	450	113	-113	-563	-900	-1238	-1575	-1125	-675	-563	-338	-225	-225	-113	0	0	0	450	225
14																							

(Fill) **total volume** **531675** cu ft

Appendix 6


BM-4
EXISTING 2-TRACK
REMOVE EXISTING CURB & FOUR EXISTING LOTS FOR CONNECTED PATH
REMOVE EXISTING CURB & FOUR EXISTING LOTS FOR CONNECTED PATH
EXISTING TELEPHONE
EXISTING STORM DRAIN
100-YR FLOODPLAIN
BM

Appendix 7


REMOVE EXISTING CURB & GUTTER EXISTING LOTS FOR CONNECTED PATH
REMOVE EXISTING CURB & GUTTER EXISTING LOTS FOR CONNECTED PATH
EXISTING 2-TRACK
EXISTING TELEPHONE
WETLAND LIMITS

Appendix 8

JOINT PERMIT APPLICATION

U.S. ARMY CORPS OF ENGINEERS (USACE)	MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY (MDEQ)
Detroit District Office	Land and Water Management Division (LWMD)
Phone: 313-226-2218, Fax: 313-226-6763	Phone: 517-373-9244, Fax: 517-241-9003
Website: www.lre.usace.army.mil	Website: www.michigan.gov/deq

The MDEQ, LWMD, regulates activities under the following Parts of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The regulated activities are summarized in Appendix D. The complete statutes and rules can be downloaded from our website at www.michigan.gov/jointpermit.

• Part 301, Inland Lakes and Streams	• Part 353, Sand Dunes Protection and Management
• Part 303, Wetlands Protection	• Part 323, Shorelands Protection and Management
• Part 325, Great Lakes Submerged Lands	• Part 315, Dam Safety
• Floodplain Regulatory Authority found in Part 31, Water Resources Protection	

The USACE has the authority to regulate activities within the waters of the United States under the following statutes:

• Section 10, Rivers and Harbors Act of 1899 (33 U.S.C. 403)	• Section 404, Clean Water Act of 1977 (33 U.S.C. 1344)

Before you apply, consider an Optional LWMD Pre-application Meeting for files regulated under Parts 301 and 303 available for a fee or in some cases free. For more information go to our website at www.michigan.gov/jointpermit

DIRECTIONS for completing the Joint Permit Application

For additional guidance go to the "Joint Permit Application Training Manual" link or EZ Guides for small projects designed for the average home owner on our website at www.michigan.gov/jointpermit.

Complete all items in Sections 1 through 9 on pages 1 and 2 of the application:

Make sure you:

- ❑ Provide the Township, Range, Section, and Property Tax Identification Numbers required in Section 1.
- ❑ Provide the requested information for all adjacent and impacted property owners in Section 8.
- ❑ Print your name and sign and date your application in Section 9. If applicant is a corporation, include title of authorized representative.
- ❑ Provide a letter of authorization if the legal property owner is not the individual who signs the application. A letter of authorization is a letter from the legal landowner(s) authorizing the applicant or agent to apply for the project. The letter should include the signature from the landowner, the project site address, and a brief project description.

Complete project-specific information:

- ❑ Complete items in Sections 10 through 21 on pages 3 through 7 that apply to your project. Follow the instructions at the beginning of each section. The instructions for each sample drawing in Appendix B indicate the application sections you will most likely need to complete. Utilize the application form as much as possible before adding attachments to save on paper resources and to make the review more efficient.

Provide maps and drawings with adequate detail for review. Refer to Appendix B of the application and/or www.michigan.gov/jointpermit for sample drawings.

- ❑ Vicinity Map:
  - A map to the proposed project location that includes ALL streets, roads, intersections, highways, or cross-roads to the project. Include written directions from a well-known landmark or major intersection. Do not assume field staff knows where your project is.
- ❑ Project Site Plan:
  - Overhead drawings to scale or including dimensions, length and width, of the proposed project are required.

- ☐ Section Views (cross and profile to scale or including dimensions, length, width, and height):
  - Cross sectional drawings of the proposed projects are required.
- ☐ Provide descriptive photographs of the proposed work site showing vegetation if wetlands are involved or the shoreline for shore protection projects. All photographs must be labeled with your name and the date of the photograph, indicate what they show, and be referenced to the site plan. Proposed activities or structure(s) may be indicated directly on the photographs using indelible markers or ink pens. Provide aerial photographs 1:400 or larger for major projects.
- ☐ Provide a reproducible version of maps and drawings if the originals are supplied in color.
- ☐ Elevation data must include a description of the reference point or benchmark used and its corresponding elevation. For projects on the Great Lakes or Section 10 Waters, elevations must be provided in IGLD 85. For observed Great Lake water elevations in IGLD, visit the USACE website under “water levels”. If elevations are from still water, provide the observation date and water elevation. On inland sites, elevations can use NAVD 88, NGVD 29, a local datum or an assumed bench mark. The state building code requires an Elevation Certificate for any building construction or addition in the floodplain. A sample form can be found at www.fema.gov/nfip/elvinst.shtm

Flagging/staking project sites and project impacts:

- ☐ Flag the area for site inspection including the property corners, proposed road or driveway centerlines, and areas of proposed impacts. Site must be flagged at the time the application is submitted. A site visit will not be completed or action taken if the project is not flagged.

To prevent processing delays, make sure all the following items are mailed to the LWMD at the address below, label each attachment with applicant's name and date:

- ☐ Pages 1 and 2 of the application.
- ☐ Pages 3 through 7, as applicable, of the application. Do not submit blank application pages. Submit only those pages where you have provided information.
- ☐ The Site Location Map, Overall Site Plan, Plan View and Cross-Section Drawings, Photographs, and additional information sheets on 8.5” x 11”, 8.5” x 14”, or 11” x 17” paper suitable for photocopying for public notice purposes. Aerial photographs do not substitute for site plans. If larger drawings or blueprints are required to show adequate detail for review, you may also submit 2 full size copies. The USACE requires one set of drawings on 8.5” x 11” paper, with all notations clearly legible. Larger supplemental drawings may be submitted, as well.
- ☐ An authorization letter from the property owner if someone other than the property owner is signing the application.
- ☐ A check made payable to the **State of Michigan**. Fees typically range from $50.00 to $4,000.00 depending on the type of project. Refer to Appendix C of the application and/or visit our website at http://www.michigan.gov/jointpermit to determine the appropriate fee for your project and to download a form for credit card or electronic transfer payment.

- ☐ Mail to:

  MDEQ
  LWMD-PCU
  P.O. BOX 30204
  LANSING, MI 48909-7704

  DEQ-LWM-PCU@michigan.gov

- ☐ Public Agencies eligible to receive federal and/or state transportation funding for a project involving public roadways, non-motorized paths, airports, or related facilities, do not require an application fee and should submit applications to:

  MDEQ
  LWMD-TFHU
  P.O. Box 30458
  Lansing, MI 48909-7958

APPENDICES

Appendix A: Acronyms and Abbreviations ... A-1
Appendix B: General Instructions for All Drawings and Sample Drawings
1. General Instructions for all Drawings and Sample Site Location Maps ... B-1
2. Inland Lake Shore Protection ... B-2
3. Bulkhead/Seawall ... B-2
4. Pond Construction ... B-3
5. Floodplain Fill ... B-3
6. Wetland Boardwalk ... B-4
7. Dredging Project ... B-4
8. Driveway Across Wetland ... B-5
9. Residential Wetland Fill and Boardwalk Construction ... B-5
10. Docks - Piers - Mooring Piles ... B-6
11. Beach Sanding ... B-6
12. Pipe/Utility Crossings in a Trench ... B-7
13. Pipe/Utility Crossings using Directional Bore ... B-7
14. Bridge or Culvert (4 drawings) ... B-8
15. Dam Construction ... B-12
16. Water Intake ... B-12
17. Great Lakes Shore Protection ... B-13
18. Maintenance Dredge Channel ... B-13
19. Proposed Residence in a High Risk Erosion Area ... B-14
20. Proposed Residence in a Critical Dune Area ... B-14
21. Marina Site Plan ... B-15
22. Outlet Pipe ... B-16
23. Temporary Logging Road Crossing ... B-16

Appendix C: State Fees, Federal Fees, Minor Permit and General Permit for Minor Activities Categories ... C-1
Appendix D: State Authority, Federal Authority, Privacy Act Statement, and State and Federal Penalties ... D-1
Appendix E: Glossary (listed words are italicized in the application package) ... E-1

Application status can be viewed on the MDEQ website at www.deq.state.mi.us/CIWPIS. During the application period, if any information is missing from the application or if any clarification is needed regarding materials provided, the application is incomplete and MDEQ staff will request the information from the applicant/agent by letter, email, fax or phone call. Once the MDEQ/LWMD has received the information necessary for review of the project, including a thoroughly completed application, consistent drawings that have adequate detail for review and the full application fee, the file will be reviewed for final processing. A mailed postcard or a public notice will provide the file number and the telephone number of the office where the application is being processed. The review time to determine if an application is complete for processing ranges from 15 to 30 days. Technical processing times, after the application is administratively complete, may range from 60 to 90 days. Processing times will be longer if a public hearing is held. A LWMD staff person from your local District/Field Office may visit the project site and may request additional information prior to a decision on the permit. Application fees are not refundable or transferable.

If a federal permit will also be required, a copy of the permit application will be sent to the Detroit District Office, USACE, for processing at the federal level. Additional copies of this application form can be downloaded from the MDEQ website at www.michigan.gov/jointpermit or can be photocopied from the original. If you have any questions about the permitting process or if you need to modify your application, you can contact the LWMD by phone, fax, at the addresses on the previous page, or email at DEQ-LWM-PCU@michigan.gov.

US Army Corps of Engineers (USACE) | Michigan Department of Environmental Quality (MDEQ) DEQ

AGENCY USE			
Previous USACE Permit or File Number	Date Received	Land and Water Management Division, MDEQ File Number	AGENCY USE
USACE File Number		Pre-application Number or Marina Operating Permit Number	
District Office		Fee received $	

Read Instructions pages i - iii. All of the following boxes below must be checked and information provided for the application to be processed:

- ☐ **All items in Sections 1 through 9 are completed**
- ☐ **Items in Sections 10 through 21 that apply to the project are completed**
- ☐ **Dimensions, volumes, and calculations are provided**
- ☐ **Date project was staked** ____________
- ☐ **Application fee is attached**
- ☐ **All requested supplementary attachments (➡) are included**
- ☐ **Reproducible location map, site plan(s), cross sections, and photographs are provided, one set must be black and white on 8 ½ by 11 inch paper.**
- ☐ **List any additional attachments, tables, etc.:** ____________

PROJECT LOCATION INFORMATION

Refer to your property's legal description for the Township, Range, and Section information, and your property tax bill for your Property Tax Identification Number(s).

Site Location Address (road, if no street address): 550 Trade Center Way	Zip Code: 49002	Township Name(s)	Township(s)	Range(s)	Section(s)
City/Village: Portage	County(ies): Kalamazoo	Property Tax Identification Number(s)			
Name of Waterbody	Project Name or Job Number: Trade Center Building 3	Subdivision/Plat	Lot Number	Private Claim	

Project types (check all that apply): ☑ private ☐ public/government ☐ industrial ☐ commercial ☐ multi-family ☐ building addition ☑ new building or structure ☐ building renovation or restoration ☐ river restoration ☐ single-family ☐ project is receiving federal transportation funds ☐ other (explain)

The proposed project is on, within, or involves (check all that apply):

☐ a stream ☐ a pond (less than 5 acres) ☐ a river ☐ a channel/canal ☐ a ditch or drain ☐ an inland lake (5 acres or more) ☐ a floodway area ☐ a 100-year floodplain ☐ a legally established County Drain (date established) (M/D/Y) ________ ☐ a Great Lake or Section 10 Waters ☐ a designated high risk erosion area ☐ a designated critical dune area ☐ a designated environmental area ☐ a natural river ☐ a dam ☐ a wetland ☐ 500 feet of an existing waterbody ☐ a new marina ☐ a structure removal ☐ a utility crossing

DESCRIBE PROPOSED PROJECT AND ASSOCIATED ACTIVITIES, and THE CONSTRUCTION SEQUENCE AND METHODS (attached additional sheets)

Written Summary of All Proposed Activities. Construction of (4) Story Class A Office Building - 111,705 ft² - surrounding parking & landscaping included

Construction Sequence and Methods. ____________

APPLICANT, AGENT/CONTRACTOR, and PROPERTY OWNER INFORMATION

Owner/Applicant (individual or corporate name)	Agent/Contractor (firm name and contact person) Britney Richmond
Mailing Address	Address 4601 Campus Drive
City State Zip Code	City Kalamazoo State MI Zip Code 49008
Daytime Phone Number with Area Code Cell Phone Number	Daytime Phone Number with Area Code Cell Phone Number
Fax E-mail	Fax E-mail

☑ No ☐ Yes Is the applicant the sole owner of all property on which this project is to be constructed and all property involved or impacted by this project?
➡ If no, attach letter(s) of authorization from all owners. A letter signed by each property owner authorizing the agent/contractor/other owner to act on his or her behalf or a copy of easements or right-of-ways must be provided. If multiple property owners, also attach a list of all owners along with their names, mailing addresses, and telephone numbers. If the applicant is a corporation, a corporate officer must provide written document authorizing any agent/contractor listed above to act on its behalf.
A letter of authorization must be provided from an owner receiving dredge spoils on their property, or where access through their property is required..

Property Owner's Name (If different from applicant)	Mailing Address
Daytime Phone Number with Area Code Cell Phone Number	City State Zip Code

☐ No ☐ Yes Is there a MDEQ conservation easement or other easement, deed restriction, lease, or other encumbrance upon the property in the project area?
➡ If yes, attach a copy.

PROPOSED PROJECT PURPOSE, INTENDED USE, and ALTERNATIVES CONSIDERED (Attach additional sheets if necessary)

urpose/Intended Use: The purpose must include any new development or expansion of an existing land use.

Class A Office building to serve as office space for companies in Portage area.

lternatives: Include a description of alternatives considered to avoid or minimize resource impacts. Include factors such as, but not limited to, alternative construction chnologies; alternative project layout and design; and alternative locations. For utility crossings, include both alternative routes and alternative construction methods.

LOCATING YOUR PROJECT SITE

Attach a black and white, legible copy of a map that clearly shows the site location and road from the nearest major intersection, and includes a north arrow.

there an access road to the project? ☐ No ☑ Yes (If Yes, type of road, check all that apply) ☐ private ☐ public ☐ improved ☐ unimproved

ame of roads at closest main intersection Westnedge Ave and Trade Center Way

rections from main intersection Proceed down Trade Center Way and turn right at the first driveway

yle of house or other building on site ☐ ranch ☐ 2-story ☐ cape cod ☐ bi-level ☐ cottage/cabin ☐ pole barn ☐ none ☐ other (describe) ______

olor ______ Color of adjacent property house and/or buildings ______ House number ______ Street name ______

re lane number Lot number Address is visible on ☐ house ☐ garage ☐ mailbox ☐ sign ☐ other (describe) ______

ow can your site be identified if there is no visible address? ______

ovide directions to the project site, with distances from the best and nearest visible landmark and waterbody ______

oes the project cross the boundaries of two or more political jurisdictions? (City/Township, Township/Township, County/County, etc.)

☐ No ☐ Yes ➡ If Yes, list jurisdictions: ______

List all other federal, interstate, state, or local agency authorizations required for the proposed activity, including all approvals or denials received.

Agency	Type approval	Identification number	Date applied	Date approved / denied	If denied, reason for denial

COMPLIANCE

a permit is issued, date activity will commence (M/D/Y) | Proposed completion date (M/D/Y)

as any construction activity commenced or been completed in a regulated area? ☑ No ☐ Yes
If Yes, identify the portion(s) underway or completed on drawings or ach project specifications and give completion date(s) (M/D/Y)

Were the regulated activities conducted under a MDEQ permit? ☐ No ☐ Yes
If Yes, list the MDEQ permit number ______

e you aware of any unresolved violations of environmental law or litigation involving the property? ☐ No ☐ Yes (If Yes, explain)

ADJACENT/RIPARIAN AND IMPACTED OWNERS (Attach additional sheets if necessary)

Complete information for all adjacent and impacted property owners and the lake association or established lake board, including the contact person's name. If you own the adjacent lot, provide the requested information for the first adjacent parcel that is not owned by you.

operty Owner's Name	Mailing Address	City	State	Zip Code

ame of ☐ Established Lake Board or ☐ Lake Association

ontact Person's name, phone number, and mailing address ______

APPLICANT'S CERTIFICATION **READ CAREFULLY BEFORE SIGNING**

m applying for a permit(s) to authorize the activities described herein. I certify that I am familiar with the information contained in this application; that it is true and curate; and, to the best of my knowledge, that it is in compliance with the State Coastal Zone Management Program. I understand that there are penalties for submitting se information and that any permit issued pursuant to this application may be revoked if information on this application is untrue. I certify that I have the authority to dertake the activities proposed in this application. By signing this application, I agree to allow representatives of the MDEQ, USACE, and/or their agents or contractors to ter upon said property in order to inspect the proposed activity site and the completed project. I understand that I must obtain all other necessary local, county, state, or deral permits and that the granting of other permits by local, county, state, or federal agencies does not release me from the requirements of obtaining the permit quested herein before commencing the activity. I understand that the payment of the application fee does not guarantee the issuance of a permit.

] Property Owner] Agent/Contractor] Corporation/Public Agency – Title	Printed Name	Signature	Date (M/D/Y)

PROJECTS IMPACTING WETLANDS OR FLOODPLAINS OR LOCATED ON AN INLAND LAKE OR STREAM OR A GREAT LAKE

- Check boxes A through M that may be applicable to your project and provide all the requested information.
- If your project may affect wetlands, also complete Section 12. If your project may impact regulated floodplains, also complete Section 13.
- To calculate volume in cubic yards (cu yd), multiply the average length in feet (ft) times the average width (ft) times the average depth (ft) and divide by 27.
- Some projects on the Great Lakes require an application for conveyance prior to Joint Permit Application completeness.

➡Provide a cross-section and overall site plan showing existing lakes, streams, wetlands, and other water features; existing structures; and the location of all proposed structures, land change activities and soil erosion and sedimentation control measures. Review Appendix B and EZ Guides for completing site-specific drawings.

➡Provide tables for multiple impact areas or multiple activities and provide fill and excavation/dredge calculations.

Water Level Elevation

On a Great Lake use IGLD 85 ☐ surveyed ☐ converted from observed still water elevation. On inland waters ☐ NGVD 29 ☐ NAVD 88 ☐ other ______

Observed water elevation (ft) ______ date of observation (M/D/Y) ______

A. PROJECTS REQUIRING FILL (See All Sample Drawings)

- Attach both overall site plan and cross-section views to scale showing maximum and average fill dimensions.

(Check all that apply) ☑ floodplain fill ☐ wetland fill ☐ riprap ☐ seawall, bulkhead, or revetment ☐ bridge or culvert
☐ boat launch ☐ off-shore swim area ☐ beach sanding ☐ boatwell ☐ crib dock ☐ other ______

Fill dimensions (ft) length width maximum depth | Total fill volume (cu yd) 29 yd³ | Maximum water depth in fill area (ft) ~1 ft

Type of clean fill ☐ pea stone ☑ sand ☐ gravel ☐ wood chips ☐ other ______ | Will filter fabric be used under proposed fill? ☑ No ☐ Yes (If Yes, type) ______

Source of clean fill ☐ on-site, ➡If on-site, show location on site plan. ☐ commercial ☐ other ➡If other, attach description of location.

Fill will extend ______ feet into the water from the shoreline and upland ______ feet out of the water. | Fill volume below OHWM (cu yd) ______

B. PROJECTS REQUIRING DREDGING OR EXCAVATION (For dredging projects see Sample Drawing 7, for excavation see other applicable Sample Drawings)

- Attach both overall site plan and cross-section views to scale showing maximum and average dredge or excavation dimensions and dredge disposal location.
- Refer to www.michigan.gov/jointpermit for disposal requirements and authorization.

(Check all that apply) ☐ floodplain excavation ☐ wetland dredge or draining ☐ seawall, bulkhead, or revetment
☐ navigation ☐ boat well ☐ boat launch ☐ other ______

Total dredge/excavation volume (cu yd) | Dimensions length width depth | Dredge/excavation volume below OHWM (cu yd) | Method and equipment for dredging

Has proposed dredge material been tested for contaminants? ☐ No ☐ Yes
➡If Yes, provide test results with a map of sampling locations.

Dredged or excavated spoils will be placed ☐ on-site ☐ off-site.
➡Provide detailed disposal area site plan and location map.
➡Provide letter of authorization from owner if disposing of spoils off site.

Has this same area been previously dredged? ☐ No ☐ Yes If Yes, date and permit number: ______
If Yes, are you proposing to enlarge the previously dredged area? ☐ No ☐ Yes

Is long-term maintenance dredging planned? ☐ No ☐ Yes If Yes, when and how much? ______

C. PROJECTS REQUIRING RIPRAP (See Sample Drawings 2, 3, 8, 12, 14, 17, 22, and 23. Others may apply)

Riprap waterward of the ☐ shoreline OR ☐ ordinary high water mark | Dimensions (ft) length width depth | Volume(cu yd)

Riprap landward of the ☐ shoreline OR ☐ ordinary high water mark | Dimensions (ft) length width depth | Volume(cu yd)

Type of riprap ☐ field stone ☐ angular rock ☐ other ______ | Will filter fabric be used under proposed riprap? ☐ No ☐ Yes (If Yes, type) ______

D. SHORE PROTECTION PROJECTS (See Sample Drawings 2, 3, and 17) Complete Sections 10A, B, and/or C above, as applicable.

(check all that apply) ☐ riprap – length (ft) ______ ☐ seawall/bulkhead – length (ft) ______ ☐ revetment – length (ft) ______ | Distances of project from both property lines (ft) ______

E. DOCK - PIER – MOORING PILINGS – ROOFS (See Sample Drawing 10)

Dock Type ☐ open pile ☐ filled ☐ crib
Seasonal support structure? ☐ No ☐ Yes

Permanent Roof? ☐ No ☐ Yes Mounted on ______
Maximum Dimensions: length width height

Proposed structure dimensions (ft) length width | Dimensions of nearest adjacent structures (ft) length width

F. BOAT WELL (See EZ Guides)

Type of sidewall stabilization ☐ wood ☐ steel ☐ concrete ☐ vinyl ☐ riprap ☐ other ______

Boat well dimensions (ft) length width depth | Number of boats

Volume of backfill behind sidewall stabilization (cu yd) | Distances of boat well from adjacent property lines (ft)

G. BOAT LAUNCH (See EZ Guide) (check all that apply) ☐ new ☐ existing ☐ public ☐ private ☐ commercial ☐ replacement

Proposed overall boat launch dimensions (ft) length width depth | Type of material ☐ concrete ☐ wood ☐ stone ☐ other ______

Existing overall boat launch dimensions (ft) length width depth | Boat launch dimensions (ft) below ordinary high water mark length width depth

Distances of launch from both property lines (ft) | Number of adjacent Skid piers | Skid pier dimensions (ft) length width

H. BOAT HOIST (See EZ Guide)

(Check all that apply) ☐ seasonal ☐ permanent ☐ cradle ☐ side lifter ☐ other ______ | located on ☐ seawall ☐ dock ☐ bottomlands

Continued – Projects Impacting Wetlands or Floodplains or Located on an Inland Lake or Stream or a Great Lake

I. BOARDWALKS AND DECKS IN ☐ WETLANDS - OR - ☐ FLOODPLAINS (See Sample Drawings 5 and 6. Provide table if necessary)

Boardwalk ☐ on pilings ☐ on fill | Dimensions (ft) length width | Deck ☐ on pilings ☐ on fill | Dimensions (ft) length width

J. INTAKE PIPES (See Sample Drawing 16) ☐ **OUTLET PIPES** (See Sample Drawing 22)

Type ☐ headwall ☐ end section ☐ pipe ☐ other ______________

If outlet pipe, discharge is to ☐ wetland ☐ inland lake ☐ stream, drain, or river ☐ Great Lake ☐ other ______________

Dimensions of headwall OR end section (ft) length width depth | Number of pipes | Pipe diameters and invert elevations

K. MOORING AND NAVIGATION BUOYS (See EZ Guide for Sample Drawing)

➡Provide an overall site plan showing the distances between each buoy, distances from the shore to each buoy, and depth of water at each buoy in feet.
➡Provide cross-section drawing(s) showing anchoring system(s) and dimensions.

Number of buoys | Boat Lengths | Type of anchor system | Purpose of buoy ☐ mooring ☐ navigation ☐ swimming

Dimensions of buoys (ft) width height swing radius chain length

Do you own the property along the shoreline? ☐ No ☐ Yes
➡Attach Authorization Letter from the property owner(s), if No above.

L. FENCES IN WETLANDS, STREAMS, OR FLOODPLAINS (No Sample Drawing available)

- Provide an overall site plan showing the proposed fencing through wetlands, streams, or floodplains.
- Provide drawing of fence profile showing the design, dimension, post spacing, board spacing, and distance from ground to bottom of fence.

(check all that apply) ☐ wetlands ☐ streams ☐ floodplains | Total length (ft) of fence through wetlands________ streams _______ floodplains ____ | Fence height (ft) | Fence type and material

M. OTHER - e.g., structure removal or construction, breakwater, aerator, fish shelter, and structural foundations in wetlands or floodplains
Structure description: ____

EXPANSION OF AN EXISTING OR CONSTRUCTION OF A NEW LAKE OR POND (See Sample Drawings 4 and 15)

Which best describes your proposed waterbody use (check all that apply)
☐ wildlife ☐ stormwater retention basin ☐ recreation ☐ wastewater basin ☐ other ______________

Water source for lake/pond
☐ groundwater ☐ natural springs ☐ Inland Lake or Stream ☐ stormwater runoff ☐ pump ☐ sewage ☐ other ______________

Location of the lake/basin/pond ☐ floodplain ☐ wetland ☐ upland

Maximum dimensions (ft) length width depth

Maximum Area: ☐ acres ☐ sq ft ____________

Spoils will be placed ☐ onsite ☐ offsite outside of wetland and floodplain ☐ other ____________
➡ Provide a Detailed Disposal Area Site Plan with location map, address, and disposal dimensions.
➡ Provide a Letter of Authorization from off site disposal site owner.
➡ Provide elevations and cross sections of outlets and/or emergency. Complete Section 10J.

Will project involve construction of a dam, dike, outlet control structure, or spillway? ☐ No ☐ Yes (If Yes, complete Section 17)

ACTIVITIES THAT MAY IMPACT WETLANDS (See Sample Drawings 8 & 9, and complete sections 10A and 10B for fill, dredge or excavation as applicable)

- For information on the MDEQ's Wetland Identification Program (WIP) visit www.michigan.gov/deqwetlands or call 517-373-1170.
- Complete the wetland dredge and wetland fill dimension information below for each impacted wetland area. ➡Attach tables for multiple impact areas or activities
- Label the impacted wetland areas on a site plan, drawn to scale or with dimensions. ➡ Attach at least one cross-section for each wetland dredge and/or fill area.
- If dredge/excavation material will be disposed of on site, show the location on site plan and include soil erosion and sedimentation control measures.

(check all that apply) ☐ fill (Section 10A) ☐ dredge or excavation (Section 10B) ☐ boardwalk or deck (Section 10I) ☐ dewatering ☐ fences (Section 10L) ☐ bridges and culverts (Section 14) ☐ draining surface water ☐ stormwater discharge ☐ restoration ☐ other ________

Wetland dredge/excavation dimensions maximum length (ft) maximum width (ft) | dredge/excavation area ☐ acres ☐ sq ft | average depth (ft) | dredge volume (cu yd)

Wetland fill dimensions maximum length (ft) maximum width (ft) | fill area ☐ acres ☐ sq ft | average depth (ft) | fill volume (cu yd)

Total wetland dredge/excavation area ☐ acres ☐ sq ft ________ | Total wetland dredge/excavation volume (cu yd) | Total wetland fill area ☐ acres ☐ sq ft | Total wetland fill volume (cu yd)

The proposed project will be serviced by: ☐ public sewer ☐ private septic system ➡ Show system on plans | If septic system, has an application for a permit been made to the County Health Department? ☐ No ☐Yes | If Yes, has a permit been issued? ☐ No ☐ Yes ➡ Provide a copy.

Has a professional wetland delineation been conducted for this parcel? ☐ No ☐ Yes
➡ Provide a copy of the delineation. ➡Supply data sheets.

Applicant purchased property ☐ before OR ☐ after October 1, 1980.

Is there a recorded MDEQ easement on the property? ☐ No ☐ Yes If Yes, provide the easement number ______________

Has the MDEQ conducted a wetland assessment for this parcel? ☐ No ☐ Yes ➡ If Yes, provide a copy of assessment or WIP number: ____________

Describe the wetland impacts, the proposed use or development, and any alternatives considered:

Does the project impact more than 1/3 acre of wetland? ☐ No ☐ Yes
➡ If Yes, submit a Mitigation Plan that includes the type and amount of mitigation proposed. For more information go to www.michigan.gov/deqwetlands

Describe how impacts to waters of the United States will be avoided and minimized:

Describe how impact to waters of the United States will be compensated. OR Explain why compensatory mitigation should not be required for the proposed impacts.

Is any grading or mechanized land clearing proposed? ☐ No ☐ Yes
➡ Show locations on the submitted site plan.

Has any of the proposed grading or mechanized land clearing been completed? ☐ No ☐ Yes ➡ Show labeled locations on site plan.

FLOODPLAIN ACTIVITIES (See Sample Drawing 5. Others may apply.) For more information go to www.michigan.gov/deqfloodplainmanagement
- Complete Sections 10A and 10B and other Sections, as applicable.
- A hydraulic analysis or hydrologic analysis may be required to fully assess floodplain impacts. ➡ Attach hydraulic calculations.

➡ Attach additional sheets or tables with the requested information when multiple floodplain activities are included in this application.

check all that apply) ☑ fill ☐ excavation ☐ other ____________

Site is 3'~4.5' feet above ☐ ordinary high water mark (OHWM) OR ☑ observed water level. Date of observation (M/D/Y) 10/01/10

Fill volume below the 100-year floodplain elevation (cu yd) 29 yd³ | Compensating cut volume below the 100-year floodplain elevation (cu yd) 0 yd³

BRIDGES AND CULVERTS (Including Foot and Cart Bridges) (See Sample Drawings 5, 14A, 14B, 14C, 14D, and EZ Guides)
- Provide detailed site-specific drawings of existing and proposed Plan and Elevation View, (Sample Drawing 14A), Elevation View (Sample Drawing 14B), Stream and Floodplain Cross-Section (Sample Drawing 14C), Stream Profile (Sample Drawing 14D) and Floodplain Fill (Sample Drawing 5) at a scale adequate for detailed review.
- Provide the requested information that applies to your project. If there is not an existing structure, leave the "Existing" column blank.
- If you choose to have a Licensed Professional Engineer "certify" that your project will not cause a "harmful interference" for a range of flood discharges up to and including the 100-year flood discharge, then you must use the "Required Certification Language." You may request a copy by phone, email, or mail. A hydraulic report supporting this certification may also be required. Is Certification Language attached? ☐ No ☐ Yes

➡ Attach additional sheets and table with the requested information for multiple crossings. Include hydraulic calculations.

		Existing	Proposed			Existing	Proposed
Culvert type (box, circular, arch) and material (corrugated metal, timber, concrete, etc.)				Bridge span length (perpendicular to stream) OR culvert ☐ width ☐ diameter (ft)			
Bridge type (concrete box beam, timber, concrete I-beam, etc.)				Bridge width (parallel to stream) OR culvert length (ft)			
Entrance design (projecting, mitered, wingwalls, etc.)				Bridge rise (from bottom of beam to streambed) OR Culvert rise (fill from top of culvert to streambed) (ft)			
Total structure waterway opening above streambed (sq ft)				Approach slope fill from existing grade to culvert or bridge (ft)			
☐ elevation of culvert crown (ft) ☐ bottom of bridge beam (ft)	Upstream			Higher elevation of ☐ culvert invert OR ☐ streambed within culvert (ft)	Upstream		
	Downstream				Downstream		
Elevation of road grade at structure (ft)				Distance from low point of road to mid-point of bridge crossing (ft)			
Elevation of low point in road (ft)							

Cross-sectional area of primary channel (sq ft) (See Sample Drawing 14C) | Average stream width at OHWM outside the influence of the structure (ft) Upstream ________ Downstream ________

Reference datum used (show on plans with description) ☐ NGVD 29 ☐ NAVD 88 ☐ IGLD 85 (Great Lakes coastal areas) ☐ other ____________

High water elevation – describe reference point and highest known water level above or below reference point and date of observation.

STREAM, RIVER, OR DRAIN CONSTRUCTION ACTIVITIES (No sample drawing available)
- Complete Section 10A for fill, Section 10B for dredge or excavation, and Section10C for riprap activities.
- If side casting or other proposed activities will impact wetlands or floodplains, complete Sections 12 and 13, respectively.

➡ Provide an overall site plan showing existing lakes, streams, wetlands, and other water features; existing structures; and the location of all proposed structures and land change activities.

➡ Provide cross-section (elevation) drawings necessary to clearly show existing and proposed conditions. Be sure to indicate drawing scales.

➡ For activities on legally established county drains, provide original design and proposed dimensions and elevations.

check all that apply) ☐ maintenance ☐ improvement ☐ relocation ☐ enclosure ☐ new drain ☐ wetlands ☐ other ____________

Dimensions (ft) of existing stream/drain channel to be worked on. length width depth

Dimensions (ft) of new, relocated, or enclosed stream/drain channel. length width depth | Volume of dredge/excavation (cu yds)

Existing channel average water depth in a normal year (ft) | Proposed side slopes (vertical / horizontal)

How will slopes and bottom be stabilized?

Will old/enclosed stream channel be backfilled to top of bank grade? ☐ No ☐ Yes | Length of channel to be abandoned (ft) | Volume of fill (cu yds)

If an enclosed structure is proposed, check type ☐ concrete ☐ corrugated metal ☐ plastic ☐ other ____________
Dimensions of the structure: diameter (ft) length (ft) volume of fill (cu yds)

Will spoils be disposed of on site? ☐ No ☐ Yes ➡ Show location of spoils on site plan if spoils disposed of in an upland area.

Water elevation ________ Reference datum used ☐ NGVD 29 ☐ NAVD 88 ☐ IGLD 85 (Great Lakes coastal areas) ☐ other ____________
➡ Show elevation on plans with description.

DRAWDOWN OF AN IMPOUNDMENT

If wetlands will be impacted, also complete Section 12.

ype of drawdown ☐ over winter ☐ temporary ☐ one-time event ☐ annual event ☐ permanent (dam removal) ☐ other ____________

eason for drawdown: ____________

as there been a previous drawdown? ☐ No ☐ Yes If Yes, provide date (M/D/Y) ________		Previous MDEQ permit number, if known
oes waterbody have established legal lake level? ☐ No ☐ Yes ☐ Not Sure		Dam ID Number, if known
xtent of vertical drawdown (ft)	Impoundment design head (ft)	Number of adjacent or impacted property owners
ate drawdown would start /I/D/Y)	Date drawdown would stop (M/D/Y)	Rate of drawdown (ft/day)
ate refilling would start /I/D/Y)	Date refill would end (M/D/Y)	Rate of refill (ft/day)
ype of outlet discharge structure to be used] surface ☐ bottom ☐ mid-depth	Impoundment area at normal water level (acres)	Sediment depth behind impoundment discharge structure (ft)

DAM, EMBANKMENT, DIKE, SPILLWAY, OR CONTROL STRUCTURE ACTIVITIES (See Sample Drawing 15)

For more information go to www.michigan.gov/deqdamsafety

If wetlands will be impacted, also complete Section 12.

·Attach site-specific conceptual plans for construction of a new dam, reconstruction of a failed dam, or enlargement of an existing dam for resource impact review. Detailed engineering plans are required once the activity has been determined to be permitable from an environmental standpoint.

·Attach detailed engineering plans for a dam repair, dam alteration, dam abandonment, or dam removal.

'hich one best describes your project? ☐ new dam construction ☐ reconstruction of a failed dam ☐ enlargement of an existing dam
☐ dam repair ☐ dam alteration ☐ dam abandonment ☐ dam removal ☐ other ____________

am ID Number known	Type of outlet discharge structure ☐ surface ☐ bottom ☐ mid depth	Will proposed activities require a drawdown of the waterbody to complete the work? ☐ No ☐ Yes (If Yes, also complete Section 16)	
iprap volume (cu yd)	Dredging/excavation volume (cu yd)	Fill volume (cu yd)	Does structure allow complete drainage of waterbody? ☐ No ☐ Yes
enchmark elevation t)	Datum used ☐ Local ☐ NGVD 29 ☐ other ________	Describe benchmark and show on plans	

ave you engaged the services of a Licensed Professional Engineer? ☐ No ☐ Yes If Yes, provide name, registration number, and mailing address.

ame Registration Number Mailing Address

'ill a water diversion during construction be required? ☐ No ☐ Yes If Yes, describe how the stream flow will be controlled through the dam construction area during the oposed project activities:

____

____

COMPLETE THE FOLLOWING FOR A NEW DAM, RECONSTRUCTION OF A FAILED DAM, OR ENLARGEMENT OF AN EXISTING DAM

escribe the type of dam and how you will design the dam and embankment to control seepage through and underneath the dam.

____

____

nbankment top evation (ft)	Streambed elevation at downstream embankment toe (ft)	Structural height (difference between embankment top elevation and streambed elevation at downstream embankment toe) (ft)	
nbankment length (ft)	Embankment top width (ft)	Embankment bottom width (ft)	Embankment slopes (vertical / horizontal) Upstream ________ Downstream ________
oposed normal pool elevation (ft)	Impoundment flood elevation (ft)	Maximum vertical drawdown capability (ft) (Attach operational procedure of the proposed structure, if available)	
ave soil borings been taken at dam location?] No ☐ Yes ➡ If Yes, attach results.	Will a cold water underspill be provided? ☐ No ☐ Yes If Yes, invert elevation (ft) ________	Do you have flowage rights to all proposed flooded property at the design flood elevation? ☐ No ☐ Yes	

UTILITY CROSSINGS (See Sample Drawings 12 and 13, and EZ Guide)

If side casting is required, complete Sections 10A and 10B. If spoils will be placed in wetlands or wetlands may be impacted, complete Section 12.

·Attach additional sheets or tables with the requested information as needed for multiple crossings.

'hat method will be used to construct the crossings?
] flume ☐ plow ☐ open trench ☐ jack and bore ☐ directional drilling

Crossing of ☐ Inland Lake or Stream ☐ floodplain
☐ international waters ☐ wetlands (also complete Section 12)

ype	Number of wetland crossings	Number of inland lake or stream crossings	Pipe diameter (in)	Pipe length per crossing (ft)	Distance below streambed or wetland (in)	Trench width (ft)
] sanitary sewer						
] storm sewer						
] watermain						
] cable						
] oil/gas pipeline						

MARINA CONSTRUCTION AND OPERATING PERMIT INFORMATION (See Sample Drawing 21)

- For more information go to www.michigan.gov/deqmarinas
- Marinas located on the Great Lakes, including Lake St. Clair, may be required to secure leases or conveyances from the state of Michigan to place structures on the bottomlands. If a conveyance is necessary, an application must be submitted before the Joint Permit Application can be determined complete.
- ➧Enclose a copy of any current pump-out agreement with another marina facility.
- ➧Attach a copy of the property legal description or a property boundary survey report to your application.

Marina owner			Marina name		
Mailing address			Location street address		
City	State	Zip Code	City	State	Zip Code
Marina owner's daytime telephone number with area code			Marina's daytime telephone number with area code		

Check the reasons for submitting this application
- ☐ Owner's name change/transfer
- ☐ Construction of a new marina
- ☐ Issuance of a new Marina Operating Permit
- ☐ Expansion/modification of an existing marina
- ☐ Renewal of a Marina Operating Permit

Current Marina Operating Permit Number ____________ Expiration Date (M/D/Y) ____________

	Existing	Proposed		Existing	Proposed
Number of boat slips/wells (do not include broadside)			Are sanitary pump-out facilities available?	☐ No ☐ Yes	☐ No ☐ Yes
Lineal feet of broadside dockage			Number of launch ramps/lanes		
Number of mooring buoys			Maximum number of boats at broadside		

HIGH RISK EROSION AND CRITICAL DUNE AREAS (See Sample Drawings 19 and 20, also Sample Drawing 9 if wetlands are impacted)

- For more information go to www.michigan.gov/deqsanddunes
- Construction in critical dune areas on slopes greater than a 1-foot vertical rise in a 3-foot horizontal plane (33 percent) is prohibited without a special exception.
- Construction in critical dune areas on slopes that measure from a 1-foot vertical rise in a 4-foot horizontal plane (25 percent) to less than a 1-foot vertical rise in a 3-foot horizontal plane (33 percent) requires plans prepared by a registered architect or licensed professional engineer.
- All property boundaries and proposed structure corners, septic system, water well, and driveway locations must be staked before the MDEQ site inspection.
- Scaled overhead and cross-section plans that include all property boundaries, and the location and dimensions of all structures and terrain alterations must be included.
- Additional information, including the building construction plans, may be required to complete the application review.
- ➧ Construction in critical dune areas requires inclusion of the following written assurances:
  1) permit or letter from county enforcing agent stating project complies with Part 91 (Soil Erosion and Sedimentation Control),
  2) permit or letter from County Health Department for work on a septic system, and
  3) letter from applicant stating any proposed tree or vegetation removal complies with instructions of the local Soil Conservation District.

Parcel dimensions (ft) width depth	Property is a ☐ platted lot ☐ unplatted parcel	Year current property boundaries created	Date project staked (M/D/Y)

Type of construction activities ☐ home ☐ garage ☐ driveway ☐ septic ☐ addition ☐ renovation ☐ other ____________

The proposed project will be serviced by ☐ public sewer ☐ private septic system ➧ On plans show private septic system.	If septic system, has application been made to the County Health Department for a permit? ☐ No ☐ Yes If Yes, has a permit been issued? ☐ No ☐ Yes	If Yes, critical dune projects require County Health Department approval submitted with application. ➧ Attach Written Assurance(s).	Number of individual living-units in proposed building

Existing construction is on ☐ pilings ☐ basement ☐ concrete slab ☐ crawl space	Proposed new construction will be on ☐ pilings ☐ basement ☐ concrete slab ☐ crawl space
Existing construction material above foundation wall ☐ stud frame ☐ log ☐ block ☐ other ________	Proposed new construction material above foundation wall ☐ stud frame ☐ log ☐ block ☐ other ________
Existing siding material ☐ wood ☐ vinyl ☐ block ☐ other ________	Proposed new siding material ☐ wood ☐ vinyl ☐ block ☐ other ________
Area of the existing foundation, excluding attached garage (sq ft)	Area of the proposed foundation, excluding attached garage (sq ft)
Area of the existing garage foundation (sq ft)	Area of the proposed garage foundation (sq ft)

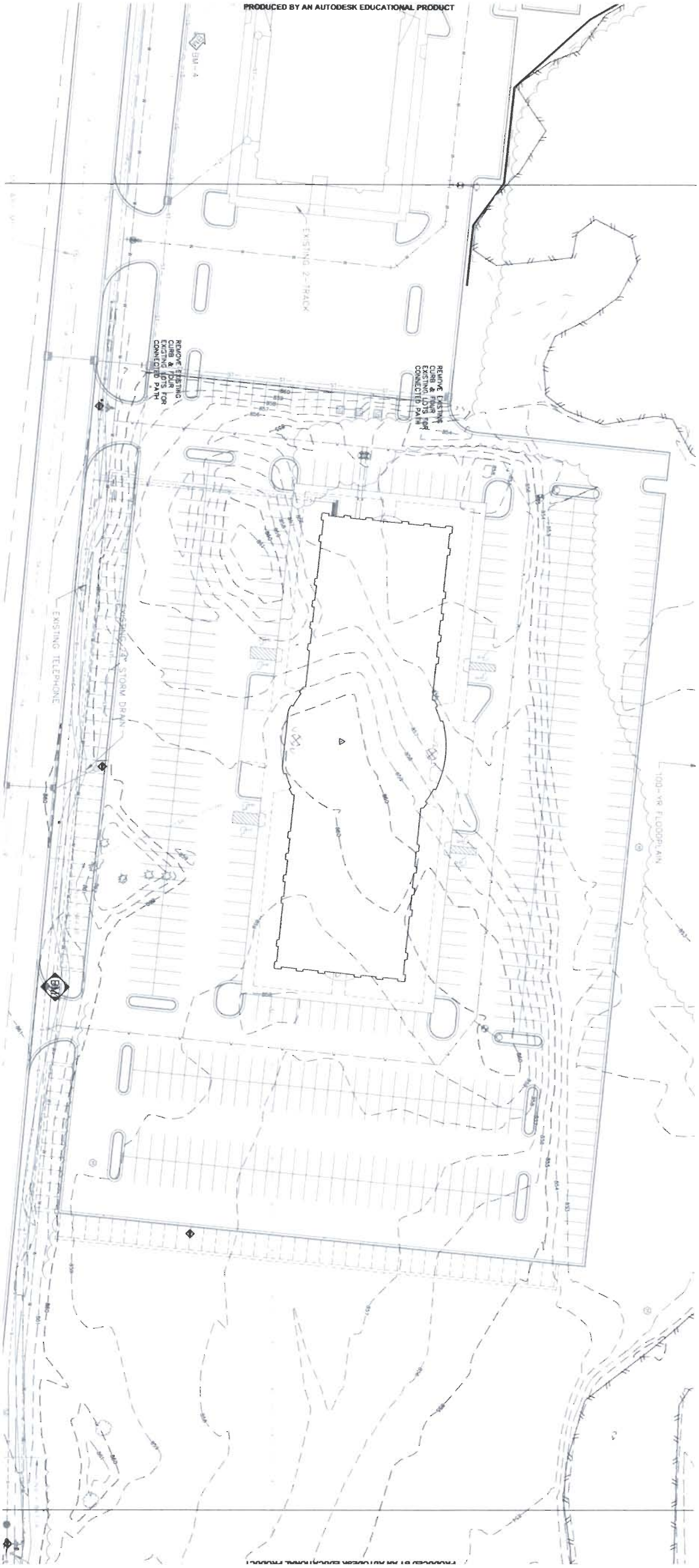
If renovating or restoring existing structure, renovation or restoration cost $ ________	Current structure replacement value $ ________	Tax assessed value of existing structure excluding land value $ ________	Assessment Year ________

ACTIVITIES IN DESIGNATED ENVIRONMENTAL AREAS (No Sample Drawings Available)

- Many designated environmental areas are completely or partially wetlands. Be sure to complete Section 12 if your proposed activities will also occur in wetlands.
- ➧Attach a detailed site plan for any alteration in a designated environmental area.

(Check all that apply) ☐ placement of structures ☐ grading or other soil alteration ☐ alteration of natural drainage ☐ alteration of vegetation ☐ other ____________

Appendix 9


BM-4
EXISTING 2-TRACK
REMOVE EXISTING CURB & FOUR EXISTING LOTS FOR CONNECTED PATH
REMOVE EXISTING CURB & FOUR EXISTING LOTS FOR CONNECTED PATH
EXISTING TELEPHONE
EXISTING 24" STORM DRAIN
100-YR FLOODPLAIN

Appendix 10

Trade Centre Office Complex Drainage CALCULATIONS

By: BR & KW
Date: 3/14/2010

Risk Zone Designation:	A	Zoning:	CPD
Site Area (Acres):	5.29	Tributary Area I(Acres):	0.4
		Tributary Area II(Acres):	1.68
		Tributary AreaIII(Acres):	1.64
		Tributary AreaIV(Acres):	1.57

Flood Control Volume (V_{fc}): $V_{fc} = CAP_2 \times 3630$

	Watershed I	Watershed II	Watershed III	Watershed IV	
C_w	0.85	0.88	0.88	0.88	
A (Ac)	0.40	1.68	1.64	1.57	
P_2 (in)	2.40	2.40	2.40	2.40	2-year Rainfall
V_{fc} (cft)	2,948.84	12,925.63	12,550.58	12,076.16	

Total= 28,425.05 cft
2x Total= 56,850.11 cft

Note: See site plan for basin volume provided.
Infiltration basin bottom elevation = (6' +/- above groundwater)
Freeboard Provided = 3 feet (provides 2 x Vfc since no overflow route)
See attached Watershed Analysis for Area and C calculations

Maximum Drain Time:

Infiltration Rate (I) = 3 in/hr (see geotechnical report)
Basin Depth (D) = 4 feet

$D \leq 72\,(I)/12$

$D \leq$ 18 feet √ Acceptable

Appendix 11

LandSaver™ Stormwater Management System

Project: Site Design for a 111,705 sft Class A Office Building

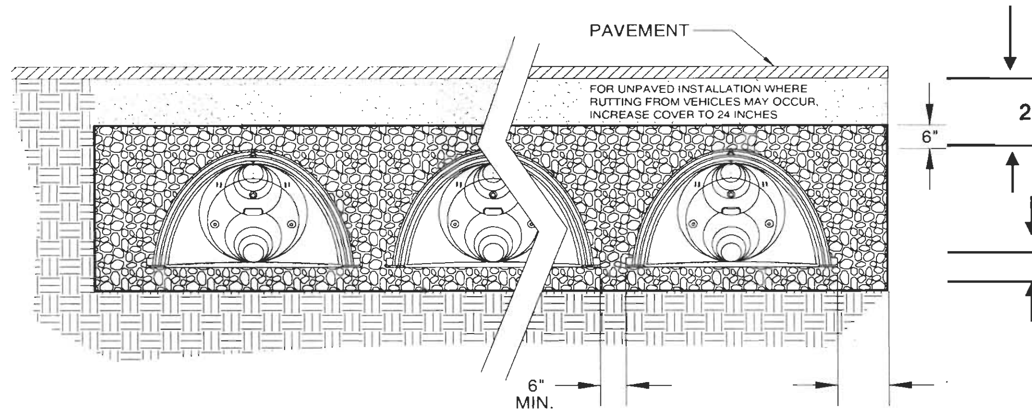
By: Britney Richmond

Senior Design Captone Project

Date: March 19th, 2010

System Requirements

Required Storage Volume (Vs)	Vs	12,551	CF
LandSaver+A99 System		LS-3051	
Stone Porosity		40%	
Stone Foundation Depth		6"	
Storage Volume Per Chamber		74.9	CF
Total Cover over Chamber		24.0	Inches
Number of Chambers Required	C	168	Each
Required Bed Size (S)	S	6,247	SF
Tons of Stone Required (Tst)	Tst	694	Tons
Volume of Excavation (Ex)	Ex	1,133	CY
Area of Filter Fabric (F)	F	1,909	SY
# of End Caps Required	Ec	4	Each
Length of ISOLATOR ROW		287	FT
ISOLATOR FABRIC		159	SY



Controlled by Width		
Width	0	FT
Length	#DIV/0!	FT
# of Chambers Long	#DIV/0!	EA
# of Rows	#DIV/0!	EA
Actual Length	#DIV/0!	FT
Actual Width	#DIV/0!	FT

Controlled by Length		
Length	287	FT
Width	21.77	FT
# of Chambers Long	40	EA
# of Rows	4	EA
Actual Length	286.36	FT
Actual Width	19.50	FT

System Cost - CONCEPTUAL BUDGET

*** PLEASE CALL LANDSAVER @ 888-892-2694 FOR CONCEPTUAL COST ESTIMATES DUE TO GEOGRAPHICAL VARIABLES.**

***Budgetary Installed Costs for LandSaver Systems range from $3.50 - $7.00 / CF of Storage.**

***Many geographical variables can effect Installed Costs and should be taken into account when estimating budgets.**

LandSaver™
Stormwater Management System

Project: Site Design for an 111,705 sft Class A Office Building

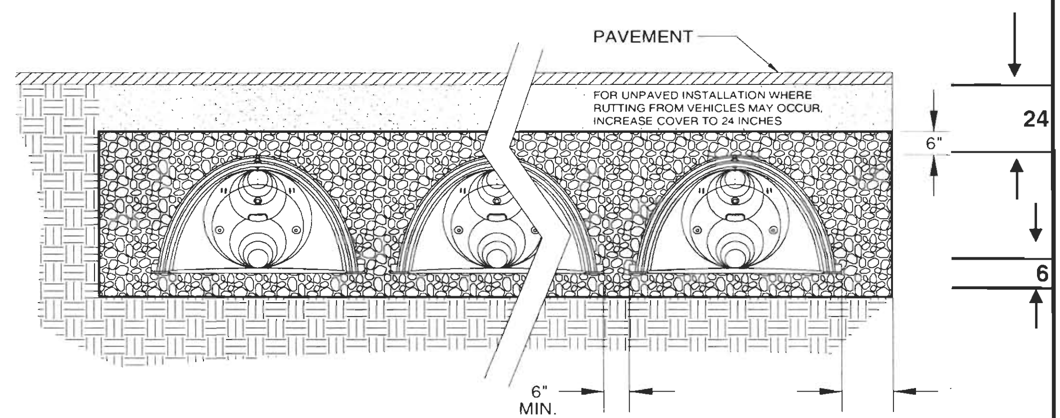
By: Britney Richmond

Senior Design Capstone Project

Date: March 19th, 2010

System Requirements

Required Storage Volume (Vs)	Vs	12,926	CF
LandSaver+A99 System		LS-3051	
Stone Porosity		40%	
Stone Foundation Depth		6"	
Storage Volume Per Chamber		74.9	CF
Total Cover over Chamber		24.0	Inches
Number of Chambers Required	C	173	Each
Required Bed Size (S)	S	6,433	SF
Tons of Stone Required (Tst)	Tst	715	Tons
Volume of Excavation (Ex)	Ex	1,166	CY
Area of Filter Fabric (F)	F	1,966	SY
# of End Caps Required	Ec	4	Each
Length of ISOLATOR ROW		282	FT
ISOLATOR FABRIC		157	SY



Controlled by Width

Width	0	FT
Length	#DIV/0!	FT
# of Chambers Long	#DIV/0!	EA
# of Rows	#DIV/0!	EA
Actual Length	#DIV/0!	FT
Actual Width	#DIV/0!	FT

Controlled by Length

Length	282	FT
Width	22.81	FT
# of Chambers Long	39	EA
# of Rows	4	EA
Actual Length	279.25	FT
Actual Width	19.50	FT

System Cost - CONCEPTUAL BUDGET

*** PLEASE CALL LANDSAVER @ 888-892-2694 FOR CONCEPTUAL COST ESTIMATES DUE TO GEOGRAPHICAL VARIABLES.**

***Budgetary Installed Costs for LandSaver Systems range from $3.50 - $7.00 / CF of Storage.**

***Many geographical variables can effect Installed Costs and should be taken into account when estimating budgets.**

LandSaver™
Stormwater Management System

Project: Site Design for an 111,705 sft Class A Office Building

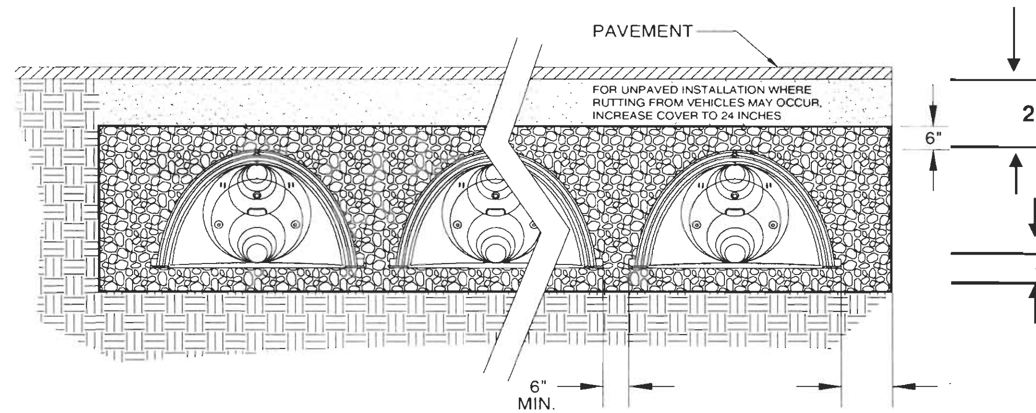
By: Britney Richmond

Senior Design Capstone Project

Date: March 13th, 2010

System Requirements

Required Storage Volume (Vs)	Vs	24,152	CF
LandSaver+A99 System		LS-3051	
Stone Porosity		40%	
Stone Foundation Depth		6"	
Storage Volume Per Chamber		74.9	CF
Total Cover over Chamber		24.0	Inches
Number of Chambers Required	C	323	Each
Required Bed Size (S)	S	12,010	SF
Tons of Stone Required (Tst)	Tst	1,335	Tons
Volume of Excavation (Ex)	Ex	2,177	CY
Area of Filter Fabric (F)	F	3,670	SY
# of End Caps Required	Ec	4	Each
Length of ISOLATOR ROW		176	FT
ISOLATOR FABRIC		98	SY



Controlled by Width			Controlled by Length		
Width	0	FT	Length	176	FT
Length	#DIV/0!	FT	Width	68.24	FT
# of Chambers Long	#DIV/0!	EA	# of Chambers Long	24	EA
# of Rows	#DIV/0!	EA	# of Rows	13	EA
Actual Length	#DIV/0!	FT	Actual Length	172.50	FT
Actual Width	#DIV/0!	FT	Actual Width	62.25	FT

System Cost - CONCEPTUAL BUDGET

*** PLEASE CALL LANDSAVER @ 888-892-2694 FOR CONCEPTUAL COST ESTIMATES DUE TO GEOGRAPHICAL VARIABLES.**

***Budgetary Installed Costs for LandSaver Systems range from $3.50 - $7.00 / CF of Storage.**

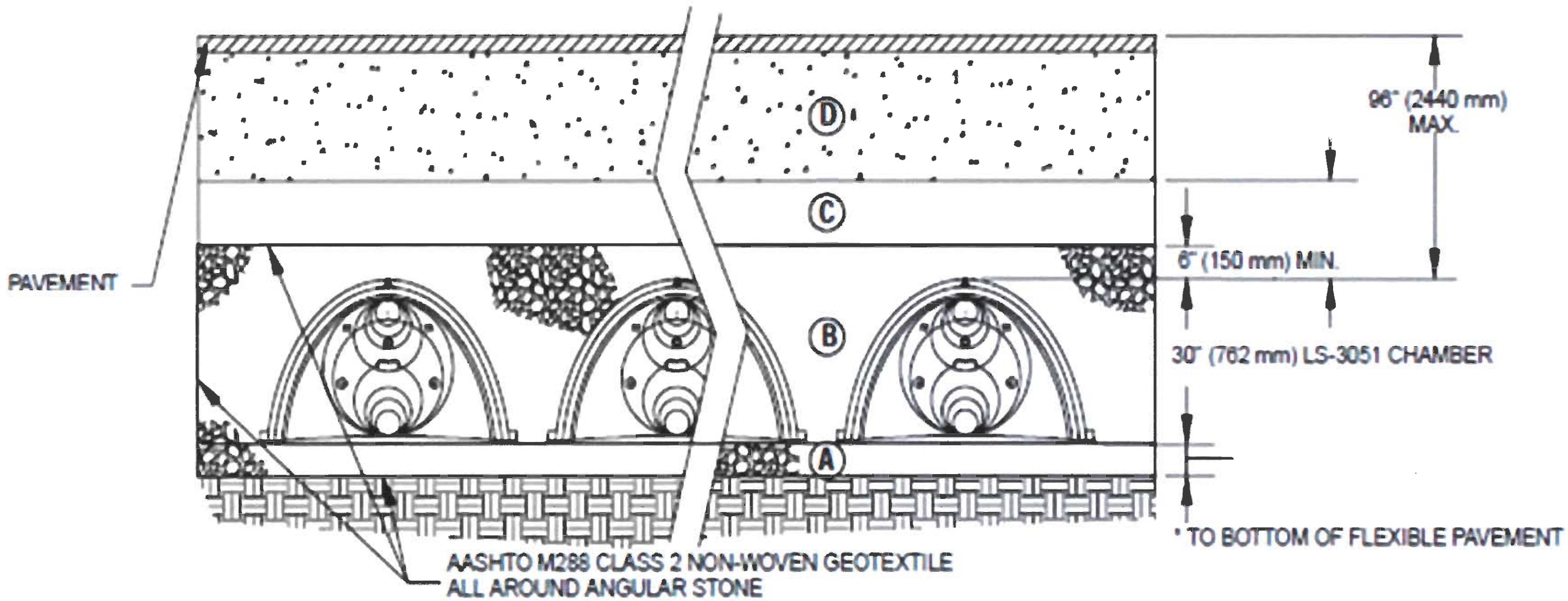
***Many geographical variables can effect Installed Costs and should be taken into account when estimating budgets.**

Appendix 12

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

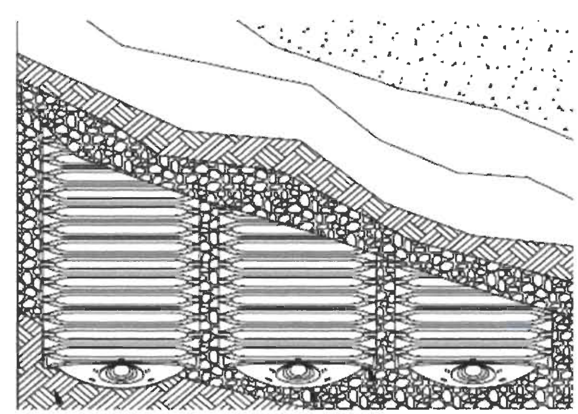
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

Appendix 13



<u>Layer description as shown above:</u>

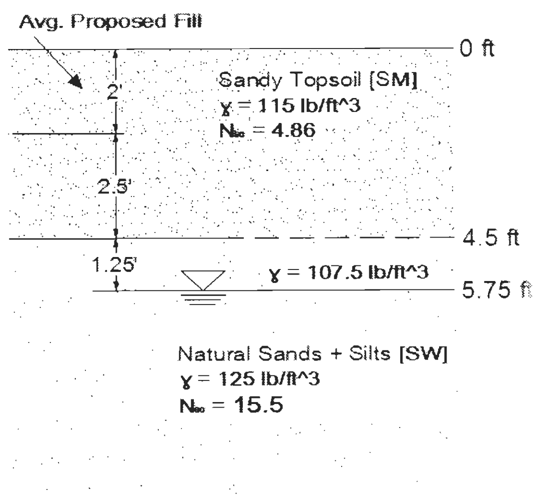
A: 3 ft of 6A stone [MDOT] below detention cylinders
B: 3 ft of embedding stone surrounding to a 6 in elevation above chambers [stone must be washed, crushed and angular]
C: 2 ft of granular well-graded soil/aggregate mixture
D: Natural top soil of the site below pavement



Appendix 14

Summary of Geotechnical Report for the Trade Centre Property from Soils and Materials Engineers, 2002

- From in-situ tests, it was seen that the groundwater table is very high on the property because of its proximity to the Portage Creek and City of Kalamazoo well field. The groundwater depth was reported on average to be between 2.5 and 4 feet below the current surface.
- The top soil layer on site is described and classified as Sandy Topsoil [SM]. This stratum continues down to an average of 2.5 feet. The second stratum is classified as Natural Sand with Silts [SW] and continues down to an unspecified depth.



- The allowable bearing capacity of the soil is determined as 2000 pounds per square foot.
- The expected settlement of the foundation is around 1 inch or less.

Appendix 15

Foundation Design – Column Loads

Assumptions:

- ✓ 25 ft column spacing on center
- ✓ Normal weight concrete used for columns, slabs, and footings
- ✓ Floor slab thickness is 5 in
- ✓ Roof thickness is assumed to be 3 in and conservatively assumed as concrete
- ✓ Columns are 16 in by 16 in
- ✓ Load combination: 1.2DL + 1.6LL
- ✓ Live loads are according to ASCE 7-05 [minimum live loads][A] (Structural Analysis)
  - ASCE 7-05 allows a reduction of live loads on a member having an influence area $K_{LL}A_T$ of 400 ft^2 or more by: $L = L_o[0.25 + \frac{15}{\sqrt{(K_{LL}A_T)}}]$; K_{LL} = 4 for both interior and exterior
    - Assume 1st floor consists 50% of office space and 50% of lobby space
    - Assume 2nd-4th floors consist of 75% office space and 25% lobby space
- ✓ Floor height is 11 ft
- ✓ 1st floor loads are taken by soil

TYPICAL EXTERIOR COLUMNS

Dead Loads

Roof: $\frac{3in}{12\frac{in}{ft}} \times 150\frac{lb}{ft^3} \times 327.4\,ft^2 = 12{,}277.5\,lb$

2nd-4th Floors: $\frac{5in}{12\frac{in}{ft}} \times 150\frac{lb}{ft^3} \times 327.4\,ft^2 \times 3 = 61{,}387.5\,lb$

Columns: $\frac{16in\times16in}{144in^2/ft^2} \times 150\frac{lb}{ft^3} \times 11ft \times 4 = 11{,}733.3\,lb$

Total DL: $85{,}398\,lb = 85\,k$

Live Loads

Live Load Reduction:

Given $A_t = 327.4\,ft^2$ and $K_{LL} = 4$

<u>Exterior Columns</u> Lobbies: $100\,psf$ Offices: $50\,psf$

$$L = 100[0.25 + \frac{15}{\sqrt{(4\times327.4ft^2)}}] = 66.45\,psf\ (Lobby)$$
$$L = 50[0.25 + \frac{15}{\sqrt{(4\times327.4ft^2)}}] = 38.22\,psf\ (Office)$$

Weighted, Reduced LL: $(66.45\,psf)(0.25) + (38.22\,psf)(0.75) = 41.53\,psf$

Roof: $20\,psf \times 327.4\,ft^2 = 6{,}548\,lb$

2nd-4th Floors: $41.53\ psf \times 327.4\ ft^2 \times 3 = 40{,}791.8\ lb$

Total LL: $47{,}339.8\ lb = 47\ k$

$$\boldsymbol{P_{unfactored} = 85k + 47k = 132\ k}$$

$$\boldsymbol{P_{factored} = 1.2(85k) + 1.6(47k) = 177.2\ k}$$

TYPICAL INTERIOR COLUMNS

Dead Loads

Roof: $\frac{3in}{12\frac{in}{ft}} \times 150\frac{lb}{ft^3} \times 623.2\ ft^2 = 23{,}370\ lb$

2nd-4th Floors: $\frac{5in}{12\frac{in}{ft}} \times 150\frac{lb}{ft^3} \times 623.2\ ft^2 \times 3 = 116{,}850\ lb$

Columns: $\frac{16in \times 16in}{144in^2/ft^2} \times 150\frac{lb}{ft^3} \times 11ft \times 4 = 11{,}733.3\ lb$

Total DL: $151{,}953\ lb = 152\ k$

Live Loads

Live Load Reduction:

Given $A_t = 623.2\ ft^2$ and $K_{LL} = 4$

<u>Interior Columns</u> Lobbies: $100\ psf$ Offices: $50\ psf$

$$L = 100[0.25 + \frac{15}{\sqrt{(4 \times 623.4 ft^2)}}] = 55\ psf\ (Lobby)$$

$$L = 50[0.25 + \frac{15}{\sqrt{(4 \times 623.4 ft^2)}}] = 27.5\ psf\ (Office)$$

Weighted, Reduced LL: $(55\ psf)(0.25) + (27.5\ psf)(0.75) = 34.4\ psf$

Roof: $20\ psf \times 623.2\ ft^2 = 12{,}464\ lb$

2nd-4th Floors: $34.4\ psf \times 623.2\ ft^2 \times 3 = 64{,}314.2\ lb$

Total LL: $76{,}778\ lb = 77\ k$

$$P_{unfactored} = 152k + 77k = 229\ k$$

$$P_{factored} = 1.2(152k) + 1.6(77k) = 305.6\ k \cong 306\ k$$

Appendix 16

Foundation Design – Geotechnical Design

Assumptions:

- ✓ Spread footings used – according to Project Mentor
- ✓ Typical depth, D, is between 3 ft and 6 ft according to Faculty Advisor
    - Depth taken as D = 3 ft
- ✓ Geotechnical data from report provided by Soils and Materials Engineers can be applied to this project... See Appendix (pg) for Summary of SME Geotechnical Data
    - $q_a = 2000\, psf$
    - Soil Strata 1: Sandy Topsoil (SW)
        1. Assumed to be well-graded
        2. $\gamma = 115 \frac{lb}{ft^3}$
        3. $N = 6.5$
        4. Assume site fill will be of similar soil
    - Soil Strata 2: Natural Sands and Silts
        1. Assume silty sand (SM)
        2. Above groundwater: $\gamma = 107.5 \frac{lb}{ft^3}$
        3. Below groundwater: $\gamma = 125 \frac{lb}{ft^3}$
        4. $N = 15.5$
    - Groundwater was encountered around 3 to 4.5 ft below existing ground surface
        1. $D_w = 3.75\, ft$
    - N-values above are based on the average blow counts per strata
- ✓ Average fill across area of proposed building according to grading plans
    - 2 ft of fill (SM) at $\gamma = 115 \frac{lb}{ft^3}$
- ✓ Normal-weight concrete is used for the footings
- ✓ Column loads are assumed in Foundation Design – Column Loads (Appendix)
- ✓ Groundwater table has no effect because spread footings are to be designed above
- ✓ The footing weight, W_f, is only an estimation
    - Estimated as γAD

Soil Profile

Information taken from Geotechnical Report Summary (Appendix)

TYPICAL EXTERIOR COLUMN FOOTING

$P_u = 132\, kips$ [Design Load]

Step 1. Bearing Pressure Capacity, $q_a = 2000\, psf$

$q_a = \frac{P+W_f}{A} - u_D$ (for spread footings)

$$2000\frac{lb}{ft^2} = \frac{132{,}000\ lb + \left(150\frac{lb}{ft^3} \times B^2 \times 3\ ft\right)}{B^2} - u_D$$

$$2000B^2 = 132{,}000 + 450B^2$$

$$1550B^2 = 132{,}000$$

$$B = 9.2\ feet$$

$B\ \geq 9.2\ feet\ to\ satisfy\ q_a$
Choose $\boldsymbol{B = 9.5\ ft}$

Step 2. Settlement

Schmertmann's Method $\delta = C_1 C_2 C_3 (q - \sigma'_{zD}) E(\frac{I_s H}{E_s})$

...where $C_1 = 1 - 0.5\left(\frac{\sigma'_{zD}}{q - \sigma'_{zD}}\right)$

$C_2 = 1 + 0.2log\left(\frac{t}{0.1}\right)$

$C_3 = 1.03 - 0.03\left(\frac{L}{B}\right) \qquad \geq 0.73$

$$(q - \sigma'_{zD}) = 2000\ psf - \left(115\frac{lb}{ft^3} \times 3ft\right) = 1655\ psf$$

E_s (SPT): $E_s = \beta_o\sqrt{OCR} + \beta_1 N_{60}$

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.6}$$

Table 4.3 (p. 119 – Foundation Design)
Assume: U.S Safety Hammer --- $E_m = 0.57$
Table 4.4 (p. 119 – Foundation Design)
Assume: 6 in borehole diameter --- $C_B = 1.05$
Standard sampler --- $C_S = 1.0$
Rod Length --- $C_R = 0.75$

$$N_{60} = \frac{(0.57)(1.05)(1.0)(0.75)(6.5)}{0.6} = 4.86$$

Assume OCR = 1 (most analyses)
Table 7.4 (Foundation Design) --- $\beta_o = 100{,}000\ psf\ (SW)$
$\beta_1 = 24{,}000\ psf\ (SW)$

therefore...

$$E_s = 100{,}000\sqrt{1} + 24{,}000(4.86) = 216{,}640\ psf$$

$$\sigma'_{zp} = 115(4.5') + 107.5(1.25') + 125(1.5') - 62.4(1.5') = 745.8\,psf$$

$$I_{\varepsilon p} = 0.5 + 0.1\sqrt{\frac{1655psf}{745.8psf}} = 0.649$$

Layer	Z_f (ft)	H (ft)	Iε		E_S (psf)	$\Sigma\frac{I_\varepsilon H}{E_S}$
1	0.75	1.5	Eq 7-19	0.186	216,640	1.29(10^{-6})
2	2.125	1.25	Eq 7-19	0.346	216,640	1.99(10^{-6})
3	6.875	8.25	Eq 7-20	0.55	216,640	2.1(10^{-5})
4	15	8.0	Eq 7-20	0.18	216,640	6.6(10^{-6})
					SUM:	**3.08(10^{-5})**

$$C_1 = 1 - 0.5\left(\frac{115*3}{1655}\right) = 0.896$$

$$C_3 = 1.03 - 0.03(1) = 1.0$$

$$\delta = (0.896)C_2(1)(1655)(3.08(10^{-5}))$$

$\boldsymbol{\delta = (0.046)C_2}$ (ft) $\quad$ *given that* $C_2 = 1 + 0.2\log\left(\frac{t}{0.1}\right)$ $\quad$ [t *in years*]

$\boldsymbol{\delta = (0.55)C_2}$ (in)

TYPICAL INTERIOR COLUMN FOOTING

$P_u = 242\ kips$ [Design Load]

Step 1. Bearing Pressure Capacity, $q_a = 2000\,psf$

$q_a = \frac{P+W_f}{A} - u_D$ (for spread footings)

$$2000\frac{lb}{ft^2} = \frac{229{,}000\ lb + \left(150\frac{lb}{ft^3}\times B^2\times 3\ ft\right)}{B^2} - u_D$$

$$2000B^2 = 229{,}000 + 450B^2$$

$$1550B^2 = 229{,}000$$

$$B = 12.15\ feet$$

$B \geq 12.15\ feet\ to\ satisfy\ q_a$
Choose $\boldsymbol{B = 12.5\ ft}$

Step 2. Settlement

Schmertmann's Method $\delta = C_1 C_2 C_3 (q - \sigma'_{zD}) E\left(\frac{I_s H}{E_s}\right)$

…where $C_1 = 1 - 0.5\left(\frac{\sigma'_{zD}}{q - \sigma'_{zD}}\right)$

$C_2 = 1 + 0.2 log\left(\frac{t}{0.1}\right)$

$C_3 = 1.03 - 0.03\left(\frac{L}{B}\right) \quad \geq 0.73$

$(q - \sigma'_{zD}) = 2000\ psf - \left(115 \frac{lb}{ft^3} \times 3ft\right) = 1655\ psf$

E_s (SPT): $E_s = \beta_o \sqrt{OCR} + \beta_1 N_{60}$

$E_s\ (SW) = 216{,}640\ psf \quad [from\ exterior\ column\ calculations]$
$E_s\ (SM) = \beta_o \sqrt{OCR} + \beta_1 N_{60}$

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.6}$$

Table 4.3 (p. 119 – Foundation Design)
Assume: U.S Safety Hammer --- $E_m = 0.57$
Table 4.4 (p. 119 – Foundation Design)
Assume: 6 in borehole diameter --- $C_B = 1.05$
Standard sampler --- $C_S = 1.0$
Rod Length --- $C_R = 0.75$

$$N_{60} = \frac{(0.57)(1.05)(1.0)(0.75)(15.5)}{0.6} = 11.6$$

Assume OCR = 1 (most analyses)
Table 7.4 (Foundation Design) --- $\beta_o = 50{,}000\ psf\ (SM)$
$\beta_1 = 12{,}000\ psf\ (SM)$

therefore…
$E_s = 50{,}000\sqrt{1} + 12{,}000(11.6) = 189{,}200\ psf$

$\sigma'_{zp}\ @\ D + \frac{B}{2} = 3 + 6.25 = 9.25$
$\sigma'_{zp} = 115(4.5') + 107.5(1.25') + 125(3.5') - 62.4(3.5') = 870.97\ psf$

$$I_{\varepsilon p} = 0.5 + 0.1\sqrt{\frac{1655psf}{870.97psf}} = 0.637$$

Layer	Z_f (ft)	H (ft)	Iε		E_S (psf)	$\Sigma\frac{I_\varepsilon H}{E_S}$
1	0.75	1.5	Eq 7-19	0.164	216,640	$1.13(10^{-6})$
2	2.125	1.25	Eq 7-19	0.28	216,640	$1.62\ (10^{-6})$
3	7.875	10.25	Eq 7-20	0.58	189,200	$3.1(10^{-5})$
4	19	12.0	Eq 7-20	0.20	189,200	$1.26(10^{-5})$
					SUM:	$\mathbf{4.64(10^{-5})}$

$$C_1 = 1 - 0.5\left(\frac{115*3}{1655}\right) = 0.896$$

$$C_3 = 1.03 - 0.03(1) = 1.0$$

$$\delta = (0.896)C_2(1)(1655)(4.64(10^{-5}))$$

$$\boldsymbol{\delta = (0.0687)C_2} \quad (ft) \qquad given\ that\ C_2 = 1 + 0.2\log\left(\frac{t}{0.1}\right) \qquad [t\ in\ years]$$

$$\boldsymbol{\delta = (0.825)C_2} \quad (in)$$

Appendix 17

Foundation Design – Structural Design

Assumptions:

- ✓ $f'_{c\,columns} = 4000\,psi$
- ✓ $f'_{c\,footings} = 3000\,psi$
- ✓ Column size is 16" by 16"
- ✓ Clear cover of 3"

TYPICAL EXTERIOR COLUMN FOOTING

$P_{factored} = 177.2\,k$
$B = 9.5\,ft$

Step 1. Estimate h, height of footing

h is typically taken as 1 to 2 times the width of the column

$1.5(16\,in) = 24\,inches$ $\qquad$ $Choose\ h = 28\,in$

Step 2. Check two-way shear – Two-way shear governs in spread footings (punching shear)

Assuming No. 4 bars… diameter = 1 inch
$d = h - (clear\ cover) - d_B = 28\,in - 3\,in - 1\,in = 24\,inches$

$b_0 = critical\ perimeter = 4 \times 28\,in = 112\,inches$

$tributary\ area = (9.5\,ft)^2 - (\frac{28\,in}{12\frac{in}{ft}})^2 = 84.8\,ft^2$

$V_u = q_{nu} \times tributary\ area = \left(\frac{177.2}{9.5^2}\right) ksf \times 84.8\,ft^2 = 166.5\,kips$

[ACI 11-33]: $V_c = \left(2 + \frac{4}{\beta_c}\right) \varphi \sqrt{f'_c}\, b_0 d$ $\qquad$ $\beta_c = 1$

$V_c = \left(2 + \frac{4}{1}\right)(1)\sqrt{3000psi}\,(112\,in)(24\,in) = 588{,}913\,lb \cong 589\,kips$

[ACI 11-34]: $V_c = \left(2 + \frac{\alpha_s \times d}{b_0}\right) \varphi \sqrt{f'_c}\, b_0 d$ $\qquad$ $\alpha_s = 40\ for\ columns\ centered\ on\ sq.footings$

$V_c = \left(2 + \frac{40 \times 24}{112}\right)(1)\sqrt{3000\,psi}\,(112)(24) = 1{,}556{,}408\,lb \cong 1556\,kips$

[ACI 11-35]: $V_c = 4\,\varphi\,\sqrt{f'_c}\,b_0\,d$
$V_c = 4\,(1)\sqrt{3000\,psi}\,(112)(24) = 588{,}911\,lb \cong 589\,kips$

Therefore, Equation [ACI 11-33] governs… $\qquad$ $V_c = 589\,kips$

$\emptyset = 0.75$

$\emptyset V_c = (0.75)(589\ kips) = 441.75\ kips \qquad (nominal\ capacity)$

$V_u = 166.5\ kips < \emptyset V_c = 441.75\ kips$ **OK**

Step 3. Check one-way shear

$$\frac{9.5\ ft(12\frac{in}{ft})}{2} - 8\ in - 24\ in = 25\ inches$$

$$tributary\ area = 9.5\ ft\left(12\frac{in}{ft}\right) \times 25\ in = 2850\ in^2 = 19.8\ ft^2$$

$$V_u = \left(\frac{177.2}{9.5^2}\right) ksf \times 19.8\ ft^2 = 38.9\ k \cong 39\ kips$$

$$\emptyset V_c = \emptyset 2\sqrt{f'_c}bd = (0.75)(2)\sqrt{3000\ psi}\left(9.5\ ft\left(12\frac{in}{ft}\right)\right)(24) = 224785\ lb \cong 225\ kips$$

$V_u = 39\ kips < \emptyset V_c = 225\ kips$ **OK**

Step 4. Flexural Design

Assumptions:
- ✓ Section treated as a cantilever beam
- ✓ Grade 60 steel is utilized

Given $\omega = q_{nu} \times B = \frac{f}{length}$

$$M_u = \frac{1}{2}\omega l^2 = \frac{1}{2}\left(\frac{177.2}{9.5^2}\right) ksf \times 9.5\ ft \times (\frac{49}{12})^2 = 155.5\ kft$$

$$A_s \geq \frac{M_u}{\emptyset f_y jd} = \frac{155.5\ kft\ (12\ in)}{(0.9)(60\ ksi)(0.95)(24)} = 1.52\ in^2$$

Check $A_{s,min} = \rho\ b\ h = (0.0018)\left(9.5\ ft\left(12\ \frac{in}{ft}\right)\right)(28) = 5.75\ in^2$

Therefore $A_{smin} = 5.75\ in^2$ governs given a max spacing of 18 inches

Try (10) No. 6 bars $\qquad A_s = 6.0\ in^2$ **OK**

$$\alpha = \frac{A_s f_y}{(0.85)f'_c\ b} = \frac{(6)(60)}{(0.85)(3)(114)} = 1.24\ inches \ll h = 28\ inches$$

Therefore assume TCS and $\emptyset = 0.9$

$$\emptyset M_n = \emptyset f_y A_s \left(d - \frac{\alpha}{2}\right) = (0.9)(60)(6)\left(24 - \frac{1.24}{2}\right) = 7575.12\ kin = 631.26\ kft$$

$M_u = 155.5\ kft < \emptyset M_n = 631.26\ kft$ **OK**

Therefore choose **(14) No. 6 bars** for flexural and transverse with **8.3 inch spacing**

$A_s = 6.16\ in$
$d_B = 0.75\ in$

Step 5. Bar Development Length

$l_d = (factor) \times d_B$

Table A-6[A] (reinf conc book)…… factor for No.6 bars is 43.8

$l_d = 43.8 \times 0.75\ in = 32.85\ inches$

Given 3 in concrete cover

$49\ in - 3\ in = 46\ in > l_d = 32.85\ inches$ **OK**

Step 6. Joint

$P_{factored\ axial\ load} = 177.2\ kips$
[ACI 9.3.2.4] $\emptyset = 0.65$

For concrete, two (2) failure modes…

On column base: $\emptyset(0.85)f'_c A_1 = (0.65)(0.85)(4)(16^2) = 565.7\ kips$

On footing: $\emptyset(0.85)f'_c A_1\sqrt{\frac{A_2}{A_1}} = (0.65)(0.85)(3)(16^2)(2) = 848.6\ kips$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{114^2}{16^2}} = 7.125 \quad > 2, therefore\ use\ 2$$

Choose smaller failure value = **565.7 kips** as max axial load that can be taken by concrete

$Extra\ load = 177.2 - 565.7 = negative, \quad therefore\ use\ minimum\ dowels$

Minimum dowels [ACI 15.8.2.1] (p 804 – reinf conc)

$A \geq 0.005\ A_g \geq 0.005\ (16^2) = 1.28\ in^2$

Use (4) No. 6 dowels, $A = 1.76\ in^2$, extending 25 in (Table A-13)

SUMMARY:

(14) No. 6 bars for transverse and longitudnal
8.3 in spacing with 3 in concrete cover
(4) No. 6 dowels
Extending 25 in into column

TYPICAL INTERIOR COLUMN FOOTING

$P_{factored} = 306\ k$
$B = 12.5\ ft$

Step 1. Estimate h, height of footing

h is typically taken as 1 to 2 times the width of the column

$1.5(16\ in) = 24\ inches \qquad Choose\ h = 28\ in$

Step 2. Check two-way shear – Two-way shear governs in spread footings (punching shear)

Assuming No. 4 bars... diameter = 1 inch
$d = h - (clear\ cover) - d_B = 28\ in - 3\ in - 1\ in = 24\ inches$

$b_0 = critical\ perimeter = 4 \times 28\ in = 112\ inches$

$tributary\ area = (12.5\ ft)^2 - (\frac{28\ in}{12\frac{in}{ft}})^2 = 150.8\ ft^2$

$V_u = q_{nu} \times tributary\ area = \left(\frac{306}{12.5^2}\right) ksf \times 150.8\ ft^2 = 295.3\ kips$

[ACI 11-33]: $V_c = \left(2 + \frac{4}{\beta_c}\right)\varphi\sqrt{f'_c}b_0 d \qquad \beta_c = 1$

$V_c = \left(2 + \frac{4}{1}\right)(1)\sqrt{3000psi}\,(112\ in)(24\ in) = 588{,}913\ lb\ \cong 589\ kips$

[ACI 11-34]: $V_c = \left(2 + \frac{\alpha_s \times d}{b_0}\right)\varphi\sqrt{f'_c}b_0 d \qquad \alpha_s = 40\ for\ columns\ centered\ on\ sq.footings$

$V_c = \left(2 + \frac{40 \times 24}{112}\right)(1)\sqrt{3000\ psi}\,(112)(24) = 1{,}556{,}408\ lb\ \cong 1556\ kips$

[ACI 11-35]: $V_c = 4\ \varphi\ \sqrt{f'_c}\ b_0\ d$
$V_c = 4\ (1)\sqrt{3000\ psi}\,(112)(24) = 588{,}911\ lb \cong 589\ kips$

Therefore, Equation [ACI 11-33] governs... $V_c = 589\ kips$

$\emptyset = 0.75$

$\emptyset V_c = (0.75)(589\ kips) = 441.75\ kips \quad (nominal\ capacity)$

$V_u = 295.3\ kips < \emptyset V_c = 441.75\ kips$ **OK**

Step 3. Check one-way shear

$$\frac{12.5\ ft(12\frac{in}{ft})}{2} - 8\ in - 24\ in = 43\ inches$$

$$tributary\ area = 12.5\ ft \times \frac{43\ in}{12\frac{in}{ft}} = 44.79\ ft^2$$

$$V_u = \left(\frac{306}{12.5^2}\right) ksf \times 44.79\ ft^2 = 87.7\ k$$

$$\emptyset V_c = \emptyset 2\sqrt{f'_c}bd = (0.75)(2)\sqrt{3000\ psi}\left(12.5\ ft\left(12\frac{in}{ft}\right)\right)(24) = 295{,}770\ lb \cong 295.77\ kips$$

$V_u = 87.7\ kips < \emptyset V_c = 295.77\ kips$ **OK**

Step 4. Flexural Design

Assumptions:

- ✓ Section treated as a cantilever beam
- ✓ Grade 60 steel is utilized

Given $\omega = q_{nu} \times B = \frac{f}{length}$

$$M_u = \frac{1}{2}\omega l^2 = \frac{1}{2}\left(\frac{306}{12.5^2}\right) ksf \times 12.5\ ft \times (\frac{67}{12})^2 = 381.6\ kft$$

$$A_s \geq \frac{M_u}{\emptyset f_y j d} = \frac{381.6\ kft\ (12\ in)}{(0.9)(60\ ksi)(0.95)(24)} = 3.72\ in^2$$

Check $A_{s,min} = \rho\ b\ h = (0.0018)\left(12.5\ ft\left(12\ \frac{in}{ft}\right)\right)(28) = 7.56\ in^2$

Therefore $A_{smin} = 7.56\ in^2$ governs given a max spacing of 18 inches

Try (13) No. 7 bars $\quad A_s = 7.8\ in^2$ **OK**

$$\alpha = \frac{A_s f_y}{(0.85)f'_c\, b} = \frac{(7.8)(60)}{(0.85)(3)(12.5\times12)} = 1.22\ inches \ll h = 28\ inches$$

Therefore assume TCS and $\emptyset = 0.9$

$$\emptyset M_n = \emptyset\, f_y\, A_s\left(d - \frac{\alpha}{2}\right) = (0.9)(60)(7.8)\left(24 - \frac{1.22}{2}\right) = 9851.87\ kin \cong 821\ kft$$

$M_u = 381.6\ kft < \emptyset M_n = 821\ kft$ **OK**

Therefore, for consistency, choose **(18) No. 6 bars** for flexural and transverse with **8.5 in spacing**

$A_s = 7.92\ in$
$d_B = 0.75\ in$

Step 5. Bar Development Length

$l_d = (factor) \times d_B$

Table A-6[A] (reinf conc book)...... factor for No.6 bars is 43.8

$l_d = 43.8 \times 0.75\ in = 32.85\ inches$

Given 3 in concrete cover

$67\ in - 3\ in = 64\ in > l_d = 32.85\ inches$ **OK**

Step 6. Joint

$P_{factored\ axial\ load} = 306\ kips$
[ACI 9.3.2.4] $\emptyset = 0.65$

For concrete, two (2) failure modes...

On column base: $\emptyset(0.85)f'_c\, A_1 = (0.65)(0.85)(4)(16^2) = 565.7\ kips$

On footing: $\emptyset(0.85)f'_c\, A_1\sqrt{\frac{A_2}{A_1}} = (0.65)(0.85)(3)(16^2)(2) = 848.6\ kips$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{114^2}{16^2}} = 7.125 \quad > 2, therefore\ use\ 2$$

Choose smaller failure value = **565.7 kips** as max axial load that can be taken by concrete

$Extra\ load = 306 - 565.7 = negative, \quad therefore\ use\ minimum\ dowels$

Minimum dowels [ACI 15.8.2.1] (p 804 – reinf conc)

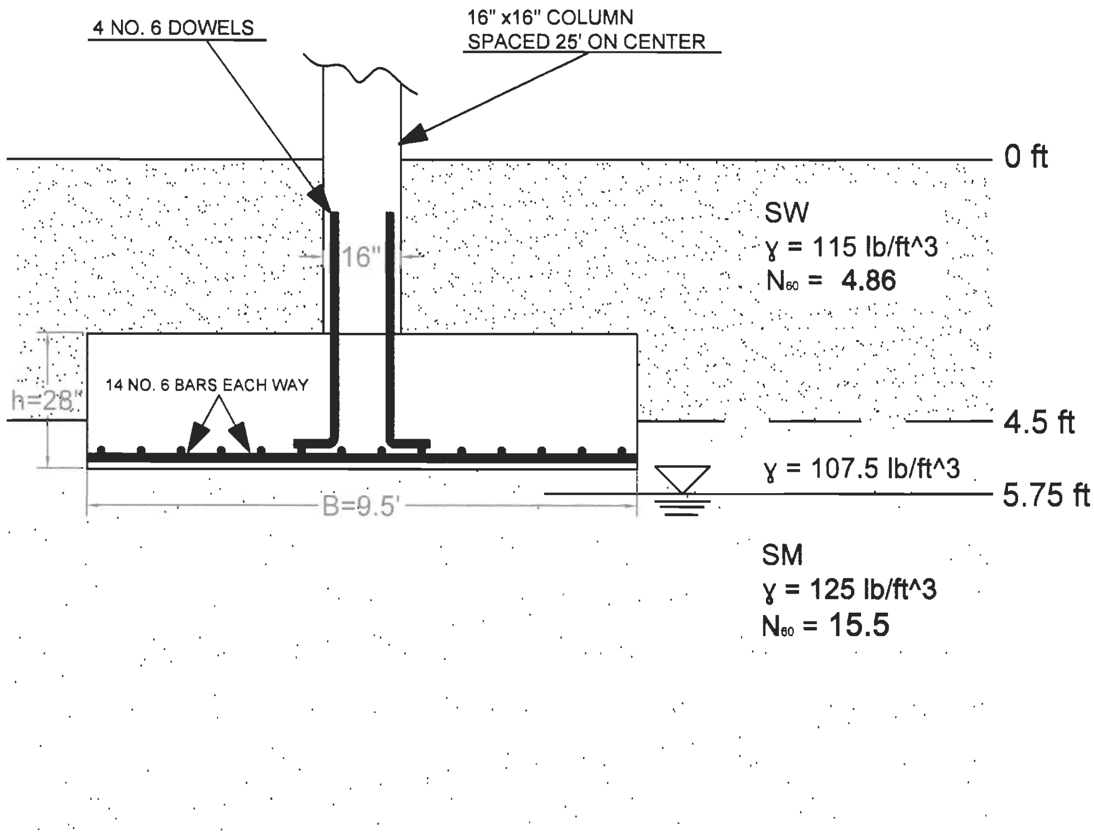
$A \geq 0.005\, A_g \geq 0.005\,(16^2) = 1.28\ in^2$

Use (4) No. 6 dowels, $A = 1.76\ in^2$, extending 25 in (Table A-13)

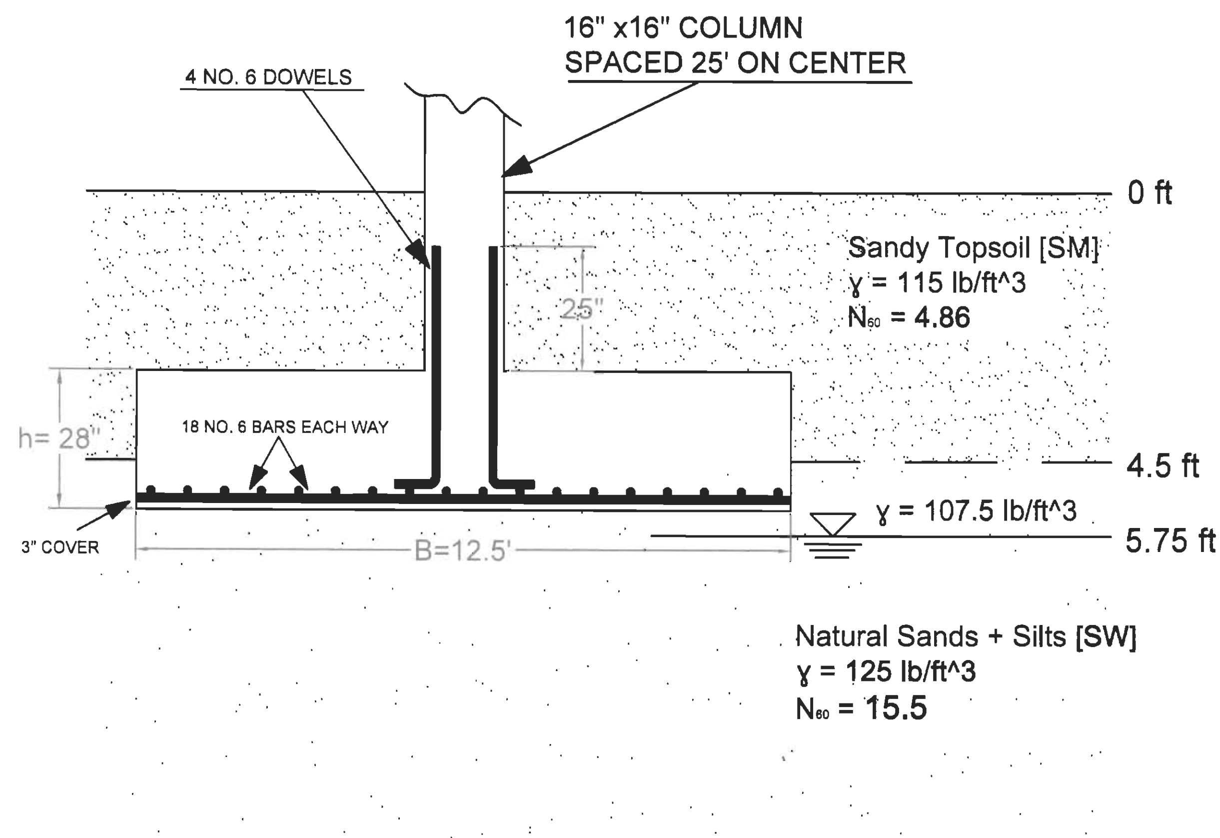
SUMMARY:

(18) No. 6 bars for transverse and longitudnal
8.5 in spacing with 3 in concrete cover
(4) No. 6 dowels
Extending 25 in into column

Appendix 18



TITLE OF DRAWING: Exterior Footing Typical	PROJECT NAME: Site Design for a 111,705 sft Class A Office Building
	CCE 4850 SENIOR CAPSTONE DESIGN
	DRAWN BY: Britney Richmond



PROJECT NAME:

Site Design for a 111,705 sft Class A Office Building

TITLE OF DRAWING:

Interior Footing Typical

CCE 4850 SENIOR CAPSTONE DESIGN

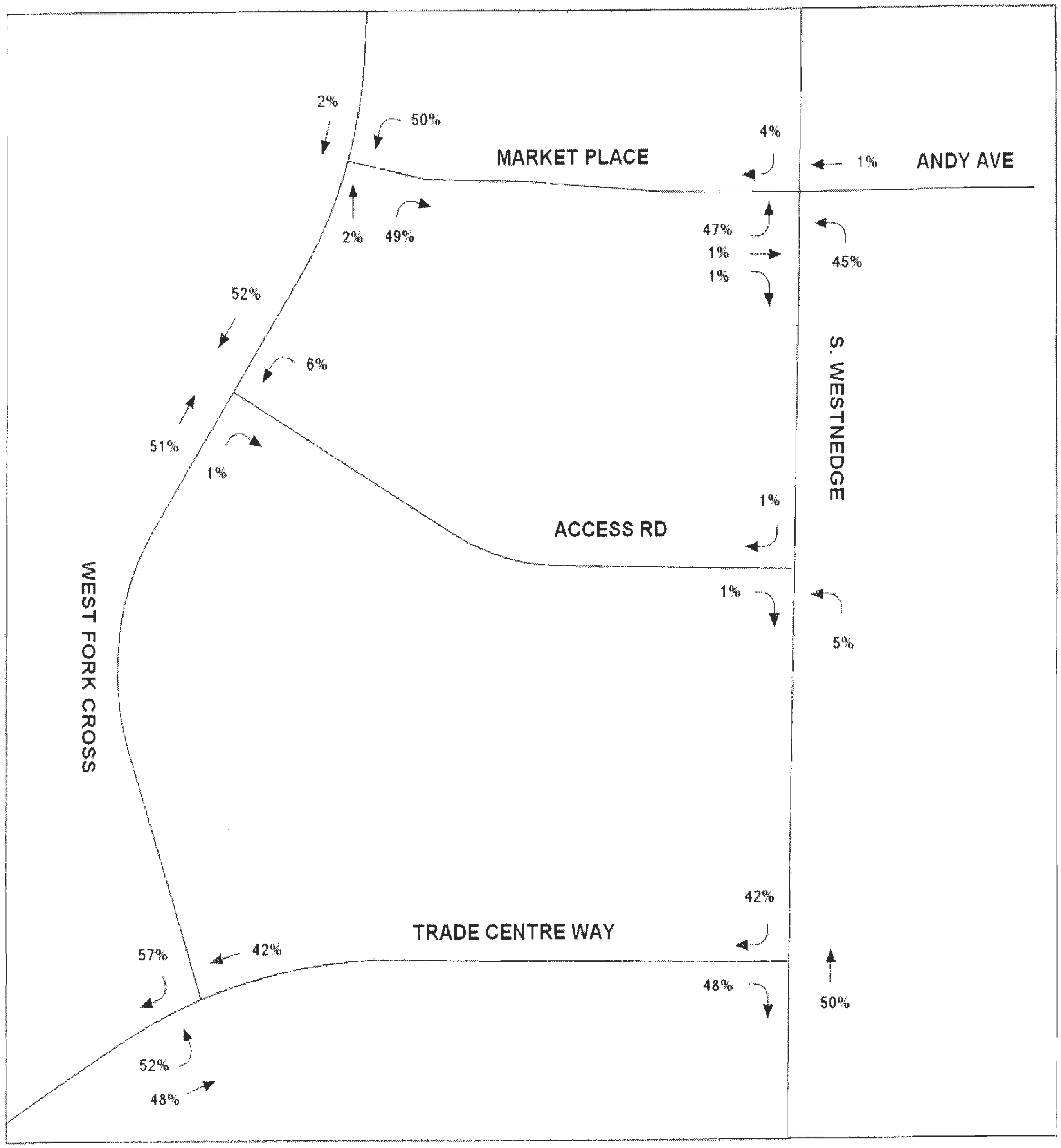
DRAWN BY:

Britney Richmond

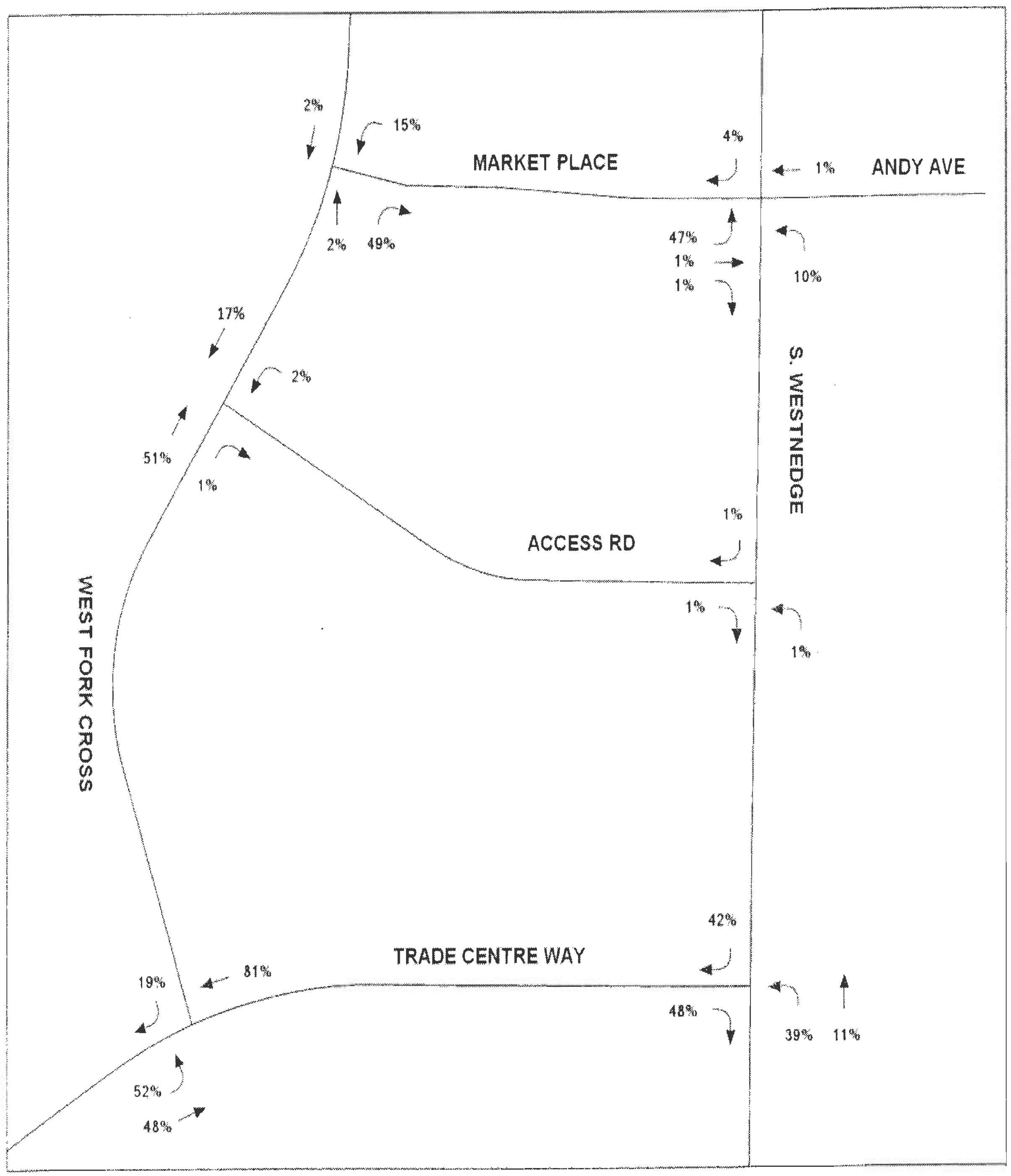
Appendix 19

Synchro File Model Before Proposed Changes

Estimated Trip Distribution for Additional Building Traffic before Proposed Changes

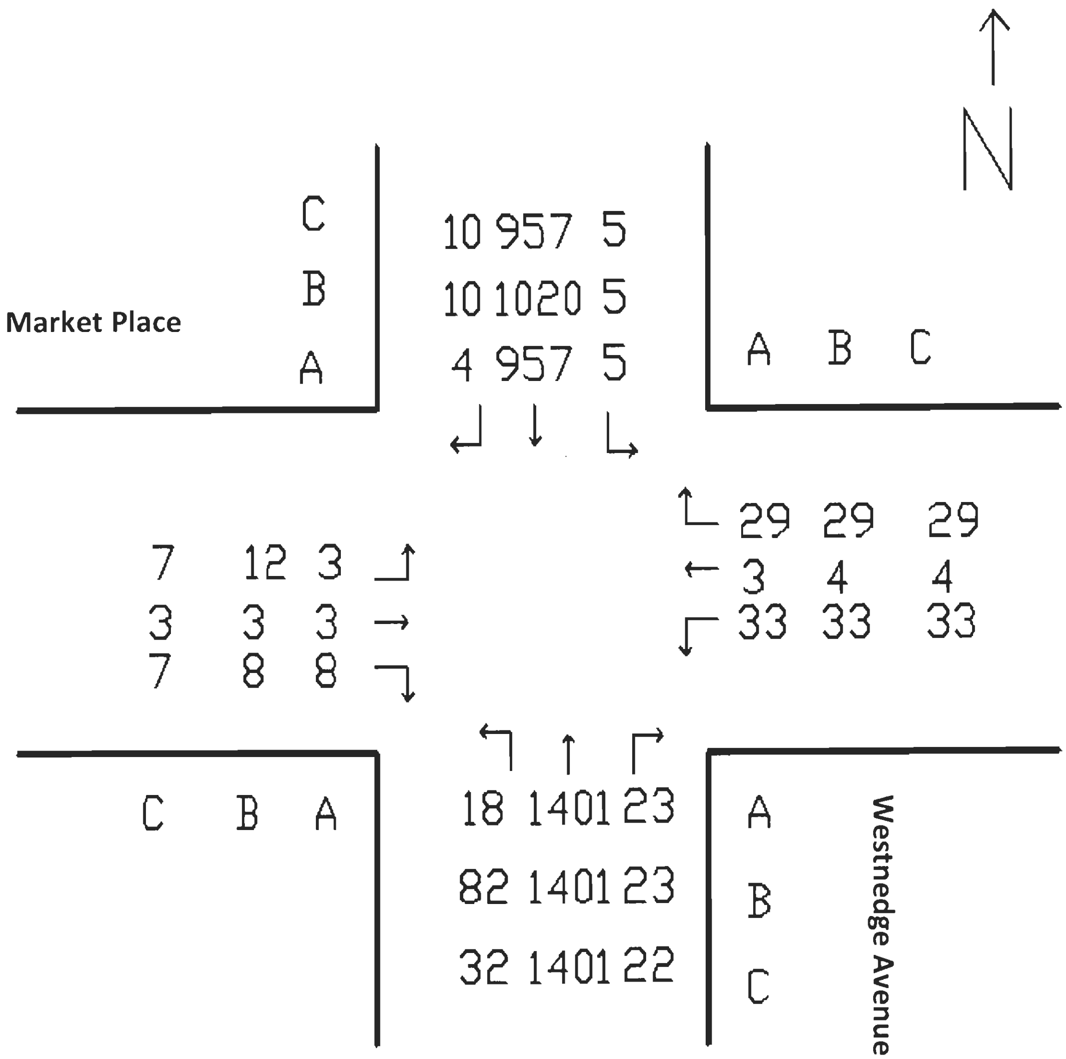


Estimated Trip Distribution after Proposed Changes



Andy/Market Place Intersection AM Peak Hour Volumes

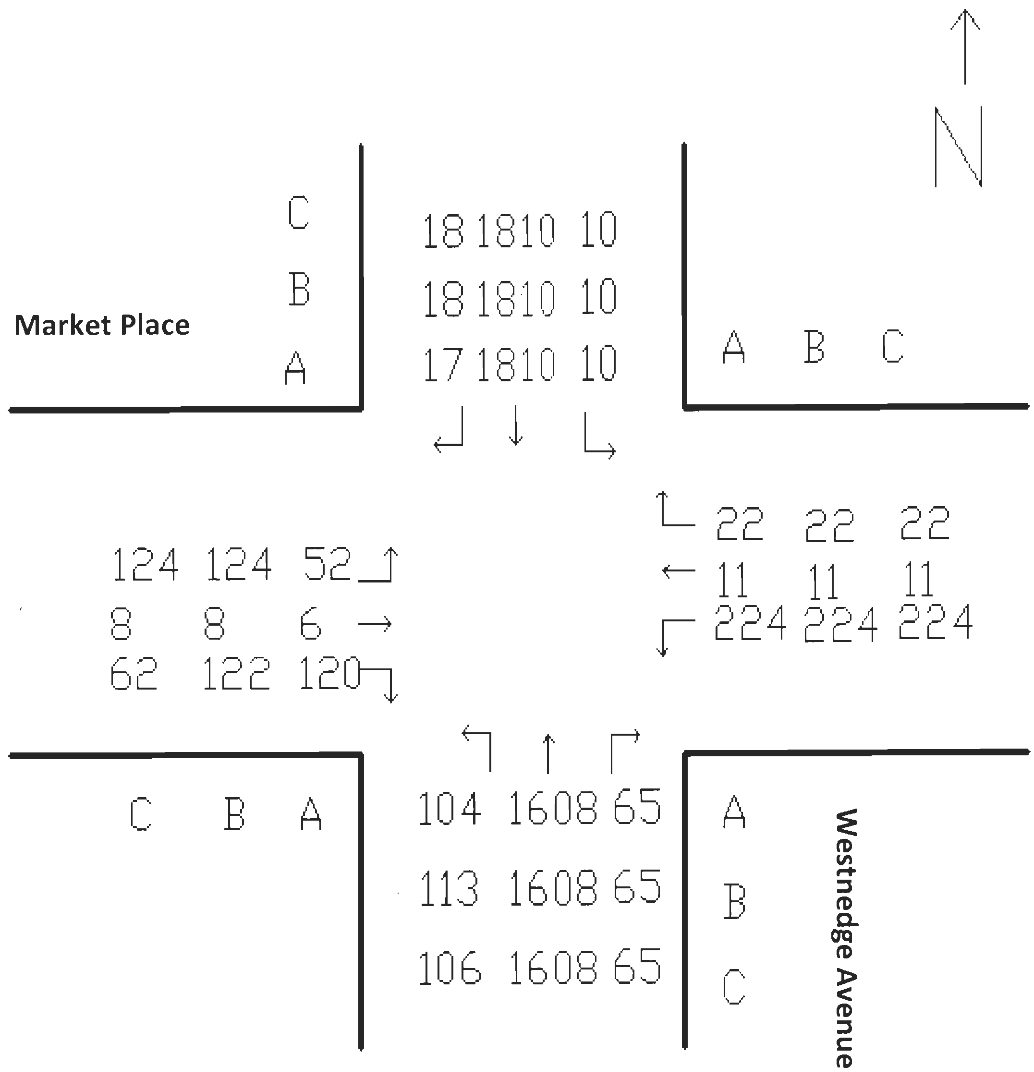
(7:45am - 8:45am)



A: Baseline 2010 Traffic Volumes
B: After Build Traffic Volumes
C: After proposed changes

Andy/Market Place Intersection PM Peak Hour Volumes

(4:45pm - 5:45pm)



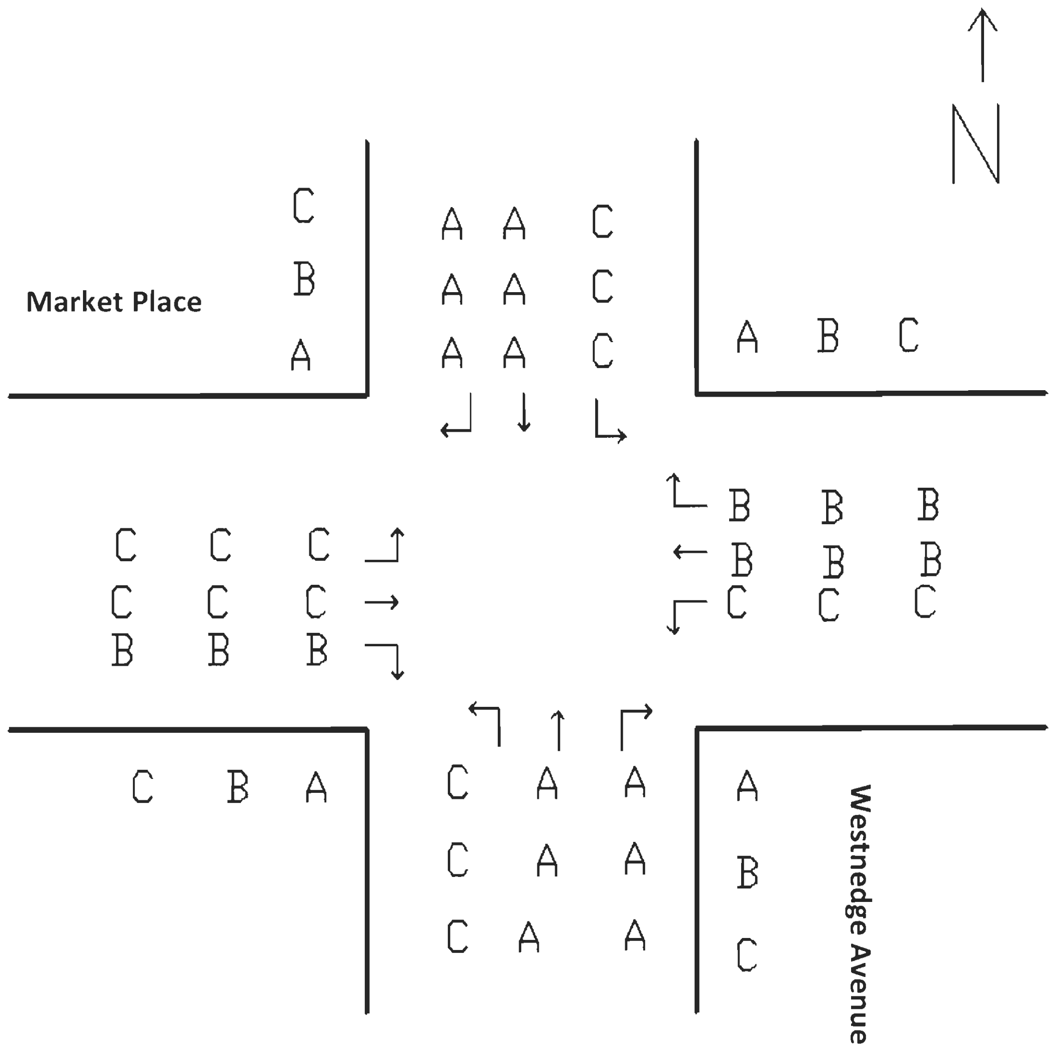
A: Baseline 2010 Traffic Volumes

B: After Build Traffic Volumes

C: After proposed changes

Andy/Market Place Intersection AM LOS

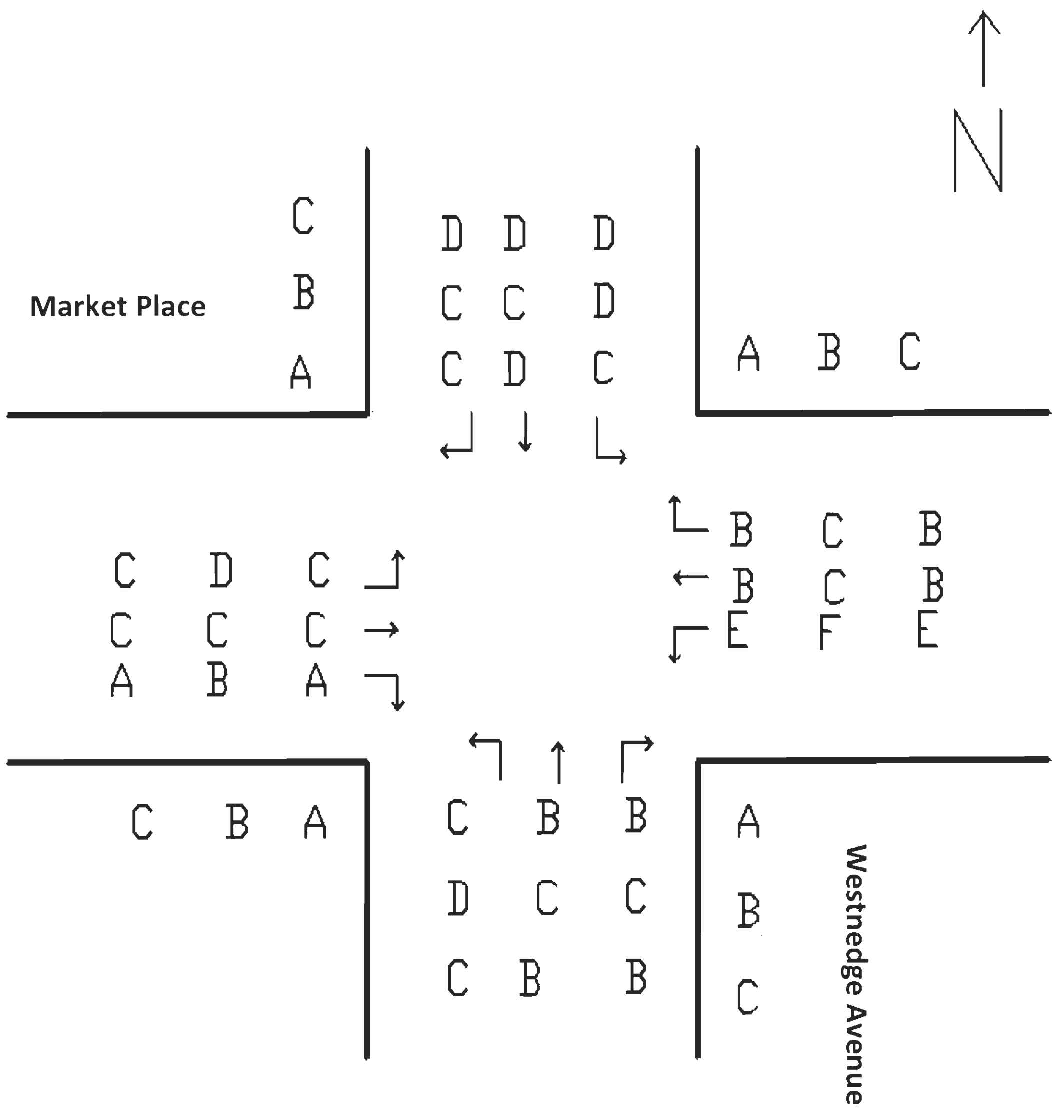
(7:45am - 8:45am)



A: Baseline 2010 LOS
B: After Build LOS
C: After proposed changes

Andy/Market Place Intersection PM LOS

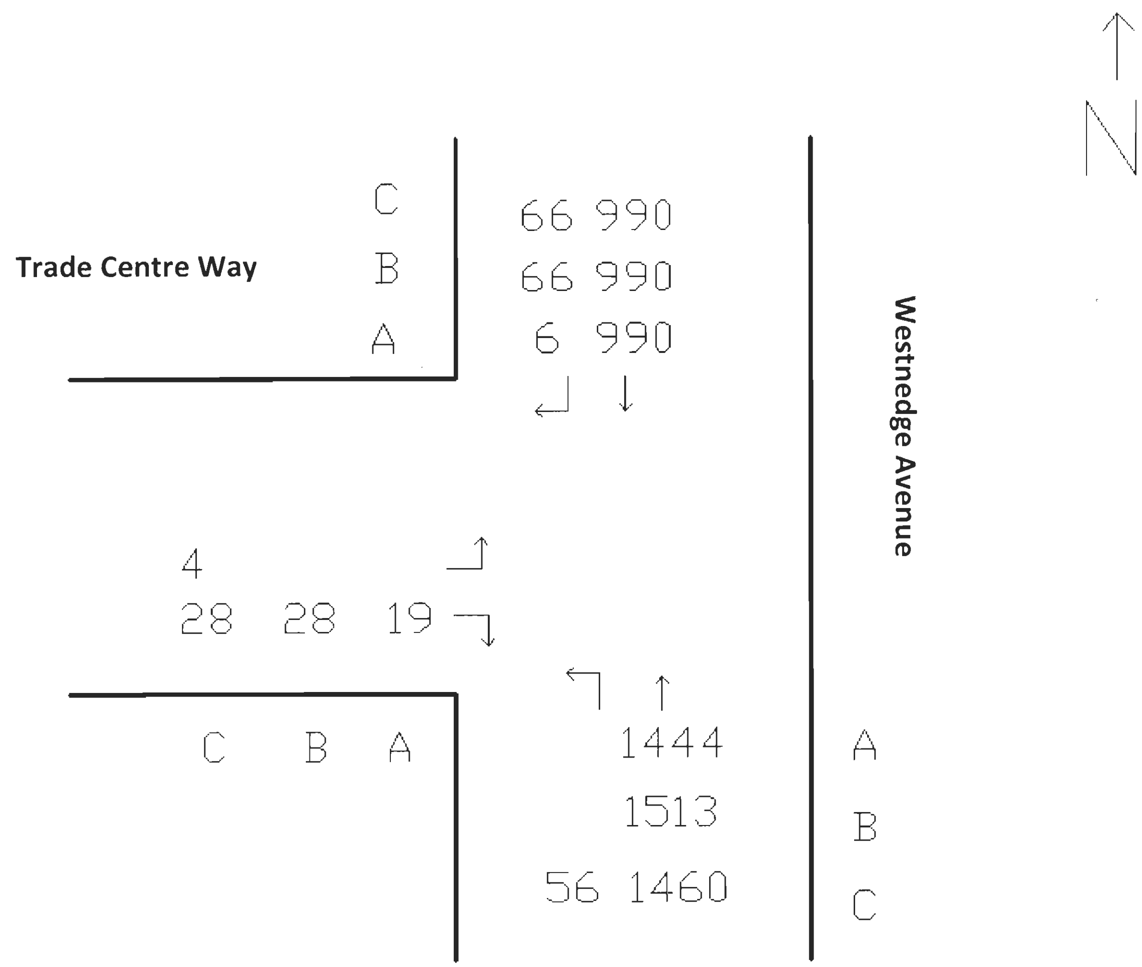
(4:45pm - 5:45pm)



A: Baseline 2010 LOS
B: After Build LOS
C: After proposed changes

Trade Centre Way Intersection AM Peak Hour Volumes

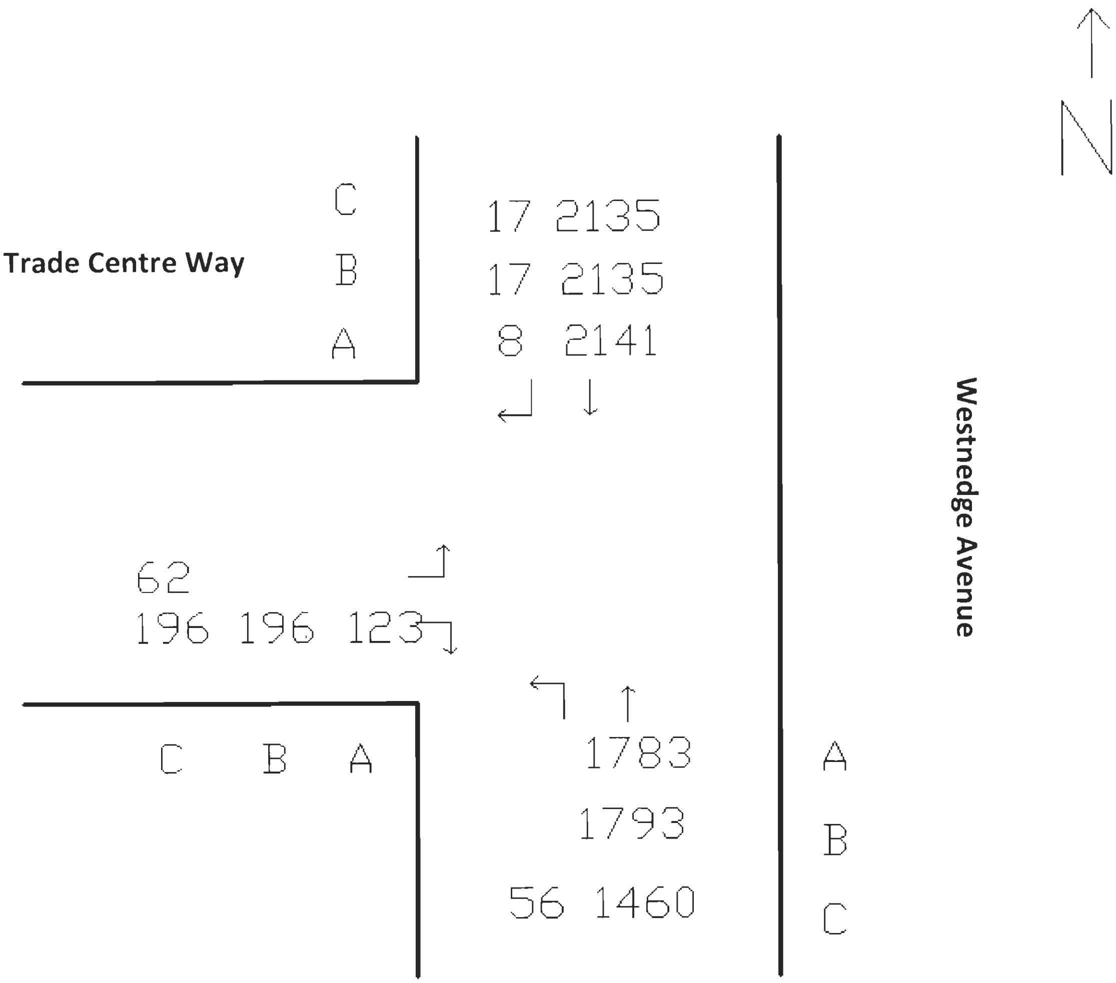
(7:45am - 8:45am)



A: Baseline 2010 Traffic Volumes
B: After Build Traffic Volumes
C: After proposed changes

Trade Centre Way Intersection PM Peak Hour Volumes

(4:45pm - 5:45pm)



A: Baseline 2010 Traffic Volumes
B: After Build Traffic Volumes
C: After proposed changes